Environmental characterisation of Reclaimed Asphalt

Anja ENELL\textsuperscript{1}, Ciaran McNALLY\textsuperscript{2}, Roman LICBINSKY\textsuperscript{3}, Aoife QUINN\textsuperscript{2}, Jiri HUZLIK\textsuperscript{3}, Ola WIK\textsuperscript{1}

\textsuperscript{1}Swedish Geotechnical Institute (SGI)
\textsuperscript{2}University College Dublin (UCD)
\textsuperscript{3}Transport Research Centre (CDV)
Re-Road - End of life strategies of asphalt pavements:

- European FP7 project
- 2009-2012

Partners of this presentation:

- Swedish Geotechnical Institute
- University College Dublin
- Transport Research Centre, Czech Republic
Objectives and Outline of the Study

The specific objectives:

- identify potential hazardous organic compounds susceptible to leach from RA
- identify and evaluate methods suitable to assess leaching of hazardous compounds from RA
- to further characterise these leachates with suitable ecotoxicity tests.

RA = Reclaimed Asphalt
Objectives and Outline of the Study

Screening test:
- Identification of organic compounds in leachates from RA

Three different leaching tests:
- Repeatability of the methods
- Effect of increased contact time on the leached concentrations
- Comparison of leached concentrations of the different methods

Ecotoxicity tests:
- An ecological test battery representing different trophic levels
Screening Analysis – Materials & Method

Materials:

1. Open porous asphalt. Surface layer, Germany. Sampled from stockpile.
2. Open porous asphalt physically modified with SBS, Surface layer. France. Sampled when milled off.
3. Porous asphalts made from a penetration grade 70/100 bitumen, modified through addition of crumb tyre rubber. Sampled after production (i.e. not an RA).
4. Blank test

Method:

- Leachates obtained with batch test (ISO/TS 21268-1:2007)
- Extraction with dichloromethane
- Qualitative GC-MS analysis
Screening analysis - Conclusions

Main findings:

- PAHs identified in all leachates
  - but fewer compounds in leachates of the virgin asphalt material containing rubber
  - coronene identified in the material with 10 years in operation
  - 1-Indanone and 9-Fluorenone

- n-alkanes in leachates of the RAs but not in rubber asphalt leachate

- Rubber asphalt leachate contained:
  - Adipates
  - Benzothiazole
  - 2-Methylbenzothiazole
  - 3,5-di-tert-butyl-4-hydroxy benzaldehyde
  - methylacetophenone

- n-alkanes, phthalates and several PAHs are ubiquitous compounds in a laboratory environment!

⇒ Important to perform blanks

⇒ 16 PAHs chosen as target compounds in future testing of RA
Leaching Tests – Material and Methods

Contaminated-RA

Preparation of representative test portions <10mm

- Percolation test
- Batch test CEN ISO/TS 21268-1
- ER-H (percolation with re-circulation)
Leaching Tests — Material and Methods

Leaching methods:

1. Percolation test
   - CEN/TC 351 N 0272. Draft Generic horizontal up-flow percolation test for the release of substances from granular construction products
Leaching Tests — Material and Methods

Leaching methods:

1. Percolation test
   - CEN/TC 351 N 0272. Draft Generic horizontal up-flow percolation test for the release of substances from granular construction products

2. Batch test
   - (ISO/TS 21268-1:2007)

L/S=2

Tested contact times
24h, 48h, 168h
Leaching Tests — Material and Methods

Leaching methods:

1. Percolation test
   - CEN/TC 351 N 0272. Draft Generic horizontal up-flow percolation test for the release of substances from granular construction products

2. Batch test
   - ISO/TS 21268-1:2007

3. Percolation with re-circulation
   - ER-H method (Gamst et al. 2007)

Percolation test with recirculation

Circulation of leachant to a fixed L/S = 2. Sampling after 7-days recirculation. No filtration.

L/S = 2

Sample for analysis

Leached amount (mg/kg) at L/S = 2 calculated from concentration in eluate.
### Leaching Tests – Results

\[
Repeatability = \frac{Sdev}{Mean\ value} \times 100\quad n=3
\]

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Naphthalene</td>
<td>1</td>
<td>27</td>
<td>0/61</td>
<td>Benzo(b)fluoranthene</td>
<td>32</td>
<td>0</td>
<td>0/47</td>
</tr>
<tr>
<td>Acenaphthylene</td>
<td>4</td>
<td>3</td>
<td>1/10</td>
<td>Benzo(k)fluoranthene</td>
<td>30</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Acenaphthene</td>
<td>2</td>
<td>18</td>
<td>2/7</td>
<td>Benzo(a)pyrene</td>
<td>32</td>
<td>43</td>
<td>0/43</td>
</tr>
<tr>
<td>Fluorene</td>
<td>1</td>
<td>11</td>
<td>0/19</td>
<td>Dibenzo(ah)anthracene</td>
<td>33</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Phenanthrene</td>
<td>3</td>
<td>13</td>
<td>0/8</td>
<td>Benzo(ghi)perylene</td>
<td>40</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Anthracene</td>
<td>2</td>
<td>16</td>
<td>4/18</td>
<td>Indeno(123cd)pyrene</td>
<td>35</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Fluoranthene</td>
<td>7</td>
<td>14</td>
<td>0/11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pyrene</td>
<td>11</td>
<td>14</td>
<td>4/12</td>
<td>\textit{PAH, sum 16}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benzo(a)anthracene</td>
<td>18</td>
<td>13</td>
<td>4/18</td>
<td>\textit{PAH, sum carcinogenic}</td>
<td>24</td>
<td>16</td>
<td>6/26</td>
</tr>
<tr>
<td>Chrysene</td>
<td>21</td>
<td>20</td>
<td>0/27</td>
<td>\textit{PAH, sum other}</td>
<td>2</td>
<td>12</td>
<td>1/8</td>
</tr>
</tbody>
</table>

