Wisconsin Wastewater Operators Association
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Fixed Film Moving Media for Wastewater Treatment

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When less is Truly MORE—the Next Generation of MBBR Technology--- Small Media Biofilm in a Continuous Flow Intermittent Cleaning Mode

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Contents of Presentation

- Brief Overview of Fixed Film Moving Media
- Advantages & Examples
- The Next Generation:
  Continuous Flow Intermittent Cleaning
Brief Overview of Fixed Film Moving Media
Fixed Film Moving Media Reactor Treatment

- Developed in the 1980’s primarily by Kaldnes Co. in Norway in collaboration with Trondheim University, Dr. Halvard Odegaard & Dr. Bjorn Rusten.

- Moving Bed Biofilm Reactor (MBBR) is a general term used to describe the process. Initially MBBR was designed as a Single Pass WWT process.
Moving Bed Biofilm Reactor Technology

- Biological process—toxicity rules apply
- Requires primary treatment, FOG < 100 mg/l
- Treatment design & configuration is arranged according to inlet & outlet parameters, including WW temp.
- Organic and Hydraulic loading is variable, dependent on Infl. parameters, Eff. goals.
Fixed Film Moving Media Reactor Treatment

Sample of Biofilm Carriers
Carriers move throughout tank with aeration or by movement of water by mixers in an anoxic tank. No unused space in Reactor.

Intimate contact of biomass w/ substrate & air

Standard MBBR maximum media fill fraction
  = 66 % fill of media in the reactor

Media Retention Screen(s) keeps media in tank
Fixed Film Moving Media Reactor Treatment

Moving Media system, Aerobic and Anoxic modes, typical Biofilm Carrier Elements.
Fixed Film Moving Media Reactor Treatment
Advantages & Examples
Advantages:

- Continuous process; Self-Cleaning Carrier Elements
- Operates as once-through (traditional MBBR) or multiple recirculation (IFAS, CFAS®)
- Cost-effective, compact design
- Stable & robust process: handles hydraulic and organic load variations
Advantages:

EASY UPGRADING OF ACTIVATED SLUDGE PLANTS TO HIGHER CAPACITIES

- addition within the Activated Sludge unit process to achieve IFAS / CFAS status, and
- added as a separate unit process within Flow Path, upstream or downstream of existing Fixed Film, AS or Lagoon.
Complete Mix Fixed Film (CMFF®)

- Once-through, no RAS, no MLSS
- BOD, COD removal at high loads:
  * Municipal >17Kg/m³-day
  * Industrial <= 17Kg/m ft³-day
- Nitrogen removal with low HRT: < 3 mg/L with 6 hr HRT
- Small footprint
- Operator friendly
- CSTR conditions, homogeneous bed, continuous solids sloughing
CMFF® - Activated Sludge

- Eliminates sludge bulking on high-loaded MLSS
  - (SVI reductions >300 down to < 100)
- Stabilizes organic removal:
  - Installations with 10x load fluctuations
  - CMFF® process providing 80-90% organic removal
- Small footprint (0.5 hour HRT or greater)
- Low Implementation Cost
Combined Fixed Film and Activated Sludge (CFAS®)

- Biomass = MLSS & Biofilm
- Compartmentalize BOD Removal, Nitrification, and Nitrogen Removal
- Biological P removal with anaerobic selector
- Carriers/Biofilm optimizes nitrification, limiting kinetic rate in BNR
- Selective pollutant degradation by carriers/biofilm: organic compounds, post DN
Small Media Aerobic Reactor Treatment (SMART On-site wastewater Treatment Systems)

- EHS has DOWN-SIZED this technology to Very Economical Decentralized SMALL FLOW and ON-SITE wastewater treatment applications

- Wisconsin approval has been accomplished for the Small Flow (<1333 P.E.) ON-SITE AEROBIC TREATMENT SYSTEM, with several EHS-SMART-Treatment On-site systems installed since 2001
### Small Media Aerobic Reactor Treatment (SMART-Treatment On-site Systems)

#### EHS SMART System Small Flow Sizing, BOD + Nitrogen Rem

<table>
<thead>
<tr>
<th>Pop Equiv</th>
<th>WW Q gpd STE</th>
<th>Inf BOD Lbs / day</th>
<th>Reactor gallons</th>
<th>HRT-av Q, hrs</th>
<th>Media, % fill</th>
<th>Tank Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>400</td>
<td>0.77</td>
<td>530</td>
<td>31</td>
<td>10</td>
<td>3.5</td>
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<tr>
<td>50</td>
<td>4,000</td>
<td>7.7</td>
<td>5300</td>
<td>5</td>
<td>64</td>
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</tr>
<tr>
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<td>40,000</td>
<td>77</td>
<td>8350</td>
<td>5</td>
<td>64</td>
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<td>1000</td>
<td>80,000</td>
<td>154</td>
<td>16,500</td>
<td>5</td>
<td>64</td>
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Small Media Aerobic Reactor Treatment
On-site package plants: cluster developments, etc.

