

# Intrusion of chlorinated hydrocarbons from an environmental contamination by dry cleaning

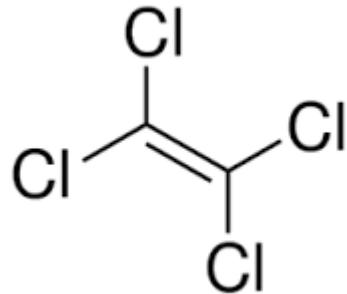
Measurement of indoor air quality and  
biomonitoring by analysis of end-exhaled air

Paul T.J. Scheepers PhD

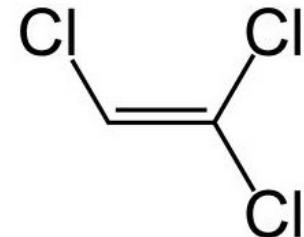
*Presented by: Martien H.F. Graumans MSc*

Radboud Institute for Health Sciences

# Gebruik van PER en TRI in de chemische wasserij



Tetrachloroethylene (PER)



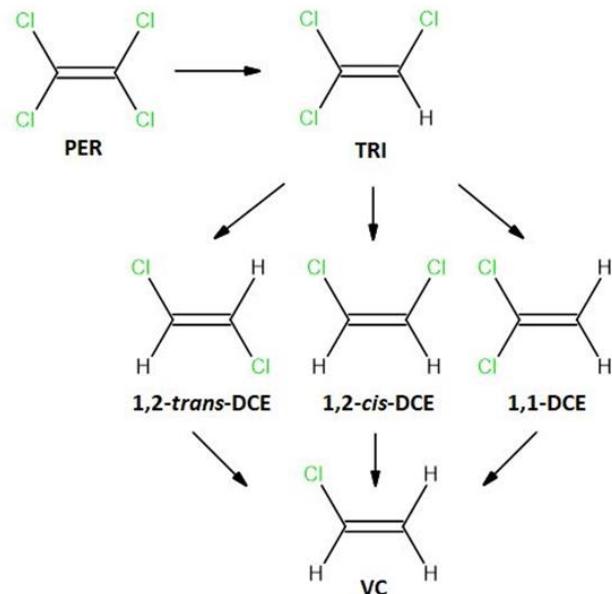
Trichloroethylene (TRI)



