VAMORAS – Reuse of filter cakes as raw materials?

Dr. ir. Liesbeth Horckmans
From AMORAS...

Port of Antwerp
- Annual dredged sediments 500,000 tonnes DM
- Traditional solutions (lagooning fields, underwater cells) exhausted
  - Need for sustainable solution

AMORAS
Antwerp Mechanical Dewatering Recycling and Applications of Sediment
- Construction 2008-2011, operational since October 2011
  - 450,000 to 800,000 tonnes DM/year filter cakes
  - Capacity of on-site storage facility 30 years – what after?
  - Reuse of filter cakes considered from the start of the project
Introduction

Sand separation (cut off 63 µm)

Underwater cell

Thickening ponds

Dewatering

Water treatment

Storage

Sediment with low contamination (80%)

Sediment with high contamination (20%)

Thickening ponds
Circa 500 kton DM filter cakes per year. Continuous, homogenous, fine-grained material of good environmental quality.

Valorisation of filter cakes as raw materials?

- Clay replacement in ceramics
  - expanded clay aggregates
  - bricks
- Filler in concrete
- Infrastructure works (dykes, roads, ...)

© 2013, VITO NV
Characterization & optimization of filter cakes
Characterization

<table>
<thead>
<tr>
<th>Metals (mg/kg DM)</th>
<th>mg/kg DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic (As)</td>
<td>50 ± 9</td>
</tr>
<tr>
<td>Cadmium (Cd)</td>
<td>6 ± 1</td>
</tr>
<tr>
<td>Chromium (Cr)</td>
<td>140 ± 14</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>82 ± 14</td>
</tr>
<tr>
<td>Mercury (Hg)</td>
<td>1.1 ± 0.2</td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>160 ± 67</td>
</tr>
<tr>
<td>Nickel (Ni)</td>
<td>38 ± 4</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>650 ± 137</td>
</tr>
</tbody>
</table>
• Linked to natural sulphides in sediment
• Seasonal trend
• Potential issue for sulphur emissions/sulphate leaching
Characterization

- Linked to brackish water
- Seasonal trend (limited impact on filter cakes)
- Potential issue for chloride emissions/chloride leaching
Optimization – Drying

- Natural drying?
  - Slow
  - Heterogeneous
  - Labour intensive
  - Large covered surface needed

Dry matter (% DM)

- Filler
- Infrastructure
- Ceramics

- Slow
- Heterogeneous
- Labour intensive
- Large covered surface needed
Optimization – Drying

Thermal drying (filler)
• Drum dryer (500-600°C)
• Calibration/milling!
• Price estimate (high): ~50 EUR/ton filler

Direct mixing of lime/cement (infrastructure)?
Optimization – As leaching

» As leaching (standard filter cakes) > Flemish threshold for reuse

» As from natural origin (sulphides, glauconite): 50 ± 9 mg/kg DM

» Test to determine influence on As leaching of
  • Composition of filter cakes
    • Type of coagulant (lime, lime + FeCl₃, PE)
    • Addition of Fe-rich sludge to immobilise As
  • Temperature (40°C, 600°C, 1000°C)
Optimization – As leaching

One step leaching, 24h, L/S 10

<table>
<thead>
<tr>
<th>40°C</th>
<th>pH</th>
<th>As (µg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lime (2.5 m%)</td>
<td>8,8</td>
<td>73</td>
</tr>
<tr>
<td>Lime (2.5 m%) + FeCl₃ (0.45 m%)</td>
<td>8,1</td>
<td>22</td>
</tr>
<tr>
<td>PE</td>
<td>8,0</td>
<td>20</td>
</tr>
<tr>
<td>Fe-rich sludge 1m%</td>
<td>8,2</td>
<td>33</td>
</tr>
<tr>
<td>Fe-rich sludge 5m%</td>
<td>8,1</td>
<td>18</td>
</tr>
</tbody>
</table>

Thermal drying?

600/1000 °C

40°C
Industrial applications

- Laboratory scale experiments
- Industrial production trials
- Pilot scale applications

- Testing of technical and environmental quality
- Market study to evaluate potential
Industrial applications – main results

» **Ceramics** (expanded clay aggregates, bricks)
  » 5- 10% clay replacement feasible
  » Filter cakes can be used without preparation
  » Further optimization experiments ongoing
  » Economic feasibility depends on additional costs

» **Filler**
  » Drying/milling very important!
  » Increased w/c due to high water demand
  » Further optimization of recipe ongoing
  » High preparation costs: aim for high value filler!
Main results industrial applications

» **Infrastructure**
  » Drying necessary – best method to be determined
  » Technically feasible as supporting layer
  » Additional strength obtained by mixing with lime/cement
  » Optimization needed for environmental quality
Conclusions

» AMORAS process results in continuous stream of homogeneous, fine-grained material of good environmental quality
  » Optimization needed for leaching of As, chloride, sulphate

» Intermediary results for applications:
  » Expanded clay aggregates: 5-10% clay replacement feasible, no pre-treatment needed, economically feasible
  » Bricks: 5-10% clay replacement feasible, no pre-treatment needed, additional maintenance and production costs
  » Filler: high pre-treatment costs (drying, milling), additional research aimed at high value filler
  » Infrastructure: mixing with lime/cement needed for additional strength, drying necessary, further investigations into optimal mixing method
Thank you for your attention!

Questions?

More information:

- www.amoras.be
- www.portofantwerp.com

Contacts:

- Joris Dockx (aMT, project leader), joris.dockx@mow.vlaanderen.be
- Liesbeth Horckmans (VITO, research leader), liesbeth.horckmans@vito.be
- Kris De Craene (GHA, project coordinator), kris.de craene@haven.antwerpen.be