



Modelling the real thing: Comparison of the calculated vapour intrusion to analysed volatile concentrations

Kari Koponen, PhD



INTRO: STUDY SITE

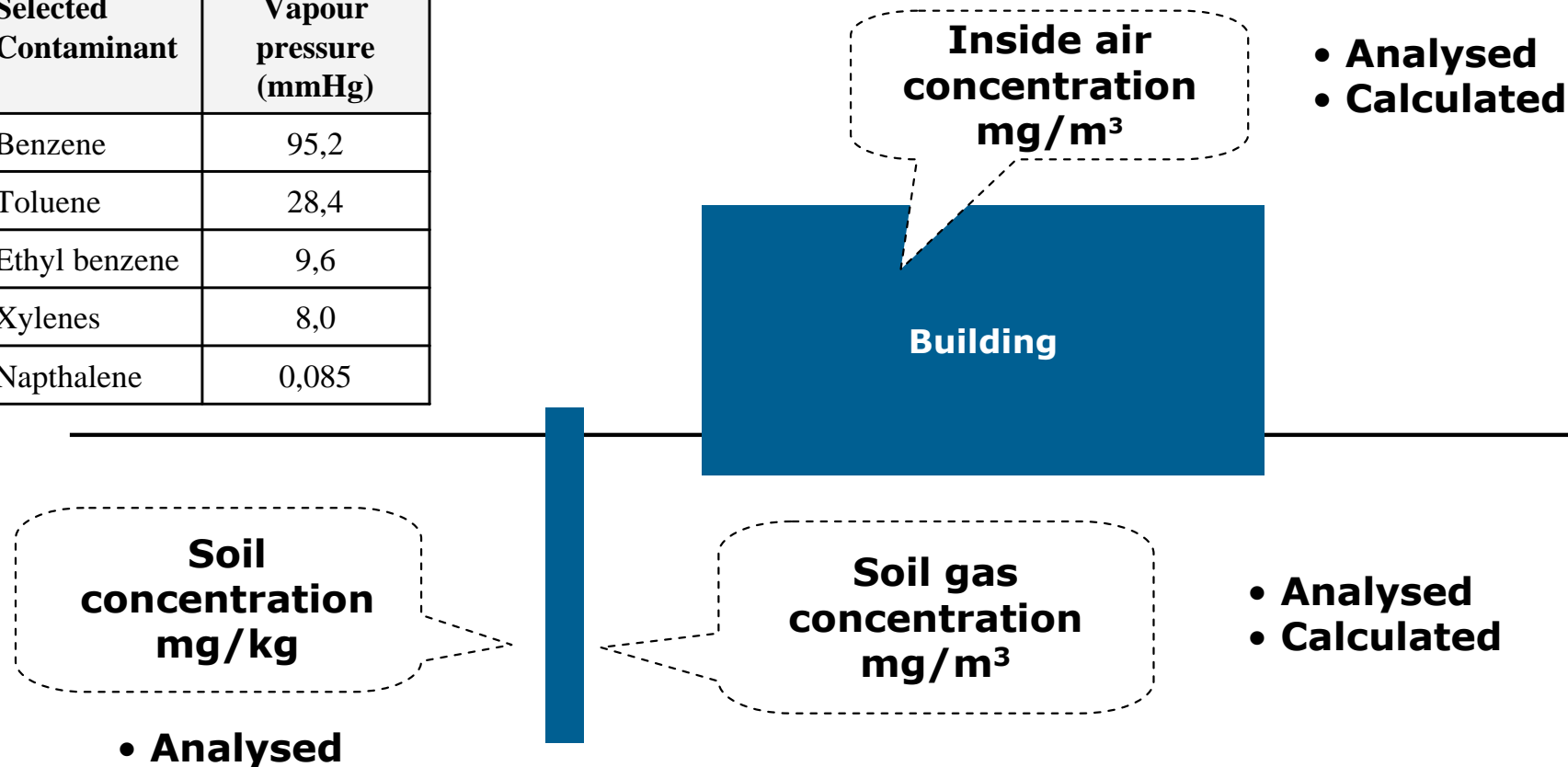


- Gas plant area, city gas production during 1910...1973
- Soil and groundwater polluted by various contaminants (BTEX, PAHs, oil, cyanide)
- Area will be renovated to commercial/Office/recreational use, starting at 2009
- Buildings are protected!