1962-1978

Radboudumc

# Afbraak in het milieu



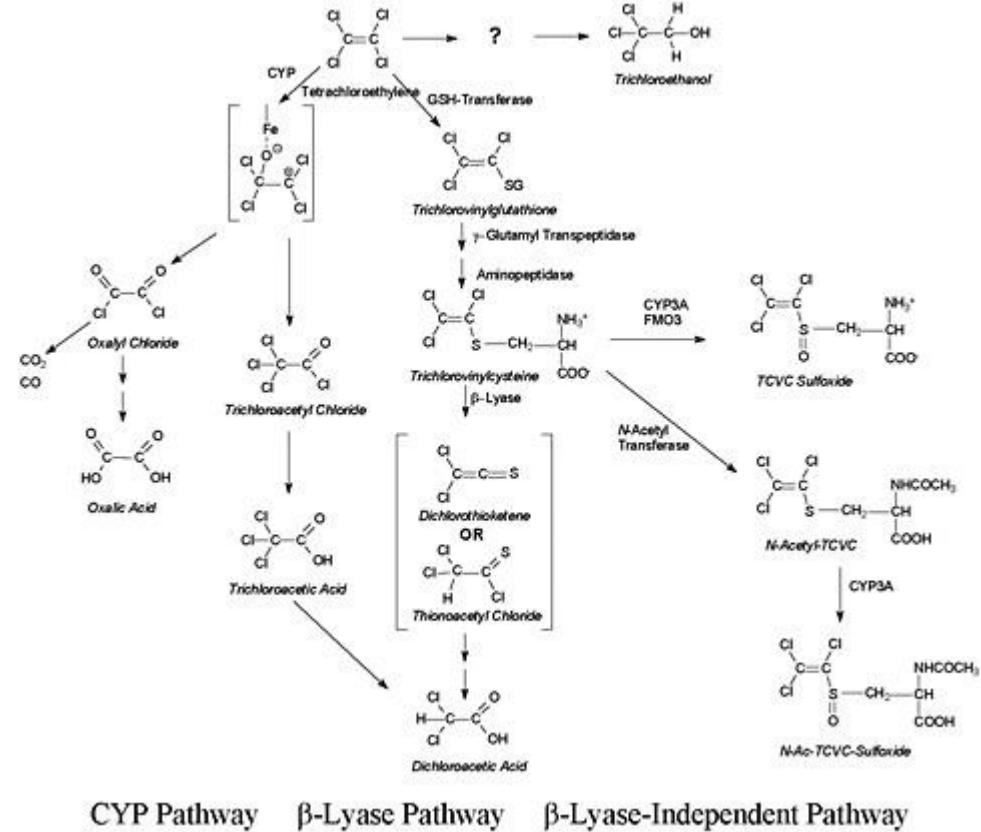
TRI = trichloroethylene

1,2-trans-DCE = 1,2-trans-dichloroethylene

1,2-cis-DCE = 1,2-cis-dichloroethylene

1,1-DCE = 1,1-dichloroethylene

VC = vinylchloride



Source: Tobiszewski M, Namieśnik J (2012) Environ Sci

Pollut Res 19:1994–2006.

Source: EPA, (2010)

