مشاورطراح و مجري
سیستم‌های تصفیه فاضلاب
صنعتی و بهداشتی

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Advantages & Applications of MBBR Technologies

HeadworksBIO

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Wastewater Technologies

Attached Growth
- Static Fixed film
  - Trickling filters
  - Rope media
  - Web media
  - Biological active filters (BAF)
- Dynamic Fixed Film
  - Rotating biological contactors (RBC)
  - Moving Bed Biofilm Reactors (MBBR)
  - Plastic seaweed type media

Suspended Growth
- Activated sludge
  - Conventional Activated sludge
  - MLE nutrient removal
  - Barden pho process
  - Membrane Bio-reactors (MBR)
- Continuous treatment
- Batch Treatment
  - Sequencing batch reactors (SBR)
  - Membrane Bio-reactors (MBR)

Integrated Fixed-Film Activated Sludge (IFAS)
General Overview of Plant’s Components

- Raw Wastewater Influent
- Preliminary Residuals (i.e., grit, rags, etc.)
- Primary Sludge
- Wastewater Treatment Residuals
- Primary Clarifier
- Biological Treatment System
- Secondary Sludge
- Secondary Clarifier
- Tertiary Clean Wastewater Effluent Discharge to Receiving Waters

A: Usually to Landfill
B: Primary Sludge
C: Secondary Sludge
Fixed Film Technologies

Trickling filters are a static, air phase fixed film treatment system.

RBCs are partially water and air phase.

MBBRs are dynamic, water phase fixed film treatment systems.
• The carrier elements, which are less dense than water, 0.93-0.95 SG, provide a large protected surface for bacteria culture.

• MBBR provides advantages of Activated Sludge and Trickling Filter systems without their disadvantages.

• MBBR is one of the most documented processes with many technical publications and presentations.
Dynamic Water Phase Fixed Films

- No problems with odors, snails or red-worms as in air phase fixed films.
- Easier transfer of contaminants and oxygen to the biomass.
- Biofilm thickness is maintained and controlled by continuous sloughing created by the aeration-mixing process.
- NO attrition of media – plants 20 years old are still using original media
Biofilm Growth on Media

Mixing energy controls the biological thickness
More Than Just Plastic

15+ Years of R&D

Successful Installations

Virgin HDPE

Superior Media Composition

Customizable Solutions

Process Design Experts

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Customizable Processes

**BOD REDUCTION**
- Screened Wastewater
- BOD
- AS or DAF
- Reuse or discharge

**POST NITRIFICATION**
- Existing BOD Reduction
- NIT
- DAF
- Reuse or discharge

**NITRIFICATION**
- Screened Wastewater
- BOD
- NIT
- DAF
- Reuse or discharge

**TOTAL NITROGEN REMOVAL**
- Screened Wastewater
- DNIT
- BOD
- NIT
- DAF
- Reuse or discharge
What’s the Difference?

IFAS
Integrated Fixed Film Activated Sludge

- **Includes Return Activated Sludge (RAS)**
- Fixed film & Suspended growth

MBBR
Moving Bed Biofilm Reactor

- **No RAS - “Once through” process**
- Fixed film Only
Why MBBR?

• Self regulating biomass.
• Flexible Design that allows for increased capacity.
• No operational adjustments, only equipment maintenance.
• Stable under large load variations.
• Smaller foot prints.
• Low investment Cost.
• Single pass treatment.
• Multiple applications.
• Extremely compact and simple biological treatment system.
Key MBBR Design Parameters

- Organic surface loading rate (g BOD/m²d)
  Normal rate: 10 – 13 g BOD₅/m²d @25 °C

- Protected surface area of carrier (m²/m³)
  400 – 680 m²/m³ for Headworks ActiveCell Media

- The Biomedia carrier filling fraction (%)
  Normally: 50 – 67 % (minimum 30%)

- Temperature
  - \( k_T = 1.07(T-10) \) (when \( T = 5 – 10 \) °C)
  - \( k_T = 1.06(T-10) \) (when \( T = 10 - 20 \) °C)
Key Components: MBBR

Aeration Grid

Retention Sieves

Activecell™ Media

1% = Equipment Supply / 99% = Knowledge
Applications

Features:
• Single pass treatment
• No operational adjustments
• Only equipment maintenance
• Self regulating biomass
• Small foot print
• Multiple applications

