Process Aeration
Micro-bubble Generators

Joe Hebert, Ottawa County Public Utilities

Bubble Size Relationship

- Course = ≥10 mm
- Medium = 4-9 mm
- Fine = 1-3 mm
- Ultra-Fine = 1 mm
- Micro = 0.5-0.01 mm
- Nano = 0.001 mm
**Bubble Size Relationship**

| Bubble(s) volume = 1 cubic feet. |
|------------------------|------------------------|
| 4.8 square feet        | 1 cu ft = 1 bubble     |
| 105 square feet        | 10mm = $5.4 \times 10^4$ |
| 1,800 square feet      | 1mm = $5.4 \times 10^7$  |
| 7,300 square feet      | 0.25mm = $3.4 \times 10^9$ |
|                        | 0.02mm = $6.7 \times 10^{12}$ |

**Terminology and Formulas**

**Oxygen Transfer Rate of Diffuser = Oxygenation Rate**

OTR Approximately = scfm air (1.036) SOTE = lb O$_2$/hr

Example Airflow = 200 scfm & diffuser efficiency 22%

OTR = 200 scfm air (1.036) 0.22 = 45.58 lb O$_2$/hr

**Oxygen Transfer Efficiency**

Efficiency/Meter as % = \( Em \)

\[ Em = \% \text{ SOTE/meter submergence} \]

\[ \text{gram/m}^3 \text{ air per m submergence} = 1.036 (Em) \frac{1000}{2.206} (1.7) \]

\[ Em \text{ as \%} = \frac{\text{gram/m}^3 \text{ air per meter}}{2.2046} \times 1.7 \times 1.036 \times 1000 \]

\[ Em = \frac{\text{SOTE/Ft submergence}}{3.2808} \]
Typical Oxygen Transfer Values
(in clean water)

<table>
<thead>
<tr>
<th>System</th>
<th>Oxygen Transfer Efficiency&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Oxygen Transfer Rate&lt;sup&gt;b&lt;/sup&gt;</th>
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<tr>
<td>Micro Bubble Generators</td>
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<td>10-27</td>
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<tr>
<td>Fine Bubble Diffusers (total floor coverage)</td>
<td>22-32</td>
<td>6.0-6.5</td>
</tr>
<tr>
<td>Fine Bubble Diffusers (side wall installation)</td>
<td>18-20</td>
<td>3.5-4.5</td>
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<tr>
<td>Jet Aerators (fine bubble)</td>
<td>18-25</td>
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<td>Static Aerators (medium bubble)</td>
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<td>2.3-2.8</td>
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<tr>
<td>Coarse Bubble Diffusers (wide band pattern)</td>
<td>8-12</td>
<td>2.0-3.0</td>
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<tr>
<td>Coarse Bubble Diffusers (narrow band pattern)</td>
<td>6-8</td>
<td>1.5-2.0</td>
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</table>

<sup>a</sup> at 15 feet submergence

<sup>b</sup> 1 lb/hp-hr = 0.61 kg/kW-hr

Existing System

- 3 cell lagoon system
- (2) 4.6 acres and (1) 1 MG final
- 300,000 gpd flow
- Influent loading: 200 – 300 mg/l BOD
- 30 hp Hinde aeration in primary lagoon

Ackley, Iowa
The Problem

- In 2000 – 30 inches sludge in primary lagoon
- >15 inches in secondary lagoon
- Estimates for sludge removal were $250-275,000
- Aging aeration system

The Solution

- August 2001 – Installed (4) 2 hp microbubble generators from WTR Solutions LLC.
  - 10.4 lbs O₂/hp/hr each unit (600 lbs/O₂/day ea.)
- 2005 – Installed 2 units in cell #2

Cost

- Approximately $10,000 each (installed)
Ackley, Iowa

ACKLEY AVERAGE SLUDGE DEPTHS

- 2005 – owner was satisfied with results and purchased 2 more aerators for installation in cell #2 to help meet effluent quality limits.
- 2011 – Superintendant Jack Boelman, PeopleServices Inc., reports sludge depths still at 6” in cell #1.
- No reported maintenance issues on units.
**Final Result**

Sludge in 1\textsuperscript{st} and 2\textsuperscript{nd} cells was significantly reduced

- Project costs: \$60,000
- Initial savings: \$200,000
- Ongoing savings: 18 hp equivalent less power usage

**Existing system - 2009**

- 110,000 gpd (during harvest)
- 6,400 mg/l BOD
- 3 Lagoons (2.38M, 2.09M, 1.1M gallons)
- Brush aerators = 105 hp
Problems

- High maintenance and electrical costs of aerators
- Low O₂ and odor problems (near tasting room)
- Plugging drip irrigation system
- Removed 250,000 gal sludge from last cell – 2009
- Up to 48” sludge in primary - April 2010

The Solution

- April 2010 - Installed (18) 3 hp VMB 750 microbubble generators delivering 10.99 lbs O₂/HP/HR each. (791.28 lbs O₂/day ea.)
- Manufactured by: VMB Technologies Inc.
- Project costs: approx. $189,000
The Result

- Reduced HP from 105 to 54 saving $39,152 yr
- Received PG&E incentive $32,417
- 4 year simple payback
- Reduced maintenance on equipment and irrigations system

August 2010 - Reduced sludge in primary to 3”-14” (30-40%)
Influent @ 4,090 mg/l BOD
Effluent @ 36 mg/l BOD₅

Existing System

- 2 Sequencing Batch Reactors
- .948 MGD capacity (.220 MGD average)
- MLSS 1,500 – 2,200 mg/l - 20-30 day CRT
- 3 - 50,000 gallon sludge blending/holding tanks
- Gravity belt thickening using polymer
- $25,000 - $30,000 year to land apply sludge
Pilot Study 2007 – Present

Goal: Reduce sludge handling cost through aerobic digestion and on-site sludge drying

- Installed (6) 2 hp microbubble generators from WTR Solutions LLC.
  10.4 lbs O₂/hp/hr each unit (600 lbs/O₂/day ea.)
- Installed reed drying beds

Monitored DO (not ORP) in determining sludge retention time and wasting rate.

Series flow through sludge tanks before pumping to reed beds.

Tried various operational techniques to reduce volatiles, decant supernatant, and maximize % solids.
2010 Observed Results

“no aeration” pump 3 days/week @ 2 hrs/day to reed beds

“with aeration” pump 1 day/week @ 2 hrs/day to reed beds

VSS reductions of 50%

More empirical data needed to determine true effectiveness and value

Operators are satisfied with performance

Thank you!

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