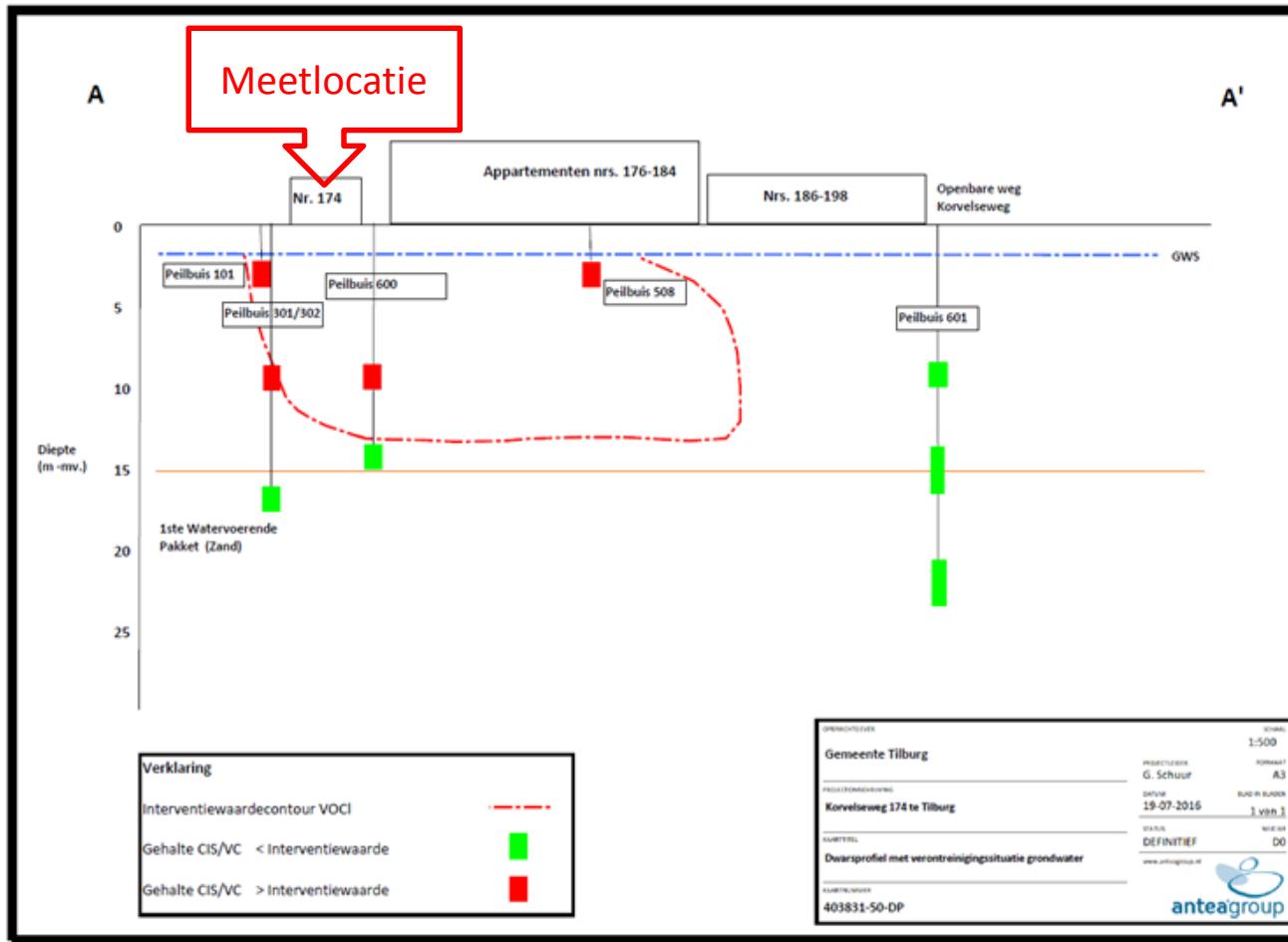
# Onderzoeksdoelen

- Exploration of real-life exposure due to intrusion of toxic vapors from a contaminated site
- Study uptake of contaminants and their degradation products by use of biomonitoring
- Study concentration time patterns and seasonal influences

