Wastewater Management in Sweden

• Wastewater treatment plants > 2000 persons

Bo Jansson
Sweden – geography and population

- One of the largest countries in Europe, 450 000 km$^2$
- Total population 9 million
- 20 inhabitants/km$^2$
- 85 percent of the population lives in the south part
- 1 600 km from north to south
- Long coastal line
- Baltic sea – a vulnerable sea
Regions with eutrophic waters

• The most eutrophic inland waters in Sweden are in the extensively farmed plainland and coastal areas of central and southern Sweden.

• Most minor lakes in the green areas marked on the map have total phosphorus concentrations exceeding 25 µg/l.

Source: Monitor 14, Swedish EPA
Historic background
Water use in urban areas - development

Water use in urban areas – development. The water production is 20 % higher. The differences are due to leakage in the network.
Increasing level of treatment in plants
> 2 000 pe; percent of urban population

Source: SEPA and SCB, published in the SCB series Mi 22

Today 70 % N-reduction
The use of water in households

- Food and drink: 70%
- Personal hygiene: 30%
- Dish washing: 40%
- Toilette flushing: 10%
- Laundry: 10%
- Miscellaneous: 0%

The use of water in households
DISCHARGES OF N AND P FROM DIFFERENT SECTORS

- N
  - Deposition from air
  - Agro: UWWTU
  - Small scale WWTI

- P
  - Agro: UWWTU
Treatment of waste water

• Mechanical treatment

• Biological treatment

• Chemical treatment

• Nitrogen removal
Typical wastewater treatment plant with mechanical, biological and chemical treatment
Gothenburg UWWTP (the largest one in Sweden)

Technique

- Mechanical cleaning (4 step)
- Chemical treatment
- Anaerobic treatment
- Aerobic treatment (active sludge)
- Sedimentation
- Nitrifying biotreatment (biological treatment)
- Secondary Nitrogen removal (biofilm carrier)
- Filtration (15 micrometer, P-reduction)

BOD7 10 mg/liter
Total-P 0.4 mg/liter
Total-N 10 mg/liter

Level 2012:
- BOD7 7
- Total-P 0.2
- Total-N 8

700,000 pe
Rya WWTP, Gothenburg
Urban wastewater treatment

• all urban households are connected to sewage treatment plants

• 95 per cent of urban wastewater undergoes both chemical and biological treatment

• there are some 500 treatment plants treating wastewater from at least 2,000 persons
Individual environmental permits for each plant

Based on

• General regulations based on UWWTD
• Water Frame Directive
• Local environmental conditions
• BAT

• Requirements for the plant are made based on what is environmentally justified, technically feasible and economically reasonable.
Urban Wastewater Treatment Directive
91/271/EEG

• Adopted by the European Council 1991
• Adressed to EC Member States
• States minimum requirements
Objectives UWWTD

• Protect the environment

• Urban wastewater (>2 000 pe) and wastewater from agro-food industry

• Collection and treatment of urban wastewater

• Requirements depending on size of the treatment plant and the sensitivity of the recipient water body

• Dead-lines end of 1998, 2000 and 2005
Effluent requirements in the UWWT-Directive

<table>
<thead>
<tr>
<th></th>
<th>&gt;2000 pe</th>
<th></th>
<th>&gt;10 000 pe</th>
<th></th>
<th>&gt;100 000 pe</th>
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<tbody>
<tr>
<td></td>
<td>mg/l</td>
<td>%</td>
<td>mg/l</td>
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<td>%</td>
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<tr>
<td>Tot-P</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>80</td>
<td>1</td>
<td>80</td>
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<tr>
<td>Tot-N</td>
<td>-</td>
<td>-</td>
<td>15</td>
<td>70-80</td>
<td>10</td>
<td>70-80</td>
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<td>BOD$_5$</td>
<td>25</td>
<td>70-90 %</td>
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<td>COD</td>
<td>125</td>
<td>75 %</td>
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<tr>
<td>SS</td>
<td>35 mg/l</td>
<td>(optional)</td>
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Swedish Statistics 2008: UWWTP >2 000 pe

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<thead>
<tr>
<th></th>
<th>mg/l</th>
<th>%</th>
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<tr>
<td>BOD$_7$</td>
<td>5,9</td>
<td>96</td>
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<tr>
<td>Phosphorus</td>
<td>0,25</td>
<td>95</td>
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<tr>
<td>Nitrogen</td>
<td>15</td>
<td>56</td>
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Financing of water treatment

Public water supply and waste water systems act
Responsibility for local authority to supply drinking water and waste water treatment

• Users pay for treatment
• Local charge, 170 rupies/m3
Sewage sludge

National ideal that sludge is recycled to cultivated lands

National goal for use of sewage sludge
60% re-use by 2015
Half of this amount should be used for cultivation
Industries connected to waste water systems

Bio gas production
Regulations for sewage sludge

National regulations for

• content of heavy metals

• conditions for the spread
Limits for use of sewage sludge for cultivation.

