Overview of Decentralized Wastewater Treatment Applications in Germany
State of the art - future developments

Sustainable Integrated Wastewater Treatment & Reuse in the Mediterranean
Roland A. Müller, 01.12.2014; Sharm el Sheik
Contents

• Urban Water Management and decentralised wastewater treatment: - What is the current situation in Germany?

• Water infrastructures subject to multiple pressures to change: Where will this lead?

• Implementation of decentralised wastewater systems: What is possible?
Sanitary services are the most important

London.-Clean water and wastewater treatment represent the most important advance in medicine since 1840. This was the result of an Internet survey conducted by the British Medical Journal (BMJ). This renowned journal listed 15 advances in medicine and asked its readers to select the most important one. Around 11,000 readers from around the world participated in the survey in the last two weeks. Behind public hygiene in first place, antibiotics came second and anaesthetics came third.

(bva)

Tages Anzeiger, 24.1.2007
What does decentralised wastewater disposal mean in Germany?

- Wastewater disposal on private property?
- Wastewater disposal for an urban area in treatment plants in individual city districts?
- Wastewater disposal in treatment plants of size class 1 as per the German wastewater regulation, i.e. with less than 1,000 connected residents?
- Wastewater disposal in treatment plants with up to 2,000 connected residents, for which no sewer connection is required according to the EU directive?
- Wastewater disposal in small-scale treatment plants with up to 50 connected residents?
- ...................................................?
Decentralised wastewater systems collect, treat and reuse or dispose wastewater at or near its point of generation.

(Crites und Tchobanoglous, 1998)
# Technologies

## Technology Line: Decentralized Wastewater Treatment

<table>
<thead>
<tr>
<th>Technologies</th>
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<tbody>
<tr>
<td>Eco-Technologies</td>
<td>Activated Sludge</td>
<td>Biofilm Technologies</td>
<td>Membrane Technologies</td>
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<td>Technologies</td>
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<td>Anaerobic Technologies</td>
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### Techniques/Processes

- **Eco-Technologies**
  - Constructed Wetlands
  - Activated Sludge Process with Sludge Recirculation
  - Activated Sludge Process in Sequencing Batch Reactor (SBR)
  - Sand Filters or Soil Filters
  - Purification Ponds

- **Activated Sludge Technologies**
  - Trickling Filter
  - Submerged Trickling Filter
  - Fixed Bed Reactor
  - Fluidized Bed Reactor
  - Rotating Disk Filter

- **Biofilm Technologies**
  - Reverse Osmosis
  - Nanofiltration
  - Ultrafiltration
  - Microfiltration

- **Membrane Technologies**
  - Upflow Anaerobic Sludge Blanket (UASB)
  - Anaerobic Fixed Bed Reactor
  - Anaerobic Fluidized Bed Reactor

- **Anaerobic Technologies**

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Quelle Wasser 2050
### Wastewater treatment plants in Germany

<table>
<thead>
<tr>
<th>Amount of WWT units</th>
<th>Size of Treatment Units [EW]</th>
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<tr>
<td></td>
<td>0 – 50</td>
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<tr>
<td>ca. 1,5 Mio.</td>
<td>4,207</td>
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<td>Percentage (%)</td>
<td>4,88</td>
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Dohmann; 2008
Facts on wastewater infrastructure in Germany: Centralized Wastewater Treatment

- **High Water Consumption**: Large quantities of water are necessary for transportation of "waste" materials. Flushing sewers are working well only with a minimum water consumption due to that a reduction of water consumption makes sense only up to a certain level.

- **Costs**: Maintenance and reconstruction of sewer system and enhancement of WWTP for nutrient elimination.

- **Mixture of Material Flows**: Dilution results in a higher effort for treatment in WWTP. Nutrients are eliminated, not utilised.

- **Stressing of Receiving Water**: With pollutants as chemicals, pharmaceuticals, endocrine effective substances.

- **Risks of Sewage Sludge Utilisation**: From heavy metals and anthropogenic organic pollutants.

- **Freshwater Demand**: Inflexible after construction.
Facts on wastewater infrastructure in Germany

- Wastewater treatment plants: Almost 10,000
- Volume of wastewater treated (2010): 10.1 billion m³ (5.2 billion m³ of sewage water and 4.9 billion m³ of precipitation water)
- Public sewer network: Length of approx. 540,000 km
- Price: Average of €2.29/m³ of wastewater
- Investments in 2010: €4.5 billion

(Federal Ministry for the Environment's water industry leaflet, 2011)
Conclusion 1:

- Wastewater companies are “logistics companies”: *Transport and storage of wastewater*
- A high-performance supply and disposal system has been developed
- German technologies are among the world-leaders
- General objective:
  - Hygiene for residential settlements (preventative health)
  - Environmental protection (nitrogen and phosphorous elimination, removal of chemicals)

*We spend a lot of money on all this ...*
Expenditure on sewer network maintenance

Annual expenditure for sewer refurbishment: €1.6 billion
Current backlog of refurbishment work: €50-55 billion

Klaus Pecher; Abwasserforum 2009

Short to medium-term refurbishment needs [%]

Annual increase in refurbishment needs:
Approx. 0.55 – 0.61%
**Age distribution of the KWL and other German sewer networks**

<table>
<thead>
<tr>
<th>Total sewer lengths in km</th>
<th>Share of overall sewer network length</th>
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<tr>
<td>DWA survey</td>
<td>KWL</td>
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<tr>
<td>&gt; 75 years</td>
<td>15%</td>
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<tr>
<td>51-75 years</td>
<td>13%</td>
</tr>
<tr>
<td>26-50 years</td>
<td>36%</td>
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<tr>
<td>0-25 years</td>
<td>32%</td>
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</tbody>
</table>

