The Science of Algae

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The Algae

• Diverse Classification (many kingdoms)

• Elaborate Characteristics

• No true roots, stems or leaves
• Over 30,000 species
• Identification
  — Important in determining management
Introduction to Algae Phyla

- **Chlorophyta**
  - Green algae

- **Cyanophyta**
  - Blue-green algae

- **Charophyta**
  - Plant like, erect

- **Euglenophyta**
  - Flagellated, eye spot (some red)
Introduction to Algae Phyla

- **Pyrrophyta**
  - Dinoflagellates, transverse flagellum

- **Bacillariophyta**
  - Diatoms, silica wall

- **Chrysophyta**
  - Yellow-green

- **Haptophyta**
  - Golden algae
Seasonal Succession
General Pattern
Algae Succession
The good?
The bad
Problematic Algae

Algal impacts

Economic

Drinking/irrigation
Tourism
Property values

Ecological

Toxins /taste & odor compounds
Disrupt habitat/ Outcompete

Water characteristics

(Vision. Science. Solutions.)

(Speziale et al. 1991; Falconer 1996; WHO 2003)
Algae Impacts

- Water quality and ecological
  - Oxygen demand
  - pH fluctuations
  - Densities

- Secondary Compounds
  - Toxins
    - Microcystins “liver”
    - Saxitoxins “brain”
    - LPS “stomach”
    - Aplysiatoxins “skin”
  - Taste and odor
    - Geosmin “dirty”
    - MIB “fishy”
Proactive Management
Sources of Nutrients

- Fertilizer
- Pet waste
- Wildlife
- Livestock/agriculture
- Municipal wastewater
- Industrial effluent
- Atmospheric deposition

Scotts to remove phosphorus in fertilizer
Phosphorus

• Limiting nutrient in freshwater
• Correlative to
  – Algae biomass
  – Increased bloom frequency
  – Harmful algae blooms (N:P)
  – Trophic status
  – 1 pound P supports 500 pounds algae
• Prevention approach (NPDES)

<table>
<thead>
<tr>
<th>Trophic Status</th>
<th>Phosphorus</th>
<th>Chlorophyll</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oligotrophic</td>
<td>12 ppb</td>
<td>0-2.6</td>
</tr>
<tr>
<td>Mesotrophic</td>
<td>12-24 ppb</td>
<td>2.7-20</td>
</tr>
<tr>
<td>Eutrophic</td>
<td>25-96 ppb</td>
<td>20-56</td>
</tr>
<tr>
<td>Hypereutrophic</td>
<td>&gt; 96 ppb</td>
<td>&gt; 56</td>
</tr>
</tbody>
</table>
Phosphorus (Evil P) Mitigation

• External BMP’s critical
• Internal accumulation (often a significant P fraction)
  - TN:TP ratio 5:1 cyanobacteria overwhelmingly dominant
    artificially induced (Ghadouani et al. 2003)
  - Low TN:TP cyanobacteria dominate (Lake Michigan) (Seale et al. 1987)
  - TN:TP ratio 29:1, dominated by green algae (Smith 1983; 12 lakes throughout the world)
  - Si:P < 25:1 Microcystis dominates, more silica more Asterionella (Holm & Armstrong 1981)

• Cyanobacteria use: carbon (use CO2 and CO3), Light (Phycocyanin), Temperature (>24C, not always), Moving water (Planktothrix, Anabaena planctonica)
Nitrogen Fixation

\[ \text{N}_2 (g) + 3 \text{H}_2 (g) \rightleftharpoons 2 \text{NH}_3 (g) \]

Heterocysts

Paerl 1990; Paerl et al. 1991
Phosphorus Management Options

• Chemical
  – Lanthanum modified bentonite (Phoslock, specific, no buffer, permanent)
  – Aluminum sulfate (Alum, non-specific, pH crash, release)
  – Algaecide/phosphorus remover (SeClear)
  – Polymers (Floc Log, Chitosan)
  – Iron (non-specific, release)/ Calcium (high pH only, release)

• Other
  – Aeration (oxygenate benthic layers)
  – Dredging
  – Bacteria?
Phoslock Application
Park Project using reclaimed water

Before Phoslock

After Phoslock
Park Lake Results

Soluble Phosphorus
• Pre Treatment   0.062 mg/l
• Post Treatment  < 0.010 mg/l
  – Maintained low from November to March
  – No cyanobacteria blooms seen

Total Phosphorus
• Pre Treatment   0.082 mg/l
• Post Treatment  0.037 mg/l

Secchi Disk
• 0.25 to 4 feet
Treated with Phoslock

No Phoslock Treatment
Reactive
Control Techniques

- **Action Options**
  - **Mechanical**
    - harvesters, sonication
  - **Physical**
    - dyes, aeration, raking
  - **Biological**
    - bacteria, grass carp, Tilapia
  - **Chemical**

VISION. SCIENCE. SOLUTIONS.
USEPA Algaecides

- Diquat Dibromide
- Endothal
- Peroxides
- Copper (Captain / SeClear)
  - Chelated v. free ion
- Adjuvants
70% reduction in P

Neurotoxins/
Hepatotoxins/
Geosmin

305,000 cells/mL

Copper
sulfate

VISION. SCIENCE. SOLUTIONS.
# Field Site 1

<table>
<thead>
<tr>
<th>Site Name:</th>
<th>K Pond</th>
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</thead>
<tbody>
<tr>
<td>Site Location:</td>
<td>Galion, OH</td>
</tr>
<tr>
<td>Size:</td>
<td>1/3 acre</td>
</tr>
<tr>
<td></td>
<td>4 ft average depth</td>
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</tbody>
</table>

### Water Character:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>pH</td>
<td>8.9</td>
<td>Dissolved Oxygen</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>44</td>
<td>Conductivity</td>
</tr>
<tr>
<td>Hardness</td>
<td>48</td>
<td>Total Phosphorus</td>
</tr>
</tbody>
</table>

0.4 mg Cu/L on algal mats, ONE application (treated 7/16/11)
“Worst ever filamentous mats”... “slimy, brownish”
### Field Site 2

<table>
<thead>
<tr>
<th>Site Name:</th>
<th>Golf Course Pond</th>
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<tbody>
<tr>
<td>Site Location:</td>
<td>Coastal, NC</td>
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<tr>
<td>Size:</td>
<td>0.47 acre</td>
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<tr>
<td></td>
<td>3.5 ft average depth</td>
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<td><strong>Water Character:</strong></td>
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<tr>
<td>pH</td>
<td>7.4</td>
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<tr>
<td>Alkalinity</td>
<td>106</td>
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<tr>
<td>Hardness</td>
<td>114</td>
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<tr>
<td>Dissolved Oxygen</td>
<td>4.8</td>
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<tr>
<td>Conductivity</td>
<td>282</td>
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<tr>
<td>Turbidity</td>
<td>17.5</td>
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</tbody>
</table>

The Mess

- SeClear Algaecide & Water Quality Enhancer
  - Applied at 200ppb + 1% sufactant to ¼ of the pond on 7/21/11
  - After 2 applications (3 weeks apart) algae gone
“Looks better than it ever has with very little re-growth”

- From 75% to 5% coverage in one week
  < 2% after three weeks
- Total Phosphorus decreased from 1502 to 1018 ppb after 5 treatments (32%)
Summary

• Algae are diverse and widespread throughout water resources
• Algae can restrict uses of a water resource and pose threats to biota
• Phosphorus mitigation is a critical piece to algae management
• Algaecides can control nuisance algae and restore a balanced community
Thank You