11th World Filtration Congress – April 16-20th, Graz, Austria

EnviCare®
consultancy for process technology

EXPERIENCE WITH MBR-SYSTEMS FOR CLEANING HIGHLY LOADED ORGANIC WASTE WATER

Bernhard Mayr

Session M08 – Water treatment II

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EnviCare®

- **Is a specialized engineering consultant active in Austria and neighboring countries, topics:**
  - Industrial process design
  - Membrane based waste water treatment
  - Solid waste treatment
  - Anaerobic digestion of organic waste
  - Renewable energy – Biogas
- **Practical experience since 20 years in the field of membrane separation processes and membrane bioreactor systems**

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Landfill leachate: background

- **Since midst 1980s landfills were tightly sealed => leachate became a problem**
- **At the landfill near Halbenrain the high percentage of disposed sludge and residues from leather industry caused a very high organic load:**
  - COD ~ 25 - 40 g/l
  - Ammonia ~ 3.5 – 4.5 g/l
  - electr. Conductivity ~ 25 – 35 mS/cm

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Landfill leachate: timeline

- 1988 – 1991: technology screening
- 1991: selection of MBR – RO (2 stage) as BAT
- 1991 – 1993: laboratory and pilot testing
- 1993 – 1994: design and construction of the large scale plant
- 1994 – now: operation

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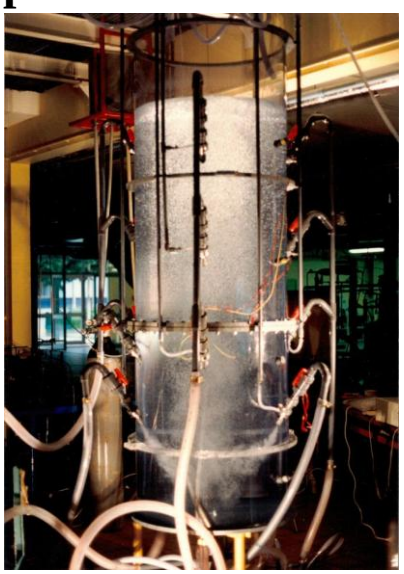
Landfill leachate: pilot phase

- Pilot scale - 1:1000
- Ceramic membranes used for the 1st time
- Additional pilot tests on jet aeration and mixing as well as on RO



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Landfill leachate: design parameters for large scale plant

- **Flow 100 m³/d**
- **Bioreactors:**
  - V_{tot} = 390 m³,
    V_{DN} = 130 m³,
    V_N = 2 x 130 m³
  - $B_{R,COD}$ = 6,4 kg/(m³.d),
    Pilot = 4,6 kg/(kg.d)
    Communal ~ 1 – 2 kg/(kg.d)
  - $B_{R,NH4-N}$ = 1,0 kg/(m³.d),
    Pilot = 0,8 kg/(kg.d)
    Communal ~ 0,1 – 0,2 kg/(kg.d)

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Landfill leachate: design parameters for large scale plant

- **Ceramic membranes**
  - Flux = 167 l/(m².h)
    Pilot: $B_{R,COD}$ = 164 l/(m².h)
  - Perm. = 67 l/(m².h.bar)
    Pilot: $B_{R,COD}$ = 47 l/(m².h.bar)
- **Jet aeration (320 kg_{O2}/h), coupled foam suction**
- **2 stage RO**
- **Cooling?**
- **Sludge treatment?**

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Biodiesel waste water: background

- **Production plants were installed since 1995**
- **Specific high yield processes lead to highly concentrated, but low quantity waste water**
  - COD ~ 80 - 150 g/l
    - **Methanol ~ 20 – 80 % of COD, depending on feedstock**
    - **Other: Glycerol , fatty acids …**
  - Ammonia < 50 mg/l, hardly any nutrients/trace elements
  - electr. Conductivity ~ 0.5 – 0.8 mS/cm

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Biodiesel waste water: timeline

- **2007 – 2008: technology screening**
- **2008: laboratory and pilot testing**
- **2008: selection of MBR as BAT**
- **01-09/2009: design and construction of the large scale plant**
- **10/2009 - operation**

