Phosphate, The Green Fuel

Jackie Kabrell

6-20-2015
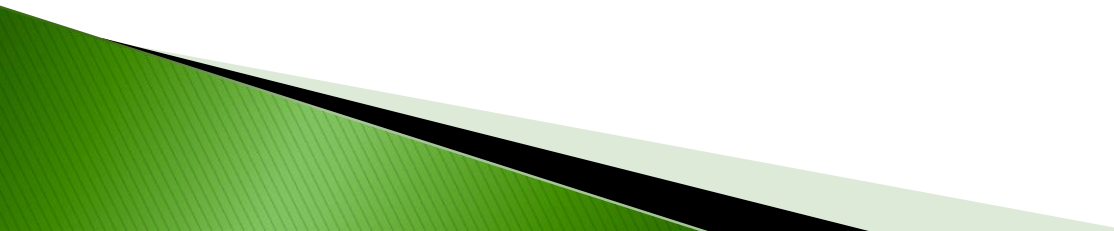
Thanks to
Tom Herron,
Idaho Department of Ecology Water Quality Manager
who introduced me to the idea of Total P of my pond

Phosphate, The Green Fuel Part I – What is It?

Phosphate, The Green Fuel

- What is phosphate?
- Where does it come from?
- What does it do in my pond?
- Why do I care?

Why do I care?

- Excess phosphate or phosphorus
  - Will cause algae to grow faster than an ecosystem can handle
  - Makes our ponds green
    - Planktonic (pea soup) algae
    - String algae
  - Can't see our fish or other plants

- Algae consumes oxygen at night
  - Potential fish stress
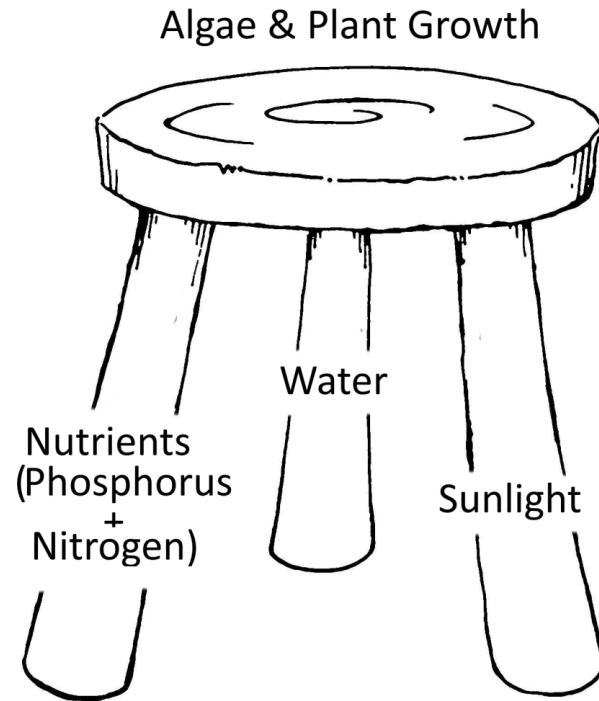
Phosphorus alone is not considered harmful to fish.

What is Phosphate?

- PO_4^{-3}
  - A molecule of phosphorus and oxygen

- Essential
  - Phosphorus is an essential nutrient for plant (Algae) growth
    - Required for photosynthesis

P is a Limiting Nutrient

Algae & Plant Growth

Water
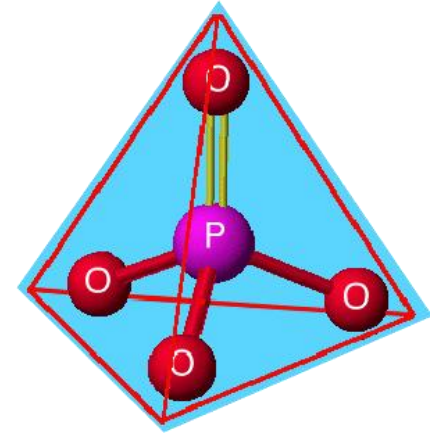
Nutrients
(Phosphorus
+
Nitrogen)

Sunlight

*Eliminate any leg …
and the stool fails.*

Nitrogen and Phosphorus are both <u>essential</u>
Nitrogen is plentiful
Phosphorus (phosphate) can be managed

Where Does it Come From?