PROCESS COMPONENTS

AEROBIC
- BIOFILM CARRIERS
- AERATION SYSTEM
- RETENTION SIEVES

ANOXIC
- BIOFILM CARRIERS
- MECHANICAL MIXERS
- RETENTION SIEVES
Small Media Aerobic Reactor Treatment
SMART On-site treatment tank
Water Environment Federation’s (1998) MOP 8, “Design of Municipal Wastewater Treatment Plants”

### Surface Area of Stationary Media Bundles

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<th>Typical Wastewater Strength Categories</th>
<th>Surface Area, Sq Ft / Cu Ft Stationary Media Volume</th>
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<td>Nitrification applications:</td>
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<td>RBC: – std den / high den</td>
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### Moving Media Comparison, at 66 % Fill Fraction

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Moving Media Comparison, at 66 % Fill Fraction

| BWT-X@198 sq ft/cu ft-bulk            | 131 sq ft / cu ft - In Reactor                  |
| BWT-15@ 253 sq ft/cu ft-bulk          | 167 sq ft/cu ft - In Reactor                    |
| CFIC—BWT-X @ 99% Fill                 | 196 sq ft / cu ft - In Reactor                  |
| CFIC—BWT 15 @ 99% Fill                | 250 sq ft /cu ft - In Reactor                   |
The Next Generation: Continuous Flow Intermittent Cleaning
Doing More with Less—Biowater’s Newest Innovation-
Better Treatment In An Even Smaller Foot Print:
Continuous Flow Intermittent Cleaning

- The CFIC® reactor contains highly packed biofilm carriers to a degree (typically 90-99% bulk volumetric fill) that little movement of the carriers occurs in the reactor during normal operation.
- For example using Biowater BWT-X carrier elements---
  - By increasing bulk volumetric fill from 66% maximum fill to 99% maximum fill, the reactor biological surface area **INCREASES** from 131 sq ft/cu ft to 196 sq ft/cu ft w/in **same reactor volume**— **A 50% INCREASE IN SURFACE AREA!**
CFIC® — Normal Operation
CFIC®—Intermittent Cleaning
CFIC Reactor---CFIC Elevation
CFIC Reactor---Clean Cycle
Typical CFIC Reactor
Biowater Technology’s CFIC® process

- The cleaning cycle is a forward wash cycle (FWC) in that influent wastewater continues to flow into the CFIC® reactor. The cleaning process removes biomass (biofilm and excess sludge) from the biofilm carriers and out of the reactor.
- The turbulence in the reactor may temporarily be increased with an air-lift pump or a propeller to facilitate effective removal of biomass from the carriers.
- The carrier shape provides a large void volume (typically an 85% void volume in a 100% fill situation) for growth and accumulation of biomass. The void volume maximizes the run time between cleaning cycles.
- Wastewater treatment with a:

  BIOLOGICAL TURBO— More Treatment in Less Space
Biowater Technology’s CFIC® process

CFIC® – The next generation biofilm technology

CFIC® biofilm technology is based on biological growth on polyethylene pieces. CFIC® provides a protective surface area for the biology to grow and can easily handle extremely high loads of wastewater without problems with clogging or shock.

Normal operation
- Bioreactor is filled >90% with biofilm carriers
- Hindered carrier movement
- Higher O₂ Transfer
- Better transportation of substrate

Open valve: 
Closed valve:

Biomea

Intermittent cleaning
- Water level in the bioreactor is increased to let the carriers move
- Accumulated sludge and adhesive biofilm are being removed from the carriers and washed out of the reactor
- The bioreactor is fed by untreated wastewater during washing and is still performing treatment during wash cycle