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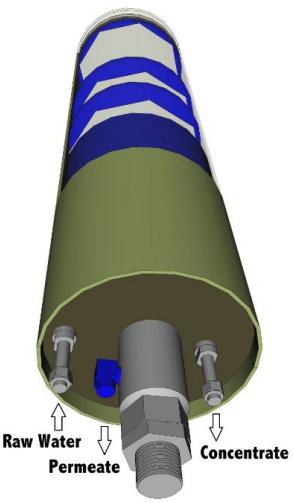
Biodiesel : pilot phase

- Tests run with RO to recover methanol
- RCDT modul by **ROTREAT**, Graz
- > 80 % of methanol can be recovered
- Reduction of COD in effluent > 60 %
- Economics depend on price of methanol and on costs for waste water



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Biodiesel : pilot phase

- Anaerobic digestion
  - Successful laboratory tests
  - Pilot test in 20 m³ CSTR tank
  - Pilot failed after 8 weeks
- Aerobic post treatment
  - Pilot scale 1/75
  - cross-flow Membrane MBR
  - Stable operation
  - Not tested stand alone

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Biodiesel : design parameters for large scale plant

- **Flow 30 m³/d**
- **Bioreactors:**
  - V_{tot} = 500 m³
    $V_{Selector}$ = 100 m³
    $V_{Aerobie}$ = 400 m³
  - $B_{R,COD}$ = 6.6 kg/(m³.d),
    Pilot: $B_{R,COD}$ = 3.4 kg/(kg.d)

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Biodiesel : design parameters for large scale plant

- **Organic membranes**
  - Flux = 40 l/(m².h)
    Pilot: 40 l/(m².h)
- **Jet aeration**
  - O_2 = 160 kg/h
- **Discharge to sewer**
  - COD < 10 g/l
- **Cooling?**
- **Sludge treatment?**

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Lessons learned

Sludge production

- Hard to predict based either on design guidelines or on pilot scale experiments (ÜS 0.05 – 0.2 => ratio of 4!!)
- Less risky if sludge production and treatment is assessed in real scale operation – overestimation is expensive!

Cooling

- Design of cooling equipment is a typical task during scale-up
- Mechanical induced heat and heat loss are easy to calculate
- Heat from biological degradation is difficult to describe and quite impossible to measure in pilot scale with regular means
- Fouling of heat exchanger surface must be considered
- Oversizing of cooling device is not too expensive but the process depends on sufficient cooling

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Lessons learned

Foaming

- The patented combination of MF-retentat – injector aeration and suction of foam proofed to be useful
- Enough head space is necessary
- Additional spraying nozzles are recommended
- Biology adapts to anti foaming chemicals – different agents are recommended and shall be tested already during pilot experiments
- Foaming might also occur in the non-aerated denitrification tank

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Lessons learned - Landfill leachate

Microfiltration

- Design flux and especially permeability were overestimated
- Area had to be expanded by 1/3
- Ceramic membrane is well resistant and was not replaced since 18 years!

Carbon source

- After appr. 5 years the addition of acetic acid became necessary because COD decreased and ammonia remained constant
- Dosing must be controlled through measurement of pH and NO_3 level

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Lessons learned - Landfill leachate

Ammonia

- A complete degradation (< 10 mg/l) is needed and ammonia level must be monitored online
- Overdosing of leachate must be avoided (1 m^3 excess => +10 mg/l NH_4)
- Aeration can be controlled through Ammonia

Lessons learned - Biodiesel:

Nutrient supply

- Despite severe concern a simple addition of a commercial fertilizer is sufficient to keep the process in stable conditions
- Anyhow N, P and K must be monitored periodically

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Summary and Conclusion

- **Usually highly loaded waste water shall be treated by anaerobic means**
- **In special cases as presented before a sole aerobic process might still be the better choice, because**
  - They process is stable and less sensitive to harmful ingredients and it is simpler
  - Anoxic denitrification needs COD as carbon source
  - Biogas is very rich in sulfide
  - Energy costs are still less important compared to investment costs

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Thank you for your

Attention!

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