



Breath analysis

A practical tool in occupational hygiene?

A pilot study in a paint manufacturing plant

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Aim

Benzene, Toluene & Xylene (BTX)

- Establish practical sampling protocol for the determination of BTX in end-exhaled air
- Check the effectiveness of respiratory protective equipment
- Determine a possible role of skin exposure





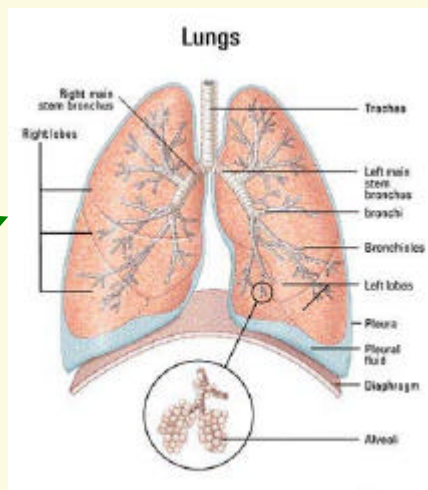
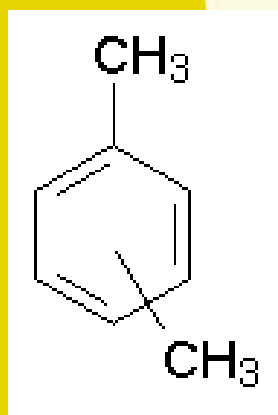
Materials & Methods

- **Uptake:** pre-and post-shift end-exhaled air (EEA), breath analysis using BIO-VOC samplers
- **Uptake:** pre- and post-shift urinary excretion of 2- and 3-Methylhippuric acids (MHA)
- Ambient concentration in **breathing zone:** personal monitoring, 8-hr shift

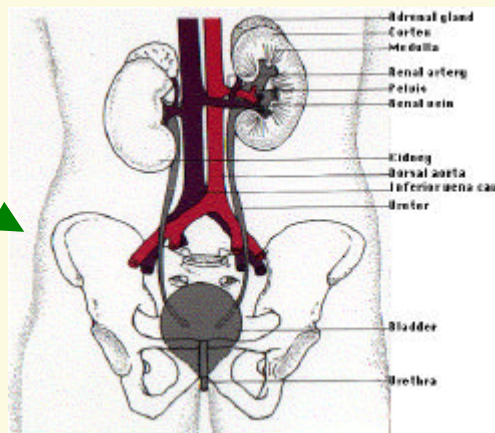




Excretion of Xylene (mixture of isomers)



~ 10% excreted **unchanged**
with expired air



~ 70-80% excreted as
Methylhippuric acids in urine



End- Exhaled Air (EEA)

- Principle: concentration of VOCs in blood is in equilibrium with concentration in the air in the alveolar portion of the lungs

because

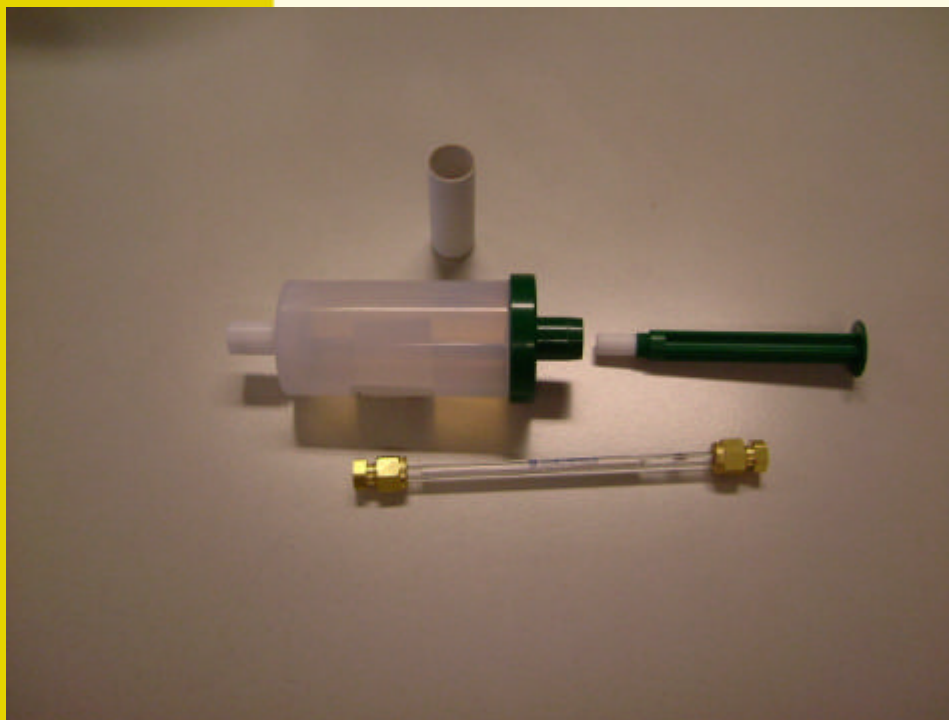
Both capillary blood vessel walls and alveoli walls are thin enough to allow free exchange of chemicals through tissue membranes