- Natural & Human Sources
  - Soil & rocks
  - Wastewater treatment plants
    - P added to process the water
  - Runoff from lawn fertilizer
  - Commercial cleaning solutions
  - Municipal Water – added to condition/protect conduit

Where Does it Come From?

- Koi Ponds
  - Fish poop
  - Uneaten Fish Food
  - Decaying Plant Matter
  - Bird Poop (& turkey poop! Turkeys love my waterfall)
  - …
  - And very possibly your source water

Understand P or Get Off the Pond Phosphorus is as Phosphorus Does

by Courtney E. Rickett & Matt Rayl

By the POND BOSS magazine

Four Types of Phosphate

- ## 1- Orthophosphate

  ◦ basically plant food and the type of phosphate found in fertilizer
  ◦ Bio Available or Reactive

- ## 2- Organically bound phosphate

  ◦ Living matter (algae, plants)
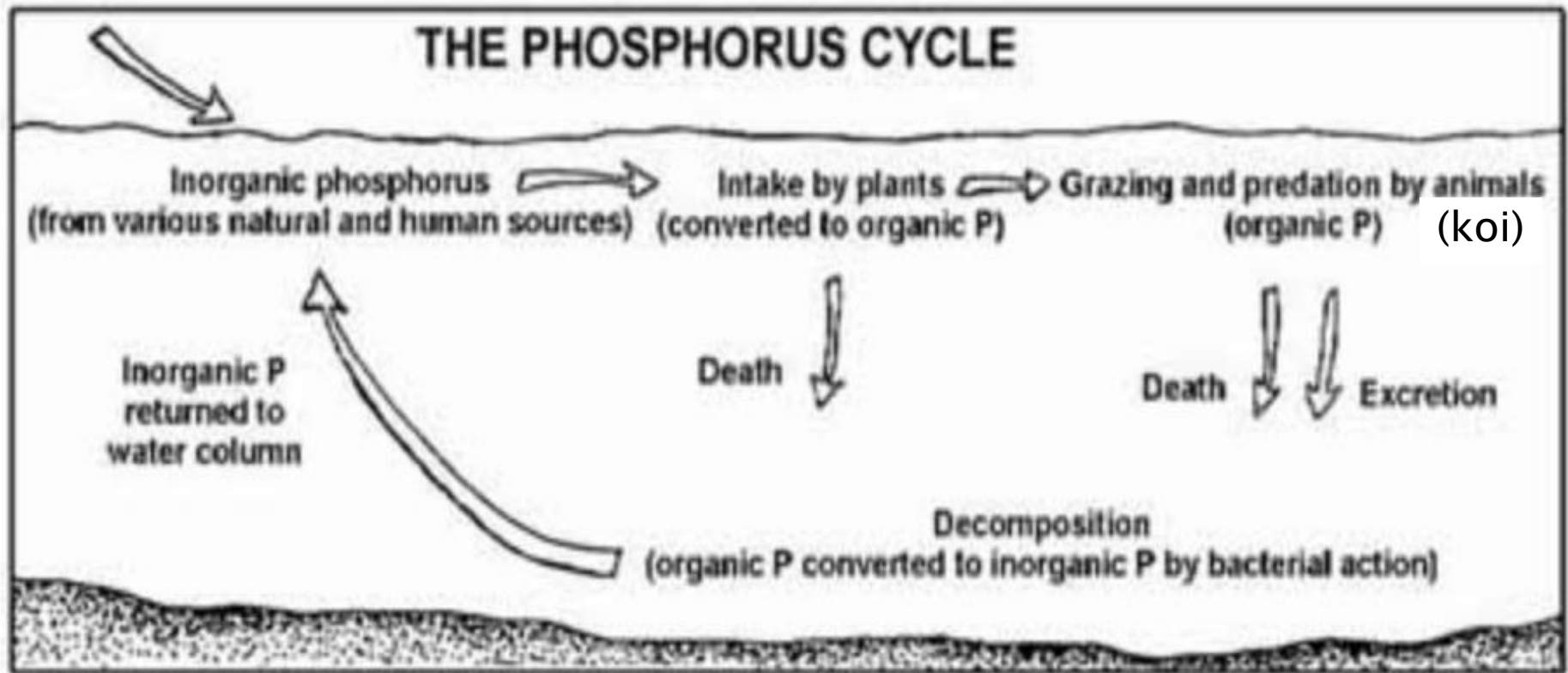   - Becomes bio available (orthophosphate) after bacteria breaks it down.

