German Environmental Survey (GerES)

Kerstin Becker
Marike Kolossa-Gehring
Federal Environment Agency
About 30 years ago...

Starting:

• more than 100 cows died after exposure to heavy metals close to a lead works

• lead in children living near a battery production plant

• lead in blood of children near a smelting works

Challenge:

• scientific basis for protection of the environment and health

• internal and external exposure

• exposure sources

• health impacts

• policy measures
GerES: study design

- Cross-sectional population study
  - Background level of exposure for a defined group of the general population: Reference values
  - Inclusion of several media and parameters
  - Identification/quantification of pathways and sources
20 years of GerES

<table>
<thead>
<tr>
<th>Survey</th>
<th>Period</th>
<th>Population sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>GerES I</td>
<td>1985 - 1986</td>
<td>2,700 adults</td>
</tr>
<tr>
<td>GerES II</td>
<td>1990 - 1992</td>
<td>4,000 adults, 730 children</td>
</tr>
<tr>
<td>GerES III</td>
<td>1997 - 1999</td>
<td>4,800 adults</td>
</tr>
<tr>
<td>GerES IV</td>
<td>2003 - 2006</td>
<td>1,790 children</td>
</tr>
</tbody>
</table>
Today

WHO/Europe

UNCED/Agenda 21

Ministry for Environment
Ministry of Health

Action Plan
Environment & Health

Political
Commitments

Environmental
Monitoring

Health Related Environmental Monitoring

GerES

Environmental Specimen Bank

Specific studies
GerES IV: Population sample

1,790 children (3 to 14 years) representative with regard to age, gender, community size and region

150 sampling locations
## GerES IV: time frame

<table>
<thead>
<tr>
<th>Date Range</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/2003-4/2008</td>
<td>Chemical analyses</td>
</tr>
<tr>
<td>5/2006-9/2008</td>
<td>Basic evaluation</td>
</tr>
<tr>
<td>9/2008</td>
<td>Public use file</td>
</tr>
</tbody>
</table>
GerES: partners involved

**German Health Survey for Children and Adolescents (KiGGS)**
- N = 18,000, 0 to 17 years
- Robert Koch Institute

**German Environmental Survey**
- N = 1,800, 3 to 14 years
- Federal Environment Agency

**ESBIO**
- universities
- laboratories
- federal agencies

Scientific advisory board
Instruments and factors

Main Instruments

- Human biomonitoring
- Ambient monitoring
- Questionnaires

Environmental factors

- biological (mould and fungi)
- physical (noise)
- chemical (pollutants)
Instruments: HBM

**Blood:**  
Cd, Pb, Hg  
persistent organochlorines  
mould specific IgE

**Urine:**  
As, Cd, Hg, Ni, U  
nicotine, cotinine  
PCP and other chlorophenols  
PAH metabolites  
pyrethroid metabolites  
metabolites of phthalates  
bisphenol A  
trialkylphosphates  
creatinine  
stress hormones
Instruments: ambient monitoring

House dust: DDT, HCH, HCB, PCBs; PCP, chlorpyrifos (vacuum cleaner bags)

Drinking water: Pb, Cd, Cu, Ni, U

Indoor air: VOC and formaldehyde (passive sampling)
Instruments: questionnaires

- indoor and outdoor environment
- health information
- socio-economic status
- food consumption
- exposure relevant habits

......
Field work

- Cooperation with the National Health Survey (KiGGS)
- 3 field teams (trained medical personnel and interviewers)
- Randomised sequence of sampling location visits to avoid regional or seasonal effects
- Visit of participants in an examination center (blood samples)
- Visit at home by interviewers to collect samples of the indoor environment and to perform the interviews
- Internal and external quality control
Budget and resources

Field work (recruitment, sampling, questionning, quality control):
1.2 mill. Euro

Chemical analysis (blood, urine, house dust, indoor air)
2.0 mill. Euro

Management and evaluation
(design, supervision, sample management, quality control of field work and chemical analysis, development of hypotheses, evaluation, reporting to the government and the public, scientific publications)