- Adult exhaling deeply ~ 4L of air
- Last 2L comes from alveolar portion
- BIOVOC holds 100 ml of air > 1L of alveolar air is required to ensure undiluted sample



Material & Methods

BIOVOC – EEA





Materials & Methods

EEA & urine

First campaign 2003:

- Pre- and post shift (10 min.) samples of EEA and urine on Monday
- Pre- shift EEA on Tuesday morning
- Repeated on Thursday and Friday

Second campaign 2004:

- Same strategy, but post shift EEA-samples 10, 20 and 35 min. after end of shift
- No samples on Tuesday and Friday

Sampling of EEA in clean environment



Materials & methods

Study population

20 production workers:

- dispersion/milling
- rinsing (cleaning) bead mills
- shift leader
- finishing (mixing)
- tapping
- rinsing (cleaning) production vessels
- stock

2 administrative workers



Materials & Methods

Study population

- **Background exposure:** questionnaire at interview
- Detailed survey on **working & process conditions** by occupational hygienist

Disperse



Rinse mill





Rinsing vessels





Tapping





Materials & Methods

Analysis EEA

- Immediately after collection transfer of sample to TENAX TA tube
- desorption from TENAX using He at 10-12 ml/min. at 150°C, captured in cold trap at -100°C, transferred to GC column at 200°C
- GC using 30 m fused silica CP-Select 624 CB column, flame ionization detection
- whole procedure about 30 min.



Materials & Methods

Urine and ambient air

- Routine sampling & analysis
- See proceedings





Results

Benzene and Toluene

Benzene:

- breathing zone and EEA: background levels

Toluene:

- breathing zone:
 - finishing (mixing): one day, 0.6 mg/m³
 - rinsing production vessels: three days, 1.75, 10 and 14 mg/m³
 - rinsing bead mills: one day, 1.14 mg/m³
- EEA above background: only rinsing production vessels, one day



Results

Xylene: breathing zone (mg/m³)

Job title	2003		2004	
	Mon	Thu	Mon	Thu
Dispers	84	80	72	44
Rinse mill	64	59	104	63
Shift lead	-	-	16	22
Finish 1	32	13	43	11
Finish 2	46	57	33	32
Tap 1	15	24	8	-
Tap 2	24	31	24	15
Rinse vessel	100	175	112	150
Stock	2.7	6.7	9	9
Office 1	n.d.	n.d.	n.d.	n.d.
Office 2	n.d.	n.d.	n.d.	n.d.



Results: Xylene, Monday 2003

Urine 2- and 3- MHA (mg/mmol creat)

Job title	2-MHA		3-MHA	
	pre	post	pre	post
Disperse	n.d.	1.8	n.d.	7.7
Rinse mill	0.5	2.8	2.0	21.5
Shift lead	-	-	-	-
Finish 1	0.6	3.5	6.0	16.9
Finish 2	n.d.	2.6	n.d.	12.6
Tap 1	11.1	3.9	2.4	11.4
Tap 2	0.5	3.7	n.d.	15.5
Rinse vessel	1.7	17.3	16.3	115
Stock	1.0	0.9	2.5	2.3
Office 1	n.d.	n.d.	n.d.	n.d.
Office 2	n.d.	n.d.	n.d.	n.d.



