European best practices on resource recovery from the water cycle

ARREAU review

July 2015
EIP-W Action Group ARREAU
**Accelerating Resource Recovery from the water cycle**

Objectives

- Review and exchange current European best practices
  - Success factors for viable and profitable value chains
  - Recommendations to remove policy, financial and legal barriers
- Jointly develop value chains and markets
Working Groups
Working Group
Drinking Water Residuals

Lead: Olaf van der Kolk
Objectives

- Explore valorisation options for drinking water residuals
- Describe a profitable valorisation governance model
- Contribute to water supply as a zero emission industry.
Type of drinking water residuals

**Processing steps**

1. Softening
2. De-ironing / removal manganese
3. Coalulation (removal of very fines)
4. De-coloring (removal of humics)
5. Activated coal filtration

**Main residuals**

- Softening pellets
- Lime-sludge
- Lime-Iron sludge
- High grade iron-sludge
- Low-grade Al-/ or Fe-sludge
- Brine
- Activated coal sludge
Way of bringing residuals to the market (1)

Tendering

Company/plant → Residual → Tender

contractor A → contractor B → contractor C → contractor ...

Best offer → Application
Way of bringing residuals to the market (2)

Best Practice: shared service centre

*Company / plant 1*
*Company / plant 2*
*Company / plant 3*
*Company / plant X*

Shared service centre

**Residual A**
+ buying/sales power
+ knowledge
- lower costs tender procedure

**Tender**

**contractor A**
**contractor B**
**contractor C**

Best offer

**Option / innovation 1**
**Option / innovation 2**
**Option / innovation x**

**consortium**

Application

*Option / innovation*

service providers
suppliers residual
shared service centre

research institutes

*Best offer*
Teaming up benefits ....
# PESTEL (organisation)

<table>
<thead>
<tr>
<th>PESTEL</th>
<th>Model: tendering per residual / location</th>
<th>Model: shared service centre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Political</td>
<td>--</td>
<td>Cooperation is supported</td>
</tr>
<tr>
<td>Economical</td>
<td>Cheapest solution per set service / application</td>
<td>Financial better results than tendering</td>
</tr>
<tr>
<td>Social</td>
<td>Gives competition within PMC</td>
<td>Gives room to innovation from SME’s and therefore quickest road to best performing PMC</td>
</tr>
<tr>
<td>Technology</td>
<td>Often set or at least delimited in tender</td>
<td>Accelerating innovation</td>
</tr>
<tr>
<td>Ecological</td>
<td>Framework set in tender</td>
<td>Better results due to innovative applications</td>
</tr>
<tr>
<td>Legal</td>
<td>In compliance to (EU-) law and policy</td>
<td>Possible challenge in anti-monopoly laws</td>
</tr>
</tbody>
</table>
## Softening pellets: market(s) (1/2)

<table>
<thead>
<tr>
<th>Issue/application</th>
<th>Agricultural</th>
<th>Isolation</th>
<th>Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific</td>
<td>Slow releasing neutralizing agent</td>
<td>Avoid evaporation to crawl space</td>
<td>A.o. tiles, structural concrete</td>
</tr>
<tr>
<td>Replaces</td>
<td>Quarry lime</td>
<td>Shells</td>
<td>Sand/gravel</td>
</tr>
<tr>
<td>Quality issues</td>
<td>Water content</td>
<td>--</td>
<td>Size distribution</td>
</tr>
<tr>
<td>Legal issues</td>
<td>Fertilizer act, REACH</td>
<td>REACH</td>
<td>REACH, Certificates</td>
</tr>
<tr>
<td>Technique</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Maturity market</td>
<td>Grow/mature</td>
<td>Mature/decline</td>
<td>Mature</td>
</tr>
<tr>
<td>Volume market</td>
<td>&gt;&gt; volume DWP</td>
<td>Geography: low situated areas (delta’s)</td>
<td>&gt;&gt; volume DWP</td>
</tr>
<tr>
<td>Number of clients</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Accession market</td>
<td>Moderate</td>
<td>Difficult</td>
<td>Moderate</td>
</tr>
</tbody>
</table>
## Softening pellets: market(s) (2/2)

