SoBRA Generic Assessment Criteria for Assessing Vapour Inhalation Risks from Groundwater Sources

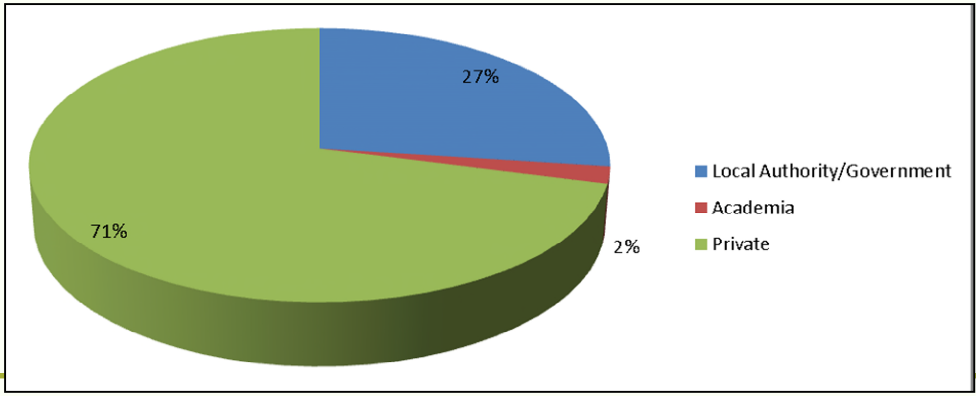
Eleanor Walker, Atkins

Introduction

- Introduction to SoBRA
- Groundwater vapour sub-group work
  - objectives
  - methodology
  - outputs – GAC/report
  - sensitivity and uncertainty analysis
  - assumptions and other considerations
- Summary
- Questions

What is SoBRA?

- The Society of Brownfield Risk Assessment
- Learned society established in 2009 to support growing number of professionals working in land contamination risk assessment
- Aims:
  - improve technical knowledge in risk-based decision-making
  - enhance professional status/profile of risk assessment practitioners



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SoBRA The Society of Brownfield Risk Assessment

