Human monitoring in Tanzania

Assessing exposure to dioxin-like compounds in Tanzanian mothers using DR CALUX®

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This study is part of project MORATANZ:

Monitoring and Risk Assessment of contaminants in Southern Africa - Arusha in Tanzania as a model

Financed by The Research Council of Norway project nr. 204051

- Biodetection Systems (Peter Behnisch, Emiel Felzel)
- Anita Solhaug Veterinary Institute
- Participating mothers and hospital staff at Mount Meru Hospital, Arusha
- Partners in the project
Overview

I - Dioxins and dioxinlike compounds
  • Toxic effects
  • Background Tanzania

M - DR CALUX®
  • Study population

R - Dioxin-like activity levels
  • Associations to mother/infant characteristics

D - Comparison of dioxin-like activity levels to other studies
  • Levels of other persistent chemicals in the same mothers

C - Sum up
**Dioxins and dioxin-like compounds**

Exposure to dioxin-like compounds in Tanzanian mothers using DR CALUX®

Norwegian University of Life Sciences
Exposure to dioxin-like compounds in Tanzanian mothers using DR CALUX®

Neurological damage, memory impairment, behavioural disorders

Breast cancer, spontaneous abortions, low birth rate

Testicular size reduced, penis size reduced, infertility, low sperm count

Immune effects
Immune cell abnormalities, respiratory infections

Carcinogenic effects
Liver cancer, pancreatic cancer, respiratory tract cancer, soft tissue sarcoma, non-Hodgkin lymphoma, bladder cancer
Tanzania

• Industrialization
• Agricultural expansion
• Urbanization
• Population growth
• Importation of consumer products
• Limited municipal waste treatment
• Ratified Stockholm

Discharge of chemicals to the environment

Exposure to dioxin-like compounds in Tanzanian mothers using DR CALUX®
Potential sources to dioxins and dioxin-like compounds in Tanzania

Waste management  backyard burning
industry, hospitals, domestic

Cooking  open fire inside the house

Food  eggs from free-range chickens  Polder et al., 2016

Geophagy  Pemba  Reeuwijk et al., 2013

Obsolete stockpiles  Vikuge Farm  IPEN 2005

Exposure to dioxin-like compounds in Tanzanian mothers using DR CALUX®
Mount Meru Regional Referral Hospital

150 mother-child couples

Maternal blood
Cord blood
Placenta
Breast milk
Meconium

Questionnaires

48 included in the present study
Materials & Methods

DR CALUX®

- Low sample amount
- Cost-efficient
- Unknown mixture of compounds
- Good monitoring tool

Exposure to dioxin-like compounds in Tanzanian mothers using DR CALUX®
Exposure to dioxin-like compounds in Tanzanian mothers using DR CALUX®

### Results

<table>
<thead>
<tr>
<th></th>
<th>pg TEQ/g plasma</th>
<th>pg TEQ/g lipid</th>
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</thead>
<tbody>
<tr>
<td>LOQ</td>
<td>0.15</td>
<td>4.41</td>
</tr>
<tr>
<td>N (%) &gt; LOQ</td>
<td>44 (92%)</td>
<td>44 (92%)</td>
</tr>
<tr>
<td>Mean</td>
<td>0.21</td>
<td>32.2</td>
</tr>
<tr>
<td>Median</td>
<td>0.19</td>
<td>30.2</td>
</tr>
<tr>
<td>Min</td>
<td>0.03</td>
<td>4.41</td>
</tr>
<tr>
<td>Max</td>
<td>0.64</td>
<td>114</td>
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</table>
Results

