Algal Turf Scrubber® as a Nitrogen and Phosphorus Control Measure

Prepared for
Alexandra Ralevski at Biomimicry Institute_AskNature
February 19, 2020
Presentation Outline

1. Introduction of Algal Turf Scrubber® Technology
   • Development History
   • Function and Design
   • Algal Biomass Products

2. Applications and Projects

3. Treatment Performance
   • Nitrogen and Phosphorus Control
   • Biomass Production

4. Treatment Costs

5. Technology Advantages
What is an Algal Turf Scrubber®?

• A culture unit for attached algae

• The algae remove nitrogen and phosphorus from the water

• The algae is regularly recovered and processed

• Recovery of algal biomass maintains the culture units in an accelerated growth phase

• Sustainable treatment performance as nutrients are continuously recovered and removed from the treatment unit
Algal Turf Scrubber® Design

- Effluent Flume
- Influent Distribution Manifold
- Lift Station
- Nutrient Impaired River, Lake or Estuary
- Receiving Water
- Algal Turf Scrubber® Design
- Biomass Recovery Station
- Compost Pad
- Solids Diversion & Settling Pond
- Receiving Water
Algal Turf Scrubber® Design
Water is surged down the sloped floway in a pulsing motion. The pulsing surge stimulates algal growth.
Algal Turf Scrubber® Design
System Inflow
The algal turf biomass is recovered on a 7-14 day cycle using HydroMentia’s proprietary harvest design. The recovered algal biomass contains excess nutrients removed from the water.
Algal turf or dense mats of simple algae are cultivated on the surface of the floway. As the algae grow, they remove nutrient pollutants (phosphorous and nitrogen) from the water.
The algal turf biomass is recovered on a 7-14 day cycle using HydroMentia’s proprietary harvest design. The recovered algal biomass contains excess nutrients removed from the water.
Harvested algae is conveyed by the water via a concrete flume to a centralized recovery facility.
Algal Turf Scrubber® Design
Centralized Biomass Recovery System
The harvested algae is removed from the water with a Flex Rake.
Algal Biomass Products
Algal Biomass Products

- Biofuel Production and Bioplastics
- Compost/Organic Fertilizer and Container Media
- Livestock Feed
Algal Turf Scrubber® Compost/Container Media Production

MAPSoil Typical Analysis

<table>
<thead>
<tr>
<th>Element</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (N)</td>
<td>2.0</td>
</tr>
<tr>
<td>Phosphorus (P₂O₅)</td>
<td>1.0</td>
</tr>
<tr>
<td>Potassium (K₂O)</td>
<td>0.5</td>
</tr>
<tr>
<td>Sulfur (S)</td>
<td>0.2%</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>1.5%</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>0.25%</td>
</tr>
<tr>
<td>Moisture</td>
<td>40%</td>
</tr>
</tbody>
</table>
Composted Algae Growing Media

Composted Algae: Floricultural Crops

Marigold in CA or Peat-Based (PB) substrate with or without fertilizer (Fert and DI, respectively)

Albano et al, 2010 (ASHS abstract/poster)
Composted Algae – Leaf Greenness

![Bar graph showing SPAD levels for different treatments: CA-Fert (A), PB-Fert (B), CA-No Fert (C), PB-No Fert (D). The graph indicates a significance level of P<0.0001 with n=6 and LSD=5.25.]

Albano et al., 2010 (ASHS abstract/poster)
Composted Algae – Fully Open Flowers

Albano et al., 2010 (ASHS abstract/poster)
Composted Algae – Consumer Survey

Consumer Preference Survey for Marigold (Expt. 2)

- 78% CA-Fert
- 20% PB-Fert
- 2% CA-Fert_PB_DI
- 1% CA-Fert

n = 38 (Expt. ME2)

