

Understanding Oxygen Dynamics in Culture Ponds

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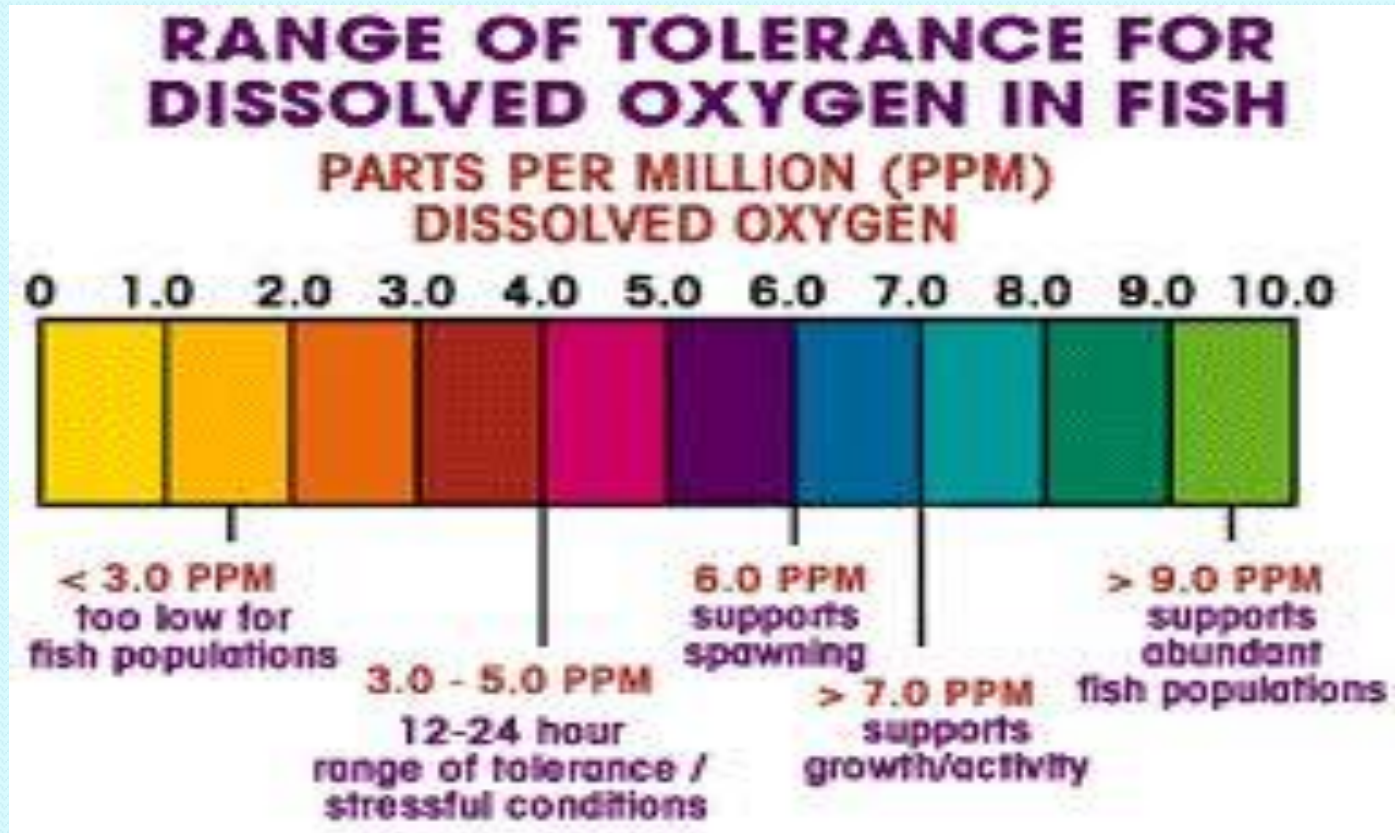
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Aquaculture Realism

- “A Severely or Chronically Stressed Fish is a Dead Fish”
 - Severe stress is typically caused by a sudden event, causing death within minutes or up to a day.
 - Chronic stress is longer term exposure to poor living conditions, causing impairment to the immune system.
 - “A chronically stressed fish is a diseased fish and then eventually a dead fish”

Low oxygen levels can cause either scenario!

Dissolved Oxygen & Fish Needs



- Considerable variation among species!