<table>
<thead>
<tr>
<th>Issue/application</th>
<th>Excipient for industry</th>
<th>Resource for industry</th>
<th>Food, feed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific</td>
<td>A.o. neutralizing waste water, power plants</td>
<td>Production glass, plastics</td>
<td>Additive to food (e.g. dairy) and feed</td>
</tr>
<tr>
<td>Replaces</td>
<td>Quarry lime</td>
<td>Quarry lime</td>
<td>Quarry lime</td>
</tr>
<tr>
<td>Quality issues</td>
<td>--</td>
<td>Different and often difficult, calcite core</td>
<td>Hygiene Calcite core</td>
</tr>
<tr>
<td>Legal issues</td>
<td>REACH</td>
<td>REACH</td>
<td>REACH, GMP+</td>
</tr>
<tr>
<td>Technique</td>
<td>--</td>
<td>Drying, seaving, grinding</td>
<td>Drying, seaving, grinding</td>
</tr>
<tr>
<td>Maturity market</td>
<td>Growth</td>
<td>Growth</td>
<td>Growth</td>
</tr>
<tr>
<td>Volume market</td>
<td>Geography: presence specific industry</td>
<td>Potential large, however local</td>
<td>Potential large</td>
</tr>
<tr>
<td>Number of clients</td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>Accession market</td>
<td>Difficult</td>
<td>Difficult</td>
<td>Difficult</td>
</tr>
</tbody>
</table>
# High grade iron sludge

<table>
<thead>
<tr>
<th>Issue/application</th>
<th>S-binding</th>
<th>P-binding</th>
<th>As-binding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific</td>
<td>Binding sulphur, mainly in digesters</td>
<td>Binding phosphate, surface water, waste water</td>
<td>Binding arsenic. Drinking water</td>
</tr>
<tr>
<td>Replaces</td>
<td>FeCl</td>
<td>FeCl, Al(SO), biological removal</td>
<td>Ion-exchanger, Al-coagulant</td>
</tr>
<tr>
<td>Quality issues</td>
<td>Presence of metals (As in particular)</td>
<td>Presence of metals (As in particular)</td>
<td></td>
</tr>
<tr>
<td>Legal issues</td>
<td>REACH, fertilizer act</td>
<td>REACH, fertilizer act</td>
<td>REACH</td>
</tr>
<tr>
<td>Technique</td>
<td>Dewatering, avoid presence of other substances</td>
<td>Dewatering, avoid presence of other substances</td>
<td>Dewatering, avoid presence of other substances</td>
</tr>
<tr>
<td>Maturity market</td>
<td>Mature</td>
<td>Mature</td>
<td>Introduction</td>
</tr>
<tr>
<td>Volume market</td>
<td>Digesters demand little &gt; than supply</td>
<td>Potential demand &gt;&gt; supply</td>
<td>??</td>
</tr>
<tr>
<td>Number of clients</td>
<td>High</td>
<td>High</td>
<td>Low-moderate</td>
</tr>
<tr>
<td>Accession market</td>
<td>Moderate-Difficult</td>
<td>Moderate-Difficult</td>
<td>Difficult</td>
</tr>
</tbody>
</table>
## Low grade iron/alum sludge

<table>
<thead>
<tr>
<th>Issue/application</th>
<th>Clay brick</th>
<th>Cement clinker</th>
<th>Backfill, sound barrier, cover layer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Specific</strong></td>
<td>Backing the sludge, using the grain distribution and colour</td>
<td>Fe and Al are an essential component of cement</td>
<td>Cover up waste in waste dump, sound barriers along highways</td>
</tr>
<tr>
<td><strong>Replaces</strong></td>
<td>Clay, Fe and/or Al-additive</td>
<td>Fe and/or Al-additive</td>
<td>Soil</td>
</tr>
<tr>
<td><strong>Quality issues</strong></td>
<td>Presence of CaCO₃, coarse material, organic material</td>
<td>Organic substances</td>
<td>Chemical properties</td>
</tr>
<tr>
<td><strong>Legal issues</strong></td>
<td>REACH</td>
<td>REACH</td>
<td>Test is applicable</td>
</tr>
<tr>
<td><strong>Technique</strong></td>
<td>Dewatering</td>
<td>Dewatering</td>
<td>--</td>
</tr>
<tr>
<td><strong>Maturity market</strong></td>
<td>Mature</td>
<td>Mature</td>
<td>Mature</td>
</tr>
<tr>
<td><strong>Volume market</strong></td>
<td>Demand &gt; than supply</td>
<td>?</td>
<td>Local dependant</td>
</tr>
<tr>
<td><strong>Number of clients</strong></td>
<td>Low</td>
<td>Low (geographical)</td>
<td>High</td>
</tr>
<tr>
<td><strong>Accession market</strong></td>
<td>Easy</td>
<td>Easy (after testing)</td>
<td>Easy (after testing)</td>
</tr>
</tbody>
</table>
# Brine

