Content

1. Municipal wastewater – basic characteristics and conditions
2. Principal wastewater treatment methods
3. Future effluent standards
4. Choice of treatment process/technique for Kalmar Sound WWTP
5. Conditions and current solution for Kalmar Sound WWTP
Municipal wastewater – basic characteristics and conditions
## Characteristics municipal wastewater

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Normal values</th>
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<tbody>
<tr>
<td>COD*</td>
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<td>300-600</td>
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<tr>
<td>BOD*</td>
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<td>150-300</td>
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<td>TOC</td>
<td>mg/L</td>
<td></td>
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<tr>
<td>TN</td>
<td>mg/L</td>
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</tr>
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<tr>
<td>AOX*</td>
<td>mg/L</td>
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*: Kommunales Abwasser, Koppe/Stozek, 1999
Conditions municipal wastewater

Flow during “normal” conditions
Conditions municipal wastewater

Flow affected by precipitation
Principal wastewater treatment methods
Principal wastewater treatment methods

• Mechanical treatment
• Biological treatment
• Chemical treatment
Mechanical treatment

- Screening
- Settlement
- Flotation
Screening – rotating drum sieve

VoR Roto-Sieve Drum Screens consist of a perforated drum (1) with internally fixed screw (2), which transports the separated particles out of the drum. The drum rotates on trunnion wheels (3) and is driven by a cog gear motor (4). Incoming liquid is fed into the drum through an inlet pipe (5), which distributes the water over a large area of the drum’s interior. During passage through the drum, the liquid is screened through the drum’s perforations and collects in the trough (6) underneath. Separated particles are transported out of the drum through the screenings outlet (7). Dewatering continues throughout transport in the drum. To prevent clogging of the unit’s perforations, all drum screens are fitted with a rotating brush (8) and a spray header with spray nozzles (9). Roto-Sieve drum screens are completely encased in removable splash guards (10) and equipped with a ventilation exhaust (11) to improve the working environment.
Screening – step screen
Screening – belt sieve
Settlement
Settlement – settling tanks
Settlement – lamella separator
Flotation

www.hubersverige.se
Biological treatment

• Activated sludge processes
• Biofilm processes
Activated sludge processes
AS-process - predenitrification
AS-process - postdenitrification

[Diagram showing a wastewater treatment process with labeled components: Carbon source, Influent, Nitrification basin, Post-denitrification, Clarifier, Effluent, Sludge recirculation.]
AS-process – Bio-P

www.responsiblebusiness.eu
Activated sludge processes

Multibio, VA-engineers
OCO, IFO-water

Oxidation ditch, Röstånga, NSVA
Visby WWTP, Gotland
Biofilm processes

MBBR – moving bed biological reactor
www.veoliawatersti.fr

Trickling filter
www.wikimedia.org
Biofilm processes

www.krishenviro.com

www.vasyd.wordpress.com

www.sanying.com.tw

www.iauga.es
Chemical treatment

- Precipitation – for phosphate removal
- Flocculation – for coagulation of small particles such as salt crystals from phosphate precipitation and suspended solids
Chemical precipitation
Chemical precipitation in AS

www.trevi-env.com
Flocculation

Source: Nijhuis Water technology, NL
Future effluent standards
Expected effluent standards for Kalmar Sound WWTP

<table>
<thead>
<tr>
<th>Parameter</th>
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<th>Value</th>
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<tr>
<td>TN*</td>
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<tr>
<td>TP*</td>
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*: yearly average
Choice of treatment technique/process for Kalmar Sound WWTP
Method

- System analysis – choice of treatment technique
- Pre-study – choice of treatment process
System analysis
System analysis

1. Principle of multi criteria analysis in real life
2. Evaluated principal process solutions
3. Evaluation scale
4. Evaluation criteria
5. Criteria evaluation
6. Result
Principle of multi criteria analysis in real life
Principle of multi criteria analysis in real life

1. Specification of
   a) possible principal process solutions
   b) evaluation scale
   c) evaluation criteria
   d) criteria weighting

2. Evaluation of each principal process solution

3. Summarizing to the final result
Evaluated principal process solutions
Evaluated principal process solutions

1. Activated sludge with pre- and post denitrification

2. Biological phosphorus removal
Evaluated principal process solutions

3. Moving bed biological reactor

4. Membrane biological reactor
Evaluation scale
Evaluation scale

Scale – points from 1 to 5

Five = best
One = least
Evaluation criteria
Kalmar Sound WWTP
Evaluation criteria and weighting Kalmar Sound WWTP

1. Chemical consumption
2. Energy
3. Emissions to water
4. Emissions to air
5. Recycling
6. Vulnerability
7. Flexibility regarding expansion
8. Flexibility regarding additional treatment requirements
9. Infectivity
10. Costs
Criteria weighting