Staff of the Federal Environment Agency
General objectives

1. **Comparable data** concerning external and internal exposure to environmental pollutants and contaminants

2. Identification and quantification of (primary-) exposure pathways

3. Evaluation of the impact of environmental factors on children’s health
## Comparable data

### DDE in blood (µg/l)

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>n&lt;LOQ</th>
<th>P10</th>
<th>P50</th>
<th>P90</th>
<th>P95</th>
<th>P98</th>
<th>MAX</th>
<th>AM</th>
<th>GM</th>
<th>CI GM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>587</td>
<td>2</td>
<td>0.09</td>
<td>0.22</td>
<td>0.83</td>
<td>1.11</td>
<td>1.93</td>
<td>5.05</td>
<td>0.370</td>
<td>0.241</td>
<td>0.224</td>
</tr>
<tr>
<td><strong>Region</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>West</td>
<td>405</td>
<td>1</td>
<td>0.08</td>
<td>0.17</td>
<td>0.52</td>
<td>0.82</td>
<td>1.90</td>
<td>2.86</td>
<td>0.277</td>
<td>0.191</td>
<td>0.177</td>
</tr>
<tr>
<td>East</td>
<td>182</td>
<td>1</td>
<td>0.16</td>
<td>0.38</td>
<td>1.12</td>
<td>1.42</td>
<td>2.51</td>
<td>5.05</td>
<td>0.575</td>
<td>0.406</td>
<td>0.357</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 6 years</td>
<td>11</td>
<td>0</td>
<td>0.13</td>
<td>0.38</td>
<td>2.20</td>
<td></td>
<td></td>
<td>2.56</td>
<td>0.585</td>
<td>0.398</td>
<td>0.238</td>
</tr>
<tr>
<td>6 - 8 years</td>
<td>143</td>
<td>1</td>
<td>0.11</td>
<td>0.25</td>
<td>1.02</td>
<td>1.27</td>
<td>2.91</td>
<td>5.05</td>
<td>0.474</td>
<td>0.290</td>
<td>0.246</td>
</tr>
<tr>
<td>9 - 11 years</td>
<td>219</td>
<td>0</td>
<td>0.09</td>
<td>0.21</td>
<td>0.73</td>
<td>1.05</td>
<td>1.74</td>
<td>3.78</td>
<td>0.339</td>
<td>0.231</td>
<td>0.207</td>
</tr>
<tr>
<td>12 - 14 years</td>
<td>214</td>
<td>1</td>
<td>0.08</td>
<td>0.20</td>
<td>0.66</td>
<td>1.03</td>
<td>1.81</td>
<td>2.30</td>
<td>0.320</td>
<td>0.217</td>
<td>0.193</td>
</tr>
</tbody>
</table>

**Notes:**
- All values are in µg/l.
- N represents the number of samples.
- n<LOQ indicates the number of samples below the limit of quantification.
- Values for P10, P50, P90, P95, and P98 represent percentiles.
- MAX is the maximum value.
- AM is the arithmetic mean.
- GM is the geometric mean.
- CI GM represents the confidence interval for the geometric mean.
Exposure pathways

Factors influencing 1-OH-Pyr levels in urine, multiple regression model (GerES IV-Pilot-study)

<table>
<thead>
<tr>
<th>Variable</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>creatinine in urine</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>age</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>grilled food consumption</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>East vs. West Germany</td>
<td>0.002</td>
</tr>
<tr>
<td>ETS exposure at home</td>
<td>0.012</td>
</tr>
<tr>
<td>exposure to traffic</td>
<td>0.044</td>
</tr>
<tr>
<td>chocolate consumption</td>
<td>0.047</td>
</tr>
</tbody>
</table>
Links between environment and health

Allergic sensitisation against indoor specific mould spores (N=600)

Irritation of eyes and respiratory system due to formaldehyde, other aldehydes and VOC in indoor air (N=600)

