The Biobed® Advanced system is cheaper and more reliable

*Biobed® SMART and Memthane® Novel Reactors and their superior control*

Lyon; November 27, 2012; 13:45
Jan Pereboom
1. Introduction
2. The Biobed® Advanced granular system
3. The Biobed® SMART reactor control system
4. The Memthane® AnMBR
5. Conclusions
Biothane: competence centre of Veolia Water

- **Veolia Water**
  - Revenues 12.6 bln€; 69 countries; 97,000 employees (2011)
  - Drinking water for 103 mln consumers; sewage of 73 mln inhabitants

- **Veolia Water Solutions and Technologies (VWS)**
  - Contracting and equipment; 350 proprietary technologies
  - Revenue 2.3 bln€; 135 business units; 10,800 employees

- **Biothane**
  - World market leader for Anaerobic industrial wastewater treatment
  - In 35 years more than 530 references were established
Anaerobic versus Aerobic WWT

100 kg COD to Aerobic

- 45% Carbon Dioxide
- 50% Biomass
- Aeration (100 kWh)
- 2-10 kg COD
- Sludge, 30-60 kg

100 kg COD to Anaerobic

- 75% Biogas (75% Methane)
- 5% Biomass
- CH₄ 26 - 30 Nm³
- CO₂ 5 - 12 Nm³
- 5% Biomass
- 10-20 kg COD
- Sludge, 5 kg

1 kg COD removed ≈ 0.35 Nm³ CH₄ or 3.8 kWh
Biothane’s Granular Technologies

- Biobed® Advanced UASB or EGSB
  - Granular Sludge Bed
  - Up to 30 kg COD/m³/d

- Biobed® Modular Plant
  - Compact off-site construction
  - 50 ~ 200 m³ reactor volume
  - 0.5 ~ 4.0 tCOD/day
Biothane technologies; non-granular

- **Biobulk CSTR**
  - Solid waste digestion
  - With or without sludge recirculation
  - Suitable for high COD / SS / FOG waste(water)

- **Upthane™**
  - Municipal UASB technology for tropical climates
  - Novel design

- **Memthane® Anaerobic MBR**
  - New technology for high strength wastewater
  - Using Cross-flow UF membranes
  - High COD / SS removal efficiencies

- **Pomethane® CSTR**
  - Palm Oil Mill Effluent
Biothane UASB vs. Biobed® EGSB

- **Upflow Anaerobic Sludge Blanket**
  - 10 ~ 15 kgCOD/m3d; 8 ~ 10 meter height

- **Expanded Granular Sludge Bed**
  - 15 ~ 25 kgCOD/m3d; 10 ~ 20 meter height

- **500 references**
Biothane UASB vs. Biobed® EGSB

- COD reduction rate EGSB is equal or lower but
- Volumetric loading rate is 2-3 x higher
2. Biobed® Advanced

Anaerobic granular technology at the next level
Reduced investment and operating costs
Combining the best of both

Challenge: combining the best of UASB and EGSB

- **Advantages of UASB**
  - Excellent performance
  - High COD removal efficiency
  - Good biomass inventory

- **Advantages of EGSB**
  - Reduced investment costs
  - Higher volumetric loading rates (2-3 times)
  - Taller reactors (2-3 times)
  - Smaller footprint

Solution

Biobed® Advanced
Objectives of Biobed® Advanced & SMART

- Improving the anaerobic performance
  - Thus reducing investment and operating costs
Novel Biobed® Advanced Settler

- **Patented** new settler and reactor design
- Multi level biogas separation
- **TTS; Tilted Tube Separator** on top of the settler
  - Increasing the settler surface area for
  - Improving the retention of biomass and SS in the reactor
- Robust effluent pipes which replace conventional effluent gutters
Based on fundamental research

- 5 years research by committed team
  - Many with more than 25 years of experience
- Lab scale testing
- Hydraulic model testing at 1:1 scale
- Pilot scale testing at 7 m3
- Full scale testing and data gathering
Pilot plant results paper wastewater

- Effect of liquid velocity in Advanced settler on effluent SS
  - Up to 19 m/h **no** effect  $\rightarrow$ designing at higher upflow velocities

![Diagram showing Effluent TSS vs Settler upflow velocity](image-url)
Testing results paper wastewater

- Biobed® Advanced pilot 140% loading as compared to EGSB full scale
- Biobed® Advanced pilot 300% loading as compared to UASB full scale

**Biothane Pilot Plant 2011**

**Volumetric loading rate**

- **Pilot plant**
- **Full scale Biobed**
- **Full scale UASB**

- Advanced Pilot
- EGSB full scale
- UASB full scale
Biobed® Advanced; smaller settler and reactor

- Smaller settler height
  - 1.0 meter lower
  - Same net volume loading rate
  - Higher gross volumetric loading rate