<table>
<thead>
<tr>
<th>Issue/application</th>
<th>Salt</th>
<th>Humid acids, fulvic acids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific</td>
<td>Reuse salt in process</td>
<td>Removal of humic- and fulvic acids</td>
</tr>
<tr>
<td>Replaces</td>
<td>Primary salt</td>
<td>Humic acids and fulvic acids derived from peat</td>
</tr>
<tr>
<td>Quality issues</td>
<td>Hygiene, purity</td>
<td>Purety, dry matter content,</td>
</tr>
<tr>
<td>Legal issues</td>
<td>Drinking water laws</td>
<td>Fertilizer laws, REACH</td>
</tr>
<tr>
<td>Technique</td>
<td>Diafiltration, nanofiltration</td>
<td>Diafiltration, nanofiltration</td>
</tr>
<tr>
<td>Maturity market</td>
<td>Growth</td>
<td>Growth</td>
</tr>
<tr>
<td>Volume market</td>
<td>Reuse, so balanced</td>
<td>In volume relatively small, but developing</td>
</tr>
<tr>
<td>Number of clients</td>
<td>Small</td>
<td>End users: high</td>
</tr>
<tr>
<td>Accession market</td>
<td>Difficult</td>
<td>Difficult</td>
</tr>
</tbody>
</table>
Activated (powdered) carbon

<table>
<thead>
<tr>
<th>Issue/application</th>
<th>Agricultural</th>
<th>Immobilize</th>
<th>Reuse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific</td>
<td>As structure material, bringing also humic acids</td>
<td>Mix with waste stream immobilizing certain components</td>
<td>Bringing it back to supplier</td>
</tr>
<tr>
<td>Replaces</td>
<td>Organic material</td>
<td>Primary activated carbon</td>
<td>Primary activated carbon</td>
</tr>
<tr>
<td>Quality issues</td>
<td>Metals and pesticides on product</td>
<td>Degree of binding</td>
<td>--</td>
</tr>
<tr>
<td>Legal issues</td>
<td>Fertilizer act</td>
<td>Degree of immobilizing</td>
<td>New product must fit standard</td>
</tr>
<tr>
<td>Technique</td>
<td>Bleeding with other products</td>
<td>Mixing</td>
<td>Manufacturing process activated carbon</td>
</tr>
<tr>
<td>Maturity market</td>
<td>Introduction</td>
<td>Growth</td>
<td>Mature</td>
</tr>
<tr>
<td>Volume market</td>
<td>Demand &gt;&gt; supply</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Number of clients</td>
<td>High (end-users)</td>
<td>Low-moderate</td>
<td>Low</td>
</tr>
<tr>
<td>Accession market</td>
<td>Moderate</td>
<td>Difficult</td>
<td>?</td>
</tr>
</tbody>
</table>
Examples Products

**Wienerberger**
Building Material Solutions

**Digester:** S-control

**WWTP:** P- and S-control
ARREAU Working Group
Phosphorus

Lead: Christian Kabbe (KWB)
Objectives

Overall objective:

- Phosphorus recovery from wastewater
- Including municipal and industrial wastewater (e.g. food industry), not from manure or other bio solids (focus “EIP-Water”)

Specific objectives:

- List possibilities for P-recovery and identifying best practice or best available technology (BAT)
- Identifying boundary conditions for BAT, since the local boundaries by infrastructure seems important for implementation

Tasks:

- Review of Best Practices considering ecological, economical, political and technical information on BAT
- Communicate the results in and outside of the EIP Water Action Group
Value Chain

**Costumer:** fertilizer user, producer or chemical industry

**Examples of companies existing from Supplier/Producer to Costumer:**
- **Ostara:** WWTP > Fertilizer (Struvite) > Costumer
- **ICL Fertilizer e.g.:** Raw material > Fertilizer > Customer (Agriculture)
Examples of existing brands and provider-names (status May 2015)

**Wet sludge and liquor**
- Aqueous phase (dissolved P)
- With enforced P dissolution

**Sludge and sludge ash**
- Acidic digestion/Leaching
- Thermal

**PEARL**
- Struvite

**NuReSys**
- Struvite

**PHOSPAQ**
- Struvite

**AirPrex**
- Struvite

**STRUUVIA**
- Struvite

**CRYSTALACTOR**
- Struvite, CaP

**REPHOS**
- Struvite

**ANPHOS**
- Struvite

**FIX-PHOS**
- CaP/CSH

**P-RoC**
- CaP/CSH

**Ecobalans**
- Struvite, NPK

**LYSOGEST**
- Struvite

**Gifhorn**
- Struvite, CaP

**Stuttgart**
- Struvite

**Budenheim**
- DCP

**LEACHPHOS**
- P-mineral

**Fert. industry**
- Mineral fertilizer

**ECOPHOS**
- DCP

**RECOPHOS D**
- P-mineral

**P-bac (INOCRE)**
- Bio-P

**TETRAPHOS**
- H$_3$PO$_4$

**MEPHREC**
- P-slag

**AshDec (Outotec)**
- P-mineral

**THERMPHOS* P$_4$**

**KUBOTA**
- P-slag

**InduCarb**
- P$_4$, H$_3$PO$_4$

* former full-scale, but insolvent
### BAT and their Value Chain

**Resource**
- High quality sewage sludge with sewer control
- Sewage Sludge
- Sludge liquor/centrate from municipal WWTP
- Industrial wastewater (food industry e.g.)

**Product**
- Sewage sludge/Biosolids
- Organic Fertilizer/Biosolids
- Struvite
- Phosphoric Acid/Fertilizer

**Recovery – Rate from Sludge**
- **Case 1**: Phosphorus recovery from wastewater
  - $\approx 100\%$
- **Case 2**: Phosphorus recovery from wastewater
  - $\approx 100\%$
- **Case 3**: Phosphorus recovery from wastewater
  - 5-15\%$
- **Case 4**: Phosphorus recovery from wastewater
  - $= 80\%$*
- **Case 5**: Phosphorus recovery from wastewater
  - 95-100\%
Examples for K.O.-Criteria for other existing Technologies

For defining a technology/option as best practice...
1. ... it has to be successfully proven in full-scale
2. ... it has the potential to become successful in full-scale near-by

Examples for K.O.-Criteria for technologies (2.):
- Costs e.g. by demand on chemicals or energy
- No valuable product chain with market acceptance for the product
- Unfavorable ratio between produced recyclate and amount of waste (by-products), which has to be disposed off
- Complexity of technology (implementation, operation and finance risks): no demo site available several years after proof of concepts
## PESTEL-Analysis