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# Metingen en analyse

# Bodem contaminatie



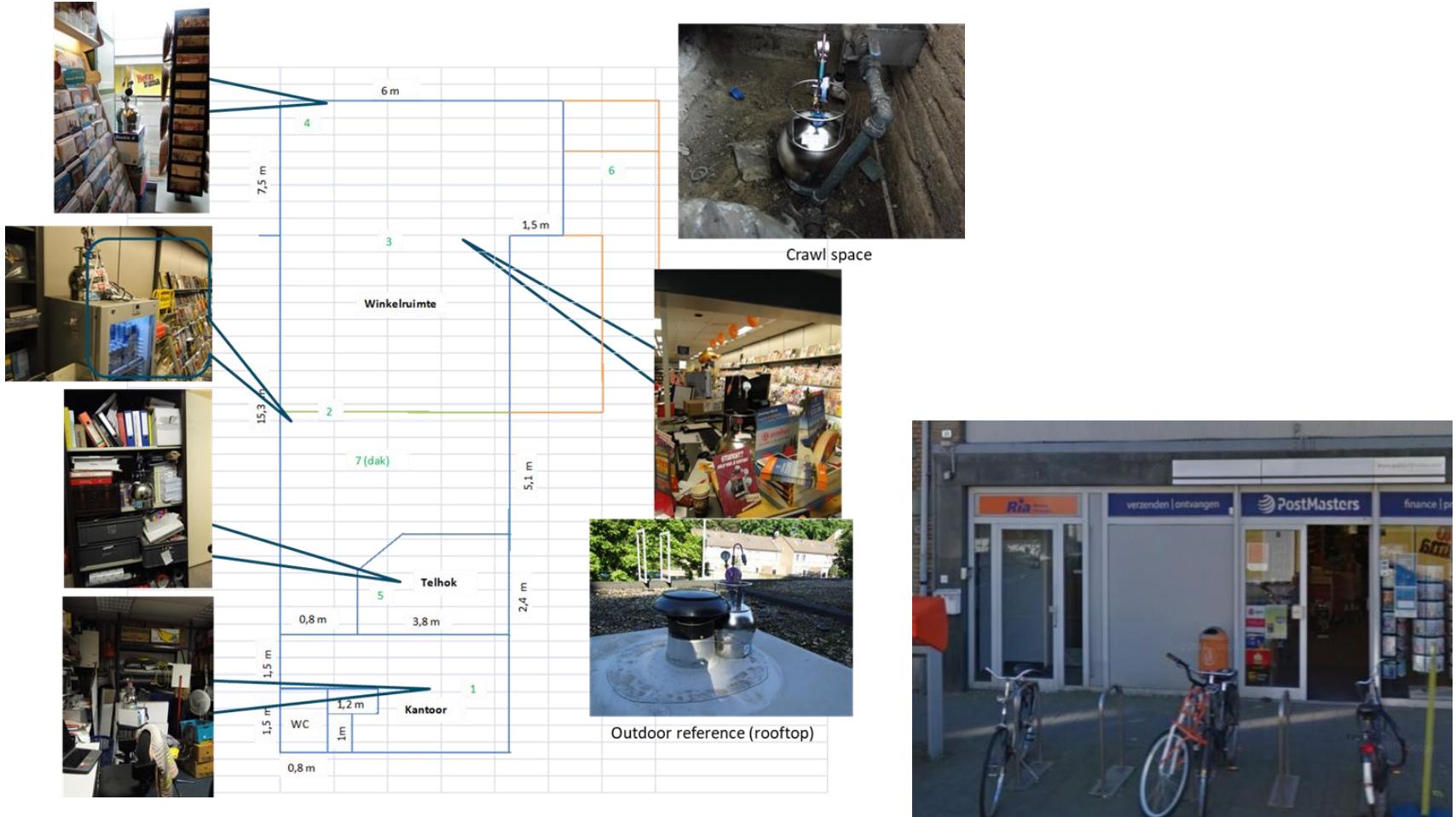
# Canister bemonstering



- Omgevingslucht monstername
- Gedurende 1 week
  - *juni 2016 en december 2017*
- Flow restrictor
- Referentie standaard
- TO-14A 43 component mix (100 ppb each, Restek, Bellefonte PA, USA)
- Analyse met thermische desorptie (Markes) gaschromatografie massaspectrometerie (Thermo)

# Plaatsing canisters

- Monstername gedurende 1 week



# Ademanalyse (end-exhaled air)



- (Bio-VOC)  
Collectie van de end-exhaled air
- Carbograph tubes  
(Camsco)  
Transfer naar Stainless Steel ATD  
Carbograph tubes (Camsco)
- Certified reference material  
Calibration standards in the range 0.5-100 ng/ $\mu$ l were prepared in MeOH
- Analyse met thermische desorptie (Markes) gaschromatografie massaspectrometerie (Thermo)

# Medewerkers

Person	Gender	Age	Cigarettes/day	Hours/week
A	Male	55	7-8	78
B	Female	37	7-8	29

## Questionnaire

- Smoking habits
- Storage of dry-cleaned clothes
- Use of specific chemical solvents
- Use of PVC plastic food wraps and casing films

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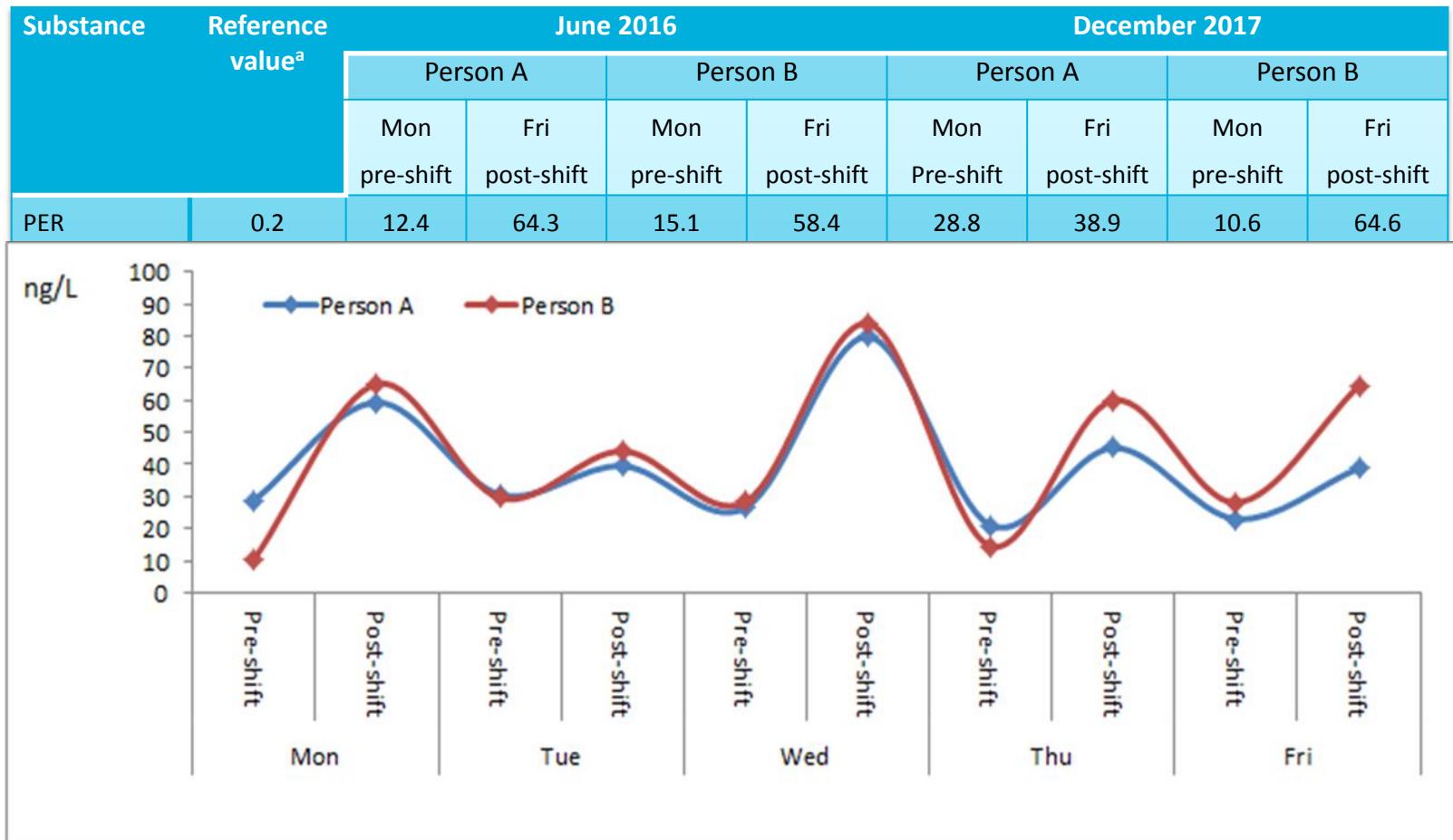
# Resultaten