THE SCOPE:

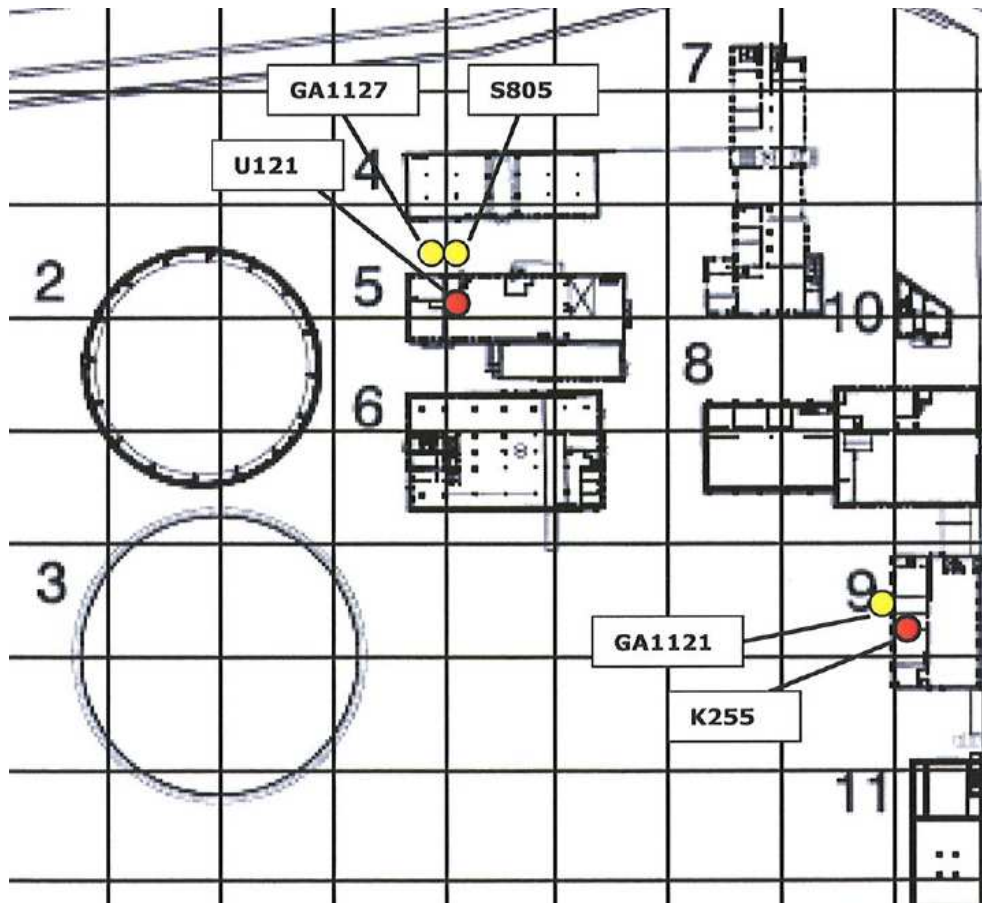
Comparison of measured and calculated concentrations in selected environmental compartments

Selected Contaminant	Vapour pressure (mmHg)
Benzene	95,2
Toluene	28,4
Ethyl benzene	9,6
Xylenes	8,0
Napthalene	0,085



Contaminant pathway: Soil → Soil gas → Inside air

SAMPLING



- Selected pathways: Building 5 and Building 9!
- Soil sampling: points S805 and GA1121
- Soil gas sampling: points GA1127 and GA1121
- Inside air sampling: points U121 and K255

Analysed soil concentrations

Table 1. Soil concentrations and guideline values.

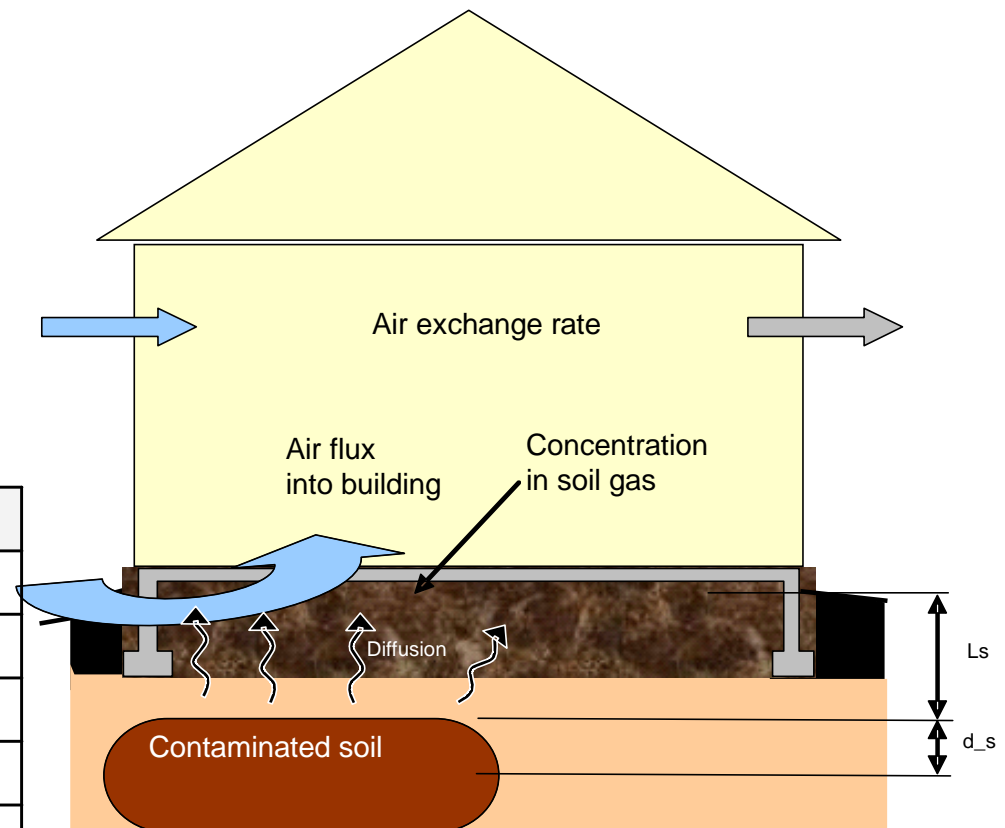
Substance	Concentrations in soil (mg/kg)		Guideline values* for soil (mg/kg)	
	Building 5 S805 (3m)	Building 9 GA1121 (2m)	Lower	Higher
Benzene	0,9	7,3	0,2	1,0
Toluene	0,23	9,8	5,0	25
Ethyl benzene	0,95	1,6	10	50
Xylenes	6,0	22,2	10	50
Naphthalene	6,0	51	5,0	15

