15 Years Experience with Membrane Bioreactors in Germany

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Comparison of conventional wastewater treatment with membrane bioreactor technology
Comparison microorganisms – membrane pore size

E. coli ~ 0.5 – 1.5 µm

B. subtilis
~ 0.3 µm

pore size ~ 0.04 µm

pore size ~ 0.2 µm

membrane

ultrafiltration

microfiltration
ZENON membrane module (submerged)
Backwashing
Cleaning
Roedingen WWTP: process scheme

S GC DN N MF

Fe RC RS ES
Rödingen wastewater treatment plant
(general plan)
First membrane WWTP in Germany (NRW) Rödingen
Rödingen membrane bioreactor (3,000 PE)

Erftverband, 1999
Roedingen WWTP (specifications)

Population equivalents (PE) : 3,000 PE
Annual volume of wastewater ($Q_a$) : 300,000 m³/yr
Daily volume of wastewater ($Q_d$) : 450 m³/d
Dry weather flow ($Q_t$) : 56 m³/h
Combined water flow ($Q_m$) : 135 m³/h

Mechanical treatment
Screen : 3 mm
Aerated grit chamber (V) : 19 m³

Biological treatment
Nitrification tank ($V_N$) : 200 m³
Denitrification tank ($V_{DN}$) : 200 m³

Membrane filtration
Total membrane surface (A) : 4,416 m²
WWTP Rödingen
Electricity Meters

Main meters
Electricity measuring points
Pumps, Blowers
Roedingen WWTP: energy consumption

- Mechanical treatment: 0.59 kWh/m³
- Biological treatment: 0.35 kWh/m³
- Filtration: 0.86 kWh/m³
- Residual consumption: 0.23 kWh/m³
Energy consumption for membrane filtration:

- Filtration aeration: 0.5 kWh/m³
- Activated sludge return: 0.16 kWh/m³
- Effluent pump: 0.02 kWh/m³
- Residual consumption: 0.18 kWh/m³
MLSS = 22g/l
Clogged Membranes
at MLSS= 22 g/l

Black colored sludge
Poor streaming of air

Bottom header (detail)
Roedingen WWTP: process scheme
Permeability

Temperature

Operation time

1999  2000  2001

l/(m² x h x bar)

Membrane replacement
Permeability and Temperature over time:

- **Permeability**: Measured in $l/(m^2 \times h \times \text{bar})$.
- **Temperature**: Measured in °C.

**Operation time**:
- **1999**
- **2000**
- **2001**

(Note: The diagram shows trends and data points, with specific emphasis on membrane replacement and intensive cleaning.)
Operational problems of existing capillary modules

Clogging

Clogging by hairs and fibres at top header

Consequence: reduction of filtration performance

Sludging

sludging in areas with poor aeration at bottom header
PURON membrane system: an innovative module concept made in Germany
Module concept

- Membrane fixation
- Filtrate collecting line
- Air supply line
- Module element
- Air supply

PURON – module row
Pilot plant at Simmerath (750 PE)

Commissioning: 03/2003
Membrane area: 1000 m²
WVER pilot plant at Simmerath
First operating scale PURON modules at Simmerath
Membrane tank with observation holes
Kaarst bioreactor (80,000 PE): process scheme

MLSS = 12 g/l

- Screen
- Grit chamber
- Fine screen
- Membrane bioreactor
- Permeate
- Sludge dewatering
- Thickener
- RC
- ES
Mesh diameter ~ 0.5 mm

fine screening to prevent clogging
Reduction of footprint with membrane technology at Kaarst WWTP
Kaarst WWTP (80,000 PE)
Kaarst WWTP (80,000 PE)
Kaarst WWTP (80,000 PE)
Grit chamber
Fine screen drum
Control center
KUBOTA - double-deck K300 module

- Membrane plates
- Permeate collecting channel
- Upper module
- Spacer
- Lower module
- Aeration channel
- 3.5 m
- Aeration pipes
Woffelsbach WWTP: membrane plate modules
Woffelsbach WWTP (7,000 PE)
MLSS 12 g/l
Membrane activated sludge process (dimensioning)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screen (100% redundancy)</td>
<td>3.0 mm</td>
</tr>
<tr>
<td>Fine screen (100% redundancy)</td>
<td>0.5 mm</td>
</tr>
<tr>
<td>MLSS</td>
<td>12 g/l</td>
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<tr>
<td>Oxygen transfer factor</td>
<td>alpha factor = 0.6</td>
</tr>
<tr>
<td>Energy consumption</td>
<td>app. 1.0 kwh / m³</td>
</tr>
<tr>
<td>Membrane filter velocity</td>
<td>20 l/(m² x h)</td>
</tr>
<tr>
<td></td>
<td>wastewater temperature of 5°C</td>
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</tbody>
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Thank you for your attention