# PER omgevingslucht concentratie en biodegradatie producten

Substance	TCL <sup>a</sup>	Season	Outdoor reference	Crawl space	Shop (front)	Shop (middle)	Shop (back)	Office	Storage room
PER	250	Warm	2.06	311.0	174.5	205.2	59.13	1 087	1 649
		Cold	-	544.6	-	836.2	-	872.6	1 866
TRI <sup>b</sup>	200	Warm	0.09	1.83	0.36	0.44	0.77	3.16	2.52
		Cold	-	1.17	-	1.18	-	1.78	2.27
VC	6.3	Warm	nd	nd	nd	nd	nd	nd	nd
		Cold	-	nd	-	nd	-	nd	nd
MC	3 000	Warm	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
		Cold	-	<0.04	-	<0.04	-	1.23	0.49
1,1-DCE	14	Warm	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
		Cold	-	<0.03	-	<0.03	-	<0.03	<0.03
1,2-cis-DCE	30	Warm	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
		Cold	-	<0.05	-	<0.05	-	0.21	0.35
1,2-trans-DCE	60	Warm	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
		Cold	-	<0.05	-	<0.05	-	<0.05	<0.05

<sup>a</sup> TCL = maximum allowable concentration in air (Otte et al., 2007; Hegger et al., 2009); <sup>b</sup> Reference value of 2.3 µg/m<sup>3</sup> for a residual risk of 1 cancer case in a million lifelong exposed (WHO).