Results: Xylene, Thursday 2003

Urine 2- and 3- MHA (mg/mmol creat)

Job title	2-MHA		3-MHA	
	pre	post	pre	post
Disperse	0.8	n.d.	3.0	2.0
Rinse mill	2.5	2.0	2.8	9.4
Shift lead	-	-	-	-
Finish 1	0.8	2.1	2.9	10.3
Finish 2	n.d.	8.4	2.3	42.5
Tap 1	0.7	9.2	2.0	35.9
Tap 2	n.d.	6.1	1.3	29.7
Rinse vessel	3.6	51.8	17.8	350.8
Stock	n.d.	1.3	n.d.	4.6
Office 1	n.d.	n.d.	n.d.	n.d.
Office 2	n.d.	n.d.	n.d.	n.d.



Results: Xylene, Monday 2004

Urine 2- and 3- MHA (mg/mmol creat)

Job title	2-MHA		3-MHA	
	pre	post	pre	post
Disperse	n.d.	6.6	15.5	18.2
Rinse mill	3.5	n.d.	1.0	15.5
Shift lead	0.9	3.0	2.8	13.8
Finish 1	n.d.	3.1	0.5	15.8
Finish 2	n.d.	2.2	0.4	9.6
Tap 1	n.d.	3.4	n.d.	3.2
Tap 2	n.d.	3.4	1.2	13.6
Rinse vessel	5.3	3.1	20.6	2.8
Stock	n.d.	1.8	n.d.	6.6
Office 1	n.d.	2.8.	n.d.	n.d.
Office 2	n.d.	n.d.	n.d.	n.d.



Results: Xylene, Thursday 2004

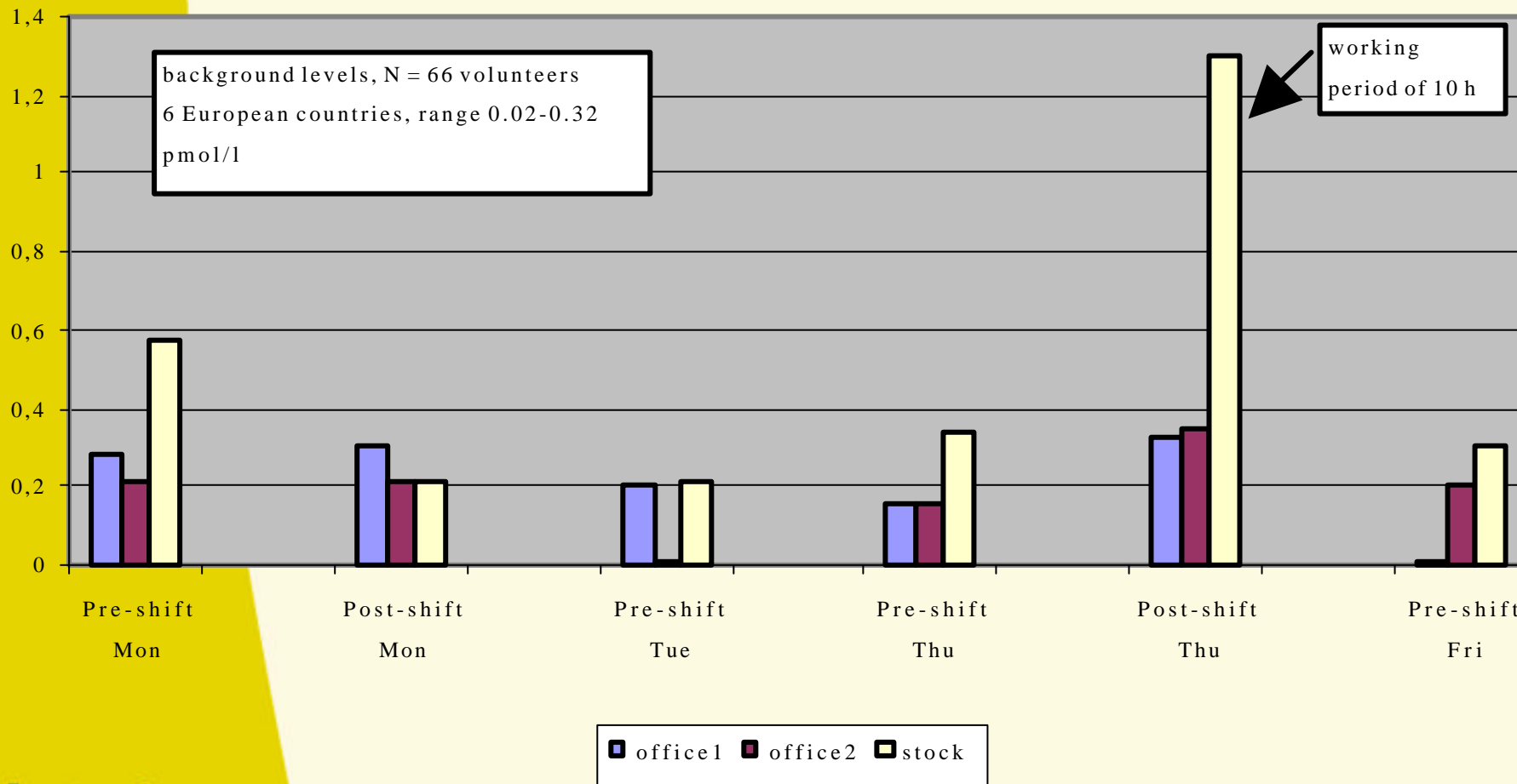
Urine 2- and 3- MHA (mg/mmol creat)