Simply

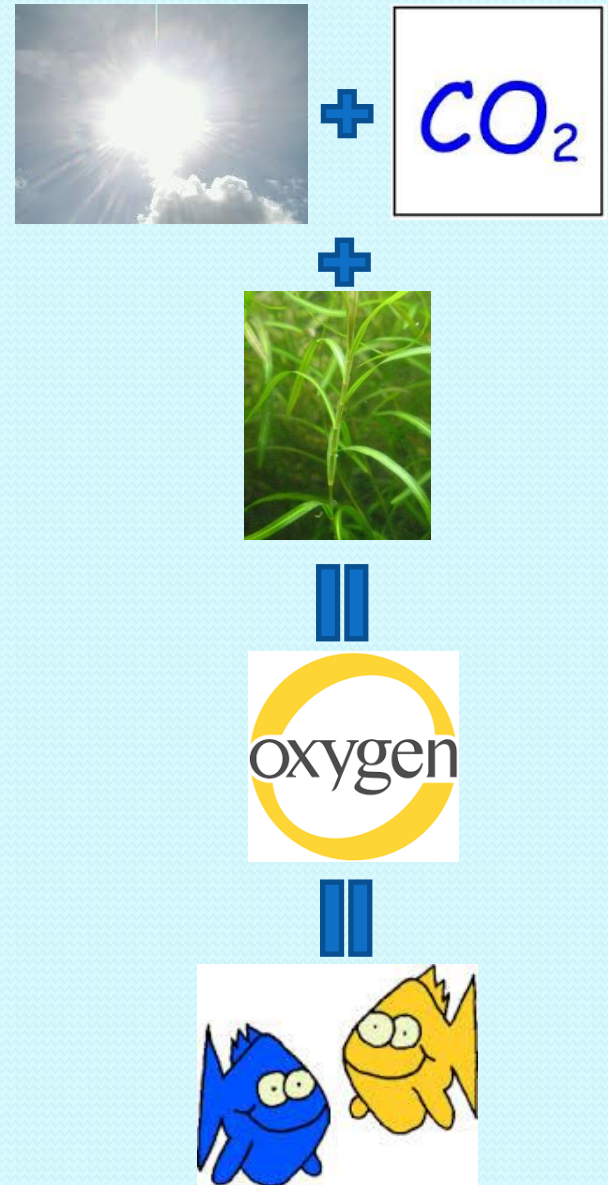


- Oxygen in aquaculture is a function of supply and demand, or more correctly, production versus consumption!
- If daily production exceeds consumption, all is well.
- If daily consumption slightly exceeds production, monitor closely.
- If daily consumption significantly exceeds production, be on your toes!

Oxygen Production I

• Photosynthesis by Plants

- Major source (95%) of oxygen production in ponds.
- Production highest on sunny days, considerably less on cloudy days.
- All aquatic plants & algae photosynthesize to produce oxygen.
- Moderate levels of plants & algae preferred.
- Too little and too much problematic for culture ponds.



Oxygen Production II

- Wind

- Minor source of oxygen production in ponds due to small size.
- Oxygen production by wind greatest on large lakes where high winds can cause breaking waves & whitecaps, aerating the top several feet of water.
- Not possible on culture ponds, nor do you want it to happen. Would tear up banks, create water turbidity, and suspend bottom organic material.



Oxygen Production III

• Artificial Aeration

- Often a life-saver for culturists, must have systems in place ready to go.
- Surface aerators most efficient at adding oxygen to culture ponds, particularly in low oxygen events.
- Bottom bubble diffusers excellent at preventing stratification, but do not add oxygen fast and efficiently.



Oxygen Consumption I

- Respiration

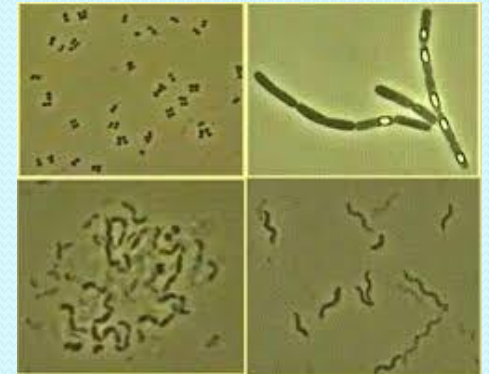
- All living organisms respire all day, taking in oxygen and releasing carbon dioxide.
- Respiration affected by water temperature, increased respiration in warmer water.
- Plants and algae also respire all day. Key is for these chlorophyll laden plants and algae to produce more oxygen during daylight than they use all day via respiration.