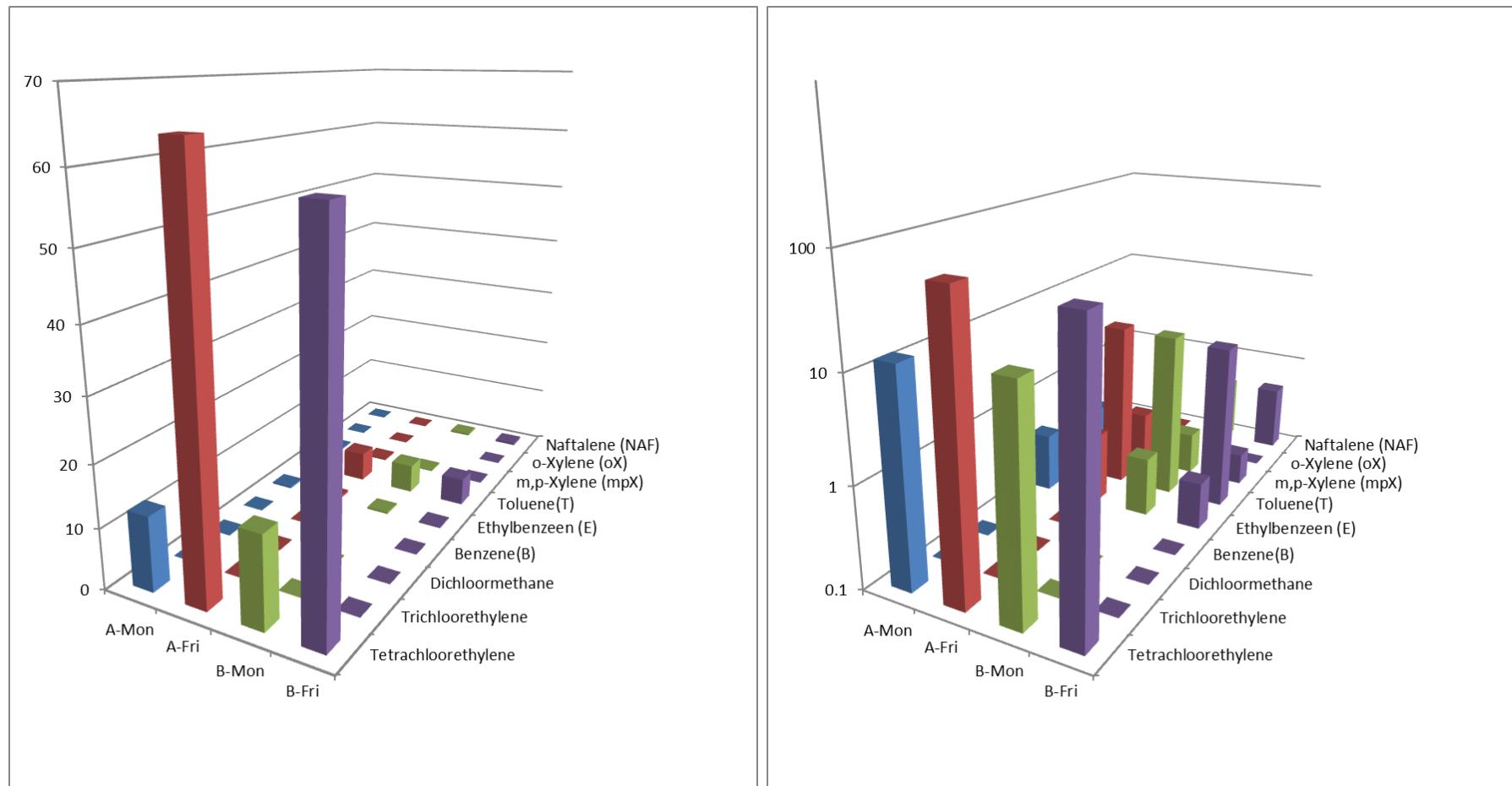
# Change from Mon pre-shift to Fri post shift



