HYBRID ACTIVATED SLUDGE PROCESS

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WHAT?

HYBACS (HYBrid ACtivated Sludge)
Innovative, advanced & economical wastewater treatment process

- Patented Technology
- Reduces OPEX (30% to 40%)
- Produces high quality effluent (Enhanced removal of Nitrogen and Phosphorus)
- Reduces Footprint (30% to 40%)
- Reduces CAPEX (15% to 30%)
- Is well-suited to plant upgrades

AT THE LOWEST COST
HYBACS PROCESS DESCRIPTION

- Two biological stages in series followed by clarification:
  - First stage is SMART™ (Shaft Mounted Advanced Reactor Technology) units based on the presence and development of high density, highly active attached biomass
  - Second stage is activated sludge basins
  - Two stages are linked by the sludge recycle to create HYBACS.
APPLICATIONS

**Municipal Applications:**
- Plant retrofitting solution
- Alternative with a clear competitive edge
- Unique & differentiated solution in the crowded market
- Solution with treatment performance higher than typical AS
- Plant capacity increase (with same treatment level & less footprint)

**Industrial Applications:**
- Food & beverage / Dairy
- Landfill leachate treatment
- Concentrated animal feed operations (CAFO)
## DESIGN CRITERIA

### Application

- BOD Removal
- NH$_3$-N Removal
- NO$_3$-N Removal
- Total Nitrogen Removal
- Phosphorus Removal

### Expected Effluent Performance

- BOD < 10 mg/L
- NH$_3$-N < 1 mg/L
- NO$_3$-N < 1 mg/L
- Total Nitrogen < 3 mg/L
- Bio-P < 30-60% Removal

### Source Water

- Municipal Wastewater
- Industrial Wastewater
SMART UNIT DESCRIPTION

- Number of plates = 30
- Plate thickness = 2”
- Plate pitch spacing = 3.75”
- Plate diameter = 6.6 feet
- Rotor speed up to 6 rpm
- Plate construction: Fiber mesh
- Plate void = 95%

Overall dimension: 15’ x 8.2’ x 8.2’
SMART UNIT

- Plastic mesh
- 2 inch thick
- Fills with biomass
- Designed to remove readily biodegradable material, consuming minimum power
- Diverse biomass capable of removing carbon, nitrifying and denitrifying in different regions
- Biomass renews itself, sustaining performance
- Robust structural design
POROUS MESH PLATE

Clean mesh during assembly

Mesh with biomass (typically 60,000 mg/l)

Comparison: MLSS in Activated Sludge Processes (typically 3,500 mg/l)
SYSTEM OPERATION

- Simple controls for rotational speed of the SMART unit
- Activated sludge tank controls (aeration, IMLR recycle, RAS recycle etc.) based on standard logic

Denitrification

- Low DO conc.
- Zero DO conc. low NO₃ conc.
- High DO conc. Carbon removal

Nitrification

TP removal

High Aeration Efficiency At Low Energy
SMART UNIT DETAILED VIEWS
SHAFT AND ROTOR CAGE FINAL ASSEMBLY
ASSEMBLY OF PLATE MODULES
INSTALLATION OF MODULES
WHY HYBACS IS NOT A ROTATING BIOLOGICAL CONTACTER

Traditional RBC

HYBACS
## COMPARISON WITH RBC

<table>
<thead>
<tr>
<th>Item</th>
<th>SMART unit</th>
<th>RBC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Volumetric COD removal rate</strong></td>
<td>15 times MORE than RBC</td>
<td>15 times LESS than SMART Unit</td>
</tr>
<tr>
<td>Plates</td>
<td>Mesh with 95% void</td>
<td>Solid</td>
</tr>
<tr>
<td>Plate thickness</td>
<td>2 inch</td>
<td>0.4 to 0.6 inch</td>
</tr>
<tr>
<td>Pitch distance of plates</td>
<td>3.75 inch</td>
<td>1 to 1.2 inch</td>
</tr>
<tr>
<td>Rotational speed</td>
<td>Up to 6 rpm</td>
<td>Up to 2 rpm</td>
</tr>
<tr>
<td>Type of treatment</td>
<td>BOD, N</td>
<td>BOD, N</td>
</tr>
<tr>
<td>Biological activity</td>
<td>Inside and surface of plates</td>
<td>Surface of plates</td>
</tr>
<tr>
<td>Mass transfer in plate</td>
<td>Convection</td>
<td>Surface</td>
</tr>
<tr>
<td>RAS recycle needed?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Thickness of active biofilm</td>
<td>1 inch</td>
<td>≈ 0.01 inch</td>
</tr>
</tbody>
</table>
BENEFIT: QUICK INSTALLATION

A Low Cost Activated Sludge Upgrade with reduced energy, carbon & physical footprint