Oxygen Consumption II

- Microbial Decay of Organics

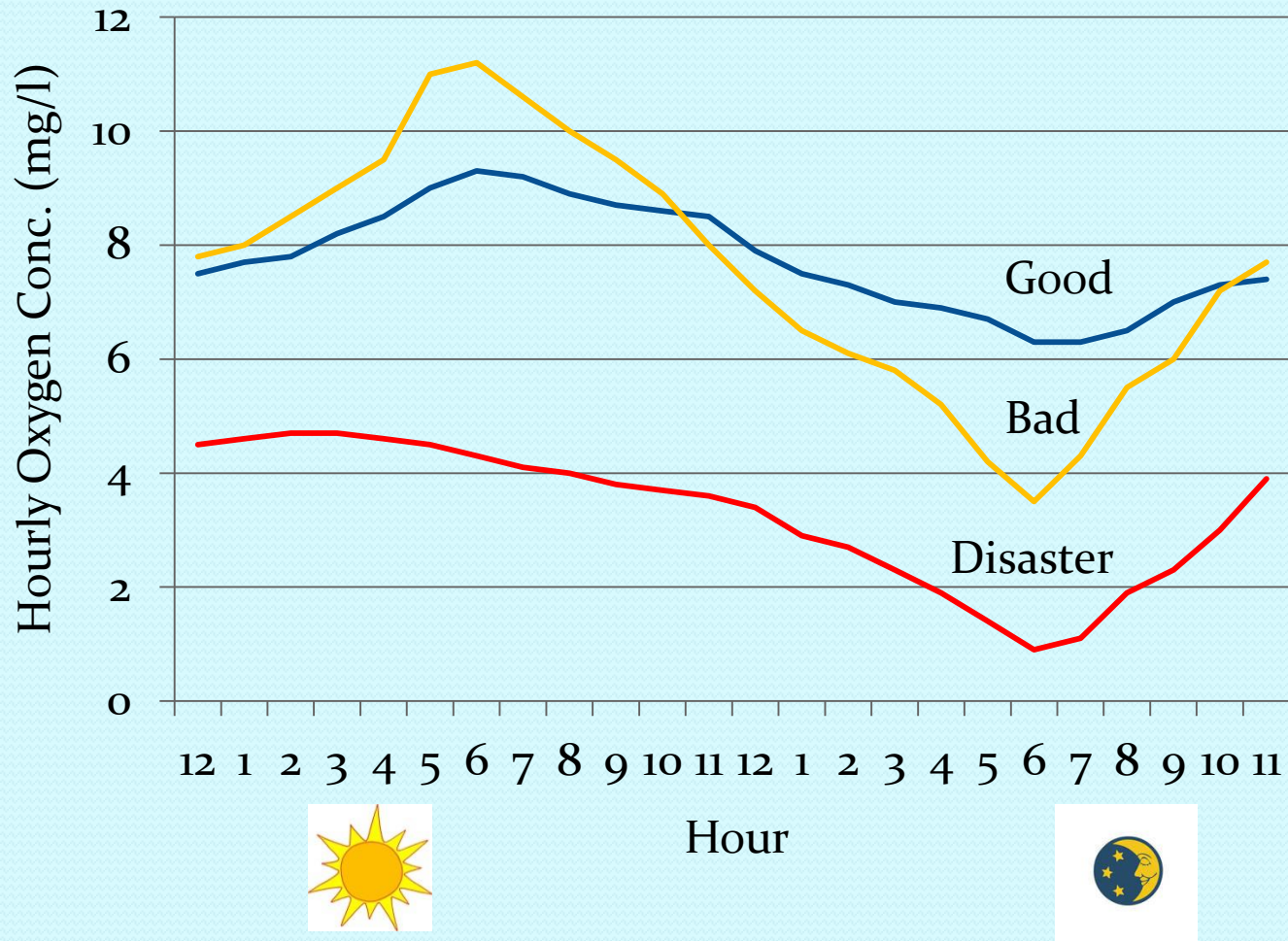
- Organic Sources:
 - Dead organisms, such as fish, invertebrates, plants & algae.
 - Organism's digestive wastes.
 - Uneaten feed (minimal we hope!).
- Aquatic bacteria community decays all this organic material.
- Decay rate is temperature dependent, increased degradation in warmer water. Very slow in winter.