# Mean pre-shift and post-shift end-exhaled air

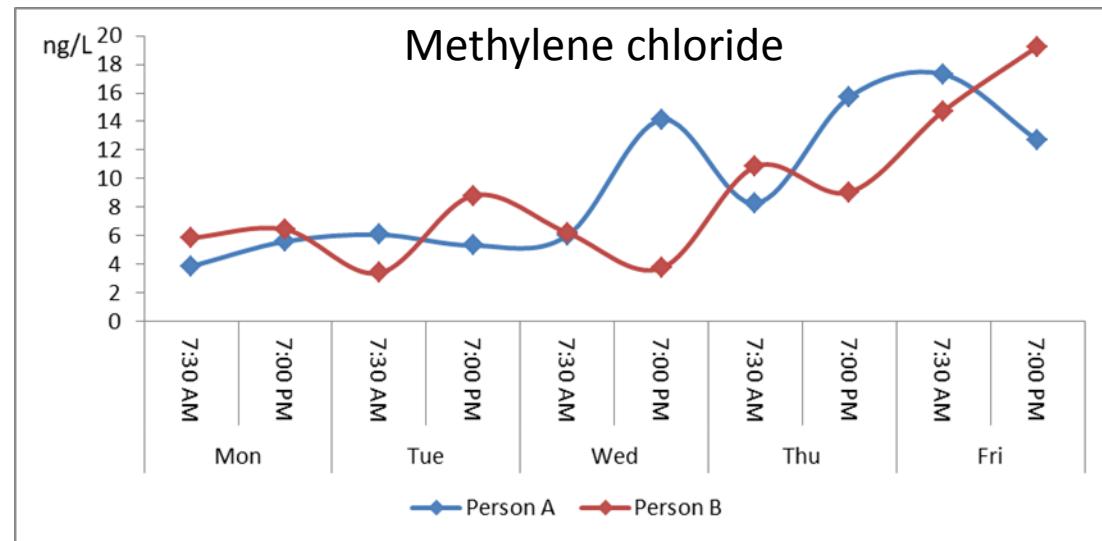
Substance	Person A		Person B	
	Pre-shift (N=5)	Post-shift (N=5)	Pre-shift (N=5)	Post-shift (N=5)
PER	26 ± 3.6	53 ± 16**	22 ± 8.0	64 ± 13**
TRI	0.59 ± 0.25	0.48 ± 0.13	0.52 ± 0.16	0.54 ± 0.16
MC	8.3 ± 4.7	10.7 ± 4.4	8.2 ± 4.1	9.5 ± 5.3
VC	Not detected	Not detected	Not detected	Not detected
1,1-DCE	1.7 ± 0.65	1.3 ± 0.32	1.5 ± 0.37	1.4 ± 0.33
1,2-cis-DCE	0.66 ± 0.52	0.37 ± 0.15	0.51 ± 0.30	0.46 ± 0.21
1,2-trans-DCE	0.77 ± 0.65	0.47 ± 0.20	0.58 ± 0.34	0.47 ± 0.23
<b>Total VOCL</b>	<b>38 ± 4.0</b>	<b>65 ± 17*</b>	<b>34 ± 8.1</b>	<b>76 ± 12**</b>
Benzene	7.4 ± 3.1	18 ± 14.1*	12 ± 3.9	8.6 ± 4.5
Toluene	2.8 ± 1.1	5.11 ± 2.0*	3.9 ± 2.1	3.2 ± 1.3
m,p-xylene	0.39 ± 0.14	0.61 ± 0.22	0.42 ± 0.15	0.30 ± 0.12
o-Xylene	0.12 ± 0.07	0.21 ± 0.26	0.19 ± 0.18	0.24 ± 0.32
Ethylbenzene	0.13 ± 0.07	0.33 ± 0.48	0.08 ± 0.06	0.01 ± 0.01*
Naphthalene	0.30 ± 0.36	0.47 ± 0.54	0.05 ± 0.10	0.04 ± 0.07
<b>Total BETXN</b>	<b>11.1 ± 2.5</b>	<b>24.7 ± 17.2</b>	<b>16.1 ± 4.5</b>	<b>12.3 ± 5.7</b>