Four Types of Phosphate

- **Condensed (Polyphosphates)**
  - Added to municipal water supplies to prevent formation of scaling in pipes.

- **Total Phosphate**
  - the sum of the above three.

Phosphorus Cycle: Inorganic<->Organic

THE PHOSPHORUS CYCLE

Inorganic phosphorus ➡️ Intake by plants ➡️ Grazing and predation by animals
(from various natural and human sources)   (converted to organic P)   (organic P)   (koi)

Inorganic P returned to water column   Death ⬇️   Death ⬇️   Excretion ⬇️

Decomposition
(organic P converted to inorganic P by bacterial action)

Organic and inorganic phosphorus are shown in this cycle.
Plants and algae consume the inorganic phosphorus, o*rthophosphate,*PO_4^{-3}.

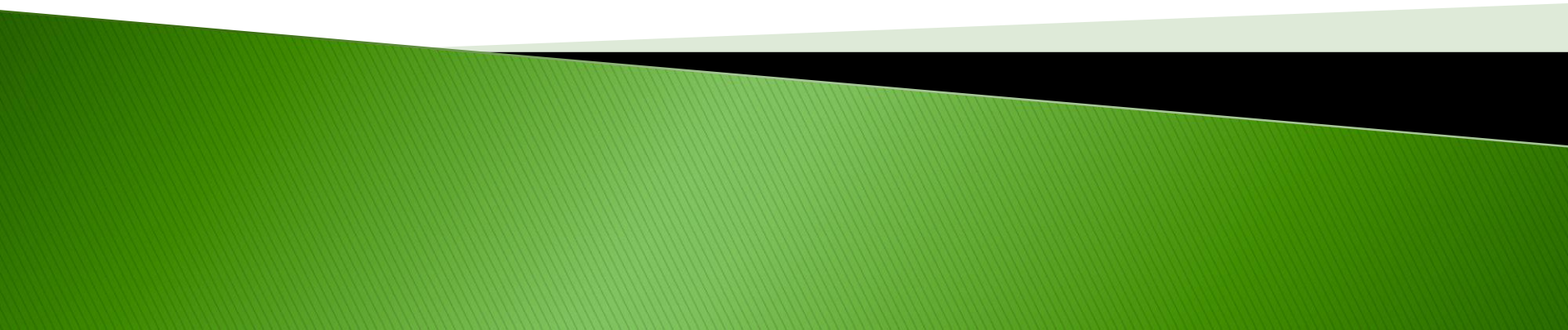*When algae dies it releases P which is often consumed by another algae bloom.*

Phosphorus or Phosphate?

- P or PO_4^{-3}

- Lazy
  ◦ Used interchangeably
  ◦ But not the same.

- PO_4^{-3} is measured in PPM
- P is measured in PPB

Phosphate, The Green Fuel
Part II – Measuring It

Measuring Phosphate

▸ Fuzzy Measurements

◦ When water is green
◦ Can't see your fish
◦ Can't see your plants
◦ Fish piping in the morning (hopefully this never happens)

Measuring Phosphate

▸ Scientific Measurements

◦ Measure P (PPB or μg/L)
◦ Measure orthophosphate PO_4^{-3} (PPM or mg/L)

◦ Be Careful … about the units

Measuring Phosphate

- Orthophosphate (inorganic)
  - Common methods do not detect organic phosphate
  - But usually do not detect "bound" phosphate
    - Important WRT treatments
- Indicator of a potential algae

- Threshold
  - 0.1 PPM

Measuring Phosphorus (P)