Allergies due to nickel, chromium or scents (N=1800)

Noise, hearing and stress (N= 1050, aged 8 to 14)
Criteria for selection of pollutants

General criteria

• toxicological properties of concern
• potential influence on children’s health
• relevance for environmental policy
• widespread exposure of the general population
• reliable sampling procedures
• analytical methods available
• costs

Discussion in expert groups / the scientific advisory board
Pollutants selected

- **Metals** (Pb, Cd, Hg, As, Ni, U)
- **Organochlorine compounds** (DDT/DDE, HCH, HCB)
- **PCB** (28, 52, 101, 138, 153, 180)
- **Pyrethroids** (Cis-Cl₂-CA, trans-Cl₂-CA, Br₂CA, 3-PBA, F-PBA)
- **Organophosphates** (DMP, DMTP, DMDTP, DEP, DETP, DEDTP)
- **Phthalates** (metabolites of DEHP, DiNP, DnBP, DIBP, DBzP)
- **PAH** (1OH-Pyr, 1OH-Phen, 2/9OH-Phen, 3OH-Phen, 4OH-Phen)
- **PCP** and other **chlorophenols** (2-MCP, 4-MCP, 2,4-DCP, ….)
- **Bisphenol A**
- **Nicotine, cotinine**
- **IgE** (mould fungi), **stress hormones**
Lead: Success of political measures

<table>
<thead>
<tr>
<th>Year</th>
<th>GM (µg/L) Adults</th>
<th>GM (µg/L) Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>GerES I 1985/86</td>
<td>60 (95%-CI)</td>
<td>30 (95%-CI)</td>
</tr>
<tr>
<td>GerES II 1990/92</td>
<td>50 (95%-CI)</td>
<td>30 (95%-CI)</td>
</tr>
<tr>
<td>GerES III 1998</td>
<td>30 (95%-CI)</td>
<td>15 (95%-CI)</td>
</tr>
<tr>
<td>GerES II 1990/92</td>
<td>20 (95%-CI)</td>
<td>15 (95%-CI)</td>
</tr>
<tr>
<td>GerES IV 2003/06</td>
<td>15 (95%-CI)</td>
<td>10 (95%-CI)</td>
</tr>
</tbody>
</table>

Note: GM denotes the geometric mean.
Dichlordiphenyltrichlorethan

Dichlordiphenyltrichlorethylen

**Exposure sources:** fatty foodstuff from animals

**Chronic toxicity:** neurotoxic, hepatotoxic, endocrine disruptor

**Carcinogenicity:** Group 2B: might be carcinogenic in humans

**Legal status:** banned since 1972 (in East-Germany some applications until 1989)
DDE: East and West Germany

GerES III (adults) 1998
East 362
West 143

GerES IV (children, 3-14 years) 2003/06
East 415
West 190

NHANES III (12 years and older) 2003
East
West 110

DDE in Blood (ng/g lipid)
DDE and Σ PCB in blood and socio-economic status

(GM in µg/l, 7 to 14 years)  

\[ p < 0.001 \]
Polychlorinated biphenyles (PCB)

Exposure sources: indoor (sealing compounds), fatty foodstuff from animals

Chronic toxicity: neuro-, immuno- and reprotoxic

Carcinogenicity: Group 2A probably carcinogenic in humans

Legal status: banned for use in open systems since 1978, completely banned since 1989
PCB: age of the mother

(GM in µg/l, 7 to 14 years)

Age of the mother at time of birth and DDE and sum of PCB in blood of children

- DDE (n.s.)
- Sum of PCB (p<0.001)
Phthalates

**Exposure sources:** nutrition (food contact materials), consumer products (plasticiser in PVC, cosmetics/personal care products), pharmaceuticals, medical devices, house dust

**Chronic toxicity:** endocrine and reprotoxic

**Legal status:** in use in a wide range of products, the EU prohibited the marketing of toys and childcare articles
- **DnBP**: di-n-butyl phthalate
- **DEHP**: di(2-ethyl-hexyl)phthalate
- **DiBP**: di-iso-butyl phthalate
- **BzBP**: butylbenzyl phthalate
- **DiNP**: di-iso-nonyl phthalate