Wastewater treatment with a biological turbo
CFIC® Biofilm Process

Controlled Wasting of Solids
• High Volatile Solids Content / Renewable Energy Component
• Solids directly to Thickening/Dewatering
• Low Effluent TSS Concentration, 50 – 90% Less Than MBBR
• Filtration for Effluent Reuse
• Continuous Biological Treatment
• Water is dischargeable depending on effluent requirements
• Water does not need to be recirculated
• No Polymer Dosing
• Energy Savings of 20-30%
CFIC®-Parallel Trains, w/ direct flow from CFIC Reactors to micro-filtration or Ultra-fine Membranes
CFIC® Pilot Development
CFIC®--Pilot Data

- Reactor diameter: $\phi = 2.5\text{m}$
- Reactor height: $H = 6.0\text{m}$
- Water level:
  - CFIC: 4.0 meter
  - FWC: 5.0 meter
- Filling degree:
  - CFIC: 95%
  - FWC: 76%
- Water volume:
  - CFIC: 12.6 m$^3$
  - FWC: 15.7 m$^3$
- Hydraulic load: $Q = 2.0 - 5.0\text{m}^3/h$
- COD: $2500 - 8000\text{mg/l}$
  ~ $300 - 850\text{kg COD/d}$
- COD Removal rate: $R > 90\%$
- Wastewater temp.: $T = 30 - 34\text{°C}$
CFIC vs. CMFF (conventional MBBR)
COD RR vs. SALR

\[ y = 0.634x^{0.0918} \]
\[ R^2 = 0.9959 \]
Sampling & Analytical

- Online Monitoring:
  - Turbidity
  - DO
  - ORP
  - Temperature
  - Nitrate, Ammonia
  - Blower Amps

- Analytical (24-hr Composites and Grabs):
  - TCOD, sCOD, TSS, VSS, Turbidity
  - Correlation of TSS to Turbidity

Wastewater treatment with a biological turbo
Online Turbidity

Online Turbidity Monitoring allows calibration to [TSS] and Process Control

Wastewater treatment with a biological turbo
Turbidity to [TSS]

\[ y = 218.68 \ln(x) - 729.93 \]

\[ R^2 = 0.9629 \]
Wasting Cycle TSS

[TSS] 3,000 – 9,000 mg/L  [VSS:TSS] 94%

Optimizes Biogas/Energy Production

Wastewater treatment with a biological turbo
Sludge Volume Index (Waste)

15 October 2011

Sludge Volume 220 mL per 1000 mL

[TSS] = 4,690 mg/L (Waste)

SVI = 47 mL/g

Peak Day
920 mg/L COD

170 mL Sludge Volume

9,000 mg/L TSS (Waste)

SVI = < 20 mL/g

Wastewater treatment with a biological turbo
---Summary—

Biowater Technologies CFIC® process

- CFIC® Biofilm process- a new development in MBBR technology
- The CFIC® reactor is filled to a high degree of biofilm carriers (typically 90-95% fill fraction)
- The high filling will create a hindered movement of the carriers in the reactor during normal operation
- The CFIC® process has continuous flow to the bioreactor and intermittent cleaning
GLOBAL PRESENCE

Biowater Technology & Licensees
BIOWATER’S EXPERIENCED TEAM

- Laura Marcolini, P.E., M.Sc. - Technical Director, US
  - Process Design Engineer for Kaldnes / Regional Manager for AnoxKaldnes.
  - ~ 20 years’ water and wastewater process experience

- Jon Gregar Siljudalen, M.Sc. – Chief Technical Officer
  - Senior Process Engineer Kaldnes Miljøteknologi - AnoxKaldnes
  - Formerly with the municipality of Oslo and Hjellnes COWI
BIOWATER’S EXPERIENCED TEAM

Thorbjørn Westrum, M.Sc. (Founder & Board Member)
• Founder of Kaldnes Miljøteknologi AS and Managing Director from 1990 to 1999.
• Managing Director of Kaldnes, one of the largest shipyards in Norway.

Terje Andersen (Founder & CEO)
• Managing Director of Kaldnes Miljøteknologi 1999 - AnoxKaldnes until June 2007.
• ~25 years International Sales and Marketing.
EHS & Biowater - A Good Team

Summary—Fixed Film Moving Media Treatment:

✓ Teamed with engineers & companies w/ the most experience & innovative products/processes in fixed film moving media treatment of Water & Wastewater

✓ Can supply process knowledge and product for ANY volume or process configuration

✓ Provides maintenance agreements where/when needed

✓ Strive for BEST Treatment @ Lowest Price, both initial investment and O & M.
Environmental /Health Products & Service

Thank You for the opportunity!