Possibilities for Reuse of Calcium Carbonate Pellets from Drinking Water Softening

Camilla Tang, PhD student

Laure Lopato (HOFOR), Sally Nyberg Kornholt (HOFOR) & Hans-Jørgen Albrechtsen (DTU)

Danish Water Forum
Annual meeting
January 30th 2017

DTU Environment
Department of Environmental Engineering
Central Drinking Water Softening

- Mitigate negative effects from water hardness:
  - Chemical consumption (soap, detergent)
  - Energy consumption and longer lifespan of appliances

- Studies conclude that there are both socio-economic and environmental benefits in households from central drinking water softening

COWI (2011)  Godskesen et al. (2012)  COWI (2015a,b)  Deloitte (2015a,b)
Design of the Softening Process

- **NaOH**
- **Ca(OH)₂**
- **Na₂CO₃**

Seeding material in

Pellets out

Waste? Resource?

Quartz sand
Limestone
Garnet sand

Water in

Base in

Water out
Methodology

- Literature review
- Study trip to the Netherlands
- Pellet analyses
Possibilities for reuse

- Particle size
- Iron
- Quartz

- Reactivity
- Heavy metals
- Color
Pellet samples

De Beitel  Weesperkarpel  Thorsbro$_{\text{Solhøj}}$  Thorsbro$_{\text{Havdrup}}$  Lejre

Hoogeveen  Seppe  Brøndbyvester  Dalum$_{\text{Before aeration}}$  Dalum$_{\text{After filtration}}$

Lindved  Marbjerg  Regnemark  Brokilde  Søndersø

Frederiksberg$_{\text{Sand}}$  Frederiksberg$_{\text{Limestone}}$  Frederiksberg$_{\text{After filtration}}$  Frederiksberg$_{\text{After aeration}}$
Chemical Composition

- A number of ions precipitate with calcium carbonate in the pellets
- Concentrations depend on influent water quality
- Iron concentration: 22 – 9.300 mg/kg dry matter
- Manganese concentration: < 1 – 996 mg/kg dry matter

<table>
<thead>
<tr>
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<th>Guideline Concentration</th>
<th>Measured Concentration</th>
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<tbody>
<tr>
<td></td>
<td>[mg/kg dry matter]</td>
<td>[mg/kg dry matter]</td>
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<tr>
<td>Cadmium (Cd)</td>
<td>3</td>
<td>&lt; 0.05 – 0.09</td>
</tr>
<tr>
<td>Chromium (Cr(VI))</td>
<td>2</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>Mercury (Hg)</td>
<td>2</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Nickel (Ni)</td>
<td>120</td>
<td>&lt; 1 – 24</td>
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<tr>
<td>Lead (Pb)</td>
<td>150</td>
<td>&lt; 2 – 0.84</td>
</tr>
<tr>
<td>Arsenic (As)</td>
<td>60</td>
<td>&lt; 1 – 0.99</td>
</tr>
</tbody>
</table>
Surface Area and Reactivity

![Bar chart showing reactivity percentages for various samples compared to commercial limestone. The graph indicates that Commercial limestone has a reactivity above 70% compared to the other samples.](image-url)
Optimizing pellet quality

The pellet quality can be optimized by:

- Implementing softening after filtration (99 % less iron and manganese)
- Replacing quartz sand with crushed pellets or limestone as seeding material

Seeding material: Sand

Seeding material: crushed pellets
Perspectives – Optimizing softening is complex

- Capital costs
- Building footprint
- Water quality
- Chemical consumption
- Technology choice
- By-product reuse
- Implementation in waterworks
- Corrosion
- Environmental effects
- Operational costs
- Health effects
Perspectives – Decision Support System

Design parameters

- Technology choice
- Process design
- Implementation in waterworks
- By-product reuse
- Etc.

Effects

- Economy
- Environment
- Health
- Corrosion
- Water quality
- Etc.

Decision Support
Conclusions

- Pellets are not waste

- Pellet reuse should be included in the design of the softening process

- A systematic approach for optimizing the softening process is lacking
Thank you!

Camilla Tang
E-mail: catang@env.dtu.dk

References