DnBP: 14% intakes above the TDI value (EFSA)

DEHP: identification of Need for Action

DEHP: Daily uptake

Tolerable daily intake (TDI)  
- **20µg/(kg·d)**  
- **48µg/(kg·d)**  

- RfD (US EPA)
- TDI (EU RAR)**
- TDI (EU RAR)*

N = 5 (1.96%)
N = 31 (12.2%)

**new borns**  
*:adults
Exceedance of the HBM value for DEHP (500 \( \mu g/L \))

- Sum of 5OH-MEHP and 5oxo-MEHP in urine [\( \mu g/L \)]
  - 4014
  - 1764
  - 949
  - 610
  - 565
  - 500

5 of 254 (2%) children exceed the HBM value

GerES IV, Pilot study
Human Biomonitoring Value, DEHP

- ADI/ TDI: 4 - 66 µg/kg bw/d
- NOAEL: 2,9 - 20 mg/kg bw/d
- derived in: 1994 - 2005

- Human-Biomonitoring-Kommission:
  NOAEL 4,8 mg/kg bw/d, Wolfe and Layton (2003): testicular effects, developmental toxicity

**Human Biomonitoring Value I**

- children (6-13 years) 500 µg/l
- women of childbearing age 300 µg/l
- rest of population 750 µg/l

„Bundesgesundheitsblatt-Gesundheitsforschung-Gesundheitsschutz, 2007“
# HBM-Values

[http://www.umweltbundesamt.de/gesundheit-e/monitor/index.htm](http://www.umweltbundesamt.de/gesundheit-e/monitor/index.htm)

<table>
<thead>
<tr>
<th>Parameter and Matrix [bibliographical data]</th>
<th>Population group</th>
<th>HBM I Value</th>
<th>HBM II Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lead in blood</strong> [6,34]</td>
<td>Children ≤ 12 years and females of a reproductive age other persons</td>
<td>100 µg/l</td>
<td>150 µg/l</td>
</tr>
<tr>
<td></td>
<td></td>
<td>150 µg/l</td>
<td>250 µg/l</td>
</tr>
<tr>
<td><strong>Cadmium in urine</strong> [11]</td>
<td>Children, adolescence and adults ≤ 25 years</td>
<td>1 µg/g Crea.</td>
<td>3 µg/g Crea.</td>
</tr>
<tr>
<td></td>
<td>Adults &gt; 25 years</td>
<td>2 µg/g Crea.</td>
<td>5 µg/g Crea.</td>
</tr>
<tr>
<td><strong>Mercury in urine</strong> [13]</td>
<td>Children and adults</td>
<td>5 µg/g Crea.</td>
<td>20 µg/g Crea.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 µg/l</td>
<td>25 µg/l</td>
</tr>
<tr>
<td><strong>Mercury in blood</strong> [13]</td>
<td>Children and adults*</td>
<td>5 µg/l</td>
<td>15 µg/l</td>
</tr>
<tr>
<td>* derived from females in reproductive age. The use is recommended for other groups.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pentachlorophenol in serum</strong> [9]</td>
<td>General population</td>
<td>40 µg/l</td>
<td>70 µg/l</td>
</tr>
<tr>
<td><strong>Pentachlorophenol in urine</strong> [9]</td>
<td>General population</td>
<td>20 µg/g Crea.</td>
<td>30 µg/g Crea.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25 µg/l</td>
<td>40 µg/l</td>
</tr>
<tr>
<td><strong>Sum of the DEHP metabolites 5oxo- and 5OH-MEHP in urine</strong> [55]</td>
<td>Children aged 6 to 13</td>
<td>500 µg/l</td>
<td>/</td>
</tr>
<tr>
<td></td>
<td>Women of childbearing age</td>
<td>300 µg/l</td>
<td>/</td>
</tr>
<tr>
<td></td>
<td>Males 14 years of age and older and remaining general population</td>
<td>750 µg/l</td>
<td>/</td>
</tr>
</tbody>
</table>
GerES, website

http://www.umweltbundesamt.de/survey-e
Reglementation of PBT/vPvB in the EU

ANNEX I: Actions arising from 9th TC NES Subgroup Meeting on Identification of PBT and vPvB Substances - Existing Substances Session (14.-15.11.2006)