Job title	2-MHA		3-MHA	
	pre	post	pre	post
Disperse	n.d.	6.4	1.8	26.6
Rinse mill	1.7	3.1	3.6	19.3
Shift lead	n.d.	5.2	3.5	20.6
Finish 1	n.d.	1.8	1.3	11.2
Finish 2	n.d.	3.1	4.8	19.6
Tap 1	-	-	-	-
Tap 2	0.6	2.4	2.1	12.9
Rinse vessel	n.d.	3.7	1.7	16.4
Stock	n.d.	n.d.	n.d.	4.4
Office 1	n.d.	n.d.	n.d.	n.d.
Office 2	n.d.	n.d.	n.d.	n.d.



Results: 2003

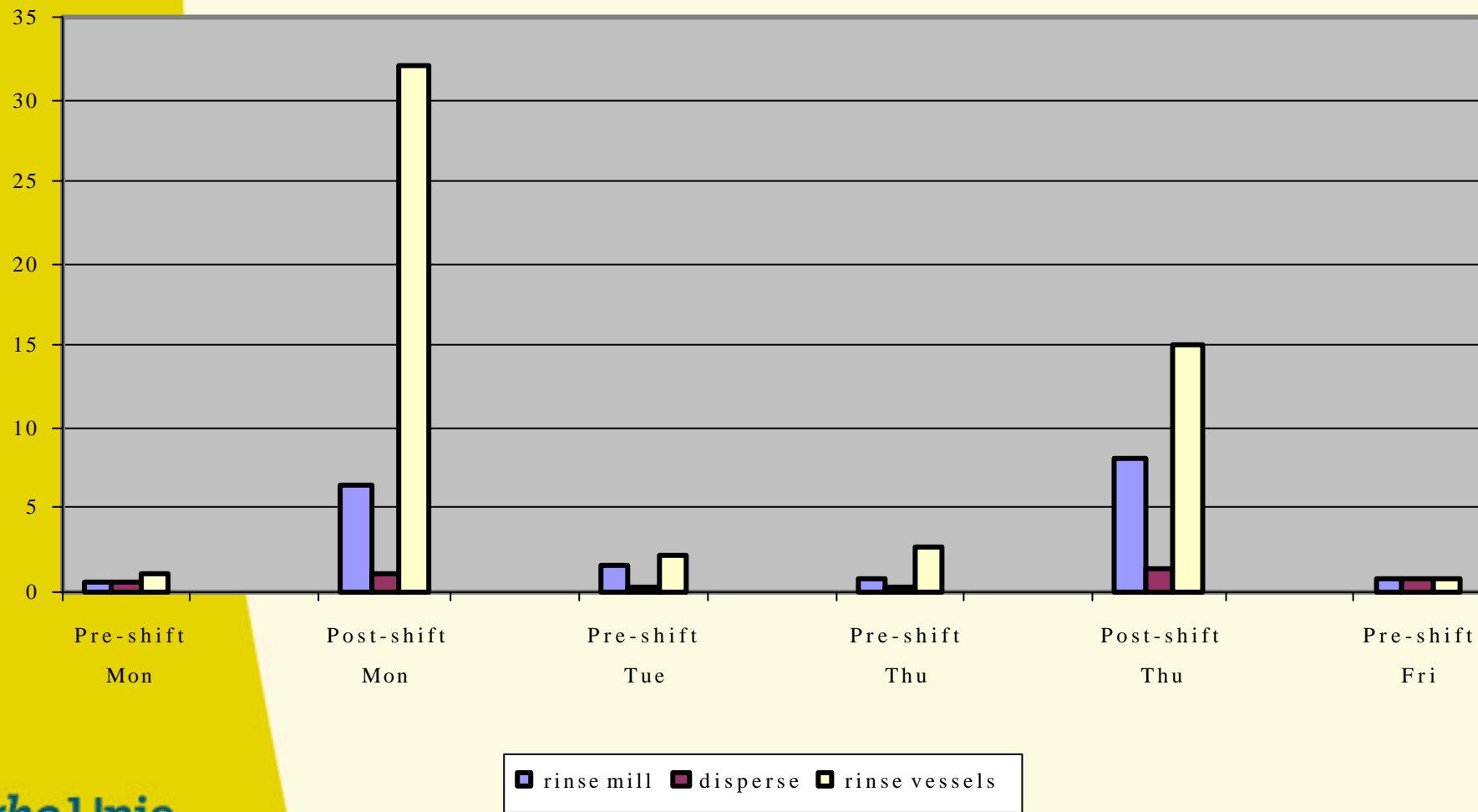
Xylene EEA (pmol/l)