Mother/infant characteristics

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>22</td>
<td>19</td>
<td>30</td>
</tr>
<tr>
<td>BMI (kg/m²) before pregnancy</td>
<td>22,6</td>
<td>18,4</td>
<td>30,9</td>
</tr>
<tr>
<td>Weight gain during pregnancy (kg)</td>
<td>6,6</td>
<td>2</td>
<td>17</td>
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<tr>
<td>Gestational age (weeks)</td>
<td>38,5</td>
<td>36</td>
<td>40</td>
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<tr>
<td>Birth weight (kg)</td>
<td>3,2</td>
<td>2,5</td>
<td>4,1</td>
</tr>
<tr>
<td>Birth length (cm)</td>
<td>48,8</td>
<td>42</td>
<td>52</td>
</tr>
<tr>
<td>Head circumference (cm)</td>
<td>34,7</td>
<td>33</td>
<td>37</td>
</tr>
<tr>
<td>Lipid %</td>
<td>0,7</td>
<td>0,4</td>
<td>2,2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant sex (male/female)</td>
<td>25/22</td>
<td>53/47</td>
</tr>
<tr>
<td>Farming as occupation</td>
<td>21</td>
<td>45</td>
</tr>
<tr>
<td>Other occupation than farming</td>
<td>26</td>
<td>55</td>
</tr>
<tr>
<td>Rural residence</td>
<td>22</td>
<td>47</td>
</tr>
<tr>
<td>Urban residence</td>
<td>25</td>
<td>53</td>
</tr>
<tr>
<td>Live close to industrial activities</td>
<td>10</td>
<td>21</td>
</tr>
</tbody>
</table>

Place of residence:

- Far from industrial activities
- Close to industrial activities

p = 0.03
**Discussion**

- Levels higher than USA and some Asian and European countries.....
- Industrial activities- increasing trend?....
- Waste disposal- no information....
- Dietary habits- interpret with caution....
- Geophagy during pregnancy....

### Table

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>N</th>
<th>Mean*</th>
<th>Reference</th>
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<tr>
<td>Tanzania</td>
<td>2012</td>
<td>48</td>
<td>32,2</td>
<td>This study</td>
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<tr>
<td>Taiwan</td>
<td>2000</td>
<td>372</td>
<td>17</td>
<td>Chen et al., 2005</td>
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<td>Korea</td>
<td>2001</td>
<td>22</td>
<td>21,5</td>
<td>Kim et al., 2005</td>
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<td>USA</td>
<td>2001-02</td>
<td>1081</td>
<td>18,7</td>
<td>Ferriby et al., 2007</td>
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<td>Germany</td>
<td>2000-03</td>
<td>169</td>
<td>28,4</td>
<td>Wittsiepe et al., 2007</td>
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<td>France</td>
<td>2003</td>
<td>10</td>
<td>45,7</td>
<td>Pirard et al., 2005</td>
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<td>Norway</td>
<td>2006-10</td>
<td>184</td>
<td>24,6</td>
<td>Vafeiadi et al., 2014</td>
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<tr>
<td>England</td>
<td>2006-10</td>
<td>111</td>
<td>26,0</td>
<td>Vafeiadi et al., 2014</td>
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<tr>
<td>Denmark</td>
<td>2006-10</td>
<td>190</td>
<td>45,7</td>
<td>Vafeiadi et al., 2014</td>
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<tr>
<td>Spain</td>
<td>2006-10</td>
<td>157</td>
<td>46,4</td>
<td>Vafeiadi et al., 2014</td>
</tr>
</tbody>
</table>

*pg TEQ/ g lipid

**In utero** exposure of greater concern than postnatally through breast milk

Maternal versus cord blood
PBDEs in maternal blood

\[ \Sigma \text{PBDEs} \text{ median } 3.88 \text{ (range 1.59-299 ng/g lipid)} \]

**BDE 47** median 1.95 (range 0.5-89.1 ng/g lipid)
- detection rate 65%
- dominated in 40% of the samples
- contributed in average 37% to \( \Sigma \text{PBDEs} \)

Levels of BDE 47 and \( \Sigma \text{PBDEs} \) correlated to the levels of dioxin-like activity

<table>
<thead>
<tr>
<th></th>
<th>rho ((p\text{-value}))</th>
<th>pg TEQ/g lipid</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BDE 47</strong></td>
<td>0.3251 ((0.02))</td>
<td></td>
</tr>
<tr>
<td><strong>( \Sigma \text{PBDEs} )</strong></td>
<td>0.3136 ((0.03))</td>
<td></td>
</tr>
</tbody>
</table>

 Exposure to dioxin-like compounds in Tanzanian mothers using DR CALUX®
**BFRs and OCs in breast milk**