- Rapid deployment (modular, offline build)
  - Reduction in H&S risks on site
  - Reduced wastage
  - Tested in the factory

2 weeks
**QUESTION: WHAT MAINTENANCE IS REQUIRED?**

### SMART Units Maintenance Schedule

<table>
<thead>
<tr>
<th>Component</th>
<th>Maintenance Task</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main shaft bearings</td>
<td>Grease</td>
<td>Monthly</td>
</tr>
<tr>
<td>Gearbox</td>
<td>Replace oil</td>
<td>6 to 12 months</td>
</tr>
<tr>
<td>Mesh panels</td>
<td>Replace as necessary</td>
<td>&gt; 10 years</td>
</tr>
<tr>
<td>Gearbox, bearings &amp; motor</td>
<td>Replace as necessary</td>
<td>&gt; 10 years</td>
</tr>
</tbody>
</table>
Tongbok, South Korea Performance

Av. wastewater BOD = 116 mg/l
Av. wastewater SS conc. = 116 mg/l
Av. wastewater TN conc. = 41.4 mg/l
Av. wastewater TP conc. = 4.8 mg/l
COLESHELL PILOT PLANT, UK: COD PERFORMANCE

[Graph showing COD removal and concentration over time from April 1 to November 25, 2010.]
COLESHILL PILOT PLANT, UK: NUTRIENT REMOVAL PERFORMANCE
CASE STUDY: ASHBORNE, UK

- 40% increase in influent loads from 25,000 to 35,000 PE

- Four solutions compared namely: HYBACS, roughing filters, SAF plant and new oxidation ditch

- Permit limit: 10 mg/l ammonia, 25 mg/l BOD
ASHBOURNE, UK: BOD AND AMMONIA PERFORMANCE
TUBLI, BAHRAIN
26 MGD UPGRADE
## TUBLI PERFORMANCE (WITHOUT CHEMICAL DOSING)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Influent</th>
<th>Effluent</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD (mg/L)</td>
<td>300</td>
<td>10</td>
</tr>
<tr>
<td>COD (mg/L)</td>
<td>646</td>
<td>27</td>
</tr>
<tr>
<td>TSS (mg/L)</td>
<td>477</td>
<td>10</td>
</tr>
<tr>
<td>Ammonia-N (mg/L)</td>
<td>22</td>
<td>0.6</td>
</tr>
<tr>
<td>TN (mg/L)</td>
<td>28</td>
<td>9</td>
</tr>
<tr>
<td>TP (mg/L)</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>
TUBLI : GOOD SLUDGE SETTLEMENT

Existing ASP sludge
SVI 233 mL/g

HYBACS sludge
SVI 43 mL/g
# TUBLI : PERFORMANCE COMPARISON

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Existing ASP Lanes</th>
<th>HYBACS Lanes</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow (ML/d)</td>
<td>50</td>
<td>100</td>
<td>Capacity doubled (treating 500,000 PE)</td>
</tr>
<tr>
<td>Effluent Ammonia (mg/L)</td>
<td>10 - 15</td>
<td>1</td>
<td>Complete Nitrification achieved</td>
</tr>
<tr>
<td>Sludge Settlement SVI (mL/g)</td>
<td>200</td>
<td>40</td>
<td>Sludge settles faster and better</td>
</tr>
<tr>
<td>Power Consumption (kWh/m³)</td>
<td>0.35</td>
<td>0.21</td>
<td>40% power saving</td>
</tr>
</tbody>
</table>
PRINCETON MEADOWS, NJ

Plant Operator:
- United Water

Demonstration Site:
- Princeton Meadows, NJ

Design Parameters:
- Design Flow: 1.6 MGD
- Future Flow: 2.5 MGD
- Future Regulations:
  NH$_3$-N: 3 mg/l
PRINCETON MEADOWS DEMONSTRATION STUDY

SMART Unit

Aeration Tank
## Pilot Stats (Operation and Design Parameters)