* The Government Decree on the Assessment of Soil Contamination and Remediation Needs (214/2007): lower guideline = Residential land use, higher guideline values = Industrial/Commercial land use

MODELLING: SOILIRISK 2.0 (ÖPK 2007)

- Risk assessment model for petroleum hydrocarbons (BTEX, oil, PAHs)
- Was used to calculate soil gas concentration and indoor air concentration

Parameter	Building 5	Building 9
Soil type	sand	sand
Measured organic carbon content	0,006	0,006
Depth of contaminated soil	0,6 m	0,6 m
Thickness of contamination	3,5 m	2,0 m
Contaminated area under building	30 %	30 %
Building floor area	390 m ²	75 m ²
Volume of the effective space	1365 m ³	225 m ³
Air exchange rate	0,5/1 hr	0,5/1 hr
Air flux into building	140 cm ³ /s	140 cm ³ /s



RESULTS: Soil gas concentrations

	Concentration in soil gas (mg/m ³)		Calculated / Measured
	Calculated	Measured	
Building 5			
Benzene	170	6,7	25
Toluene	21	28	0,75
Ethyl benzene	50	2,2	23
Xylenes	210	22,5	9
Naphthalene	2,8	0,002	1400
Building 9			
Benzene	1400	0,03	46700
Toluene	910	0,18	5050
Ethyl benzene	84	0,04	2100
Xylenes	790	1,08	730
Naphthalene	24	0,003	8000

RESULTS: Indoor air concentrations

	Concentration in inside air ($\mu\text{g}/\text{m}^3$)		RfC* ($\mu\text{g}/\text{m}^3$)	TCA** ($\mu\text{g}/\text{m}^3$)
	Calculated	Measured		
Building 5				
Benzene	48	4	30	20
Toluene	6	4	5000	400
Ethyl benzene	14	13	1000	770
Xylenes	58	83	100	870
Naphthalene	0,001	5	3	-
Building 9				
Benzene	247	0,4	30	20
Toluene	332	1	5000	400
Ethyl benzene	45	<	1000	770
Xylenes	418	1	100	870
Naphthalene	10	1	3	-

* US EPA (IRIS): Reference air concentration in chronic exposure.

** TCA = Tolerable Concentration in Air (Reinikainen 2007).

Inside air concentrations exceeding the reference values are shown **in bold**.

RESULTS: Seasonal variation

	Measured concentration in inside air ($\mu\text{g}/\text{m}^3$)	
	Winter 2007	Summer 2008
Building 5		
Benzene	4	2
Toluene	4	4
Ethyl benzene	13	<
Xylenes	83	5
Naphthalene	5	7
Building 9		
Benzene	0,4	<
Toluene	1	0,7
Ethyl benzene	<	<
Xylenes	1	1
Naphthalene	1	0,8

DISCUSSION I: about analyses

- Higher concentrations in soil did not result higher concentrations in soil gas nor inside air?
 - Soil texture and layering, extent of contamination,
 - Sampling technique with VOCs,
 - Analytical uncertainty!!
- Background concentrations in inside air! Naphthalene!
- Seasonal changes were surprisingly insignificant!
- Money saved at sampling costs will be lost with interest later!
 - Solid sampling data as foundation to build the case
 - Poor data → off-the-target modelling → overlooked risks/overprotective risk management measures!



DISCUSSION II: about modelling

- Basic modelling overestimated chemical concentrations along the pathway! ... nothing new there...
- Overestimation is good for safety!
- Overestimation is bad for business!
 - Overestimated concentrations → higher risks → lower risk-based clean-up guidelines → higher remediation costs!
- Would it be better to use more sophisticated and complex models?
 - Consultants are not scientists!
 - "Good is enough, excellent is just too expensive"?!
- "Trash in - garbage out",
 - know and ensure your parameters!
 - Get best possible sampling data before modelling approach!



DISCUSSION: pearls of wisdom!

- Impossible to rule out all the environmental, technical and/or analytical uncertainties!
- The "Belt & Suspenders" –approach! Do them both!

"All models should be as simple as possible, but not simpler"

- Albert Einstein

"Never put the modeling cart before the sampling horse"

- George Box

