Effects of further effluent treatment stages at pulp and paper industries

Åsa Sivard, ÅF, Sweden
asa.sivard@afconsult.com
Project goal

- Desktop study - Consequences of upgrading an existing secondary treatment with an additional treatment stage
- Membrane filtration
- Chemical precipitation
- Sand filter
- Review of:
  - Discharge reductions
  - Effects in the receiving waters
  - Total environmental impact (LCA)
Mills in the study

Billerud Gruvön, Grums
685 000 t/year
Kraft paper, fluting, market pulp

Smurfit Kappa
Kraftliner, Piteå
700 000 t/year
Kraftliner

Integrated Kraft pulp mills
### Discharge from existing biological treatment

<table>
<thead>
<tr>
<th></th>
<th>Gruvön</th>
<th></th>
<th>Kraftliner</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In Bio</td>
<td>Out Bio</td>
<td>In Bio</td>
<td>Out Bio</td>
</tr>
<tr>
<td>Flow</td>
<td>m³/d</td>
<td>43 000</td>
<td>43 000</td>
<td>35 000</td>
</tr>
<tr>
<td>COD</td>
<td>t/d</td>
<td>46</td>
<td>18</td>
<td>29</td>
</tr>
<tr>
<td>COD</td>
<td>mg/L</td>
<td>430</td>
<td></td>
<td>160</td>
</tr>
<tr>
<td>SS GF/A</td>
<td>mg/L</td>
<td>44</td>
<td></td>
<td>34</td>
</tr>
<tr>
<td>Tot N</td>
<td>mg/L</td>
<td>4.9</td>
<td></td>
<td>5.5</td>
</tr>
<tr>
<td>Tot P</td>
<td>mg/L</td>
<td>0.7</td>
<td></td>
<td>1.1</td>
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<tr>
<td>Extractives</td>
<td>mg/L</td>
<td>1.3</td>
<td></td>
<td>0.1</td>
</tr>
</tbody>
</table>

COD, Tot N and Tot P within EU guidelines for BAT (2001)
Membrane filter, Ultra filtration

Moderate COD reduction, low concentrate flow, low separation of inorganic ions

From biological treatment → Pumping station → Disc filter → Membrane filter → To recipient

Concentrate → Evaporation Recovery boiler → To biological treatment

Suspended solids discharge ~ 2 mg/L
Chemical precipitation

Good effect on suspended solids, COD, extractives and phosphorus

From biological treatment → Pump station → Chemical precipitation and Dissolved air flotation → Flotation sludge → Sludge dewatering → Sludge for incineration in power boiler → To recipient

~ 20 mg/L
Sand filter

Good effect on suspended solids

By-pass at high flow

To recipient

From biological treatment

Pump station

Sand filter

Suspended solids discharge ~ 10 mg/L

Backwash water

Chemical precipitation Flotation

Alum NaOH Polyelectrolyte

Sludge for incineration in Power boiler

Fibre sludge Polyelectrolyte

Sludge dewatering

Innovation by experience
COD after treatment (t/d)

Gruvön

Kraftliner

Filled bar mean value, total bar max month
N tot after treatment (kg/d)

Gruvön

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<tr>
<th>Out bio</th>
<th>SF</th>
<th>Ch Pr</th>
<th>MF</th>
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<tr>
<td>400</td>
<td>450</td>
<td></td>
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Kraftliner

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<tr>
<td>050</td>
<td>100</td>
<td>150</td>
<td>200</td>
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Filled bar mean value, total bar max month
P tot after treatment (kg/d)

Gruvön

Kraftliner

Filled bar mean value, total bar max month
More reduction figures

Reduction, Chemical precipitation and UF stages

- AOX, about 50 %
- Extractives, about 70 %
- Heavy metals, 5-20 %
  (Cd, Cu, Pb, Cr, Ni, Zn)
Investment and operating costs

- **Sand filter**
  - Investment: 11-12 MUSD
  - Operating cost: 0.6-1 MUSD/year

- **Chemical precipitation**
  - Investment: 11-15 MUSD
  - Operating cost: 2.5-7 MUSD/year

- **Membrane filtration**
  - Investment: 15-18 MUSD
  - Operating cost: 2.5-3.5 MUSD/year
Effects in the receiving waters

- The ecological status is good in the waters close to the two example mills
- Further treatment stages will give low effects in the mill’s surrounding waters
- Further treatment stages could be of some importance for the total water system
LCA

- Membrane filtration and Chemical precipitation
- ISO 14044, GaBi LCA software
- Sludge composition calculations
- Energy and chemicals used
- Incineration of chemical sludge, ashes sent to landfill
- Oil is used as support fuel for evaporation of concentrate from membrane filtration
- Membranes and disc filter material are seen as consumables
- Manufacturing of equipment and erecting of buildings have been neglected
- Average transportation 500 km
Impact categories

- Eutrophication
- Ecotoxicity (fresh water, sea water, terrestrial)
- Human toxicity
- Climate change
- Stratospheric zone depletion
- Acidification
- Photochemical oxidant potential
- Abiotic resource depletion
Environmental balance - effluent treatment

Revenue

Inlet

Costs

Chemicals +

Energy +

Sludge +

Avoided environmental impact

- Outlet

Environmental impact

Innovation by experience
Comparison

- A positive effect of the further treatment stages is **reduced Eutrophication**
- For **Ecotoxicity** and **Human toxicity** are the avoided effects by water purification lower than the effects caused by the new treatment stages
- For most impact categories there is no avoided impact due to the new treatment stages but there is an impact caused by the new stages
Normalisation and weighting

- Normalisation of different impact categories can be done by comparison with the total impact from society.
- Normalisation can also be done by comparison with political decided discharge goals.
- Normalisation has been done using the two different methods, the results depends on the method.
- It is difficult to see a significant positive environmental effect of the further treatment.
Increased CO₂ discharge - Reduced nutrient discharge

- Cost for CO₂ discharge 15-85 USD/ton
  (EU CO₂ emissions trading, Study McKinsey & Company 2009)

- Cost for Phosphorus discharge 40-400 USD/kg
  (The Swedish Water & Wastewater Association, suggestion for discharge taxes to the Baltic Sea)

- Cost for Nitrogen discharge 4-30 USD/kg
  (The Swedish Water & Wastewater Association, suggestion for discharge taxes to the Baltic Sea)
Monetary valuation (USD/day) of operation and discharges

Gruvön mill

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Innovation by experience
Conclusions

- The total discharge of nutrients is reduced due to the new treatment stages - reduced eutrophication
- There is an impact caused by the new stages due to increased consumption of chemicals and energy
- The environmental benefit of further treatment is uncertain
- Improved methods to compare impact categories are required
- More explicit principles for valuation of different environmental impacts are required from society
Acknowledgments

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- Olle Simon and Tomas Ericsson, ÅF
Thank you for your attention!