- P (inorganic) vs. Total P (organic + inorganic)
- Orthophosphorus (inorganic)
  - Common methods do not detect organic phosphorus
  - Also do not detect "bound" phosphorus

- Professional Laboratories
  - Can provide Total P measurements

- Threshold
  - 30 PPB

Measuring Phosphate & P

P (PPB)	PO4 (PPM)	Trophic State
5	0.015	Oligotrophic
10	0.031	
15	0.046	Mesotrophic
20	0.061	
25	0.077	
30	0.092	
35	0.107	Eutrophic
40	0.122	
45	0.138	
50	0.153	
60	0.184	
70	0.214	
80	0.245	
90	0.275	
100	0.306	
105	0.321	Hypereutrophic
110	0.337	

Healthy levels

Runaway algae likely

Carlson Trophic Index (TSI)

- Used by industry, including the EPA, to quantify the problem of too much phosphorus in bodies of water

- Four classifications of capacity of water to support life (algae).

P (PPB)	PO4 (PPM)	Trophic State
5	0.015	Oligotrophic
10	0.031	Oligotrophic
15	0.046	Mesotrophic
20	0.061	Mesotrophic
25	0.077	Eutrophic
30	0.092	Eutrophic
35	0.107	Eutrophic
40	0.122	Eutrophic
45	0.138	Eutrophic
50	0.153	Eutrophic
60	0.184	Eutrophic
70	0.214	Eutrophic
80	0.245	Eutrophic
90	0.275	Eutrophic
100	0.306	Eutrophic
105	0.321	Hypereutrophic
110	0.337	Hypereutrophic

Carlson Trophic Index (TSI)

- ## Oligotrophic
  - Supports little or no plant growth
  - (Lake Pend Oreille)
  - <12 PPB P

- ## Mesotrophic
  - may support some plant growth
  - 12-24 PPB P

Carlson Trophic Index (TSI)

- ## Eutrophic
  - Supports significant plant growth
  - My pond today, most ponds today
  - 24-96 PPB P

- ## Hypereutrophic
  - Supports excessive plant growth
  - My pond last year
  - 96-384 PPB P

Which to Measure?

▸ Measure and track both orthophosphate and total P if you can and you are interested to do so.

▸ If you are only going to track one, ideally measure total P
  ◦ But this is time consuming and more costly ($15-20 per test)

What to Measure?

- Source Water
  - Essentially all P is Inorganic Phosphorus
  - Are you introducing a problem with every water change?

- Pond Water
  - Difficult
  - Inorganic and organic P in the water.
    Most OTS tests detect inorganic only.
  - Have a lab determine Total P.
  - Get a sense of potential algae blooms with home meters
  - Algae in the water may affect home measurements (colorometers)

- Compare Total P (source water vs pond water)
  - Clue if you have additional significant sources of P from fish food, decay, turkeys etc.

Thresholds / Targets:

Total P : below 24 PPB

Orthophosphate levels: near 0

Orthophosphate is indicative of the algae potential

(So don't expect to detect high orthophosphate during an algae bloom. Most phosphate will be consumed by the algae.)

Conversion

▸ Convert PO_4^{-3} to P
  ◦ P (PPB) = PO_4^{-3} (PPM) *1000/3.06

▸ <u>Example</u>:

Convert 0.122 PPM Phosphate
  to PPB Phosphorus:

P (PPB) = PO_4^{-3} (PPM) *1000/3.06
        = 0.122 * 1000/3.06
        = 40 P (PPB)

P (PPB)	PO4 (PPM)
5	0.015
10	0.031
15	0.046
20	0.061
25	0.077
30	0.092
35	0.107
40	0.122
45	0.138
50	0.153
60	0.184
70	0.214
80	0.245
90	0.275
100	0.306
105	0.321
110	0.337

How to Measure Phosphate (not P)

I think all over the counter products that measure Phosphate measure only Orthophosphate.

How to Measure Phosphate (not P)

Product Resolution: 5 PPM
Healthy pond threshold 0.1 PPM
(therefore Max desired resolution 0.05 PPM or less)

Inadequate by 50X

Using dip strips for Phosphate is like measuring the length of a pencil with a 66 ft ruler, with no markings.