1. Chemical consumption 40
2. Energy 40
3. Emissions to water 100
4. Emissions to air 10
5. Recycling 40
6. Vulnerability 80
7. Flexibility regarding expansion 60
8. Flexibility regarding additional treatment requirements 60
9. Infectivity 100
10. Costs 50
Criteria evaluation
Criteria evaluation

1. Chemical consumption
   - Precipitation chemicals – least with Bio-P
   - External carbon source –
     - None with Bio-P
     - Some with AS and MBR
     - Most with MBBR
   - Chemicals for membrane cleaning
     - Only with MBR – risk for uncontrolled AOX-production

<table>
<thead>
<tr>
<th>Scale: 1 = least; 5 = best</th>
<th>AS</th>
<th>MBBR</th>
<th>Bio-P</th>
<th>MBR</th>
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<tbody>
<tr>
<td>Chemical consumption</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>
Criteria evaluation

2. Energy
   - Energy for aeration only
     • Same with Bio-P and AS
     • More with MBBR
     • Most with MBR
   - Energy production - biogas
     • Most with AS
     • Less with MBR + MBBR
     • Least with Bio-P

<table>
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<th>Bio-P</th>
<th>MBR</th>
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<td>Energy consumption</td>
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<td>3</td>
<td>2</td>
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</tbody>
</table>
Criteria evaluation

3. Emissions to water
   - Least with MBR
   - Same with AS, Bio-P and MBBR

<table>
<thead>
<tr>
<th>Scale: 1 = least; 5 = best</th>
<th>AS</th>
<th>MBBR</th>
<th>Bio-P</th>
<th>MBR</th>
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<td>Emissions to water</td>
<td>3</td>
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</tbody>
</table>
Criteria evaluation

4. Emissions to air
   - Methane – as biofuel
     • Same with AS, MBBR and MBR
     • Least with Bio-P
   - $\text{N}_2\text{O}$ – same with all
   - From sludge transports – same with all
   - From transports of chemicals
     • Least with Bio-P due to least precipitation chemicals
     • Same with AS and MBR
     • Most with MBBR due to large use of external carbon source

<table>
<thead>
<tr>
<th>Scale: 1 = least; 5 = best</th>
<th>AS</th>
<th>MBBR</th>
<th>Bio-P</th>
<th>MBR</th>
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<td>4</td>
<td>3</td>
<td>2</td>
<td>3</td>
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</tbody>
</table>
Criteria evaluation

5. Recycling
   - Accessibility of P - same with all
   - Quality – same with all

<table>
<thead>
<tr>
<th>Scale: 1 = least; 5 = best</th>
<th>AS</th>
<th>MBBR</th>
<th>Bio-P</th>
<th>MBR</th>
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## Criteria evaluation

### 6. Vulnerability

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<th>Grades</th>
<th>Resilience</th>
<th>Recuperation</th>
<th>Repairability</th>
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<tr>
<td>1</td>
<td>6 months</td>
<td>3 hours</td>
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<td>2</td>
<td>3 months</td>
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<td>5</td>
<td>3 hours</td>
<td>6 months</td>
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<table>
<thead>
<tr>
<th>Vulnerability</th>
<th>AS</th>
<th>MBBR</th>
<th>Bio-P</th>
<th>MBR</th>
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<tbody>
<tr>
<td>Hydraulic overload</td>
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<td>Overload BOD</td>
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<td>12</td>
<td>8</td>
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<td>Chemical spill</td>
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<td>Blackout</td>
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<td>Filamentous bacteria in AS</td>
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<td>64</td>
<td>24</td>
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<tr>
<td>Wreckage flotation/filtration</td>
<td>6</td>
<td>12</td>
<td>6</td>
<td>10</td>
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<tr>
<td>Wreckage automation system</td>
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<tr>
<td><strong>Average grade</strong></td>
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<td><strong>16</strong></td>
<td><strong>24</strong></td>
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**Scale:** 1 = least; 5 = best

<table>
<thead>
<tr>
<th>Vulnerability</th>
<th>AS</th>
<th>MBBR</th>
<th>Bio-P</th>
<th>MBR</th>
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</thead>
<tbody>
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<td>Vulnerability</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
Criteria evaluation

7. Flexibility regarding expansion – stepwise construction
   - Easiest expansion with MBBR
   - Additional lines with rectangular basins for all process solutions
   - Bio-P – least flexibility due to process design (hydrolysis)

<table>
<thead>
<tr>
<th>Scale: 1 = least; 5 = best</th>
<th>AS</th>
<th>MBBR</th>
<th>Bio-P</th>
<th>MBR</th>
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Criteria evaluation

8. Flexibility regarding additional treatment requirements
   - Total P - easiest with AS and MBR
   - Total N – easiest with AS, MBR and MBBR
   - Medicinal residues – same with all