**ng/g lipid**

<table>
<thead>
<tr>
<th></th>
<th>% &gt; LOD</th>
<th>Min</th>
<th>25&lt;sup&gt;th&lt;/sup&gt;</th>
<th>50&lt;sup&gt;th&lt;/sup&gt;</th>
<th>75&lt;sup&gt;th&lt;/sup&gt;</th>
<th>95&lt;sup&gt;th&lt;/sup&gt;</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lipid %</td>
<td>0.20</td>
<td></td>
<td>14.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>HCB</td>
<td>83</td>
<td>&lt;LOD</td>
<td>0.65</td>
<td>1.44</td>
<td>2.25</td>
<td>4.56</td>
<td>29.8</td>
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<tr>
<td>ΣHCH</td>
<td>88</td>
<td>&lt;LOD</td>
<td>0.44</td>
<td>1.11</td>
<td>2.25</td>
<td>13.4</td>
<td>24.5</td>
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<tr>
<td>ΣCHL</td>
<td>56</td>
<td>&lt;LOD</td>
<td></td>
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<td>12.9</td>
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<tr>
<td>ΣEndosulfans</td>
<td>4</td>
<td>&lt;LOD</td>
<td></td>
<td></td>
<td></td>
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<td>11.1</td>
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<tr>
<td>ΣDDTs</td>
<td>100</td>
<td>26.3</td>
<td>95.7</td>
<td>205</td>
<td>619</td>
<td>1340</td>
<td>2486</td>
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<tr>
<td>Dieldrin</td>
<td>66</td>
<td>&lt;LOD</td>
<td>1.82</td>
<td>3.74</td>
<td>8.99</td>
<td>60.3</td>
<td>937</td>
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<tr>
<td>Σ&lt;sub&gt;7&lt;/sub&gt;PCBs</td>
<td>89</td>
<td>&lt;LOD</td>
<td>2.48</td>
<td>4.19</td>
<td>8.38</td>
<td>29.0</td>
<td>157</td>
</tr>
<tr>
<td>Σ&lt;sub&gt;7&lt;/sub&gt;PBDEs</td>
<td>100</td>
<td>&lt;LOD</td>
<td>7.2</td>
<td>19.8</td>
<td>45.5</td>
<td>307</td>
<td>785</td>
</tr>
</tbody>
</table>

Müller et al. 2016; Müller et al. in prep.

Exposure to dioxin-like compounds in Tanzanian mothers using DR CALUX®

Norwegian University of Life Sciences
BFRs and OCs in breast milk

**EDI exceeded RfD in 10% of the nursing infants**

**Estimated Daily Intake (EDI):**
\[ C_{\text{milk}} \times F \times 700g / 5 \]

**Reference Dose:** estimate of a daily oral exposure to a toxic substance that is likely to be without an appreciable risk of harmful effects during a lifetime.

**HQ:** ratio between EDI and toxicological values. HQs exceeding 1 indicate a possible health risk.

*Müller et al. 2016*

*µg/kg/day US EPA RfD for neurodevelopmental toxicity*
BFRs and OCs in breast milk

EDI exceeds PTDI in 6 infants

PTDI dieldrin: 100 ng/kg bw/day

FAO/WHO, 1995

EDI exceeds PTDI in 2 infants

PTDI DDT: 10 000 ng/kg bw/day

FAO/WHO, 2001

Provisional Tolerable Daily Intake (PTDI)

Müller et al. in prep

Exposure to dioxin-like compounds in Tanzanian mothers using DR CALUX®
• The compounds giving the dioxin-like activity?
• Chemical analysis for confirmation

Chlorinated versus brominated dioxins/furans/biphenyls

• additive effects in animal studies
• similar effects
• effects at similar low doses indicating comparable potencies
• limited *in vivo* and *in vitro* data for PBDDs, PBDFs, and non-ortho dl-PBBs

Support the use of similar TEFs as temporary values for human risk assessment
• **DR CALUX:**
  Valuable tool for our monitoring purposes
  Use CALUX- TEQ in risk assessment?

• Confirmation of the dioxin-like compounds by chemical analysis

• Risk communication to increase Governmental efforts

• Nutritional guidance of women in child bearing age

• Further studies needed to assess
  - Sources
  - Potential health risks - especially for fetuses and nursing infants!


Thank you for your attention!