(Accuracy is not stated for this product. Assume perfect accuracy)

Dip Strips

How to Measure Phosphate (not P)
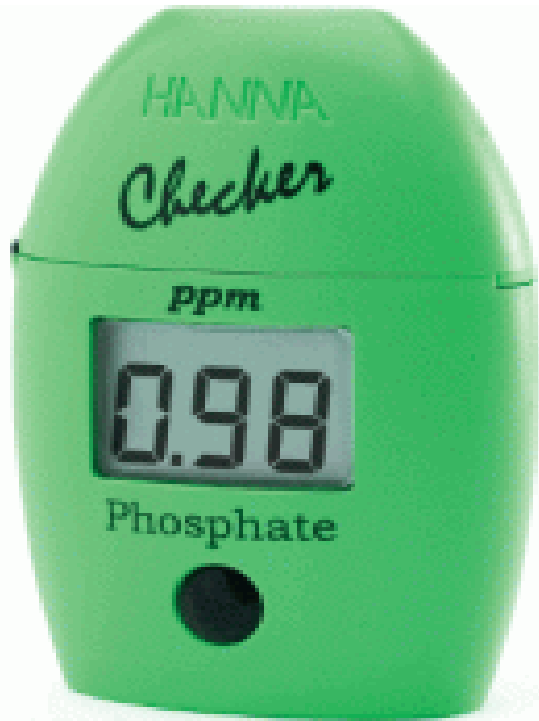

PondCare
Master Liquid
Test Kit

Product Resolution: .25 PPM
Healthy pond threshold 0.1 PPM
(therefore Max desired resolution
0.05 PPM or less)

Inadequate by 5X

Using kits like this for Phosphate is like measuring the length of a pencil with a 6 ft ruler, with no markings.

(Accuracy is not stated for this product. Assume perfect accuracy)

How to Measure Phosphate (not P)

Hanna Instruments HI713 Phosphate Checker

Product Resolution: 0.01 PPM

Product Accuracy: ± 0.04 PPM

"Window of 0.08 PPM" for every measurement

Healthy pond threshold 0.1 PPM

(therefore Max desired resolution 0.05 PPM or less)

Useful to determine a problem

$47 plus 25cents/test

Using this checker is like using a 9" ruler to measure a 6" pencil.

How to Measure Phosphorus

I think all over the counter products that measure phosphorus also measure only bio-available (reactive, inorganic) phosphorus.

How to Measure Phosphorus (P)

Product Resolution: 1 PPB

Product Accuracy: $\pm$ 4 PPB

"Window of 8 PPB" for every measurement

Healthy pond threshold 30 PPB

(therefore Max desired resolution 15 PPB or less)

Very Useful

But….A word about variation of reagents

$47 plus 25 cents/test

Using this checker is like using a 3" ruler to measure a 6" pencil.

Hanna Instruments HI736 ULR P Checker

How to Measure Phosphorus (P)

Professional Lab
Resolution: .0001 PPM (0.1 PPB)
Product Accuracy: $\pm$ 0.01 PPM (10 PPB)
"Window of 20 PPB" for every measurement
Healthy pond threshold 30 PPB
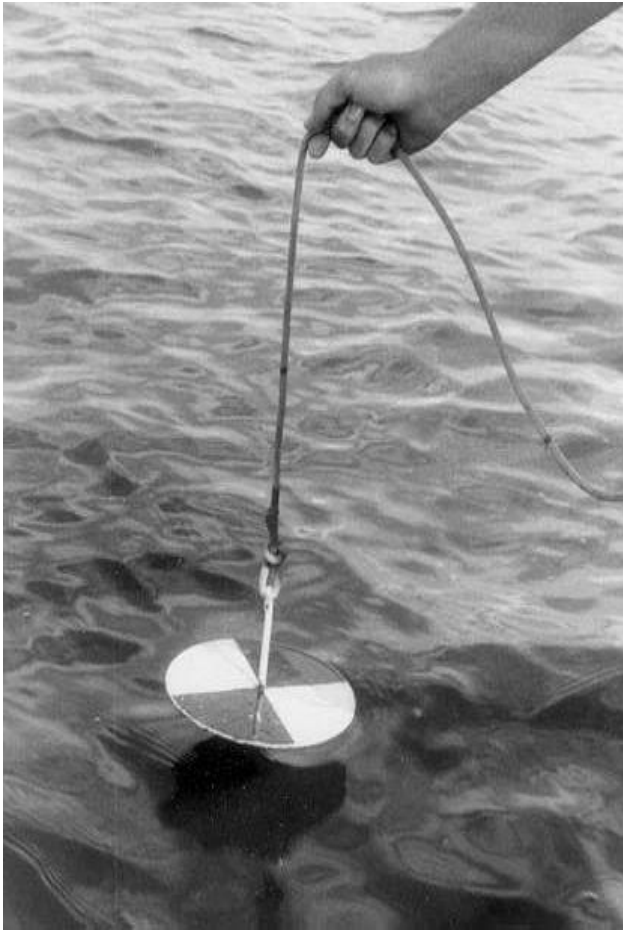(therefore Max desired resolution 15 PPB)