Albano et al, 2010 (ASHS abstract/poster)
Algal Biomass Products

<table>
<thead>
<tr>
<th>Product</th>
<th>15</th>
<th>20</th>
<th>35</th>
<th>40</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compost @ $10/ton</td>
<td>$664</td>
<td>$885</td>
<td>$1,549</td>
<td>$1,770</td>
<td>$2,213</td>
</tr>
<tr>
<td>Methane Gas @ $4.20/MMBTU *</td>
<td>$1,339</td>
<td>$1,795</td>
<td>$2,688</td>
<td>$3,581</td>
<td>$3,591</td>
</tr>
<tr>
<td>Feed @ $80/ton (8% Moisture) *</td>
<td>$5,247</td>
<td>$6,997</td>
<td>$12,244</td>
<td>$13,993</td>
<td>$17,492</td>
</tr>
<tr>
<td>Electrical Energy @ $0.12/kWh *</td>
<td>$8,423</td>
<td>$11,230</td>
<td>$16,845</td>
<td>$22,460</td>
<td>$28,075</td>
</tr>
<tr>
<td>Feed @ $150/ton (8% Moisture) *</td>
<td>$9,839</td>
<td>$13,119</td>
<td>$22,958</td>
<td>$26,237</td>
<td>$32,797</td>
</tr>
<tr>
<td>Container Mix @ $200/ton</td>
<td>$13,276</td>
<td>$17,702</td>
<td>$30,978</td>
<td>$35,403</td>
<td>$44,254</td>
</tr>
<tr>
<td>Feed @ $300/ton (8% moisture) *</td>
<td>$19,678</td>
<td>$26,237</td>
<td>$45,916</td>
<td>$52,475</td>
<td>$65,594</td>
</tr>
</tbody>
</table>

Algal Productivity (dry-g/m²-day)

* Costs of converting biomass to byproducts have not been determined and will vary considerably between products
### Top 5 Florida Agricultural Commodities

<table>
<thead>
<tr>
<th>Rank</th>
<th>Items</th>
<th>Value of Agricultural Sales (Thousands $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Greenhouse/Nursery</td>
<td>1,745,219</td>
</tr>
<tr>
<td>2</td>
<td>Oranges</td>
<td>1,248,875</td>
</tr>
<tr>
<td>3</td>
<td>Tomatoes (Fresh Market)</td>
<td>630,750</td>
</tr>
<tr>
<td>4</td>
<td>Sugarcane</td>
<td>542,951</td>
</tr>
<tr>
<td>5</td>
<td>Cattle/Calves</td>
<td>502,456</td>
</tr>
</tbody>
</table>

2012. Florida Agriculture by the Numbers, FDACS
Algal Turf Scrubber® Applications and Projects
### Surface Water Restoration

<table>
<thead>
<tr>
<th>Application</th>
<th>Segment</th>
<th>Description of Opportunity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface water restoration</td>
<td>Municipal</td>
<td>Direct treatment and removal of pollutants causing Impairments such as nitrogen and phosphorus</td>
</tr>
</tbody>
</table>

### Non-Point Source Pollution Reduction

<table>
<thead>
<tr>
<th>Application</th>
<th>Segment</th>
<th>Description of Opportunity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment of agricultural runoff</td>
<td>Agricultural</td>
<td>Reduction of pollutants primarily nitrogen and phosphorus from agricultural lands to meet TMDLs</td>
</tr>
<tr>
<td>Treatment of urban runoff</td>
<td>Municipal</td>
<td>Reduction of pollutants primarily nitrogen and phosphorus from urban lands to meet TMDLs</td>
</tr>
<tr>
<td>Potable water supply enhancement</td>
<td>Municipal</td>
<td>Reduction of pollutants primarily nitrogen and phosphorus that impact potable water quality through stimulation of algal growth in surface waters</td>
</tr>
</tbody>
</table>
# Point Source Pollution Reduction

<table>
<thead>
<tr>
<th>Application</th>
<th>Segment</th>
<th>Description of Opportunity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic wastewater treatment</td>
<td>Municipal</td>
<td>Reduction of pollutants primarily nitrogen and phosphorus from municipal wastewater discharges</td>
</tr>
<tr>
<td>Industrial wastewater treatment</td>
<td>Industrial</td>
<td>Reduction of pollutants primarily nitrogen, phosphorus and metals from industrial discharges</td>
</tr>
<tr>
<td>Remediation of confined animal feedlot operations and aquaculture</td>
<td>Agricultural</td>
<td>Reduction of pollutants primarily nitrogen and phosphorus from operations livestock production facilities to meet National Pollutant Discharge Elimination System (NPDES) permitting</td>
</tr>
</tbody>
</table>
Patterson ATS™
Stanislaus County, CA
0.2 MGD x 500’
HMI Aquaculture ATS™ (2000-2002)  
Okeechobee County, FL  
30 MGD x 220’
S-154 ATS™ with WHS Pre-Treatment (2003-2004)
Okeechobee County, FL
1-6 MGD x 300’
System Stability – Extreme Weather Conditions
2004 Hurricanes Frances and Jeanne