- Higher applicable liquid upflow velocity
  - Smaller required settler area

- Reduced settler price

- Substantial influence on Capex and Opex
  - Lower energy demand
Biobed® Advanced; Easy effluent pipes

- Novel effluent pipes replacing conventional gutters
- Less critical in levelling
  - Reduces short circuiting risk
- Less maintenance
Biobed® Advanced: flexible reactor height

- Wastewater characteristics (process) determines reactor height
- Complex: Biobed® Advanced UASB up to 6 ~ 10 meters height
- Simple: Biobed® Advanced EGSB 10 ~ 20 meters height
- Both either in steel or concrete reactors; round or square
Biobed® Advanced; Optimizing investment and operating costs

Compact settler result in more flexible reactor design

- Optimal size: Diameter = 0.8 x Height
- Tall is more costly and requires more energy
Biobed® Advanced; Reduced operation costs

- Novel superior settler
  - Excellent biomass inventory
  - Stable growth of granular biomass

- Therefore
  - High COD removal efficiency (long SRT)
  - Less chemical consumption; pH, nutrients, anti-foam
  - Less operator attention

- Overall lower operating costs
  - Smaller aerobic post treatment
  - Less overall maintenance cost

- Confirmed by numerous full scale results

- Novel Biobed® SMART control system
  - Will further improve stability and performance
Biobed® Advanced; Resume of advantages

- Improved performance
  - Based on fundamental research
  - Improved superior COD removal efficiencies
  - Excellent biomass inventory
  - No odour emission

- Tailor made design
  - Flexible reactor height
  - Flexible in construction; round steel or square concrete
  - Easy effluent pipes

- Reduced Capex and Opex
  - Small compact settler and small reactor
  - Low chemical consumption
  - Reduced aerobic post treatment
  - Small foot print
A proven track record

- **Proven Innovation**
  - 25 full-scale Biobed® Advanced plants
  - 5 years of full-scale industrial operation
  - 2 pilot plant testing locations
  - Overall track record of 530 plants

- **Implemented in**
  - Pulp & Paper
  - Chemicals and PTA
  - Food: Dairy, Sugar, Potato, Soya
  - Brewery & Distillery
Biobed® Advanced full scale; chemical case

Very high COD removal efficiency for PTA wastewater
Steady biomass increase observed
3. Biobed® SMART

Sludge Management and Reactor control Techniques

BIOTHANE
Biobed®SMART reactor control system (1)

- Sludge Management and Reactor Control Techniques

Objectives:

- Achieve more stable reactor operation
- Achieve higher COD removal efficiency
- Reduce operating costs

“Real time video from inside the anaerobic reactor”
Development of Biobed® SMART

SMART control box

1. **SMART process indicators (early warning)**
   - Online continuous insight for operator in process performance
   - Based on a combination of different online measurements
   - Red / green lights to indicate process performance

2. **SMART process control loop**
   - Stable process load (dynamic control)
   - Optimized nutrient dosing
   - pH optimization
   - Temperature optimization

3. **SMART imaging**
   - Online view on biomass granules in reactor
Biobed® SMART Process Indicators

- Relation between VFA and CH4 in biogas
**Biobed® SMART Process Indicators**

- **Capacity indicator** defines if spare capacity is left in the plant (in situ biomass activity test)
  - Based on patented measuring principle
Biobed® SMART control loop

- Pilot plant results with and without Dynamic Control

Fluctuations in gas production in standard operations

Variation ± 40%

Fluctuations in gas production SMART Load control

Variation ± 25%
Dynamic Control: Client Case-study

- Fruit juice factory in the Netherlands
  - Flow 600 m³/day
  - Load 1.5 ~ 2.0 tons of COD / day
    → 200 m³ Equalisation tank
    → 200 m³ storage tank
    → 3 x 50 m³ Biobed® Modular Plant

- High fluctuations in load, flow and low nutrient content

- Resulted in poor performance and high costs

Dynamic Control: Client Case-study

- Net Biomass growth
- Reduction in N-consumption despite of increased average load
- Stable operation reduced operator and analysis cost
Biobed® SMART in situ real-time imaging
Biobed® SMART; Advantages

- **Lower Capex**
  - Smaller required reactor volume; handling more load
  - Less hydraulic buffer volume
  - Reducing Carbon Footprint

- **Reduced Opex**
  - Lower post treatment cost; slightly more biogas
  - Lower chemical costs; pH and Nutrients
  - Better sludge inventory
  - Less maintenance/operator costs

- **Quality improvement**
  - Better effluent quality
  - Early warning system for possible reactor upset
  - Improve reliability and availability
  - Reduced start-up time
Memthane®

The preferred solution for high-strength wastewaters resulting in crystal clear effluents
Drivers for Anaerobic MBR (1)