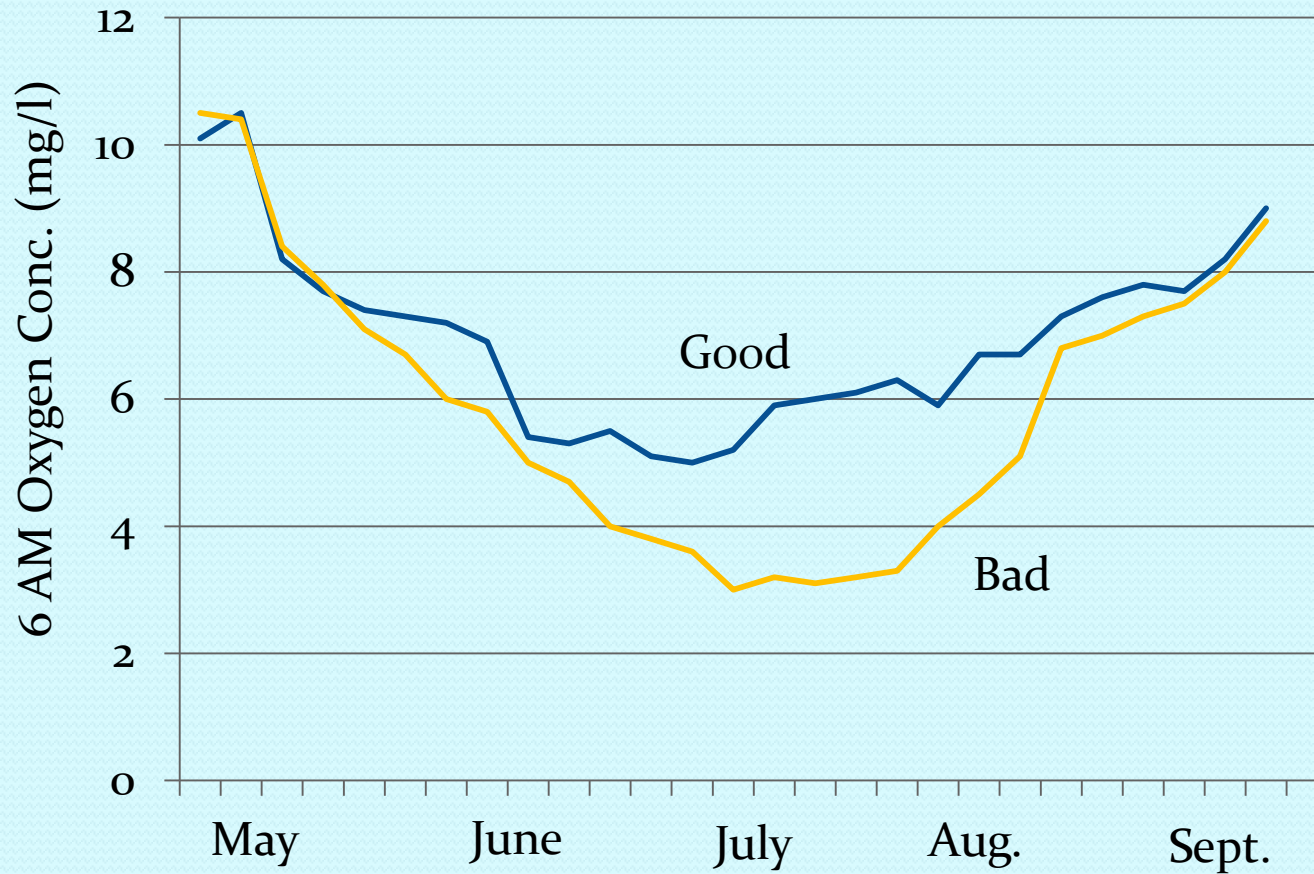
Good and Bad Bacteria

- **Aerobic bacteria (good)**
 - Very efficient at completely decaying organic matter in the presence of oxygen.
 - Typically found in oxygenated shallow water and on the surfaces of plants.
 - Can be found in deep water of culture ponds if operator uses aeration to enhance deep water oxygen levels.
- **Anaerobic bacteria (bad)**
 - Very inefficient at decaying organic matter, outcompeted by aerobic bacteria if good oxygen levels are maintained.
 - Causes the buildup of black muck, higher ammonia and nitrite levels, and release of obnoxious hydrogen sulfide gas.