Results: 2003

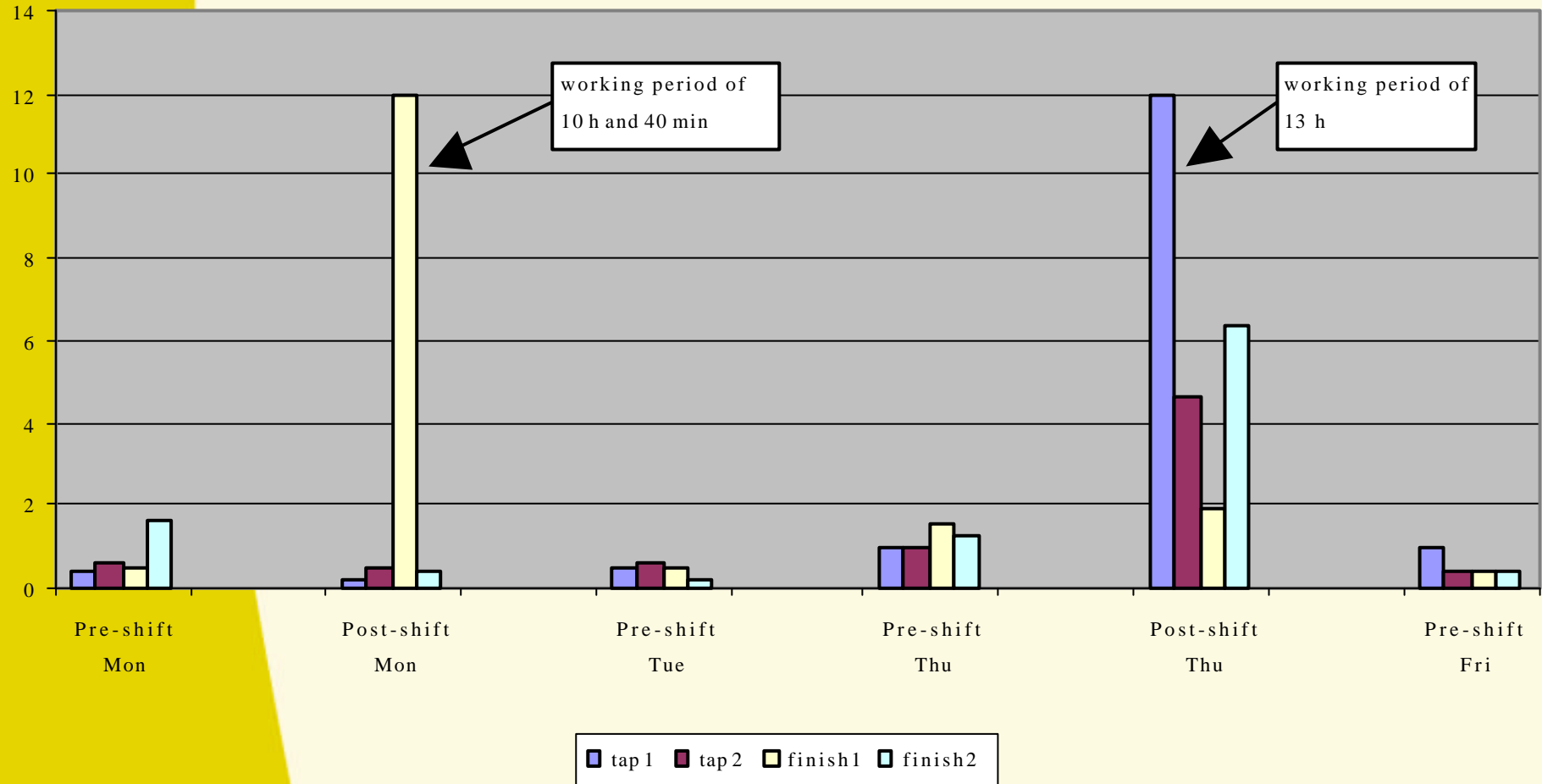
Xylene EEA (pmol/l)