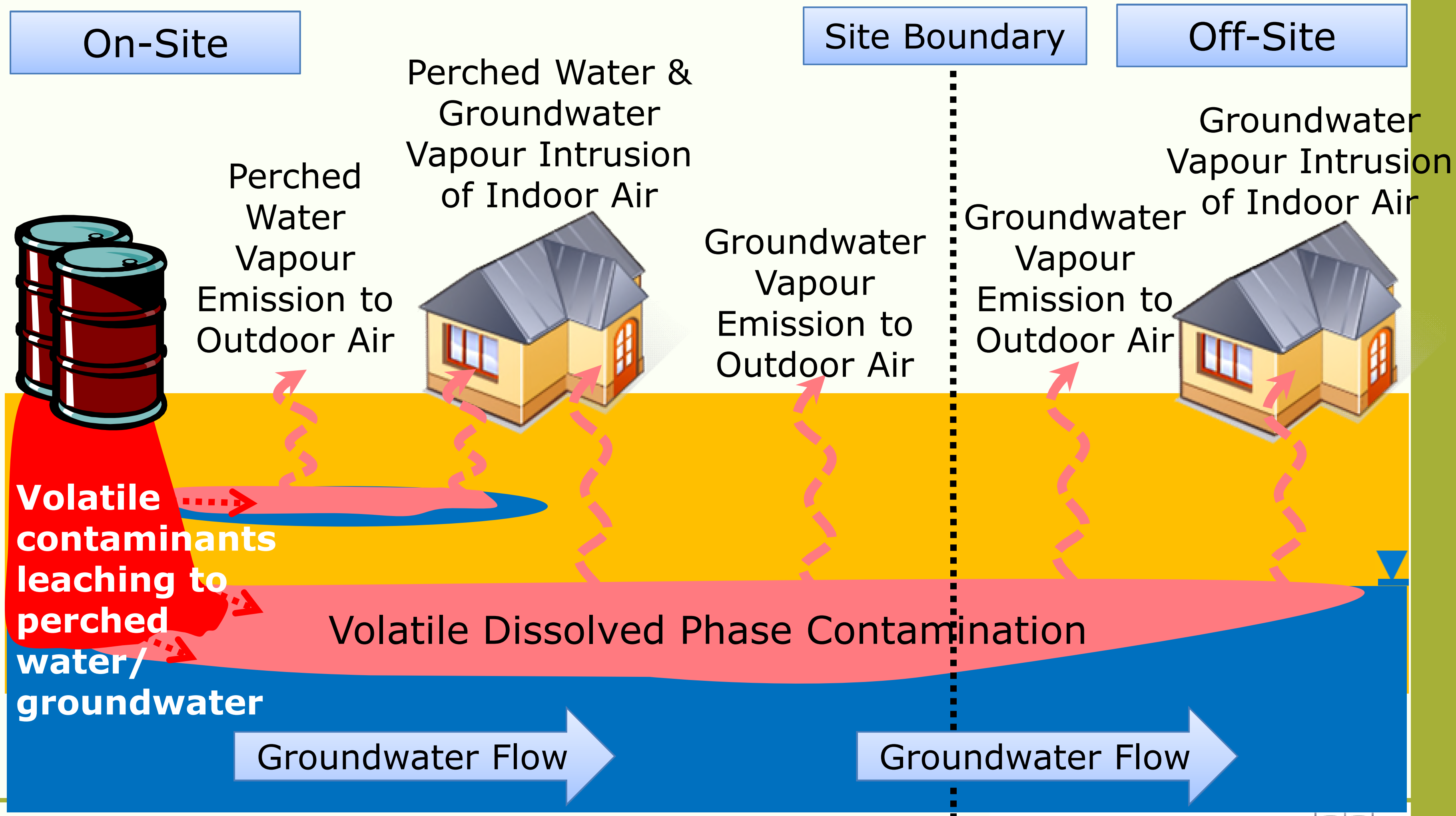
Groundwater vapour sub-group

- Tim Rolfe (AECOM)
- Oliver Balcock (Ashfield Solutions Ltd.)
- Andrew Fellows (Atkins)
- Eleanor Walker (Atkins)
- Hannah White (Atkins/National Grid Property Holdings)
- Simon Clennell Jones (Delta Simons)
- Simon Firth (Firth Consultants Ltd.)
- James Rayner (Geosyntec)
- Naomi Earl (independent)
- Jonathan Parry (SLR Consulting)
- Executive Committee

Objectives

- Develop methodology for assessing chronic risk to human health via inhalation of groundwater-derived vapours in a manner compliant with current UK guidance
- Derive generic assessment criteria (GAC) for selected contaminants and accompanying guidance
- Free-to-use defensible conservative screening tool for GQRA
- Increase awareness of groundwater-vapour exposure pathway

What is the problem?



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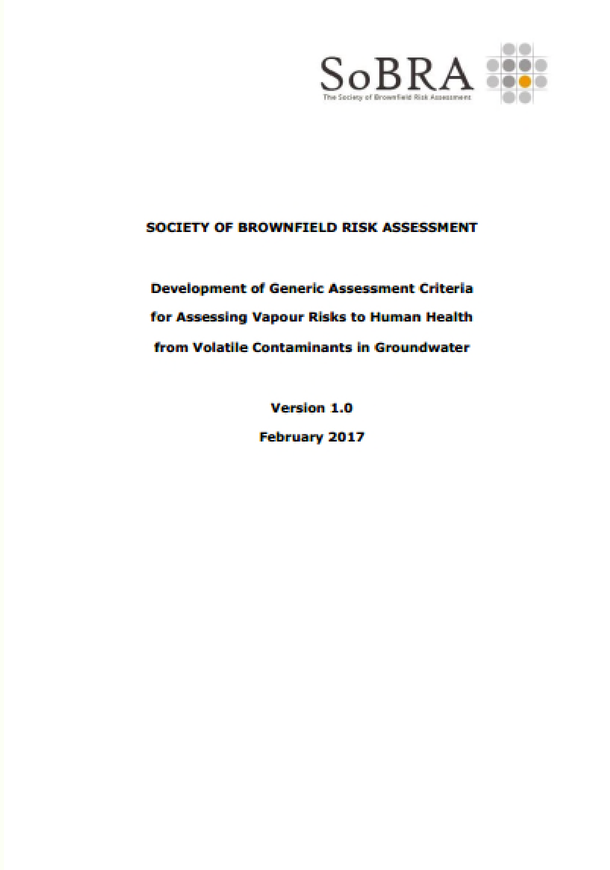
SOBRA report