<table>
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<th>Metal</th>
<th>mg/kg dry substance</th>
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<tr>
<td>Lead (Pb)</td>
<td>100</td>
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<tr>
<td>Cadmium (Cd)</td>
<td>2</td>
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<tr>
<td>Copper (Cu)</td>
<td>600</td>
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<tr>
<td>Chromium (Cr)</td>
<td>100</td>
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<tr>
<td>Mercury (Hg)</td>
<td>2.5</td>
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<tr>
<td>Nickel (Ni)</td>
<td>50</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>800</td>
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Use of sludge to make biogas

Sludge is digested to make biogas at the biggest plants.

Previously the biogas was used to warm up the plant and the rest was often burnt off.

Nowadays in some cases the gas is purified so it can be used for car fuel. Development and use of purified gas will continue to evolve.

Most buses in Stockholm and Gothenburg are run on biogas
Some future areas of development

• Increased nitrogen removal
• Production and use of biogas
• Use of sludge
• Recovery of P from sludge
• Emissions of pharmaceuticals

• Maintainance of pipe system
Small-scale wastewater treatment in Sweden

• Brief introduction 5-2000 pe
• Regulation
• Current situation
• Most common technologies
Regulation of water and wastewater

• Environmental standards - Swedish environmental code

• Provision of water and wastewater
  – Public Water Supply and Wastewater Systems Act
  – Councils must supply water and sewerage for villages (20-30 households)
Regulation 5-2000 pe

- Environmental board at local council responsible for permits
- 290 local councils

- Each plant must apply for a permit for establishment and operation
- Requirements for specific plant or property suited to locality

- Detailed regulation
  - 5-25 pe general recommendations
  - 25-2000 pe no general recommendations
  - 200-2000 pe testing and control

- Most common
  - larger plants according to regulations for >2000 pe
  - smaller plants according to recommendations
Current situation – sewage systems 5-25 pe

- 850,000 properties with on-site sewage treatment system
- 60% permanent residence
- 40% holiday residence
- 65% black and greywater
- 35% greywater only or no sewage
- 60% of properties have an approved sewage system
EPA Recommendations (from 2006)

- Treatment level for nutrients dependent on environmental sensitivity: normal and high
- No risk for human health
- Dimensioned for 5 pe, year-round
- Enable recycling of nutrients
- Easily controlled
- Maintenance instructions

- High: 90 % BOD, 90 % P, 50 % N
- Normal: 90 % BOD, 70 % P
Most common technologies for 5-25 pe

- Soil-based system predominate
- Complementing technologies to soil-based systems
- On-site small treatment plants
- Source-separation systems with recycling of nutrients
  - Urine-diversion
  - Black-water separation
  - Dry toilets
Soil-based treatment systems; complementing technology

• Soilfiltration with existing soils
• Additional sand layer in areas with clay soil
• To meet requirements from 2006
  – Phosphorous trap
  – Chemical treatment in septic tank
On-site small treatment plant

- Many different manufacturers and models
- EU-standard, additional Swedish parameters
- Mechanical, biological and chemical treatment
- Manufacturer provides on-going service
Source-separation systems : nutrient recycling
Source-separation systems: urine-diversion

- Special toilet with 2 "bowls"
- Urine leads to separate tank
  - Reduced release P (40 %) N (60 %)
  - Reduced water use
- Complete system for other wastewater

- Urine collected by council, delivered to nearby farms
- Replace fertiliser in farming

- Approx 20,000 toilets installed in Sweden
Source-separation systems: blackwater

- Special toilet with vacuum-unit
- Blackwater leads to separate tank
  - Reduced water use
  - Reduced risk to human health
  - Reduced release P (85 %) N (90 %)
- Simpler system for greywater treatment

- Blackwater collected by council, delivered to wet-compost system
- Increasingly popular
Source-separation systems: dry toilet

- Toilet model varies – dry, compost, urine-separating, combustion
  - Reduced water use
  - Reduced risk to human health
  - Reduced release P (85 %) N (90 %)

- Simpler system for greywater treatment, often only summer-time

- Toilet-waste collected by local council or on-site composting

- >35 % of properties, common in holiday residences

- Development of more reliable and attractive toilet models
Ownership and management: 25-2000 pe

- Approximately 3000 sewage systems of this size
- 50% council owned and managed
- 50% privately owned or property owners together own and managed
- Environment board at local council – control 1/year
Most common technologies: 25-2000 pe

- 50% conventional sewage treatment plants
  - most have primary, secondary and tertiary treatment
- 40% soil-based treatment systems
- 4% biological or chemical treatment in open dams
- 4% system with source separation
- 2% only septic tank separation (no treatment system)
Conclusions

• Individual permits with site-specific solutions
• Currently lot of activity to renovate on-site sewage systems
• Many of systems for 25-2000 require upgrading
• Possibility for developing and marketing new technologies
  - market of 1 million households