Results: 2003

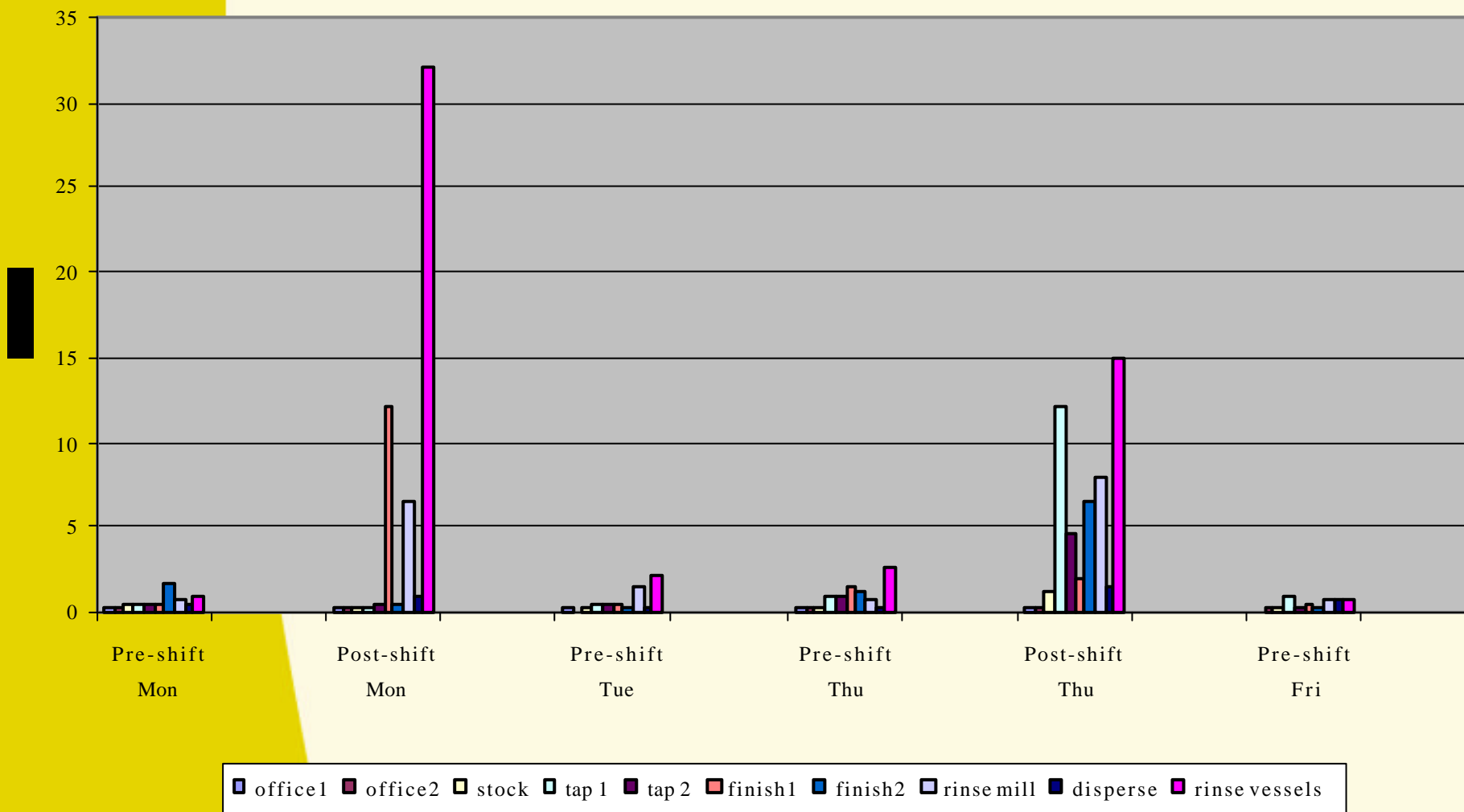
Xylene EEA (pmol/l)