IN SOUTH FLORIDA

△ S-154 ATS™
▲ STA 1W ATS™
Lake Lawne ATS™ (2008-2009)
Orange County, FL
2 x 110 m³/day x 500’
Powell Creek ATS™
(2009)
Lee County, FL
Pilot
Santa Fe ATS™
(2009)
Alachua County, FL
Pilot
Egret Marsh ATS™
(2010)
Indian River County, FL
38,000 m³/day x 575’
Dalton GA ATS™
(2010)
New York, NY
110 m³/day x 880'
Rockaway NY  ATS™
(2010)
New York, NY
110 & 220 m³/day x 300'
PC South ATS™
(2011)
Indian River County, FL
110 m³/day x 500’
Osprey Marsh ATS™
(2015)
Indian River County, FL
38,000 m³/day x 575’
2017 – Indian River County Florida – Osprey Marsh Algal Turf Scrubber®

View of Headworks
2017 – Indian River County Florida – Osprey Marsh Algal Turf Scrubber®

View of 575’ ATS™ Floway from Headworks
2017 – Indian River County Florida – Osprey Marsh Algal Turf Scrubber®

View from Effluent
2017 – Indian River County Florida – Osprey Marsh Algal Turf Scrubber®

Natural planting at Headworks of ATS™
2017 – Indian River County Florida – Osprey Marsh Algal Turf Scrubber®

View of Headworks
Algal Turf Scrubber®
Treatment Performance
Nutrient Areal Removal Rates Based on Algal Productivity (dry-g/m2-day) and Tissue Nutrient Concentrations.
Algal Turf Scrubber® Relationship of Inflow Nitrogen Concentration and Areal Removal Rates

![Graph showing the relationship between inflow nitrogen concentration and areal removal rate]
Algal Turf Scrubber® Relationship of Inflow Phosphorus Concentration and Areal Removal Rates
Algal Turf Scrubber® Optimization for High Level Total Nitrogen Reduction

Data from Recycle ATS™ (RC-ATS™) System
Algal Turf Scrubber® Optimization for High Level Total Phosphorus Reduction

Data from Recycle ATS™ (RC-ATS™) System
NonPoint and Point Source Phosphorus Control
Relationship of Phosphorus Mass Loading and Areal Removal Rate
Algal Turf Production Rates from Six (6) Algal Turf Scrubber® Water Treatment Systems
Productivity Reported as dry-g/m²-day
Algal Turf Scrubber®
Treatment Costs
Figure 1. Nutrient Areal Removal Rates Based on Algal Productivity (dry-g/m²-yr) and Tissue Nutrient Concentrations.

Figure 2. 25YR Present Worth Costs for Nutrient Removal at Varying Nutrient Areal Removal Rates based on application of a 25 MGD Algal Turf Scrubber® System.
Algal Turf Scrubber® (ATS™)

Estimate Pollutant Treatment Price given Areal Removal Rate and Facility Size. Assume Water Delivery Provided by Others.

Algal Turf Scrubber® Based Phosphorus Treatment Price Assumes 25 Year Ammortization of Capital Costs and Includes System Engineering & Design, Construction, Technology Fees and Operational Costs.
Algal Turf Scrubber® Technology Advantages
Algal Turf Scrubber® Technology

Advantages:

• High Level Treatment Capabilities – Restoration to Background Levels

• Cost Effective Treatment Even as Pollutant Concentrations are Reduced Over Time

• Quantified Removal of Pollutants

• Direct Treatment

• Lower Treatment Costs

• Reduced Land Requirements

• Revenue Generating Byproducts