Very Useful Measures TOTAL P
(inorganic + organic)
$15-20/test

Using a lab is like using a 6" ruler to measure a 6" pencil.

How to Measure P and PO_4^{-3}

Secchi Disk
8" black and white disk

Lowered into the water
until it disappears from view.
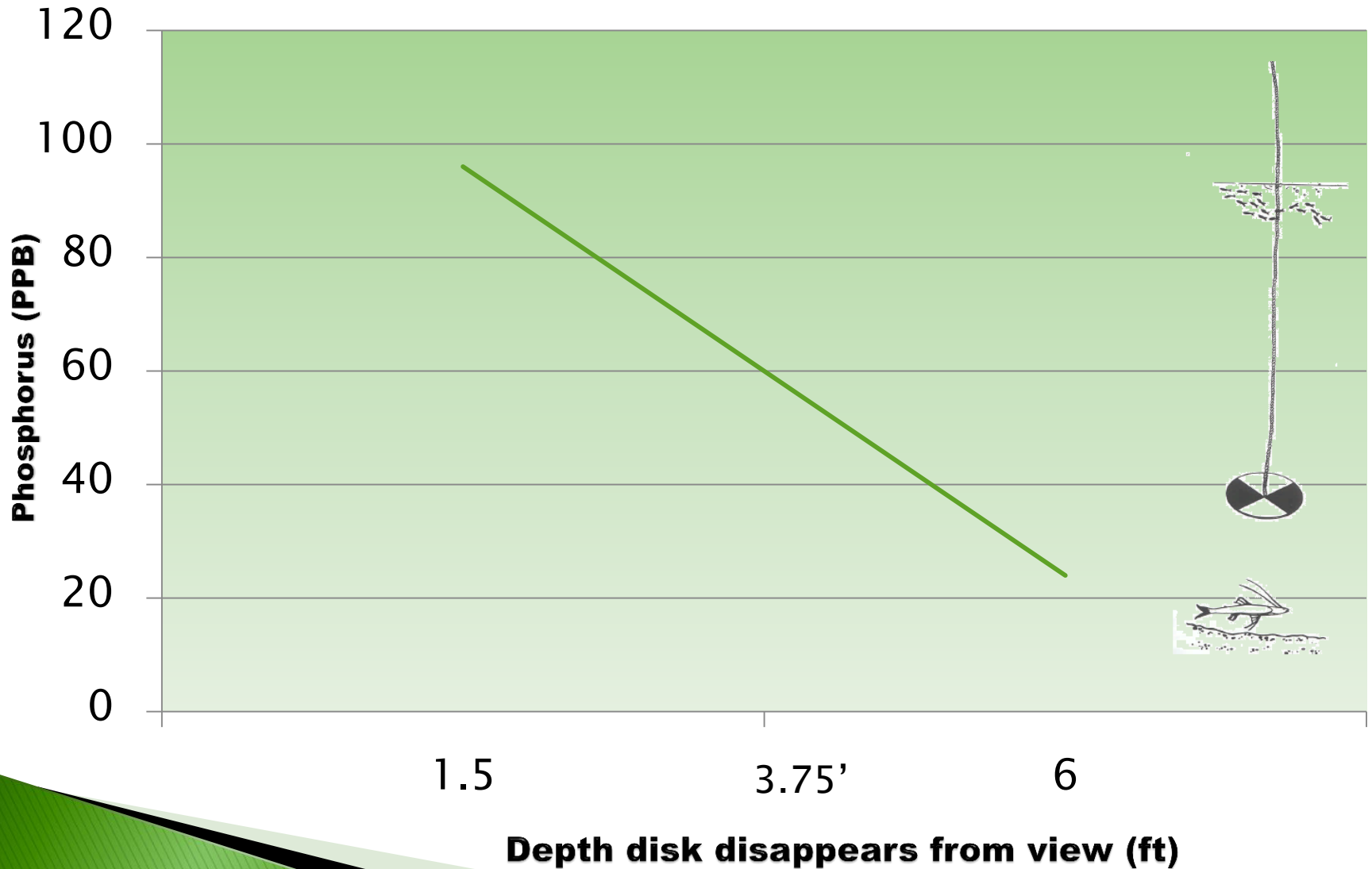
Very Easy

