Change your Mind about Phosphorus:

Higher Quality Products from Lower Quality Rock or Urban Waste

Rob de Ruiter contact data for:
P-recycling (Ecophos): rob.deruiter@ecophos.com
Circular Economy (TNO): rob.deruiter@tno.nl
The element phosphorus (P) is essential for all life on earth, from micro-organisms and plants to animals and man.

Every cell of every living organism on earth contains phosphorus.
What does that imply?

If we can use the low grade rock phosphate, the map of available phosphate dramatically changes.

The only condition: **to have the right technology**
### Alternative P sources (kt P/a)

<table>
<thead>
<tr>
<th></th>
<th>Waste Water</th>
<th>MBM</th>
<th>Manure</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU</td>
<td>300</td>
<td>130</td>
<td>&gt;1000</td>
</tr>
<tr>
<td>NA</td>
<td>150</td>
<td>60</td>
<td>800</td>
</tr>
<tr>
<td>China</td>
<td>600</td>
<td>200</td>
<td>&gt;1000</td>
</tr>
</tbody>
</table>
Manure (work to be done)

- Nutrient imbalance (N/P/K/C)
- P content is limiting spreading
- Local oversupply and transport issue, negative value, e.g. NL
- Fragmented stakeholder structure
- Try to align 3000 farmers
- NO TECHNOLOGY – NO MARKET PRODUCT
- NO BUSINESS CASE
SEWAGE SLUDGE

4.4. The dairy farm sets up plant nutrient balances for nitrogen (N) and phosphorus (P).
   (Arla Foods recommendation)

4.5. Sewage sludge is not spread on fields cultivated by the dairy farm.
   (Arla Foods and agricultural sector requirement)
   Documentation: Fertilisation plan (Requirement)

4.6. The dairy farm complies with special rules and regulations concerning liquid manure from biogas plants and the spreading of composted materials
STRUVITE \((\text{NH}_4\text{MgPO}_4\cdot6\text{H}_2\text{O})\)

- Generates a lot of attention (50+ operators)
- Access to everybody’s own phosphate
- Saves WWTP costs and down time
- Nutrient imbalance
- Magnesium? \(\rightarrow\) Ca, K deficiencies
  (DEFRA HH3504SPO (White/Hammond – field trials))
- Low recovery rate (3-25% on P) – Ostara up to 40% (sludge hydrolysis at 150 deg C)
- Quality (Organics, Pathogens, drugs, Pharmaceuticals) \(\rightarrow\) why not incinerate?
- Product – niche fertilizer on golf courses
SLUDGE INCINERATION

- All P in the ash
- More industry compatible material
- Large scale, centralized, mono-incinerators
- No organics, pathogens, drugs, et cetera
- Energy recovery possible
- Processes leading to known/accepted products (solving nutrient imbalance)
- Loss of N, C
- Large investments for incinerators (NL, CH, D, DK trend setting)
Fly ashes vs. Phosphate rock

<table>
<thead>
<tr>
<th>Element</th>
<th>Unit</th>
<th>Fly ash</th>
<th>Phosphate rock</th>
</tr>
</thead>
<tbody>
<tr>
<td>P\textsubscript{2}O\textsubscript{5}</td>
<td>%</td>
<td>23.6</td>
<td>20-27</td>
</tr>
<tr>
<td>Ca</td>
<td>%</td>
<td>12.7</td>
<td>35</td>
</tr>
<tr>
<td>Si</td>
<td>%</td>
<td>10</td>
<td>1.1</td>
</tr>
<tr>
<td>Al</td>
<td>%</td>
<td>6</td>
<td>0.2</td>
</tr>
<tr>
<td>Fe</td>
<td>%</td>
<td>9.4</td>
<td>0.9</td>
</tr>
<tr>
<td>Mg</td>
<td>%</td>
<td>1.7</td>
<td>0.9</td>
</tr>
<tr>
<td>K</td>
<td>%</td>
<td>2.2</td>
<td>0.09</td>
</tr>
<tr>
<td>Na</td>
<td>%</td>
<td>0.77</td>
<td>1</td>
</tr>
<tr>
<td>As</td>
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<td>35</td>
<td>9.3</td>
</tr>
<tr>
<td>Cd</td>
<td>ppm</td>
<td>3.8</td>
<td>49</td>
</tr>
<tr>
<td>Cr</td>
<td>ppm</td>
<td>130</td>
<td>200</td>
</tr>
<tr>
<td>Cu</td>
<td>ppm</td>
<td>1200</td>
<td>200</td>
</tr>
<tr>
<td>Ni</td>
<td>ppm</td>
<td>67</td>
<td>125</td>
</tr>
<tr>
<td>Pb</td>
<td>ppm</td>
<td>250</td>
<td>21</td>
</tr>
<tr>
<td>Ti</td>
<td>ppm</td>
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<td>160</td>
</tr>
<tr>
<td>Zn</td>
<td>ppm</td>
<td>3300</td>
<td>230</td>
</tr>
<tr>
<td>F</td>
<td>%</td>
<td>0</td>
<td>3.2</td>
</tr>
<tr>
<td>SO\textsubscript{4}</td>
<td>%</td>
<td>7.7</td>
<td>2.7</td>
</tr>
<tr>
<td>TOC</td>
<td>%</td>
<td>0</td>
<td>3.35</td>
</tr>
<tr>
<td>CO\textsubscript{2}</td>
<td>%</td>
<td>0</td>
<td>7.2</td>
</tr>
</tbody>
</table>