Oxygen: Daily Variation



Oxygen: Growing Season Variation



Factors Affecting Daily & Seasonal Oxygen Levels

- Sunlight
 - Sunlight critical to photosynthesis that produces oxygen, respiration & organic decomposition uses oxygen at night.
 - Cloudy days lower daylight oxygen production, affecting night levels.
 - After June 21, losing daylight. Nearly 3 hrs. less by Sept. 21.
- Water temperature
 - Warm water holds less oxygen than cool water.
 - Oxygen saturation at 55 F is 10.52 ppm; at 75 F it is 8.40 ppm



Factors Affecting Daily & Seasonal Oxygen Levels

- Amount of aquatic plants / algae / planktonic algae
 - “Choked” greenery elevates daytime oxygen to very high levels but night levels are very low (Respiration).
 - Sudden die-off of planktonic algae major cause for concern.
 - Aquatic plants / filamentous algae do not die-off suddenly unless you do it!
 - Whole pond treatments with herbicide or algaecide can crash oxygen levels!



Bad



Good

More Factors Affecting Daily & Seasonal Oxygen Levels

- Feeding
 - Lower oxygen levels during periods of heavy feeding.
 - Begin to elevate a pond's BOD quickly once feeding exceeds 15 lbs. per day per acre.
 - There is a feed / waste cumulative effect.
- Fish size
 - 2nd year growout equals higher feed amounts in June, July, & August as compared to 1st year fingerlings.



More Factors Affecting Daily & Seasonal Oxygen Levels

- Aeration
 - Nighttime oxygen levels can be raised with vigorous surface aeration.
- Volume of oxygen-less water
 - Increased volume of “hypolimnion” lacking oxygen lowers night levels.
- Sudden pond “turnover”
 - Only in stratified ponds.
 - Heavy rain / wind / inflow (i.e. storms) can cause pond to mix suddenly, lowering oxygen levels quickly.



Oxygen BMP I

- **Monitor Oxygen Level Trends**
 - Trend monitoring allows assessment of how the production pond is functioning.
 - Allows assessing impacts of changes to pond oxygen levels, such as increased feeding.
 - Can alert culturist to impending problems, thereby allowing a corrective action(s) to be instituted early.
 - **Oxygen must be monitored regularly to allow development and evaluation of trends.**
 - Daily during warm weather and periods of heavy feeding. Once every 3-4 days otherwise.