- Peaks in construction activity - very little infrastructure with an age of 26-50 years
- One third is older than 75 years (great need for refurbishment, but already written off)
Case Study Leipzig: Long-term water infrastructure focal points of investment in Leipzig

Investment focus:
- Sewer network refurbishment
- Applies for the next 20 years

Investment backlog:
- 1/3 of the sewer network is over 75 years old

Distribution of investment requirements of KWL
(From KWL's long-term planning 2013-2032)

2nd BDZ symposium 28.11.2013
Conclusion 2:

- Alternatives to conventional expansion/refurbishment of the sewer network could help to save billions of euros in the short and long terms
Advantages of centralised wastewater treatment

High efficiency for

- High availability of water
- Concentrated settlement
- Stable planning horizon
- Slow population development
- Availability of public funds

Low efficiency for

- Water scarcity
- Dispersed settlement
- Lack of planning security
- Dynamic population development
- Low availability of public funds

Advantages of small-scale systems

High efficiency for
II. German Water infrastructures subject to multiple pressures to change

⇒ Quality of life and of the environment
  - Hygiene for residential settlements and protection of bodies of water
  - “Water in the city” (ecological services, aesthetics)
  - Affordable water services in long term

⇒ Resource efficiency
  - “Wastewater as a resource” (P, N, heat)
  - Energy savings, generation
  - Water efficiency

⇒ Resilience
  - Climate change, flood protection and
  - More dryness and heat
  - Demographic development
Future of water infrastructures

Technologies

System architecture
- Degree of centralisation (de-/semicentr.)

Material flows
- Resource efficiency
- Energy positive, reuse

Governance

Political framework
- Economic, legal

Infrastructural and urban planning
III. Demographic Change (DC) in Germany as a key factor for implementation of WWT systems?

- DC is highly specific on a regional scale
- Due to the population forecasts especially rural regions of Germany (East Germany, Hessen, Lower Saxony...) will suffer from shrinkage
- Some Metropolitan areas will register an increase in population
- Furthermore: Tendency towards elder Population and smaller household sizes

Regional Planning Report, 2011
Conclusion 3:

- Beyond rural applications for decentralized/semicentralized WWT the urban landscape (suburban areas, Neighbourhood areas) becomes important for DWWT.
- Pilots, Implementation and Demonstration of principles in Germany will be launched in 2015: Management approach combines WWT with waste and energy “nexus”
- Cities of the Future
Current situation; today's city

Source: Meeten, 16th International EWA Symposium, 2012

Have the limits of natural ecosystems been reached?

Potable water brought in

Sewer networks

Wastewater removed

Source: Meeten, 16th International EWA Symposium, 2012
Tomorrow's city?

Meeten, 16th International EWA Symposium, 2012

Decentralised or semi-centralised Infrastructure

- Better use of water
- More resilient network
- Adaptable to change

Advanced wastewater treatment with water recycling

LESS water brought in

LESS wastewater removed

Redirected capital investments

Savings?
DEUS 21 – demonstration project (Knittlingen)

Demonstration project in a development area: 105 plots
A newly built estate is being equipped with

- vacuum sewers
- rainwater utilization system
- decentralized wastewater treatment plant (anaerobic membrane bioreactor)
DEUS 21 – Decentralized urban water infrastructure systems

Saving water, utilizing resources:

- Utilization of locally available resources: Water, energy, nutrients
- Rainwater harvesting
- Intelligent collection of wastewater (vacuum sewer system)
- Anaerobic wastewater treatment
- Reuse of treated water and nutrients

Water management in Knittlingen
Wastewater treatment in Knittlingen

Anaerobic Membrane Bioreactor
Energy and mass balance per capita and year

- Production of biogas on conventional WWTP: ca. 20 - 25 l/cap/d
- Production of biogas in DEUS 21: ca. 60 l/cap/d
- Challenge: efficient utilization of energy
Example Hamburg: Jenfelder Au

- Appr. 750 Housing Units connected (low energy/passive houses)
- Fokus: Revitalisation of former military barracks into a new urban district
- Special social, cultural and commercial infrastructures: Housing (60 %), commercial (20%), green spaces (20%)

Source: Hamburg Wasser
Urban Planning: Hamburg-Water Cycle

Hamburg Water Cycle: Model District

- Individual blackwater, greywater and rainwater collection
- Vacuum sewers for blackwater transportation
- Anaerobic Blackwater treatment; residential heat and power supply
Outlook: Clustered Decentralized Systems

Regional implementation approach that is characterised by

→ Centralised management of clustered decentralised infrastructures

• Tendency towards more flexibility with O&M Modules are visible in Germany
• Flexibility as well for decision making process: Small units and group solutions should be under the control of Wastewater companies
• Pilots in Federal states of Saxony, Badenwürtenberg, Rheinland Pfalz.
Summary

• Sustainable decentralized systems are available in terms of both, planning and engineering
• The complementarity of system advantages and disadvantages has to be harnessed better
• Resilient (Waste-)Water Management strategies are complex (…no one fit all solution…)
• Capacity Development (academic education, technical training, round tables with decision makers) Best Practise examples) are a critical building block for the development and implementation of sustainable wastewater treatment systems
• Results are needed for the “City of the Future”
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Thank you for your interest!

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