- "Development of Generic Assessment Criteria for Assessing Vapour Risks to Human Health from Volatile Contaminants in Groundwater", v1.0, Feb 2017
- Available soon at: http://sobra.org.uk/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SOCIETY OF BROWNFIELD RISK ASSESSMENT

Development of Generic Assessment Criteria
for Assessing Vapour Risks to Human Health
from Volatile Contaminants in Groundwater

Version 1.0
February 2017

Methodology

- Produced using CLEA v 1.07 model
  - vapour inhalation pathways only
  - default gas ingress rate turned off
- Soluble (>1 ug/L), volatile contaminants (K_{aw} < 4 x10^{-4})
- Source depth 0.65 m
- Sand soil – 1% SOM
- C4SL exposure parameters with minimal risk HCVs
- Physical-chemical parameters from EA SR7 (2008), Nathanail et al S4UL (2015), CL:AIRE/EIC/AGS GAC (2010)
- Sub-surface soil to indoor air correction factor (10) for TPH/BTEX

Step by step guide

1. Set up model with appropriate parameters/calculations
2. Derive results
3. Unhide/unprotect “Media Calculations” sheet
4. Convert reported soil solution concentration (pore water dissolved concentration) to GAC (mg/cm^3 to ug/L)

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GAC

- GAC for 66 contaminants
- Commonly analysed volatile constituents in groundwater
  - 19 Petroleum hydrocarbons
  - 4 PAHs
  - 3 Pesticides
  - 35 Halogenated Organics
  - 5 Others
- Residential and commercial land uses

Example GAC

Table 6 - GAC_{gwvap} for Petroleum Hydrocarbons

Chemical	CAS	GAC_{gwvap} (µg/l) [1,2]		Aqueous Solubility (µg/l)
		Residential	Commercial	
1,2,4-Trimethylbenzene	95-63-6	24	2,200	559,000
Benzene [3]	71-43-2	210	20,000	1,780,000
Ethylbenzene [3]	100-41-4	10,000	*960,000 (sol)*	180,000
Isopropylbenzene	98-82-8	850	*86,000 (sol)*	56,000
Propylbenzene	103-65-1	2,700	*240,000 (sol)*	54,100
Styrene	100-42-5	8,800	*810,000 (sol)*	290,000
Toluene [3]	108-88-3	230,000	*21,000,000 (sol)*	590,000
TPH Aliphatic EC5-EC6 [3]		1,900	*190,000 (sol)*	35,900
TPH Aliphatic >EC6-EC8 [3]		1,500	*150,000 (sol)*	5,370
TPH Aliphatic >EC8-EC10 [3]		57	*5,700 (sol)*	427
TPH Aliphatic >EC10-EC12 [3]		37	*3,600 (sol)*	34
TPH Aromatic >EC5-EC7 [2,3]		210,000	*20,000,000 (sol)*	1,780,000
TPH Aromatic >EC7-EC8 [3]		220,000	*21,000,000 (sol)*	590,000
TPH Aromatic >EC8-EC10 [3]		1,900	*190,000 (sol)*	64,600
TPH Aromatic >EC10-EC 12 [3]		6,800	*660,000 (sol)*	24,500
TPH Aromatic >EC12-EC16 [3]		39,000	*3,700,000 (sol)*	5,750
meta-Xylene [3,5]	108-38-3	9,500	*940,000 (sol)*	200,000
ortho-Xylene [3,5]	95-47-6	12,000	*1,100,000 (sol)*	173,000
para-Xylene [3,5]	106-42-3	9,900	*980,000 (sol)*	200,000