<table>
<thead>
<tr>
<th>Date</th>
<th>Phase</th>
<th>Flow GPM</th>
<th>HRT Hrs</th>
<th>Int. Recy GPM</th>
<th>RAS GPM</th>
<th>SRT Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/23-8/3</td>
<td>I. normal</td>
<td>47</td>
<td>5.6</td>
<td>1.7 Q</td>
<td>.9 Q</td>
<td>6.6</td>
</tr>
<tr>
<td>8/4-9/19</td>
<td>I. stress</td>
<td>59</td>
<td>4.5</td>
<td>Q</td>
<td>.7 Q</td>
<td>2.7</td>
</tr>
<tr>
<td>9/20-11/26</td>
<td>II. stress</td>
<td>54</td>
<td>4.9</td>
<td>Q</td>
<td>.8 Q</td>
<td>2.8</td>
</tr>
<tr>
<td>11/27-1/4</td>
<td>II. cold</td>
<td>41</td>
<td>6.4</td>
<td>1.1 Q</td>
<td>.9 Q</td>
<td>4.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Phase</th>
<th>CODs mg/l</th>
<th>CODt mg/l</th>
<th>BODs mg/l</th>
<th>BODt mg/l</th>
<th>TSS mg/l</th>
<th>VSS mg/l</th>
<th>NH₄-N mg/l</th>
<th>NO₃-N mg/l</th>
<th>TKN mg/l</th>
<th>T °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/23-8/3</td>
<td>I. normal</td>
<td>106</td>
<td>306</td>
<td>44</td>
<td>141</td>
<td>82</td>
<td>79</td>
<td>23</td>
<td>0.5</td>
<td>38</td>
<td>23</td>
</tr>
<tr>
<td>8/4-9/19</td>
<td>I. stress</td>
<td>117</td>
<td>272</td>
<td>36</td>
<td>99</td>
<td>69</td>
<td>67</td>
<td>24</td>
<td>0.6</td>
<td>38</td>
<td>25</td>
</tr>
<tr>
<td>9/20-11/26</td>
<td>II. stress</td>
<td>88</td>
<td>370</td>
<td>27</td>
<td>215</td>
<td>131</td>
<td>122</td>
<td>28</td>
<td>0.6</td>
<td>41</td>
<td>21</td>
</tr>
<tr>
<td>11/27-1/4</td>
<td>II. cold</td>
<td>90</td>
<td>432</td>
<td>21</td>
<td>207</td>
<td>198</td>
<td>182</td>
<td>29</td>
<td>1</td>
<td>47</td>
<td>16</td>
</tr>
</tbody>
</table>
PRINCETON MEADOWS - RESULTS

COD Removal

Phase I
Avg. COD Removal = 83%
Avg. Inf. COD = 293 mg/l
Avg. Eff. COD = 50 mg/l

Phase II
Avg. COD Removal = 88%
Avg. Inf. COD = 393 mg/l
Avg. Eff. COD = 47 mg/l
Ammonia Removal Efficiency

Phase I
Avg. NH₄ Removal = 97%
Avg. Inf. NH₄ = 24 mg/l
Avg. Eff. NH₄ = 0.6 mg/l

Phase II
Avg. NH₄ Removal = 94%
Avg. Inf. NH₄ = 28 mg/l
Avg. Eff. NH₄ = 1.7 mg/l

Influent and Effluent NH₄ (mg/l)

Events:
- Hurricane
- Mechanical shutdowns
“Advanced biological treatment processes”

Minimum SRT at 25 °C = 4 days

Aeration Tank volume is reduced by 43%

### Metcalf-Eddy (MLE nitrification) vs. HYBACS

<table>
<thead>
<tr>
<th>Metcalf-Eddy (MLE nitrification)</th>
<th>HYBACS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRT = 7 - 20 days</td>
<td>SRT = 1.5 - 4</td>
</tr>
<tr>
<td>MLSS 3000-4000 mg/l</td>
<td>MLSS 1200-2000</td>
</tr>
<tr>
<td>HRT 5 - 15 hrs (Anoxic 1 - 3) (Aerobic 4 - 12)</td>
<td>HRT 5.5 (Anoxic 1.4) (Aerobic 4.1)</td>
</tr>
<tr>
<td>F/M Ratio – 0.4 to 0.6</td>
<td>F/M &gt; 1</td>
</tr>
</tbody>
</table>
HYBACS

Process Advantages

- 30 to 40% CAPEX reduction in aeration energy usage
- 30 to 40% Footprint reduction
- Whole Life Cost reduction
- Easiest Upgrade for plants due to modular installation
- Versatile technology for all BOD, and nutrient removal applications
- Higher nitrification rate
- Improved TN removal without chemical dosing
- Improved secondary sludge settleability
- Intrinsically odourless
## CONCLUSIONS

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>ADVANTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD &lt; 10 mg/l</td>
<td>Compliance with legislation</td>
</tr>
<tr>
<td>N removal 75% to 95%</td>
<td>Environmental improvement</td>
</tr>
<tr>
<td>P removal to &lt; 2 mg/l</td>
<td>Potential water reuse</td>
</tr>
<tr>
<td>30% reduction in energy</td>
<td>Reduced OPEX</td>
</tr>
<tr>
<td>Typical 20 - 40% reduction in CAPEX</td>
<td>Sustainability</td>
</tr>
<tr>
<td></td>
<td>Reduced CAPEX</td>
</tr>
<tr>
<td>Typical 30% reduction in footprint</td>
<td>Reduced environmental impact</td>
</tr>
<tr>
<td>Well suited to upgrading</td>
<td></td>
</tr>
</tbody>
</table>
THANK YOU

Questions?

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