Results: 2003

Xylene EEA (pmol/l)





Results: 2004

Xylene EEA

Office and stock:

comparable to 2003, background – low levels





Results: Monday 2004

Xylene EEA (pmol/l)

Job title	pre	post		
		10 min	20 min	35 min
Disperse	0.43	2.9	3.7	2.3
Rinse mill	1.0	7.1	2.6	1.0
Shift lead	0.6	2.1	1.8	1.4
Finish1	0.58	1.1	1.1	2.0
Finish2	0.44	1.2	1.4	0.38
Tap1	0.16	0.96	0.51	0.70
Tap2	0.32	0.61	2.1	0.63
Rinse vessel	0.27	1.5	2.1	2.2



Results: Thursday 2004

Xylene EEA (pmol/l)

Job title	pre	post		
		10 min	20 min	35 min
Disperse	0.21	2.4	2.2	3.8
Rinse mill	0.39	8.1	2.3	1.9
Shift lead	0.43	1.4	2.0	1.8
Finish1	0.20	2.3	1.7	2.3
Finish2	2.0	1.3	1.6	-
Tap1	-	-	-	-
Tap2	0.44	1.8	2.1	2.2
Rinse vessel	0.33	6.2	3.0	2.2



Results

In general:

correlations between Xylene EEA, MHA and Xylene air concentrations were **low**

highest correlation MHA – Xylene ambient air
($r^2 = 0.41$)



Discussion & conclusions

Benzene & Toluene:

- Ambient air concentrations (very) low
- Production process: no Benzene (except occasional contamination) and hardly Toluene
- Benzene: occasional contamination of technical solvent mixtures and/or background air pollution
- Solvents mostly used: Butylic acetate and Xylene
- Low exposure to Benzene & Toluene > low EEA concentrations



Discussion & conclusions

Xylene

- Exposure substantial
- Rinsing activities highest exposure:
range 29% - 97% TLV (Dutch TLV 210 mg/m³)
- Rinsing production vessels:
 - highly exposed on four working days > not completely reflected in MHA and EEA concentrations
 - MHA and EEA in 2003 highest, not in 2004 (although exposure comparable)
 - MHA 2003: 73 - 220% BEI (ACGIH)
 - Likely explanation: two different persons > difference in use of RPE and personal hygiene (skin exposure) > difference in internal uptake

Discussion & conclusions



Rinsing production vessels:
use of RPE & skin exposure





Discussion & conclusions

Xylene

External exposure

- Finishing/mixing intermediate
- Shift leader & tapping low
- Stock very low
- Office background

Low correlations EEA, MHA and ambient air concentrations

- interindividual differences in biotransformation
- skin exposure
- personal air monitoring > overestimation internal uptake due to RPE



Discussion & conclusions

Post shift EEA concentrations:

- decrease in time only for high internal uptake, other workers not always seen
- artefact during sampling? (contamination?)
- EEA reflects recent exposure (last part of shift) due to fast kinetics vs. 8-hr time weighted personal air monitoring
- no accumulation (next morning background levels)



Conclusions

Analysis of End-Exhaled Air: **user friendly method**

To use: **check effectiveness of RPE** and relevance of **skin exposure**

No Biological Limit Values for Benzene, Toluene and Xylene
EEA > **internal benchmarking** between different job titles
within a plant

At present only one BEI EEA: tetrachloroethylene

Intermittent exposure > collect EEA samples during shift