Sensitivity analysis

- Sensitivity tested using CLEA for residential land use
- 5 contaminants: benzene, carbon disulphide, naphthalene, TCE, vinyl chloride
- Parameters tested
    - **Soil type**
    - **Depth to source**
    - **Building type**
    - **SOM**

Soil type

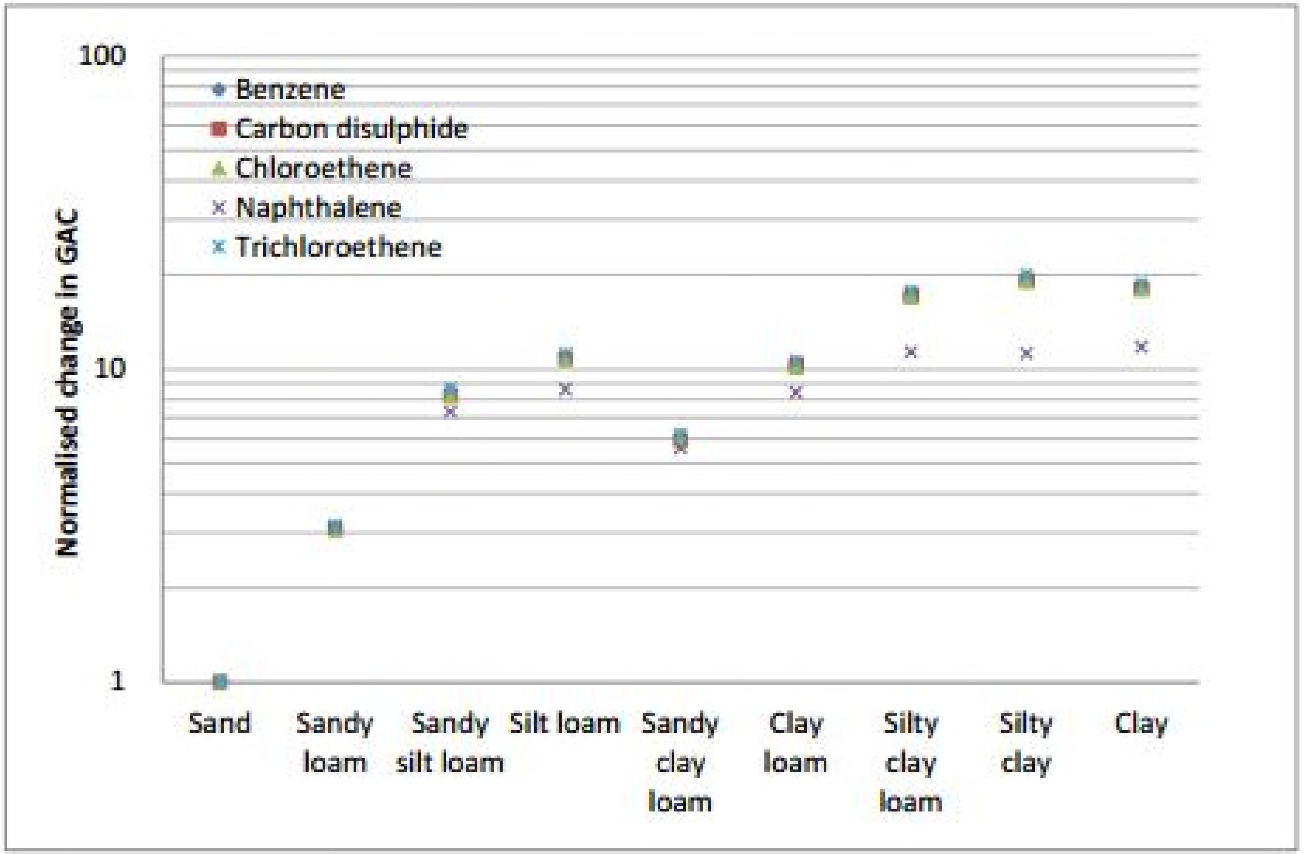

Figure 2 - Influence of Soil Type on Residential GAC_{gwvap}

Depth to source

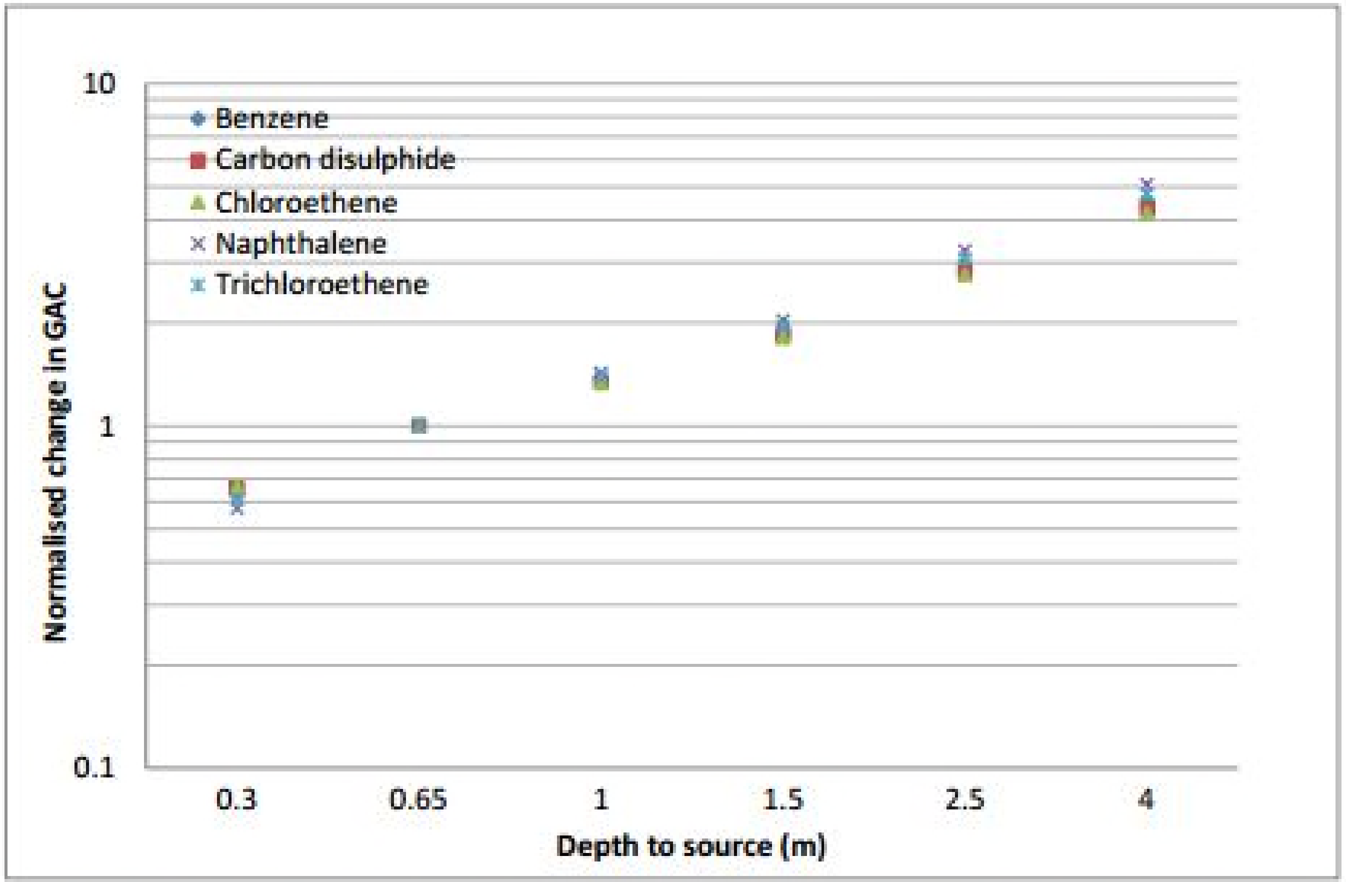

Figure 1 - Influence of Source Depth (i.e. Groundwater Depth) on Residential GAC_{gwvap}