- Specific wastewater characteristics

- FOG (Fat, Oil & Grease) and LCFA (Long Chain Fatty Acids)
  - Hamper granulation in UASB or EGSB

- High concentrations (COD + salts); e.g. Whey & Thin Stillage
  - Un-diluted: no granulation in UASB due to high HRT, salts
  - Diluted: too large UASB reactor volume
  - Solution often low loaded CSTR systems
Drivers for Anaerobic MBR (2)

- Higher loading rate in CSTR digester achieved by
  - Uncoupling of HRT and SRT by use of membranes

- Higher COD removal efficiencies & clear effluents
  - Smaller post treatment; more compact & less energy consumption
  - Higher digestion efficiency, more biogas
  - Effluent free of suspended solids; easy nutrient recovery
Memthane® step-by-step

Conditioning of high-strength wastewaters.

Influent is fed to the anaerobic bioreactor where the organic components are converted into energy-rich biogas.

Cleaning In Place (CIP)

After anaerobic treatment, the UF membrane unit separates the clean permeate from the biomass.

If required, several polishing techniques are available to further treat the suspended solids free effluent for reuse or recovery of nutrients, while the low COD permeate is often clean enough for direct discharge to sewer.

Biomass is returned to the bioreactor, while a small amount of biomass is removed from the system and discharged after dewatering.
Memthane®; Features

- Treat high-strength effluent previously considered untreatable
  - High concentrated streams: COD 15,000 – 250,000 ppm
  - Superb effluent quality
  - Create product for nutrient recovery (N+P)

- Maximize renewable green energy production
  - Generates biogas from wastewater
  - Minimizes carbon footprint and water footprint

- Remove COD efficiency: > 98%
  - Avoids costly aerobic post treatment
  - Generates more biogas

- Reduced OPEX
  - Reduces disposal costs while generating biogas
Impact of membranes on anaerobic process

Biogas
- CH₄ 28 Nm³ ≅ 280 kWh
- CO₂ 9 Nm³

Biogas
- CH₄ 33 Nm³ ≅ 330 kWh
- CO₂ 11 Nm³

* Based on 95% biogas production

Anaerobic
100 kg COD

80% Biogas
(75% Methane)

15 kg COD

Sludge 5 kg COD

An-MBR
100 kg COD

95-99% Biogas
(75% Methane)

1-5 kg COD

Sludge 5 - 7 kg COD

1 kg COD removed ≅ 0.35 Nm³ CH₄ ≅ 3.8 kWh
Anaerobic MBR; full scale case

- Dairy wastewater

COD loading and COD removal over 2.5 years
3 day moving average

9 tCOD/day
Memthane®; Track record

- **Proven Innovation**
  - 9 full-scale Memthane® plants
  - 4 years of full-scale industrial operation
  - 14 pilot plant tests

- **Implemented in:**
  - Dairy industries
  - Bio-ethanol plant; thin stillage
  - Cellulosic Bio-ethanol; condensate
  - Biodiesel plant
  - Food processing
Ethanol distillery; Case study

- Production Capacity: 10,000 m³ Ethanol per year
- Bases: Corn
- Flow: 700 m³/day / COD: 48 ton/day
- TKN: 720 ppm / t-P: 820 ppm
Ethanol distillery - Case study

- Stillage
- Centrate
- DAF
- BT
- Dilution Effluent
- DAF Float
- Biogas
- BT
- AnMBR sludge stream
- Post Treatment

- BIOBED
- MEMTHANE
- Boiler
Memthane Development Works...

- Biogas
- Electricity
- Memthane®
- Decanter
- Thin Stillage
- Water Re-use Evaporator
- Water Re-use RO Treatment
- N-removal Ammonia Stripping
- P-removal Struvite & Anitamox
- Back set water
- Boiler Feed Water
- Cooling Water & Other
- Ammonia for Re-use
- Fertilizer
Full scale design Bio-ethanol

- Memthane® treating thin stillage of 45 ton COD/d
- COD removal efficiency  > 98 - 99%
  - Gross caloric value  >5.4 MW
- Electrical balance
  - Production  2.2 MWe
  - Consumption Memthane®  0.3 MWe
- Post treatment options
  - Struvite precipitation
  - Water Re-use
  - Ammonia re-use
Observations and Conclusions

- **Biobed® Advanced** reactor
  - Reduced investment and operating costs
  - Stable and reliable operation
  - 25 full scales

- **Biobed® SMART**
  - Substantial reduction in operating costs
  - More stable operation
  - Especially as retrofit to existing plants

- **Memthane® AnMBR**
  - Cost effective solution for concentrated wastewaters
  - Crystal clear effluents
Biothane: Establishing growth through innovation

Thanks for your attention

For further information or questions
Please contact:
Jan Pereboom; Marketing Manager at Biothane
jan.pereboom@veoliawater.com

or visit our booth: Hall 5  F124
54 slides minus 8 hidden