<table>
<thead>
<tr>
<th>Option/Technology</th>
<th>Political</th>
<th>Economics</th>
<th>Socio-Cultural</th>
<th>Technology</th>
<th>Environment</th>
<th>Legislative</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Case 1</strong> Sewage sludge in agriculture</td>
<td>-/+ (partly unwanted)</td>
<td>+ (cheap way of sludge disposal)</td>
<td>- (concern regarding human health)</td>
<td>+ (non)</td>
<td>- (concern regarding environment)</td>
<td>+/- (partly forbidden, quality control)</td>
</tr>
<tr>
<td><strong>Case 2</strong> Organic fertilizer from sewage sludge</td>
<td>-/+ (partly unwanted)</td>
<td>+ (cheap way of sludge disposal)</td>
<td>- (concern regarding human health)</td>
<td>+ (simple)</td>
<td>- (concern regarding environment)</td>
<td>+/- (partly forbidden, quality control)</td>
</tr>
<tr>
<td><strong>Case 3</strong> Struvite from municipal WWTP</td>
<td>0/+ (unknown, registered as fertilizer in D, NL)</td>
<td>+ (cheap process, market increases)</td>
<td>0</td>
<td>+ (simple)</td>
<td>+ (“clean” fertilizer)</td>
<td>+ (REACH, fertilizer regulation)</td>
</tr>
<tr>
<td><strong>Case 4</strong> Struvite from industrial WWTP</td>
<td>0/+ (unknown, registered as fertilizer in D, NL)</td>
<td>+ (cheap process, market increases)</td>
<td>0</td>
<td>+ (simple)</td>
<td>+ (“clean” fertilizer)</td>
<td>+ (REACH, fertilizer regulation)</td>
</tr>
<tr>
<td><strong>Case 5</strong> Phosphoric acid/ Fertilizer from sewage sludge ash</td>
<td>0/+ (unknown, technical solutions preferred?)</td>
<td>+ (by-product selling, market for H₃PO₄ or MCP/DCP)</td>
<td>0</td>
<td>- (complex)</td>
<td>+ (“clean” raw material, fertilizer)</td>
<td>+ (REACH, fertilizer regulation)</td>
</tr>
<tr>
<td>Option/Technology</td>
<td>Opportunities</td>
<td>Challenges</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Case 1</strong> Sewage sludge in agriculture</td>
<td>WWTP in areas without other sludge disposal infrastructure (incineration) or low contaminated wastewater and sludge</td>
<td>Logistics (incl. storage); Ensure sludge quality through monitoring in synergy with measures (enhanced sludge treatment or reductions of hazards in the influent)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Case 2</strong> Organic fertilizer from sewage sludge</td>
<td>WWTP in areas without other sludge disposal infrastructure (incineration) or low contaminated wastewater and sludge</td>
<td>Ensure sludge quality through monitoring in synergy with measures (enhanced sludge treatment or reductions of hazards in the influent)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Case 3</strong> Struvite from municipal WWTP</td>
<td>WWTP with EBPR (and high P-concentrations in sludge liquor), prevention of incrustations, reduced polymer demand, reduced return (and effluent) load</td>
<td>Harvesting efficiency of struvite and enable a higher demand on the European market for recycled struvite</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Case 4</strong> Struvite from industrial WWTP</td>
<td>Industrial WWTP with high N- and P-loads after anaerobic treatment, reduced effluent load</td>
<td>Harvesting efficiency of struvite and enable a higher demand on the European market for recycled struvite</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Case 5</strong> Phosphoric acid from sewage sludge ash</td>
<td>Existing ashes from mono-incinerations of municipal sewage</td>
<td>Demonstration on full-scale, Selling of by-products, Establishing on the market</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
All full-scale operating plants are Case 3 and Case 4.

References/Companies mentioned in the templates per Case

Existing Case Studies
Value and Market potential

What products do you have at the end and at which costs to WWTP operator?

- Sewage sludge (Case 1, reference): 2-3 €/kg P (equivalent to 120 €/t DS disposal costs)
- Organic fertilizer (Case 2, reference): < 5 €/kg P (equivalent to disposal costs)
- Struvite (Cases 3 & 4): 0-5 €/kg P, sludge still needs to be disposed off
- Phosphoric acid/Fertilizer from ash (Case 5): 0-1 €/kg P + approx. 10 €/kg P for new mono-incineration if required

Why there is success on the market?

Recovery-Recycling-processes have synergies with disposal/ maintenance/ by-product production etc...
Green jobs with P-recycling from wastewater

1. Safeguard existing jobs in EU fertilizing industry
   • Today about 20,000 direct employments in N/P/K producers (source Fertilizer Europe)
   • Under threat of delocalisation / external competition (risk of value chain being transferred to countries mining phosphate rock)
     • LOVOCHEMIE (CZ): stopped processing P-rock (apatite) from Russia
     • THERMPHOS (NL): insolvency 2012 due to price dumping by Kazakhstan
     • ICL (NL): 100% green P-fertilizer by 2025