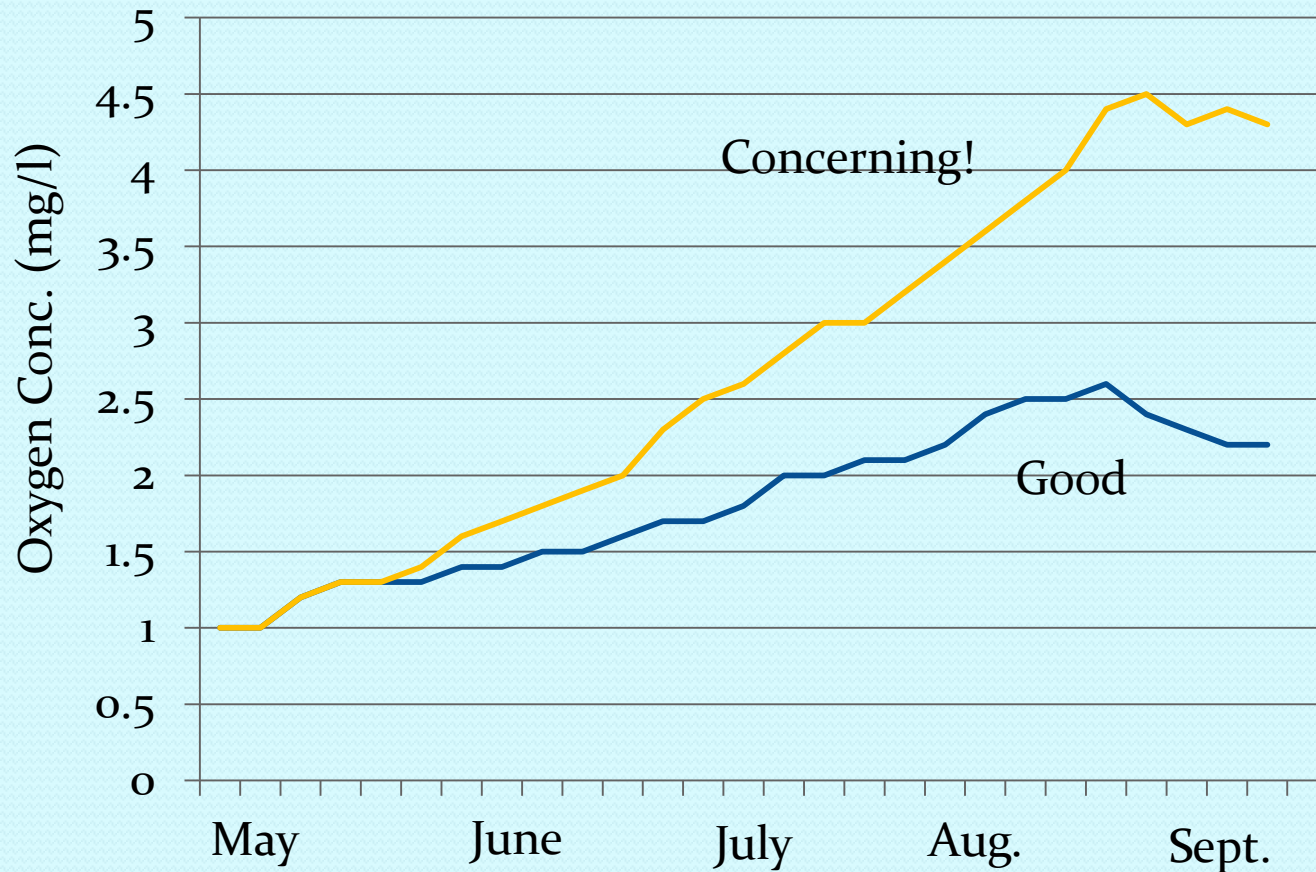


Oxygen BMP II

- **Know Overnight BOD!**

- BOD is biological oxygen demand, a sum of all oxygen consumption processes.
- Knowing dusk to dawn BOD provides insight into potential surface aeration needs.
- BOD generally increases as summer progresses due to:
 - Declining sunlight
 - Warmer water
 - Increased feeding
 - Plant abundance increases, then slowly dies off
- Calculated as dusk oxygen level minus dawn oxygen level.

Overnight BOD: Growing Season Variation



Oxygen BMP III

- **Have Surface Aerators Nearby & Ready!**
 - Only reliable way to efficiently add oxygen quickly.
 - Surface aeration should be used at night when dawn oxygen levels are about 6 ppm and/or overnight BOD exceeds 3 ppm.
 - Leave on during cloudy days when the above scenarios are occurring.



Oxygen BMP IV

- **Aerate your bacterial community!**
 - Bottom bubble diffusers, or direction surface aeration in ponds.
 - Prevents water column oxygen stratification in ponds. No turnovers!
 - Better oxygen profile, including oxygen along the pond bottom.
 - Improves aerobic bacteria abundance & efficiency.
 - Enhances waste degradation and conversion of ammonia into harmless nitrates.
 - Keeps un-ionized ammonia levels at very low levels if not zero.



Oxygen BMP V

- **Encourage / Tolerate a Diverse Aquatic Plant Community!**
 - Combination of algae & submerged plants at 15-20 % coverage.
 - Mitigates seasonal and daily “boom & bust” oxygen levels prevalent in ponds dominated by planktonic algae.
 - Improves aerobic bacteria abundance & efficiency due to increased surface area on plant stems & leaves
 - Enhances waste degradation and conversion of ammonia into harmless nitrates.
 - Keeps un-ionized ammonia levels at very low levels if not zero.



Oxygen BMP VI

- **Avoid Whole Pond Treatments with Herbicides or Algaecides!**

- Can lead to lethal levels of oxygen.
 - Eliminates major source of oxygen – photosynthesis.
 - Living organisms still need oxygen.
 - Decomposition of dead plants & algae use up large amounts of oxygen.
- Decomposition can cause high levels of ammonia, including toxic, un-ionized ammonia.



Questions?