<table>
<thead>
<tr>
<th>Flexibility treatment requirements</th>
<th>AS</th>
<th>MBBR</th>
<th>Bio-P</th>
<th>MBR</th>
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<td>3</td>
<td>2</td>
<td>4</td>
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</tbody>
</table>
Criteria evaluation

9. Infectivity
   - Aerosols – same with all
   - Bacteria/virus in treated water:
     • Best with MBR
     • Same with AS, MBBR and Bio-P

<table>
<thead>
<tr>
<th>Scale: 1 = least; 5 = best</th>
<th>AS</th>
<th>MBBR</th>
<th>Bio-P</th>
<th>MBR</th>
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<tr>
<td>Infectivity</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>5</td>
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</table>
10. Costs
   - Same with AS + MBBR
   - More with Bio-P
   - Most with MBR

<table>
<thead>
<tr>
<th>Scale: 1 = least; 5 = best</th>
<th>AS</th>
<th>MBBR</th>
<th>Bio-P</th>
<th>MBR</th>
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<td>Costs</td>
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Multi criteria analysis result
## Multi criteria analysis - result

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<th>Weighing</th>
<th>%</th>
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<th>Result MBBR</th>
<th>Result Bio-P</th>
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<td><strong>Chemical consumption</strong></td>
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<td>5</td>
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<td>40</td>
<td>6,9</td>
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<td>3</td>
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<td>2</td>
<td>40</td>
<td>6,9</td>
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<tr>
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<td>3</td>
<td>5</td>
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<td>17,2</td>
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<td><strong>Infectivity</strong></td>
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<td>3</td>
<td>5</td>
<td>100</td>
<td>17,2</td>
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<td>300</td>
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<td>200</td>
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<td><strong>Weighted sum</strong></td>
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<td><strong>2040</strong></td>
<td><strong>1870</strong></td>
<td><strong>1550</strong></td>
<td><strong>1960</strong></td>
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</tbody>
</table>
Simple is best –
AS+SS with TT and SF

1. The water runs by gravity through three treatment stages
2. Basic automation – fair competence requirements for operators
3. Acceptable requirements for operators “on call”
4. What if… – vulnerability low with well proven technology
5. None toxic environment – no production of AOX
Conditions and current solution for Kalmar Sound WWTP
Conditions for Kalmar Sound WWTP
Conditions for Kalmar Sound WWTP

1. Increasing loads through expansion and extension
2. Experience with variations in flow
3. Existing sludge handling for further use
4. Climate adaption
5. Accessible land
Increasing loads through expansion and extension

2013: ca 65 000 pe
2040: ca 90 000 pe

=> Pollutant loads increase with almost 50%
Experience with variations in flow

- Treatment of low loaded wastewater in the biological stage
  - Little treatment effect
  - Activated sludge process is negatively affected
    - Disturbed balance in the biological treatment stage
    - Considerable change in sludge settlability
    - Pin point flocs

- Treatment of flows larger than $\sim 2xQ_{\text{dim}}$ are treated nicely with only mechanical and chemical treatment

$\Rightarrow$ Strategy:
  a) Bypass of biological stage at high flows
  b) Need for tertiary treatment (chemical treatment)
Existing sludge handling for further use

Existing sludge handling plant includes:

- 2 thickeners for sludge
- 2 digesters for sludge digestion
- Sludge dewatering
- Required buildings, machinery and energy system

Good condition of plant makes it available for further use
=> investment only in water treatment process
Climate adaption

Neccessity to adapt to rising sea water level
Accessible land
Current solution for Kalmar Sound WWTP
View
3-D-model
Essential plant details

1. Redundancy in screening and grit trap – one line can do it all
2. Waste handling station:
   - Sludge from private sludge tanks
   - Black water from private tanks
   - Water/sand mixture from maintenance of pumping stations/pipes
   - Water/sand mixture from maintenance of storm water sand traps
3. Several lines per treatment stage in order to keep operational stability during planned maintenance
4. Test line
5. Large water depth in settling tanks
Essential plant details

6. Culvert-system for:
   – Accessible installation of pipes, valves and measuring instruments
   – => god working environment due to inhouse installation
   – => easy fix / easy redoing
   – possible energy storage (warmth during winter; cold during summer)

7. Power transformation: redundancy

8. 4 smaller power distribution centers

9. Survey tower
   – God visual survey of plant
     => attractive working environment
     => effective planning for maintenance

10. Produced biogas – use for production of CNG or power

11. Roof-area for capture of solar energy – power or heat?
Design - inlet
Design – grit trap and preclarifier
Design – biol. treatment
Design – chemical treatment
Design – final filtration
Development of Kalmar Sound WWTP

Thank you for your attention!

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Existing WWTP plant Kalmar