# PER valt op vergeleken met BTEXN

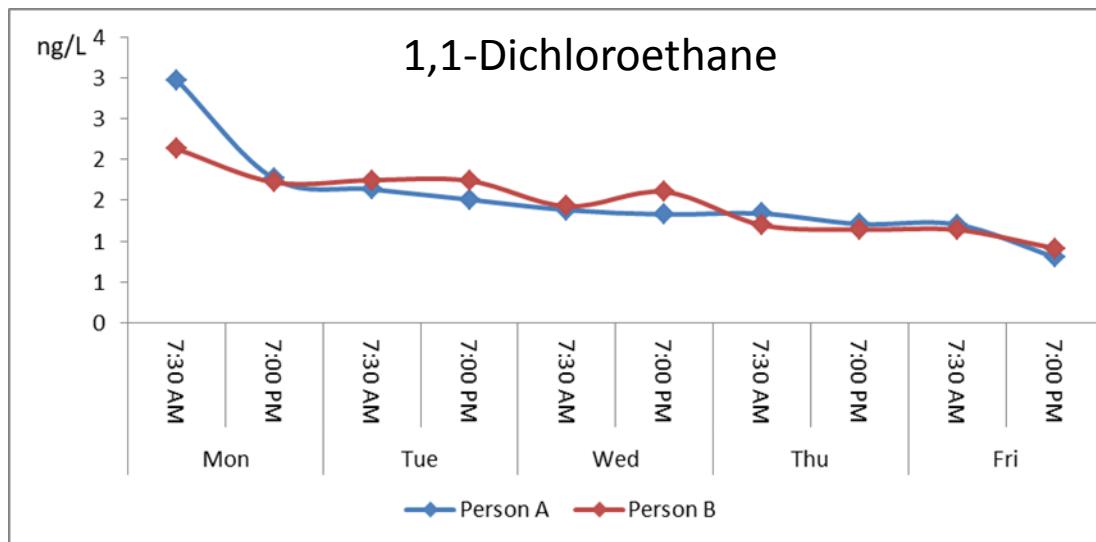


# Time patterns in exhaled air

Individual factors influence kinetics



A decrease may suggest involvement of other sources e.g. PVC plastic monomer\*



\* Ohno H, Kawamura Y. (2006) Analysis of vinylidene chloride and 1-chlorobutane in foods packaged with polyvinylidene chloride casing films by headspace gas chromatography/mass spectrometry (GC/MS). Food Addit Contam. 2006 Aug;23(8):839-44.

# Weer condities

Period	Week day	Date	Air pressure (mbar)	Average air Temperature (°C)	Day minimum air temperature (°C)	Day maximum air temperature (°C)	Sun hours (h)	Precipitatio n (mm)	Humidity (%)	Wind speed (m/s)	Wind directio n ( °)
Cold	Sat	9-12-2017	1011.3	2.6	0.8	4.4	0.7	0.7	79	4.8	238
	Sun	10-12-2017	983.9	2.2	0.0	6.3	0.0	14.7	91	5.9	200
	Mon	11-12-2017	981.8	-0.1	-3.4	1.5	0.0	20.3	93	5.5	39
	Tue	12-12-2017	1006.5	1.0	-0.6	2.1	2.2	3.8	93	3.9	227
	Wed	12-12-2017	997.9	4.1	0.5	7.3	0.0	13.1	90	6.8	201
	Thu	13-12-2017	990.7	0.8	3.5	6.3	0.5	7.0	87	4.8	224
	Fri	14-12-2017	996.1	2.8	0.4	4.8	0.2	0.2	91.0	2.1	199
			995.5	1.9	0.2	4.7	0.5	8.5	89.1	4.8	189.7
			10.2	1.3	1.9	2.0	0.7	7.1	4.5	1.4	63.2
Warm	Mon	20-6-2016	1016.3	15.8	10.0	20.5	0.2	12.0	90	5.3	201
	Tue	21-6-2016	1018.4	17.1	15.5	20.7	0.2	4.2	94	2.6	214
	Wed	22-6-2016	1021.0	16.6	13.4	26.6	9.8	0.0	79	3.0	177
	Thu	23-6-2016	1016.7	23.5	17.9	30.2	4.9	5.7	82	2.5	92
	Fri	24-6-2016	1017.8	19.5	13.5	21.5	6.9	0.0	82	3.3	271
	Sat	25-6-2016	1016.3	14.9	10.8	18.8	1.7	4.7	89	2.0	257
	Sun	26-6-2016	1017.0	14.6	10.4	19.1	0.0	5.8	85	3.3	232
			1017.6	17.4	13.1	22.5	3.4	4.6	85.9	3.1	206.3
			1.5	2.9	2.7	4.0	3.6	3.8	4.9	Radboudumc	55.3

# Discussie

- PER and TRI are good sentinel compounds for apportionment to industrial sources of pollution. BTEXN have a considerable background (indoor/outdoor are not easily attributable to specific sources. (Wintersen et al. Advies meten van vinylchloride in bodem- en binnenlucht RIVM briefrapport 607711013/2013)
- In our case biodegradation products provided support for involvement of soil/groundwater contamination and are picked up in exhaled air (not indoor air).
- Atmospheric low pressure episodes are suggested to contribute to higher vapor intrusion from soil (Tillman et al. 2005 Environ Engineering Science, 22:25-37; Barnes, et al. 2017 Atmos Environ 150:15-23.

# Discussie

Substance	Ambient air	Groundwater	Soil	Exhaled air
PER	+	+	+	+
TRI	+	+	+	+
1,1-DCE	-	.	.	+
1,2-cis-DCE	+	+	-	+
1,2-trans-DCE	-	-	-	+
VC	-	+	-	-

# Conclusie

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- ‘Biodegradation signature’ from environmental contamination is picked up in end-exhaled air
- Mixture signatures and concentration time patterns in indoor air and in exhaled air support attribution to sources

# Acknowledgments

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