PULSE process demonstrator trials
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Content

• PULSE process concept
• PULSE demonstrator
• demonstrator trials
• PULSE product
• conclusions
PULSE (Phosphorus University of Liège Sludge Extraction) process

- **dewatered sludge** (18 - 25% DM) → **drying** → **leaching**
- **waste water** → **precipitation** → **PULSE product CaP**
- **acid solution** → **leach liquor** → **reactive extraction**
- **solvent** → **precipitated metals** → **re-extraction**
- **alkaline stripping solution** → **solid waste**
PULSE mobile demonstrator

drying, crushing, leaching and precipitation modules

mixer-settlers for solvent extraction
P content in sludge

- **German**: Total P (35 g/kg DM) and Acid-soluble P (30 g/kg DM)
- **Belgian**: Total P (15 g/kg DM) and Acid-soluble P (10 g/kg DM)
- **Scottish**: Total P (10 g/kg DM) and Acid-soluble P (5 g/kg DM)
P dissolution efficiency

German sludge trial
acid: HCl 2 mol/l
S/L ratio 1:4

soluble P fraction

degree of P leaching

pH

Aqion tool
SLLE tool
lab experiments
pilot test

acid : HCl 2 mol/l
S/L ratio 1:4
solvent extraction of metals

German sludge trial
2 stages
counter-current operation
solvent:
Alamine 336, TBP & Exxal 10 in Ketruil D80
O/A phase ratios tested:
1.5 to 3
metal stripping from solvent

Belgian sludge trial
single stage operation
NH$_3$ (3.5 mol/l) +
NH$_4$HCO$_3$ (1.5 mol/l)
O/A phase ratio: 4
PULSE product

German product
Oupeye product
Scottish product

Essen & online, 22 - 23.09.2021 | Phos4You final conference | Z.Shariff | ULiège |
PULSE product granulation by Prayon

- dried filter cake
- granulation of ground product
# PULSE pilot trial summary

<table>
<thead>
<tr>
<th></th>
<th>German sludge</th>
<th>Belgian sludge</th>
<th>Scottish sludge</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>sludge source</strong></td>
<td>Dortmund</td>
<td>Oupeye</td>
<td>Sterling</td>
</tr>
<tr>
<td><strong>wwtp</strong></td>
<td>Deusen</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>operation site</strong></td>
<td>at ULiège</td>
<td>at wwtp</td>
<td>Bo’ness testing facility</td>
</tr>
<tr>
<td><strong>quantity treated</strong></td>
<td>~340</td>
<td>~280</td>
<td>~250</td>
</tr>
<tr>
<td>(kg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>P recovery</strong></td>
<td>60 – 65%</td>
<td>60 – 65%</td>
<td>48 – 52%</td>
</tr>
<tr>
<td><strong>P$_2$O$_5$ %</strong></td>
<td>~33</td>
<td>~31</td>
<td>~29</td>
</tr>
</tbody>
</table>
conclusions

- sludge drying → lower acid consumption, better filtration
- acid-soluble P → recoverable P
- solvent extraction → Fe, Cd, Cu, Hg, Pb and Zn extracted
- product analysis and granulation by Prayon → sufficient $P_2O_5$ content and good granulation
- equilibrium tool → validation with experimental results, process optimization for different sludges
- optimization potential: bio-gas/ solar drying, ashes as input, bio-leaching
Acknowledgements

- The Phos4You project receives ERDF- funding through the INTERREG VB North-West Europe Program (2014-2020). The matching funding for the work at ULiège is provided by Walloon Region
  - free samples of chemicals were received from BTC Europe GmbH – samples of Alamine336; TOTAL Belgium - samples of Ketrul D80; Exxon Mobil- samples of Exxal 10
  - EGLV; Scottish Water; Oupeye WWTP & SPGE for support with pilot trials
  - Prayon → product analysis and granulation and Faculty of Bioscience Engineering - UGhent → sample analysis
Thank you