*Not calculated; n<2
Leaching Tests – Results

Effect of increased contact time

![Graph showing the effect of increased contact time on PAH-L and PAH-M concentrations over time. The x-axis represents different compounds: Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene. The y-axis represents concentration in µg/L. The graph indicates varying levels of concentration over time, with different colored bars for 24 h, 48 h, and 168 h.]
Leaching Tests – Results

Effect of increased contact time

![Graph showing the effect of increased contact time on leaching of PAH-H](image)

- Benzo(a)anthracene
- Chrysene
- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- Benzo(a)pyrene
- Dibenzo(a,h)anthracene
- Benzo(ghi)perylene
- Indeno(123cd)pyrene

**Units:** μg/L

**Time:**
- 24 h
- 48 h
- 168 h
Leaching Tests — Results

Comparison of methods

**PAH-L and PAH-M, L/S=2**

![Graph showing the comparison of methods for PAH-L and PAH-M with L/S=2. The x-axis represents different PAH compounds (Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene) and the y-axis represents concentration in μg/kg. The graph compares ER-H, Batch, and Percolation methods.](image_url)
Leaching Tests – Results

Comparison of methods

PAH-H, L/S=2

μg/kg

Benz(a)anthracene  Chrysene  Benzo(b)fluoranthene  Benzo(k)fluoranthene  Benzo(a)pyrene  Dibenzo(ah)anthracene  Benzo(ghi)perylene  Indeno(123cd)pyrene
Summary / Conclusions

- Sufficient repeatability of all methods.
- Increased time of shaking did not provide higher concentrations in the eluates, however,
- the concentrations of PAH-H appear to be a result of prevalence of particulate matter in the leachate.

- The batch test could possibly be used as compliance test to the percolation method when studying PAH-L and PAH-M, but
- will overestimate the leaching of PAH-H.

➔ ER-H method may be a better choice.
Ecotoxicity tests – Materials and methods

Materials:

Materials from stockpiles:
1. Contaminated-RA, Sweden
2. Mixed source stockpile in Ireland
3. Mixed source stockpile in Czech Republic

Asphalt mixes containing:
1. Only virgin material
2. Virgin material + 15% RA
3. Virgin material + 30% RA
4. Virgin material + 50% RA and the rejuvenator “Storbit”.

Method:

- Leachates obtained with batch test (ISO/TS 21268-1:2007)
- An ecological test battery representing different trophic levels
## Ecotoxicity tests - Methods

<table>
<thead>
<tr>
<th>Bioassay</th>
<th>Organism</th>
<th>Exposition duration</th>
<th>Measured parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN ISO 6341 Mobility of Daphnia magna</td>
<td>Daphnia magna</td>
<td>48 hours</td>
<td>Immobilisation</td>
</tr>
<tr>
<td>EN ISO 8692:2004 Algal growth inhibition</td>
<td>Desmodesmus subspicatus</td>
<td>72 hours</td>
<td>Inhibition / stimulation</td>
</tr>
<tr>
<td>ISO 7346-2 Acute lethal toxicity to a freshwater fish - Semi-static method</td>
<td>Poecilia reticulata</td>
<td>96 hours</td>
<td>Mortality</td>
</tr>
<tr>
<td>OECD 208/2006 Terrestrial plant seedling emergence and seedling growth test</td>
<td>Sinapis alba</td>
<td>72 hours</td>
<td>Inhibition / stimulation</td>
</tr>
<tr>
<td>Leachate</td>
<td>Animal bioassay</td>
<td>Plant bioassay</td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td>-----------------</td>
<td>-------------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Daphnia magna</td>
<td>Poecilia reticulata</td>
<td>Desmodesmus subspicatus</td>
</tr>
<tr>
<td>Repository RA</td>
<td>10% No effect</td>
<td>6.1% stimulation</td>
<td>8.1% stimulation</td>
</tr>
<tr>
<td>Contaminated RA</td>
<td>5% No effect</td>
<td>7.5% stimulation</td>
<td>4.7% stimulation</td>
</tr>
<tr>
<td>Ref. mix 1</td>
<td>No effect No effect</td>
<td>2.3% inhibition</td>
<td>3.4% inhibition</td>
</tr>
<tr>
<td>Ref. mix 2</td>
<td>No effect No effect</td>
<td>1.4% stimulation</td>
<td>0.1% stimulation</td>
</tr>
<tr>
<td>Ref. mix 3</td>
<td>No effect No effect</td>
<td>1.1% stimulation</td>
<td>0.1% stimulation</td>
</tr>
<tr>
<td>Irish RA</td>
<td>No effect No effect</td>
<td>1.8% inhibition</td>
<td>3.8% inhibition</td>
</tr>
<tr>
<td>50% RA+storbit</td>
<td>No effect No effect</td>
<td>6.8% inhibition</td>
<td>6.8% inhibition</td>
</tr>
</tbody>
</table>
Summary / Conclusions

- No toxic response detected in the acute lethal toxicity test to freshwater fish.
- No or low toxic response detected by freshwater algae, terrestrial plant, and Daphnia magna.
- No relation between analysed inorganic and organic components in the leachates and the response in bioassays could be identified.

Final deliverable available in October at: http://re-road.fehrl.org
Thank you for listening!

More information:
http://re-road.fehrl.org

or contact:
anja.enell@swedgeo.se