Building type

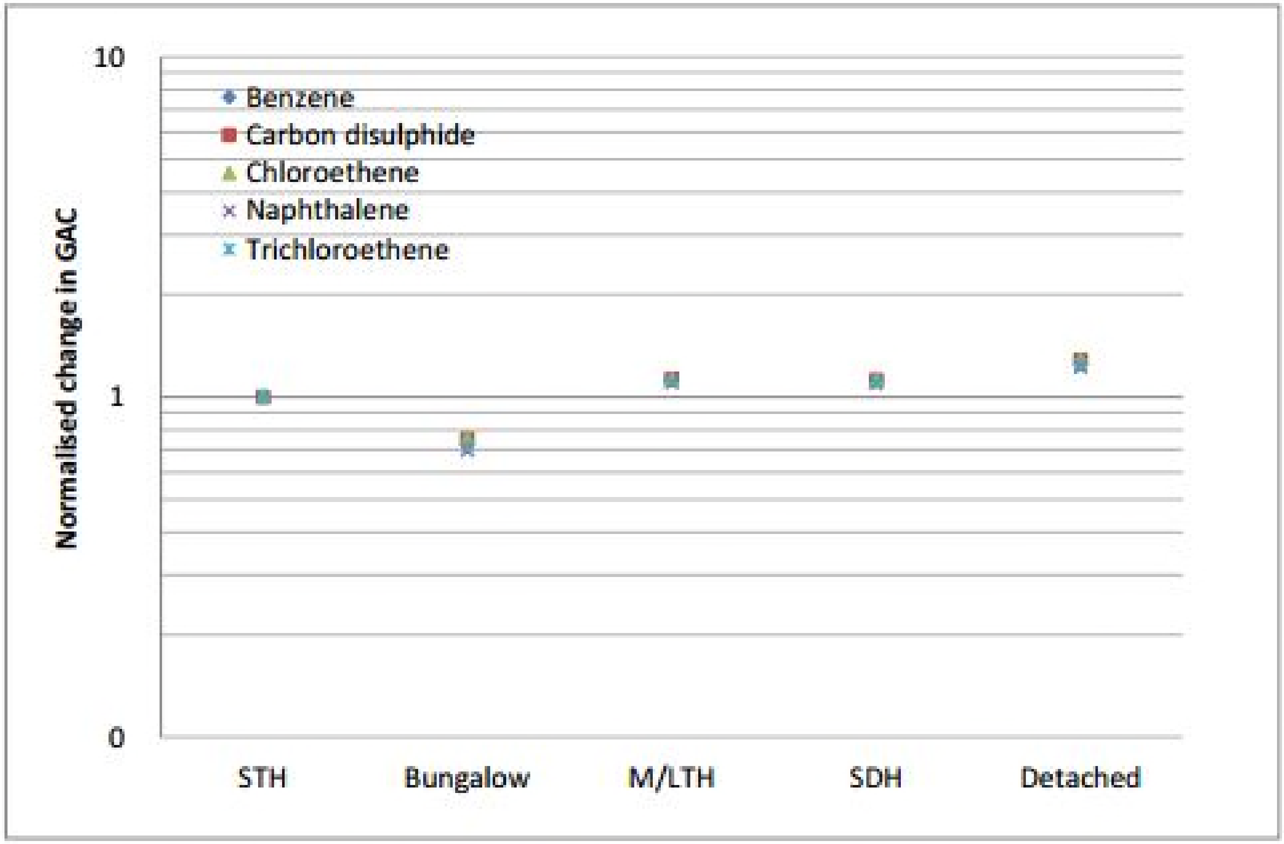

Figure 3 - Influence of Building Type on Residential GAC_{gwvap}

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SOM

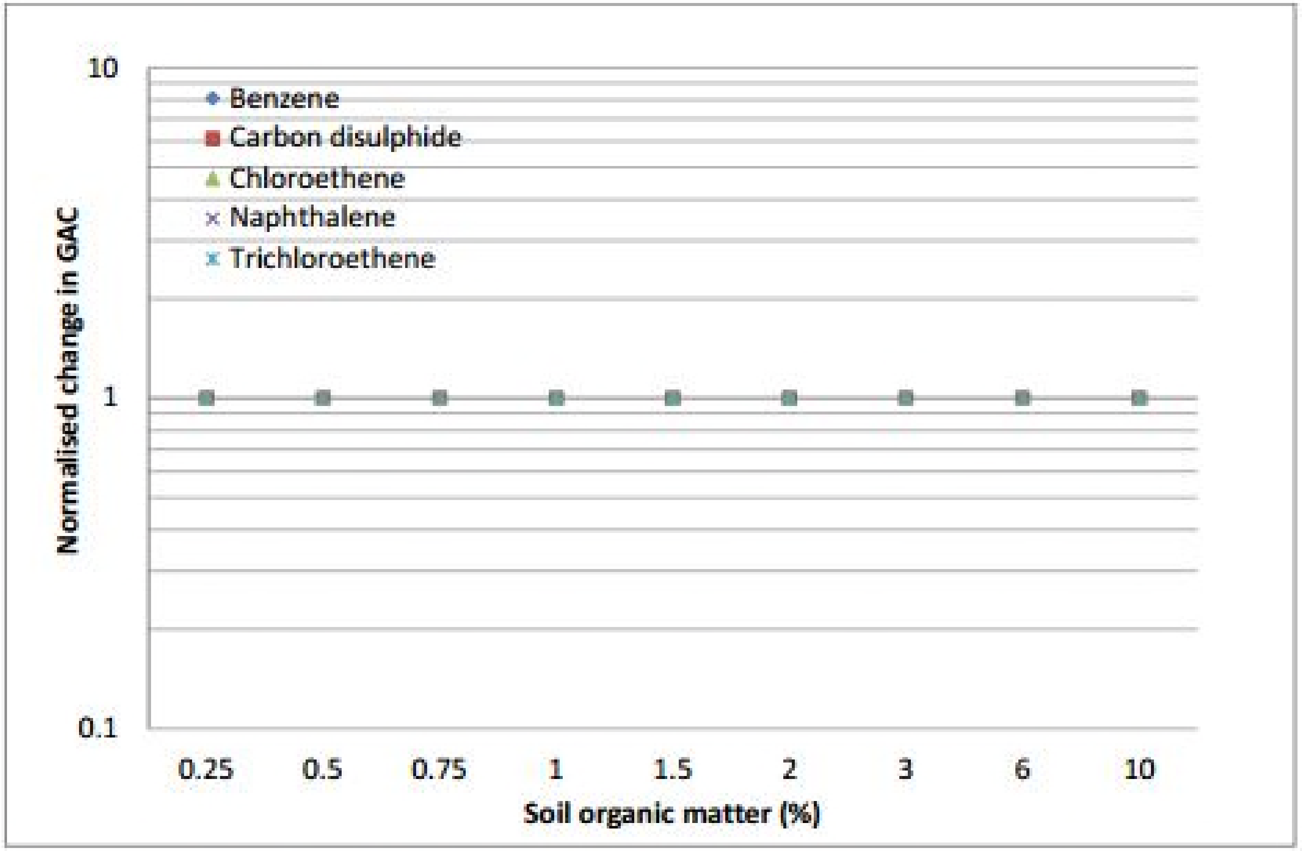

Figure 4 - Influence of Soil Organic Matter on Residential GAC_{gwvap}

Sensitivity analysis summary

- **Soil Type** – most sensitive parameter (sand to silty clay GAC increase up to 20x)
- **SOM** – no effect on GAC
- **Building type** – limited effect (within land use) - 25-30% lower GAC for bungalow)
- **Depth to source –** increasing depth to source to 4m increases GAC 4x

Comparison with J&E model

- CLEA uses USEPA Johnson & Ettinger (J&E) soil source vapour model
- J&E groundwater source vapour model accounts for reduced diffusion through capillary fringe – CLEA does not
- Run for sand, sandy loam and clay loam soils
- CLEA more conservative (predicted indoor air concentrations 1.5 to 7.1 times higher than J&E groundwater source vapour model)

J&E comparison - sand

Table 3: Comparison of CLEA and J&E predicted indoor air concentrations associated with the GAC_{gwvap} for residential land use with sand soil

Contaminant	Unit	Benzene	Carbon Disulphide	Naphthalene	Vinyl Chloride	TCE
CLEA Groundwater Residential GAC_{gwvap}	µg/l	211	56.2	216	0.62	5.65
