Chemical Treatment of Phosphorus in Lake Okeechobee Sediments as a Management Option to Reduce Bioavailability

July, 2010
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Our Legacy

The Sediments Become the Source
Study Objectives

- Determine if chemical treatment is a feasible option for reducing phosphorus in the Lake Okeechobee water column
- Determine if chemical treatment will also control the release of phosphorus from the sediments
  - Typical lake conditions
  - Sediment resuspension - hurricanes
- Determine the most effective chemical(s) for treatment
- Determine fish toxicity of key chemicals
Sediment contaminant data at 19,398 sampling stations nationwide

- 8,348 or 43% are *probably* associated with harmful effects on aquatic life or human health
- 5,846 stations or 30% are *possibly* associated with harmful effects on aquatic life or human health
- 5,204 or 27% have *no indication* of associated harmful effect
Five Major Types of Pollutants are Found in Sediments:

- **Nutrients**, including phosphorous and nitrogen compounds such as ammonia.
- **Bulk Organics**, a class of hydrocarbons that includes oil and grease.
- **Halogenated Hydrocarbons or Persistent Organics**, a group of chemicals that are very resistant to decay. DDT and PCBs are in this category.
- **Polycyclic Aromatic Hydrocarbons (PAHs)**, a group of organic chemicals that includes several petroleum products and byproducts.
- **Metals**, such as iron, manganese, lead, cadmium, zinc, and mercury, and **metalloids** such as arsenic and selenium.
Possible Sediment Management Options

- Dredge
- Chemically treat
- Do Nothing – natural attenuation
- ASR Releases
- Combination of the Above
The Lake O. and S. Florida Problem

- Frequent blue-green algal blooms
- Loss of macroinvertebrate diversity in lake sediments
- Impact of phosphorus on downstream ecosystems
- South Florida has over 1,800 miles of canals that have diverted fresh water from the Everglades
Nutrient Cycling in Aquatic Systems

- Algal Biomass
- Lysed Cells
- POC/DOC Pool
- N&P Release
- Bacteria
- Water & Sed
- CO₂
- N&P Runoff
- POC/DOC Runoff
- O₂
The mud sediments are characterized as black organic-rich mud and high water content (84.2%).

Analytical testing of sediment cores obtained from the mud zone indicated that TP in the mud sediments ranges from approximately 200 to 2,000 milligrams per kilogram (mg/kg),
M9 Background

- It has been estimated that there are 80,000 hectares of lake bottom covered by organic mud.
- Internal cycling of P is driven by diffusion and wind-driven resuspension of the sediments.
- The internal loading is estimated to be similar to the current level of external loading.
- Could delay the reduction of the current water column P concentration.
It is an important state and local resource which provides water supply
- For nearby towns
- Agricultural operations
- Downstream ecosystems

A multi-million dollar recreational fishery

Provides flood control for surrounding communities

Home to migratory water fowl, wading birds and the federally endangered Everglade Snail Kite
Variables Studied

- 4 Chemicals
- 4 Dose concentrations
- Time
- Stationary
- Resuspended sediments
- Total Phosphorus (TP)
- Soluble Reactive Phosphorus (SRP)
- Turbidity
- Conductivity
- pH
Sediment Core Collection

- Gravity corer – 9.5 cm diameter
- 20 cm of sediment
- 50 cm of overlying water
- 27°C ambient water temperature
Sample Treatment

- Three cores were collected for each treatment including 3 control samples
  - 51 cores stationary treatment
  - 51 cores for resuspension treatment
- 200 gallons of lake water
- Only laboratory treatment was aeration and kept in the dark
- Cores were not biologically poisoned
Test Chemicals and Dose Concentrations

- Alum (10, 20, 30 and 40 mg/L)
- FeCl₃ (5, 10, 50 and 100 mg/L)
- CaCO₃ (10, 50, 100 and 200 mg/L)
- Ca(OH)₂ (10, 50, 100 and 200 mg/L)
Resuspension Simulator
Laboratory Setup
- Water samples taken 10 cm above the sediments
- SRP Samples were filtered and analyzed
- TP Samples analyzed as collected
# Means, SD and CV for Day 0

<table>
<thead>
<tr>
<th></th>
<th>Turbidity (NTU)</th>
<th>Conductivity (microsiemens/cm)</th>
<th>SRP (mg/L as P)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>14.703</td>
<td>0.463</td>
<td>0.099</td>
</tr>
<tr>
<td><strong>Standard Deviation</strong></td>
<td>5.360</td>
<td>0.009</td>
<td>0.018</td>
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<tr>
<td><strong>Coefficient of Variation</strong></td>
<td>0.365</td>
<td>0.019</td>
<td>0.182</td>
</tr>
</tbody>
</table>
Average SRPS for Stationary Calcium Carbonate Samples

CaCO3 Stationary SRP

Sample Day

SRP mg/L

0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16 0.18 0.2

0 5 10 15 20 25 30 35

10 mg/L
50 mg/L
100 mg/L
200 mg/L
Average SRPS for Resuspended Calcium Carbonate Samples

CaCO3 SRP Resuspended

Sample Day

SRP mg/L

0  5  10  15  20  25  30  35

0  0.02  0.04  0.06  0.08  0.1  0.12

10 mg/L
50 mg/L
100 mg/L
200 mg/L
Average SRPS for Stationary Calcium Hydroxide Samples
Average SRPS for Resuspended Calcium Hydroxide Samples

CaOH SRP Resuspended

Sample Day

SRP mg/L

10 mg/L
50 mg/L
100 mg/L
200 mg/L
Average SRPS for Stationary Alum Samples

Stationary Alum SRP

SRP mg/L

Sample Day

0 5 10 15 20 25 30 35

SRP ng/L

0 0.02 0.04 0.06 0.08 0.1 0.12 0.14

10 mg/L

20 mg/L

30 mg/L

40 mg/L
Average SRPS for Resuspended Alum Samples

![Graph showing Alum SRP Resuspended over Sample Days for different concentrations (10 mg/L, 20 mg/L, 30 mg/L, 40 mg/L).]
Average SRPS for Stationary Ferric Chloride Samples

FeCl SRP Stationary

 SRP mg/L

Sample Day
Average SRPS for Resuspended Ferric Chloride Samples
In Summary

- Calcium carbonate did not show any real control over SRP
- Calcium hydroxide did initially reduce SRP at the higher doses but data showed a release over time
- Alum was effective in reducing SRP and increased water column clarity but showed a release over time
- Ferric chloride above 5 mg/l was effective in reducing SRP over the 32 day study
- Toxicity studies with bluegill larvae for alum and ferric chloride did not have an effect at the highest dose