BOD/COD Reduction

Nitrification

Denitrification
BOD / COD Removal

- High loads
- Up to 6000 mg/l
- Small foot print
- Single pass treatment
- No recycle
- No operator adjustments
- Biology self regulating
- Low BOD effluent
- 50% to 80% reduction in 30 minutes
- < 10 mg/l BOD (after clarification)
IFAS Applications

(work best at temperatures < 25°C)

Existing Plant
BOD & TSS = 30 mg/L

Nitrification Only
NH₃-N < 1 mg/L

Pre-DN & Nitrification
NH₃-N < 1 mg/L & TN >8 mg/L

Pre & Post DN
NH₃-N < 1 mg/L & TN < 3 mg/L
• Decreases tank volume required for BOD/COD and Nitrification allowing room for Bio-P and De-nitrification.

• Allows for the suspended growth sludge age to be tailored for maximum phosphorus removal.

• Nitrification biology grows on media and is not affected by low sludge ages of suspended growth.
AT EQUAL LEVELS OF BOD REMOVAL:

MBBR Provides Five times the Biofilm Surface Area in less than ¼ Reactor Volume as Trickling Filter

Kinetics = MBBR is More Active & Efficient than Trickling Filter
Footprint comparison

- MBBR + DAF
- MBBR + CLARIFIER
- ASP + CLARIFIER

Footprint, m²
RBC vs MBBR

Example Plant with 5000 m3/d design flow:

Influent: BOD: 600mg/l, COD: 1000 mg/l, TSS 600 mg/l
Effluent: BOD: 50 mg/l, COD: 80 mg/l, TSS 60 mg/l

RBC requires 800 m2 area and 93 kW for disk drives

MBBR requires 195 m2 area and 93 kW for air blowers.

The power on the MBBR can be varied based on the influent load where the RBC cannot.
MBBR Areas of Focus

INDUSTRIAL

MARINE

MUNICIPAL
MBBR Size vs. Activated Sludge

- Activated Sludge Extended Air process is designed for 12 to 24 hours hydraulic retention time (HRT).
- The MBBR need only 2 to 3 HRT to achieve the same level of nitrification.
- This is less than or equal to ¼ the tank volume.
- Typical biomass levels in activated sludge plants is between 2500 mg/l to 3500 mg/l of suspended solids.
- Typical equivalent biomass in an MBBR is 6000 mg/l of attach growth.
- This is 2 times more available treatment mass.
40m Diameter, 9m high – 40,000m³/d
Carousel Upgrade
(Typical Saudi Arabian Wastewater Plant)

Current Design
- Capacity: 25,000 m³/d
- Effluent Quality: ?

Option 1
- Capacity Increases to 45,000 m³/d
- Effluent Quality: 10/10/3*

Option 2
- Capacity Increases to 90,000 m³/d
- Effluent Quality: 10/10/3*

Option 3
- Capacity Increases to 45,000 m³/d
- Effluent Quality: 10/10/3*

* BOD / TSS / NH₃
Options for Upgrading Carousel System

<table>
<thead>
<tr>
<th></th>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in Treatment Capacity</td>
<td>2X</td>
<td>4X</td>
<td>2X</td>
</tr>
<tr>
<td>% Media Full</td>
<td>30%</td>
<td>60%</td>
<td>40%</td>
</tr>
<tr>
<td>Number of Internal Walls Removed</td>
<td>2</td>
<td>1</td>
<td>None</td>
</tr>
<tr>
<td>Number of New Internal Walls</td>
<td>1 Short</td>
<td>1</td>
<td>3 Short</td>
</tr>
<tr>
<td>New Influent Location</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>New Effluent Location</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>% Retrofit Existing Tank with Diffused Aeration System</td>
<td>100%</td>
<td>100%</td>
<td>25%</td>
</tr>
<tr>
<td>Remove Existing Surface Aerators</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
Capacity Increase

Flow increase of 4 x 250 m³/d up to 4 x 1000 m³/d
Phased increase in capacity

Existing plant capacity can be increased by adding more media into the MBBR Tank

Existing MBBR

<table>
<thead>
<tr>
<th>Flow</th>
<th>1000 m3/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD Load</td>
<td>300 kg/d</td>
</tr>
<tr>
<td>Fill fraction</td>
<td>50 %</td>
</tr>
</tbody>
</table>

After

<table>
<thead>
<tr>
<th>Flow</th>
<th>1400 m3/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD Load</td>
<td>420 kg/d</td>
</tr>
<tr>
<td>Fill fraction</td>
<td>70 %</td>
</tr>
</tbody>
</table>
Moorhead, MN: 22,750 m$^3$/day