2. Create new green jobs in Europe
   • P-content in wastewater sludge (EU): 400,000 t P/y
   • P-content in wastewater sludge not used in land spreading: 240,000 tP/y
   • Market generated if P-recycling was enforced by law: 1,200 M€/y (assuming the costs for P-recovery is 5,000 €/tP, ~5 €/pers./a)
   • Potential new green direct job creation (without distribution): 5,000 jobs, or 10,000 direct + indirect jobs?
   • In addition, cost saving on P-rock import: 240 M€
Lighthouses (high quality sludge/ biosolids)

**Käppala municipal sewage works, Sweden**
- REVAQ sewage sludge certification
- 260 t P/year recycled to agriculture
- Reductions in industry & household contaminants
- Sludge mixing with manure for contaminant degradation

**Similar lighthouses Brunswick, Germany**
Lighthouses (struvite from municipal WWTP)

**AirPrex-Technology by CNP, Germany**
- 7 installations recovering P as struvite
- Approx. 1000 t struvite/y recovered, partly recycled to agriculture
- Benefits in Maintenance of the WWTP sludge line
- Savings in Energy and Greenhouse Gases on the WWTP
- Berlin Struvite called „Berliner Pflanze“ – Winner of the GreenTec Award 2015

**Similar lighthouses / technologies: Pearl, Canada; NuReSys, Belgium**
Lighthouses (struvite from industrial sector)

**NuReSys, Belgium**
- 8 installations recovering P as struvite
- Water sectors: Potato processing, dairy, pharmaceuticals, ...
- Reduction of P and N in UASB outflow

**Similar lighthouses/ technologies: Pearl, Canada; AirPrex, Germany**
Lighthouses (H$_3$PO$_4$ from sewage sludge ash)

**SNB – HVC Groep – Ecophos, Netherlands, France**

- Contract signed 2015/ Start in 2017
- Netherlands / France (Dunkerque)
- Sewage sludge incineration ash
- Production of H$_3$PO$_4$/DCP for fertilisers or animal feed
- Treating 60,000 t ash/y for P-recovery

**Similar lighthouses/ technologies:**
* TetraPhos, Germany*
Summary

- **Objectives:** Phosphorus recovery from wastewater
- **Value Chain:** Sewage (> Raw material) > Fertilizer
- **Existing Technologies:** > 20 but only 5 market relevant “Best Practices”
- **Tools for assessment:**
  - Results WA 4 of P-REX (EU FP7): Life-Cycle-Assessment, Costs, Risk Assessment, Plant availability, Toxicity
  - Results WA 5 of P-REX (EU FP7): Market and legislative analysis, regional case studies, strategy development for implementation
- **Existing Case Studies:** many success-stories in Europe
- **Adding Value especially through synergies...**
- **Ongoing development of other technologies, to be followed-up ...**
Conclusion

There is no one-fits-all-solution

There is a manageable number of best practices

Which of this best practices fits best to your plant/region is...

- dependent on regional infrastructure (e.g. EBPR, incineration, drying capacity, fertilizer industry, agriculture)
  - first use existing local infrastructure for P-recovery, then think about additional infrastructure for P-recovery

- dependent on regulations in your country and on public discussions
  - regulations can be changed, discussions can be started (agree on realistic P-recycling target for the region, considering local context and trade-off between technical P-recovery and energy efficiency)
Past and Running projects about phosphorus (list not complete)

BioEcoSIM, www.bioecosim.eu
Boirefine cluster, www.biorefine.eu/cluster/projects
End-o-sludg, www.end-o-sludg.eu
FERTIPLUS, www.fertiplus.eu
ImproveP, www.improve-p.uni-hohenheim.de
LIFE PHORWater, www.phorwater.eu
ManureEcoMine, www.labmet.ugent.be/content/manureecomine
RISE Foundation, www.risefoundation.eu
P-REX, www.p-rex.eu
R3Water, www.r3water.eu
RecoPhos (Austria), www.recophos.org
RecoPhos (Germany), www.recophos.de
REFERTIL, www.refertil.info
Routes, www.eu-routes.org
SuWaNu, www.suwanu.eu
TL-BIOFER, www.life-tlbiofer.eu
KRN-Mephrec, www.nuernberg.de/internet/km_mephrec/

Full list by ESPP with research projects, initiatives and networks:
Working Group
Cellulose

Lead: Coos Wessels
Facts and figures

- Toilet paper is appr. 30-50% of the Total Suspended Solids (TSS);
- Representing 25-45% of the COD;
- Western Europe average 12-16 kg toilet paper per person;

Top 30 Countries per Capita Tissue Consumption 2007

NL: 150,000 to 180,000 ton TSS/year!
Screenings a new site product

- Finescreens, they are of added value!

