

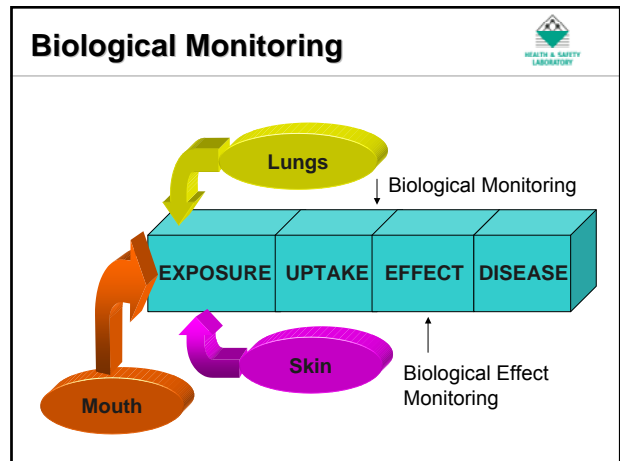



## Biological Monitoring in Contaminated Land Risk Assessment

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## What is Biological Monitoring?

Assessment of overall **systemic** exposure to chemicals by measurement of the chemicals or their breakdown products in


blood                  urine                  and breath






## The role for biological monitoring

- BM can assess exposure by all routes
  - Inhalation
  - Ingestion
  - Skin Absorption
- BM measures *actual uptake* of chemicals rather than *potential exposure*
- BM measures total uptake so cannot directly identify exposure source(s)



## Occupational BM

- Occupational BM is well-established
- Guidance values exist for about 50 chemicals – US/Germany most active
- In UK, only blood lead is compulsory – there are 17 other guidance values



## Occupational BM

Rank Order	Analyte	Guidance
1	Isocyanates	UK
2	Blood Lead	CLAW
3	Chromium	UK
4	Nickel	D
5	PAHs	UK
6	Mercury	UK
7	Benzene	US
8	Cadmium (blood)	US
9	Cadmium (urine)	US
10	Cholinesterase	MS17
11	Toluene	US
12	Arsenic	US
13	MDA	UK
14	Drugs of Abuse	
15	Cobalt	D
16	Bromide	
17	Thallium	
18	Liver function	
19	Aniline	D
20	Lead (urine)	US

## Environmental BM



- Environmental BM 'taking off'
- Initially driven by pressure groups
- Large population surveys underway
  - NHANES (US) – 1000s samples/100s analytes
  - GerES (Germany)
  - European-wide under discussion

## Environmental BM



- The ability to detect chemicals often outstrips our ability to interpret the results
- Presence ≠ Harm

**Chemical Check Up**  
An analysis of chemicals in the blood of Members of the European Parliament



## Intake Values for Humans



- |   |   |
|---|---|
| <ul style="list-style-type: none"><li>• Arsenic</li><li>• Benzo[a]pyrene</li><li>• Cadmium</li><li>• Chromium</li><li>• Inorganic Cyanide</li><li>• Lead</li><li>• Mercury</li><li>• Nickel</li><li>• Phenol</li><li>• Selenium</li><li>• Benzene</li><li>• Dioxins Furans and Dioxin-like PCBs</li></ul> | <ul style="list-style-type: none"><li>• Toluene</li><li>• 1,1,2,2-tetrachloroethane</li><li>• 1,1,1,2-tetrachloroethane</li><li>• Ethylbenzene</li><li>• Vinyl Chloride</li><li>• Xylenes</li><li>• Naphthalene</li><li>• Carbon Tetrachloride</li><li>• 1,2 Dichloroethane</li><li>• Tetrachloroethane</li><li>• Trichloroethene</li><li>• 1,1,1 trichloroethane</li></ul> |
|---|---|

## Cadmium



- Hogervorst et al (2007) compared biomarkers for residents with cadmium soil contamination (>3 mg/kg).
- A two-fold increase in the metal loading rate in house dust was associated with increases ( $P < 0.001$ ) in blood cadmium (+2.3%) and 24-h urinary cadmium (+3%) independent of the vegetable index and other covariates.
- The estimated effect sizes on the biomarkers of internal exposure were three times greater for house dust than vegetables.

## Dioxins/Furans



- Aberg et al (2010) investigated a heavily PCDD/F contaminated saw mill site in Sweden.
- A specific marker congener (1234678-HpCDF) was identified in the soil and in blood samples of site-exposed individuals.
- People who participated in the restoration of a contaminated building showed higher levels of 1234678-HpCDF compared to controls.