CLEA predicted indoor air concentration	µg/m³	2.15	22.0	1.06	0.462	0.877
J&E predicted indoor air concentration	µg/m³	0.301*	3.18	0.262	0.0676	0.126
Ratio of predicted CLEA:J&E indoor air concentrations	-	7.1	6.9	4.0	6.8	7.0

* soil to indoor air correction factor of 10 applied by dividing the J&E predicted indoor air concentration by 10

J&E comparison – clay loam

Table 5: Comparison of CLEA and J&E predicted indoor air concentrations associated with the GAC_{gwvap} for residential land use with clay loam soil

Contaminant	Unit	Benzene	Carbon Disulphide	Naphthalene	Vinyl Chloride	TCE
CLEA Groundwater Residential GAC_{gwvap}	µg/l	2190	575	1820	6.33	60
CLEA predicted indoor air concentration	$\mu g/m^3$	2.15	22	1.06	0.462	0.877
J&E predicted indoor air concentration	$\mu g/m^3$	0.429*	3.78	0.712	0.0769	0.167
Ratio of predicted CLEA:J&E indoor air concentrations	-	5.0	5.8	1.5	6.0	5.3

* soil to indoor air correction factor of 10 applied by dividing the J&E predicted indoor air concentration by 10

Conservative assumptions

- Assumes source directly beneath building
- Infinite source term
- No biodegradation
- Shallow source depth (0.65 m)
- Sand soil type
- Omission of capillary fringe

Conservative assumptions

- Intended for initial assessment of vapour migration pathways from groundwater/perched water
- Conservative screening criteria – NOT remediation criteria
- Consider CSM and relevance of GAC to your site

Some other considerations

- GAC only consider vapour inhalation from groundwater/perched water source
- May need to consider other contaminant linkages (e.g. exposure from soil contamination/potential presence of NAPL)
- Preferential pathways
- Potential toxicological additivity (e.g. TPH)
- Potential degradation to more toxic daughter products
- Odour thresholds
- Uncertainty in recorded groundwater concentrations

Other approaches / considerations

- GAC intended as one potential tool for making an initial assessment of groundwater vapour risk
- May also consider:
  - empirical data on 'safe' lateral and vertical distances to source to screen out implausible risk
  - degradation of petroleum hydrocarbons in unsaturated zone
  - potential for acute risk
- Other recent UK / international guidance sign-posted in report

Summary

- GAC for 66 common volatile contaminants
- Methodology and step-by-step guide
- Conservative initial screening tool compliant with current UK guidance
- Consider applicability to your CSM

Questions

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