- Need of an innovative approach to get rid of impurities
- Mono-incineration is a must to avoid P2O5 dilution
Product purity and new legislations

- New EU legislation for Cd in fertilizers:
  - 2018: <60mg/kg P2O5 ~ 30ppm in PA 54% P2O5
  - 2021: <40mg/kg P2O5 ~ 20ppm in PA 54% P2O5
  - 2030: <20mg/kg P2O5 ~ 10ppm in PA 54% P2O5

- Typical Cd content in fertilizer: 30-40ppm in PA 54% P2O5

➡ Purification of phosphoric acid will become a must for phosphate producers
  ➡ Capex
  ➡ Opex
  ➡ Loss of P₂O₅ in purification
Low-grade rock, Sewage Sludge Ash
no beneficiation
no pre-treatment

Low $P_2O_5$  High Mg, Fe, Al  High HM  High organics  High Cl

Conventional process  V.S.  EcoPhos process

Viable process using low-grade rock or urban waste
- Reduced production cost
- Expanded resources
Proven EcoPhos technology

- Modular Technology:
  - Adapt process to raw-material, products and co-products
EcoPhos process

1. **CaCO_3**
2. **Rock/SSA**
3. **H_2SO_4**
4. **Module 1A**: PO_4/CaCl_2 Solution
5. **Module 1B**: Dicalcium Phosphate
6. **Module 4**: HCl
7. **Module 3**: CaCl_2 Solution
8. **Module 1B**
9. **Insolubles**
10. **DCP / Super rock**
11. **To existing plant**: phosphoric Acid or NPK
12. **Increases capacity**
13. **H_3PO_4**
14. **Pure gypsum**
- CaCl₂ solution is purified by precipitation of heavy metals at high pH
- Mg and Cd are removed as solid residue
- Pure CaCl₂ solution at a concentration of 15 to 18% is obtained
HCl is used as vector of the acidity from sulfuric acid:

= $H^+$ transporter
Phosphoric acid route

Fly ashes → Aches digestion reactor → Filter → IEX → IEX → IEX → Purified H₃PO₄ → Evaporator

HCl

H₃PO₄

Vapor

H₃PO₄ commercial grade

Other impurities:
- Al/Fe solution
- Mg/Ca solution
- Si/Al/Fe residue
• **Business case**
  • Incineration company provides
    – Site
    – Fly ashes
    – Utilities
    – Plant operation (limited: fully automated plant)
    – Residue disposal (sand, gypsum)
  • **EcoPhos provides**
    – Patented technology
    – Necessary chemicals
    – Investment,
    – Design and construction of the plant
    – Offtake of $\text{H}_3\text{PO}_4$ and co-products
An ECO-feasible Solution

• **Same market products, new process design**
• **40% lower investment cost compared to conventional process**
  No rock beneficiation, Short residence time (45min-1h), High process yield (up to 99%)
  Reasonable temperature, atmospheric pressure, Simple material of construction
  Highly concentrated phosphoric acid out of filter (min 42% P2O5)
• **Up to 50% lower variable cost**
  Low-grade phosphate rock, no benefication, Low energy consumption
• **Green process:**
  – Low levels of Cd (or other HM): easily below 20mgCd/kgP2O5
  – 6 times less waste !
  – Low energy consumption !
  – Pure and valuable co-products: non radioactive pure gypsum, Al/FeCl3 solution
• **Highly flexible plants:**
  – Process adapted to client’s raw materials and products
EcoPhos’ worldwide activities
France – Aliphos France – 220ktpa DCP Modules 1A(6)+1B+CCP
THANK YOU FOR YOUR ATTENTION