Full scale experience with ultrafiltration and in-line coagulation of surface water with high humic concentration

Hilde Prummel (WLN)
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• 50 employees
• Turnover € 4 million/year
1. Introduction
2. Overview installations / projects
3. Experience on the full-scale
4. Evaluation after 7 years
EXPERIENCE UF

Re-use drinking water (backwash sandfiltration)
- Annen 40 m³/h
- Nietap 90 m³/h

Production greenery water
- Erica 160 m³/h
- Klazienaveen 400 m³/h

Re-use waste water
- ZOO Emmen 60 m³/h
- Penguins 220 m³/h
- Hippo’s 110 m³/h
ZOO
EXPERIENCE UF

Pre-treatment production deminwater
- Kisuma 130 m³/h
- Norit 100 m³/h

Re-use wwtp-effluent production industry water
- Pilot 2-5 m³/h
OTHER MEMBRANES EXPERIENCE

Reverse Osmosis
- Production Aqua light mineral water: Annen
- Production deminwater: Kisuma en Norit

Anaerobic Nanofiltration
- Production drinking water, water softening and removal color: Zuidwolde
BASIC DESIGN FULL SCALE UF-INSTALLATIONS

<table>
<thead>
<tr>
<th></th>
<th>Pretreatment RO Kisuma/Norit</th>
<th>Direct UF Greenery (2x)</th>
<th>ZOO (P/H/R) Circulation</th>
<th>wwtp pilot</th>
<th>wwtp pilot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed flow raw water m³/h</td>
<td>130 / 100</td>
<td>160 / 400</td>
<td>220 / 110 / 60</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Net flux UF l.m⁻².h⁻¹</td>
<td>80</td>
<td>70 / 70</td>
<td>65</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>Recovery UF %</td>
<td>85</td>
<td>75 / 83</td>
<td>~ 90</td>
<td>85</td>
<td>95</td>
</tr>
<tr>
<td>type</td>
<td>XFlow</td>
<td>XFlow</td>
<td>XFlow</td>
<td>XFlow</td>
<td>Zenon</td>
</tr>
</tbody>
</table>
INDUSTRY LOCATIONS
TYPICAL SURFACE WATER

→ Variation in quality between summer and winter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Summer</th>
<th>Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>Suspended Solids</td>
<td>mg/l</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>Iron</td>
<td>mg/l</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Manganese</td>
<td>mg/l</td>
<td>0,1</td>
<td>0,3</td>
</tr>
<tr>
<td>DOC</td>
<td>mg/l</td>
<td>15</td>
<td>35</td>
</tr>
<tr>
<td>UV (245 nm)</td>
<td>abs/m</td>
<td>50</td>
<td>200</td>
</tr>
<tr>
<td>Conductivity</td>
<td>µS/cm</td>
<td>650</td>
<td>250</td>
</tr>
</tbody>
</table>
TYPICAL UF

- Good pretreatment RO
- Good direct treatment on several water
- Absolute barrière particles and bacteria
- High flux only with (in-line) coagulation (Al or Fe)
- Need for pH-correction
- Flocculant for filtration and/or removal organic compounds for higher performance RO (UV/DOC)

→ sludge and high chemical use (1-15 ppm Al/Fe)
TMP WITH FLOCCULATION

KISUMA: TMP with and without flocculant dose
TMP ↔ TURBIDITY

Kisuma: TMP and FTU effluent CSF
PROBLEMS UF

- Critical flocculant dosage / pH-correction (Kisuma example)
- Variation waterquality (UV, DOC, Suspended solids, algea, pH, ….)
- Integrity
- Scaling inorganic compounds (Fe, Mn, Ca)
- Variation in load (dirty tanks)
- Performance / capacity
- Chemical cost (flocculant+cleaning) (≤ € 0,15/m³)
Kisuma TMP (normalised)
CASE: PRODUCTION GREENERY WATER
**CASE: PRODUCTION GREENERY WATER**

<table>
<thead>
<tr>
<th></th>
<th>Unit</th>
<th>Source</th>
<th>Greenery water</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>ppm</td>
<td>0 - 5</td>
<td>0</td>
<td>&lt; 0.25</td>
</tr>
<tr>
<td>Suspended solids</td>
<td>ppm</td>
<td>10</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>&lt; 20</td>
<td>0.1</td>
<td>&lt; 0.8</td>
</tr>
<tr>
<td>UV</td>
<td>Abs/m</td>
<td>&lt; 25</td>
<td>15</td>
<td>-</td>
</tr>
<tr>
<td>DOC</td>
<td>ppm</td>
<td>&lt; 10</td>
<td>8</td>
<td>-</td>
</tr>
</tbody>
</table>

Flocculant dose: 2 – 10 ppm Fe
CASE: PRODUCTION GREENERY WATER

Klazienaveen (TMP; Normalised)

- UF 1
- UF 2
- UF 3
- T-ref 10 °C
- Temperatuur
- V-debiet

new membranes
CASE: PRODUCTION GREENERY WATER

→ Integrity (June 2003)
CASE: PRODUCTION GREENERY WATER

Erica (TMP, Normalised)

- Algae
- High load
- Integrity ↓
CASE: PRETREATMENT RO

Norit Klazienaveen
UV absorption (254 nm (m-1))

start flocculant dose for NOM removal -> beter performance RO
RESEARCH WLN

- Type flocculant
- In-line coagulation / precoating (trail-and-error)
- EPCE (Kiwa)
- Re-use backwash water
- Chemical cleaning (ascorbine acid / oxaal acid)
- In-line monitoring performance and quality:
  - UV-monitoring (UV/DOC-ratio)
  - Integrity (MFI, Turbidity)
  - Dataprocessing and modeling (NMT)
- Labscale test minimonitor (Kiwa)
- Autopsies UF-membranes
- In-side-out / out-side-in UF
TEST RESULTS (ref.Kiwa)

The graph shows the specific flux (y-axis) against the permeate volume (x-axis) for different locations and dates. The specific flux values range from 0 to 1, and the permeate volume ranges from 0 to 800 L/m².

- Kisuma
- Kisuma dec 05
- Erica
- Erica dec 05

Locations: Kisuma, Erica, Twente canal, Heemskerk, Emmen, Ouddorp, Klazienaveen, Norit, Baanhoek.
(AN)ORGANIC FOULING

used membranes

clean membranes
ASCORBINE + OXAAL ACID

- Disconnection of inorganic and organic compounds (humic acids)
- Dissolution of inorganic compounds (iron / manganese) and organics
EVALUATION UF

• Pre-treatment UF is essential by high flux:
  - load
  - (in-line) coagulation or precoating
  - pH-correction
• Some turbidity is necessary for stable UF
• Preventive cleaning (organic or inorganic)
• Controll integrity (MFI, particle, Turbidity)
• Process optimization (lab/fullscale and models with participants (IHE, Kiwa, Norit/NMT))
• New types UF (low flux, ceramic, chemical-free, ...)

QUESTIONS ?