The ActiveCell450 biofilm carriers are used for a separate-stage MBBR nitrification system designed to nitrify ammonia. They meet seasonal compliance standards of less than 4 mg/L NH$_3$. 
Agnico Eagle LeRonde Mine: Cadillac, Quebec

The original SBC started to face mechanical failures. A decision was made to use attached growth biological treatment to degrade thiocyanate based on successful pilot testing.
Jamaica: 8,000 m³/day

- Three ActiveCell bioreactors in series designed for BOD and Nitrification to less than 10 mg/L and < 2 mg/L respectively.
- Dissolved Air Flotation (DAF)
- Chlorination and sand filtration prior to re-use as cooling tower make-up.
- A portion of the filtered flow is demineralized prior to re-use as boiler feed water.
Finland: 18,500 m³/day
Marine Installations
CleanSea® Shipboard Wastewater Treatment
Onboard the Largest Cruise Ship in the World

Passengers & Crew: ~8,400
Hydraulic Capacity: 3,000 m³/day 0.79 MGD
Typical Flow: 2,000 m³/day 0.53 MGD
Max. Influent BOD: Max. Influent TSS
~1,500 mg/L ~850 mg/L
Effluent BOD: Effluent TSS < 15 mg/L < 15 mg/L
Extensive Installation List

Installations including municipal in the following industries:

- Domestic/Resort
- Food Processing
- Landfill Leachate
- Marine
- Meat Processing
- Mining
- Petrochemical
- Pharmaceuticals
- Power Plant
- Pulp & Paper
- Septage Processing
- Vehicle Wash
HIT System™
Headworks Integrated Treatment System

Flow: (60 m3/day) Influent: 300/300/40 Effluent: 10/10/2
## Comparison: MBR vs MBBR

<table>
<thead>
<tr>
<th></th>
<th>MBR Plant</th>
<th>MBBR Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Investment</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Footprint</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Flow Tolerance</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Aeration Blowers</td>
<td>Required</td>
<td>Required</td>
</tr>
<tr>
<td>Recirculation Pumps</td>
<td>Required</td>
<td>Not Required</td>
</tr>
<tr>
<td>Air Scouring Blowers</td>
<td>Required</td>
<td>Not Required</td>
</tr>
<tr>
<td>Screening Requirements</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Chemical Usage</td>
<td>High</td>
<td>N/A</td>
</tr>
<tr>
<td>Operational Difficulty</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>
### Comparison: 800 m$^3$/day

<table>
<thead>
<tr>
<th>MBBR</th>
<th>RBC</th>
<th>Activated Sludge</th>
<th>SBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>No residual suspended solids</td>
<td>No residual suspended solids</td>
<td>Requires residual suspended solids (MLSS)</td>
<td>Requires residual suspended solids (MLSS)</td>
</tr>
<tr>
<td>Self regulating, no operator adjustments</td>
<td>Self regulating, no operator adjustments</td>
<td>Operator adjusts MLSS levels</td>
<td>Operator adjusts MLSS levels</td>
</tr>
<tr>
<td>Single pass flow through</td>
<td>Single pass flow through</td>
<td>MLSS sludge recycled back through plant</td>
<td>May or may not require MLSS recycle</td>
</tr>
<tr>
<td>1 hour retention time (based on 800m3/d)</td>
<td>4 hours retention time</td>
<td>4 hours retention time</td>
<td>5 hours retention time (includes clarification)</td>
</tr>
<tr>
<td>8.25 m$^2$ treatment area</td>
<td>64 m$^2$ treatment area</td>
<td>33.75 m$^2$ treatment area</td>
<td>31.5 m$^2$ treatment area (includes clarification)</td>
</tr>
<tr>
<td>Not affected by high flows</td>
<td>Biology stripped of media with high flows</td>
<td>MLSS can be flushed out with high flows</td>
<td>Rarely affected by high flows</td>
</tr>
<tr>
<td>Low mechanical equipment</td>
<td>High mechanical equipment</td>
<td>Moderate mechanical equipment</td>
<td>Low mechanical equipment</td>
</tr>
<tr>
<td>Stable nutrient removal</td>
<td>Unstable nutrient removal</td>
<td>Unstable nutrient removal</td>
<td>Stable nutrient removal</td>
</tr>
</tbody>
</table>
Which Activecell media has the larger protected surface area?
Questions?

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