## Health Criteria Value



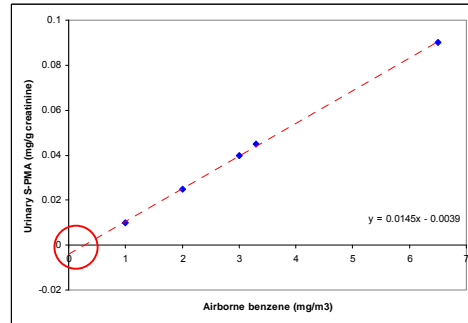
- This is a toxicological benchmark below which it can be assumed that there is no human health impact (for threshold contaminants) or the risk of such an impact is minimal (threshold contaminants).
- How do you convert HCVs into biological monitoring?

## HCV - Benzene



- Benzene, being carcinogenic, is considered a non-threshold chemical. The HCV is therefore set at the Index Dose
  - 0.29  $\mu\text{g kg}^{-1} \text{bw day}^{-1}$  oral
  - 1.4  $\mu\text{g kg}^{-1} \text{bw day}^{-1}$  inhalation
- Inhalation dose set based on the Air Quality Objective in England and Wales of  $5 \mu\text{g.m}^{-3}$

## HCV - Benzene



## HCV - Benzene



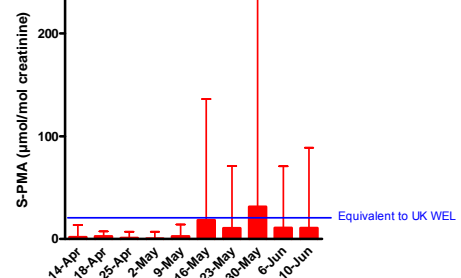
- Therefore HCV prediction would result in no detectable S-PMA however most of the population have detectable levels:
  - 95<sup>th</sup> percentile is 7  $\mu\text{g/g}$  creatinine
  - Smokers have greater levels than non-smokers
  - Urban dwellers have greater levels than rural

## HCV - Benzene



- Exposure to benzene present in soils is likely to be through the following major routes:
  - Inhalation of indoor vapour following vapour intrusion from soil into indoor air within buildings
  - Consumption of home-grown vegetables, which have taken up benzene from soil or have residual soil attached
- Other sources of exposure
  - Cigarette smoke and motor vehicle exhausts
  - Drinking water
  - Air fresheners

## Benzene contamination



## “Unacceptable Intake”



- Does BM offer a solution to “unacceptable intake”?
- Like all measures, ‘acceptable intake’ is easier to define:
  - Background ranges of chemical contaminants in the general population define ‘acceptable’
  - Are occupational limits suitable to define ‘unacceptable’ for residential?
  - Germany have ‘action limits’ for general population

## German Action Limits



Damage to health	Recommendation
Possible	<ul style="list-style-type: none"> <li>• Care by experts in environmental medicine and</li> <li>• Immediate action to reduce exposure</li> </ul>
<b>HBM-II</b>	
Cannot be excluded with sufficient certainty	<ul style="list-style-type: none"> <li>• Check analytical results</li> <li>• Identify specific sources of the exposure and</li> <li>• Reduce exposure in adequate way</li> </ul>
<b>HBM-I</b>	
Not to be expected according to current knowledge	<ul style="list-style-type: none"> <li>• No need for action</li> </ul>

## German Action Limits



Substance	Population	HBM I	HBM II
Lead (blood)	Children/WRC General	<i>Withdrawn</i>	
Cadmium (urine)	<25 years	1 µg/g	3 µg/g
	>25 years	2 µg/g	5 µg/g
Mercury (urine)	Children & adults	5 µg/g	20 µg/g
PCP (urine)	General	25 µg/g	30 µg/g
Phthalates (urine)	Children 6-13	500 µg/l	
	WRC	300 µg/l	
	Rest	750 µg/l	

## Conclusions



- BM can assess total exposure, potentially over extended periods of time.
- Interpretation of results needs care
  - Other sources of exposure
  - Guidance values?
  - What is ‘unacceptable’?

## References



Hogervorst et al. Environ Res. 2007 Jan;103(1):30-7

Aberg et al (2010) Environ Sci Pollut Res Int. 2010 Jan;17(1):26-39