- Challenges:
  - How do we get the maximum added value from screenings;
  - Where can we use the cellulose recovered
An innovative way of maxgrading

Biofuel
- Biogas
- Biodiesel

Basic chemicals

Use as a fiber
- Carton board
- Composite

Bioplastic
Ongoing re-processing routes

Consumer
Toilet paper in sewer system

Waterboards
Screening of toilet paper from sewage, using a finescreen

SCREENCAP
Impact on downstream biological treatment

CADOS
Screenings as raw fiber material
Use for sludge dewatering

Cellulose from sources
- Paper;
- Diapers;
- Beverage carton;
- Textile

CelluSCycle
Screenings as carbon source
Speedy composting with Fibral and compost reactor
Different WWTP, eg. Kulstad (NO)

- Recirculated newspaper
- Added absorbent (polymer)
- 4-6% additive to sludge
  - (Other composting methods must have 100-150% addition of structural fiber (from trees and bushes/ garden waste))
Optimisation of sludge dewatering
WWTP Ulrum (NL) – started 19-09-2014

Capacity: 20,000 pe
DWF: 107 m³/h
FFT: 457 m³/h

Screenings 30 - 70 kg Ds/h (dewatered)

Improve dewatering to >30% Ds
Reduction polymer consumption to < 3 g/kg Ds

Possible dosage of cellulose from other sources
Production of Bioplastics (PLA)
WWTP Beemster - under construction

Capacity: 170,000 pe
DWF: 1,860 m$^3$/h
FFT: 3,600 m$^3$/h

Screenings 770 ton Ds/y

Production 130 ton PLA/y

Challenges:
- Separation of clean cellulose fiber
- Tests for using cellulose in composites
Separation of cellulose fibers
WWTP Uithuizermeeden (NL) – start 01-01-2015

Capacity: 55,000 pe
DWF: 465 m$^3$/h
FFT: 860 m$^3$/h

Screenings 130 ton Ds/y

Focus:
- Getting clean cellulosic fibers as raw material for composit
ScreenCap

Finescreen supported biological wastewater treatment to enhance plant capacity

Full scale pilot at Waste Water Treatment Plant Aarle Rixtel (NL)

Started 1 November 2014, 3 years duration
Working Group
Cross Cutting Issues

Lead: Staffan Filipsson
ARREAU Working Group
Cross cutting issues

An general overview of barriers, constraints, requirements and success factors for implementation of viable and profitable value chains of recovered resources from waste water
Barriers for implementation of viable and profitable value chains

Many water related resource recovery initiatives take place in Europe. All initiatives are challenging existing system structures, which is typical for systemic eco-innovations.

Main regulation- and trade barriers:

- Europe is lacking specific recovery and reuse policies for waste water resources
- There is lack of clarity in the regulatory framework
- There is uncertainty regarding future development of regulations
- There is fear for potential trade barriers for recovered product
Barriers for implementation of viable and profitable value chains

Main regulation- and trade barriers, continued:

- Policy and decision makers as well as stakeholders are usually uninvolved and unaware of the rapidly growing field of recycling and reuse research and knowledge.
- Too high cost for recovered product / Tax on recovered products
- Recovered product not seen as a component of integrated product management
- Big players dominate the market – not interested in new and small volumes
- Recovered product does not have the same characteristics of traditional product, which is an issue for the process industry as well as for the end user who may be scared off
Barriers for implementation of viable and profitable value chains

Main barriers depending on lack of knowledge:

• Completeness of assessing and implementing recycling and reuse technologies has been the subject of controversy and debate in the current literature as well as in practice.