<table>
<thead>
<tr>
<th>No.</th>
<th>MS Rapporteur</th>
<th>CAS</th>
<th>Name</th>
<th>Description of the Action</th>
<th>Time Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>AT</td>
<td>118-82-1</td>
<td>2,2',6,6'-tetra-tert-butyl-4,4'-methylenebisphenol</td>
<td>IND to perform a test on water solubility and a BCF study (if practical feasible OECD 305 otherwise dietary study). Substance is included in the 12(2) Regulation. Labelled substance is available now. Ind to perform the test on water solubility. Depending on WS the appropriate method for BCF testing has to be decided.</td>
<td>BCF study to be started if WS is available.</td>
</tr>
<tr>
<td>15</td>
<td>UK</td>
<td>15571-58-1</td>
<td>2-ethylhexyl 10-ethyl-4,4'-dioctyl-7-oxo-8-oxa-3,5-dithia-4-stannatetradecanoate</td>
<td>Relevant for 15, 16 and 99. After 3 year the water chemistry is still unknown. UK and IND will have a meeting in 12/2006 to decide on the further steps and if some of the achievements of ICCA program are useful for PBT assessment. If no progress to include the substance into Art 12.2 list.</td>
<td>December 2006</td>
</tr>
<tr>
<td>16</td>
<td>UK</td>
<td>3542-36-7</td>
<td>Dichlorodicylstannane</td>
<td>No progress since the last meeting. No progress since the last meeting. NL to discuss with IND the proposed testing program.</td>
<td>As soon as possible</td>
</tr>
<tr>
<td>22</td>
<td>NL</td>
<td>50849-47-3</td>
<td>5-Nonylsalicylaldehyde oxime</td>
<td>No progress since the last meeting. No progress since the last meeting. NL to discuss with IND the proposed testing program.</td>
<td>As soon as possible</td>
</tr>
</tbody>
</table>
• Dodecylphenol (CAS 27193-86-8)
• Octamethylcyclotetrasiloxan (CAS 556-67-2)
• 2,2',6,6'-Tetra-tert-butyl-4,4'-methylenediphenol (CAS 118-82-1)
• Hexabromocyclododecan (CAS 25637-99-4)
Towards HBM in Europe

Starting position
- different chemicals
- different methods
- different objectives
- different population samples
- different study designs
- different questionnaires
- no comparable data
- insufficient knowledge

ESBIO
Expert team to Support
BIO monitoring in Europe

map: wikimedia commons
ESBIO: proposed biomarkers

Szenario 1
“Basic”
- Lead in blood
- Cadmium in urine
- Mercury in hair
- Cotinine in urine

1. Metabolites of PAHs in urine
2. Phthalate metabolites in urine
3. Perfluorinated und polybrominated chemicals in blood
4. Polybrominated flame retardants in blood
5. Organochlorine compounds in blood
6. Metabolites of organophosphates in urine
7. Metabolites of pyrethroids in urine
Basic documents:

- Proposals for objectives of EU HBM approach and for pilot project including a justification of recommended priorities
- Proposal for pollutants and biomarkers including a justification of recommendations
- Protocol for population sampling, recruitment and biological monitoring
- Questionnaires for the Pilot Project
- Protocol for harmonised way of collecting and analysing selected pollutants and for data management
ESBIO, internet

http://www.eu-humanbiomonitoring.org
Thank you for your attention!

Special thanks to our team members

André Conrad
Andreas Hünken
Margarete Seiwert
Christine Schulz

marike.kolossa@uba.de
kerstin.becker@uba.de