• The expertise, data and methods developed are often not in a format useful to the decision-makers who need tools and information they can apply in their day to day activities

• Negative public perception on the quality of the recovered product

• Lack of awareness of the multiple benefits of recovery

• An array of technological solutions does already exist but are either seen as being costly or complex.

• Scientific uncertainties – lack for large scale demonstration plants
Success factors for implementation of viable and profitable value chains

Ways to underpin the break down of regulation- and trade barriers:

- Create political support for circular economy in water and set proper responsibilities among stakeholders (favorable tax systems for sustainable approaches)
- Create EU-wide quality requirements within and outside of the framework to ensure a high trust for the novel recovered products.
- Introduce mechanisms for distribution of cost and financing models for demonstration projects.
- Introduce incentives like lower taxation for non fossil products, quota of non fossil products in European fertilizer market etc.
Success factors for implementation of viable and profitable value chains

Ways to underpin the break down of regulation- and trade barriers:

- On Member State level we see initiatives to strengthen the regulations such as in Switzerland, Germany and the Netherlands, but a more EU wide policy development is needed to accelerate resource recovery from water and waste water.

- We need rethink regarding established practices and responsibilities of water utilities and other stakeholders.

- We need improved understanding of policies and regulations in combination will manage the lack of clarity in regulations regarding risks associated with reuse and how the policies and regulations can be improved for this purpose.
Success factors for implementation of viable and profitable value chains

Ways to underpin increased knowledge regarding recovered products:

- Introduce combinations of innovation, market analysis, customer collaboration, and new methods for teamwork in the supply chain that creates generic knowledge that can be diffused.

- Communicate the advantages of recovery and reuse:
  - Europe will less dependent on scarce resources
  - Substantial job opportunities, huge export opportunities outside Europe
  - Assess the impact on beneficiaries and innovation of the proposed solutions
  - Resource recovery from water can already be financially profitable (e.g. drinking water residuals) or affordable (e.g. phosphorous $<10 \text{€/yr}$ per citizen).
  - Recycling water resources makes Europe less dependent on critical raw materials and offers huge opportunities for new markets and jobs.
Success factors for implementation of viable and profitable value chains

Ways to underpin increased knowledge regarding recovered products:

- Financing for innovation
  - Better knowledge in the value chain will increase the willingness to invest.
  - Establish projects with strong a private-public consortium
  - Build interfaces between funders, industry, companies, SMEs and research organizations by introduction of a systemic supply chain model combining innovation, market analysis, customer collaboration, lean production and new methods for teamwork in the supply chain:
    - this will lead to concrete business plans for access to finance for involved SMEs which all have potentially disruptive technologies and a high export potential
    - this will generate generic knowledge for SME`s in the European and OECD countries water cycle.
Success factors for implementation of viable and profitable value chains

Tools to underpin increased knowledge regarding recovered products:

- Increase the knowledge of the environmental and economical impact by both Life Cycle Analysis (LCA) and Life Cycle Cost (LCC).

- Make use of Environmental Technology Verification (ETV) for large scale demonstration projects that support the market uptake of the innovative technologies in Europe and beyond.

- In order to be able to increase the benefits from any reuse and recycling technologies, a larger systemic analysis of the overall environment is needed:
  - the use of Decision Support Systems (DSS) offers an enlargement of the traditional narrow planning and management approaches
  - a well designed DSS operates on different levels and integrates management of plants with monitoring and support for water governance on a higher organizational level (e.g. pertinent local or regional agencies).
  - a DSS can also be used for evidence based decisions supporting market deployment of new eco-innovative technologies and can be combined with pilot region case studies to demonstrate how reuse effectively can be a component of integrated water management
Success factors for implementation of viable and profitable value chains

Ways to underpin increased knowledge regarding recovered products

- Stimulate large scale demonstration projects of technologies for reuse of resources
- Increase the communication and dissemination of results from demonstration projects with the public and the decision makers
- Involve strategic public customers that has an interest in reuse and introduce training and models for public procurement as well as pre-commercial procurement

We see incentives for the market to change. Examples are companies that want to diversify their raw sources and companies that want to contribute to circular economy initiatives at local scale.
European best practices on resource recovery from the water cycle

ARREAU review

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