Total Phosphate (PPB)	Secchi Depth	Trophic Class
0—12	>8—4m (24-12ft)	Oligotrophic (little or no support of plant life)
12—24	4—2m (12-6ft)	Mesotrophic (little to moderate support of plant life)
24—96	2—0.5m (6ft – 1.5ft)	Eutrophic (supporting plant life)
96—384+	0.5—<0.25m (less than 1.5ft)	Hypereutrophic (high plant life, choking)

Trophic State Index

Using a Secchi Disk

Phosphate, The Green Fuel Part III – Combating it

Prevention

- Similar as algae prevention
  - Feed fish what they can eat in a couple minutes
  - Remove excess food
  - Remove decaying plant matter
  - Remove leaves, etc
  - Keep birds from the pond
    - See the POND BOSS article for the amounts of phosphorus in fish food, bird poop, etc…..

Removal-All old news

- Use a skimmer
- Use bottom drains
- Clean your filters
- Get rid of sludge build up

- When bacterial breaks down organic matter, it releases the phosphorus as inorganic phosphorus.
  - …. And it supports new algae growth ☹

▸ Getting rid of sludge build up

A rubber coupling, ball valve and 25' sump pump hose attached to the drain port made this wet-dry vac an effective pond vacuum.
Total cost ~$150.

Remove It

Demo Bags

▶ Plants
  ◦ Try soil-less plants

▶ Do Water Changes
  ◦ Watch your source water P levels.
    You might be adding P.
    • If so consider binding P prior to water changes (more later)

▶ Flocculent
  ◦ Remove accumulated matter
  ◦ Watch PH. Non Bufferred Alum can induce PH swings.
    • A rule I found was that 1/3 C of baking soda will raise the Alkalinity (KH) of 1000 gallons of water by 25 PPM

Bind It

▸ Phosphorus has to be "bio-available" to support algae growth.

- Binding it makes it unavailable.

The Phosclear rep recommended this process when binding phosphorus in a green pond:

First, use an algaecide. When the algae dies off in a couple days, it will release its phosphorus making it bio-available for a rebound algae bloom.

Apply the phosphorus binder three days after the algaecide to bind the phosphorus prior to the rebound algae bloom.

Bind It

- Phosphorus that is bound will not be detected by common phosphorus or phosphate tests.

- I believe a "Total P" test is required from a laboratory.

Binding Phosphorus

▸ Binding phosphorus will not kill algae.

▸ It will prevent new algae from growing, until more P is introduced to the pond.

Products

Fast acting

Samples available

Microbe-lift Pond Phosphate Remover

The MSDS is inconclusive (all "**proprietary**" materials). This product binds phosphate. It will not affect pH, if dosed correctly.

Application: 16 oz per 1600 gallons of water. (1 oz per 100 gallons) per 1.5 PPM phosphate. (That's a HIGH concentration of phosphate.)

This is the ONLY PRODUCT THAT ACTUALLY REFERS TO THE POND WATER PHOSPHATE CONCENTRATION to meter the dosage.

Cost: $9.56 per 16 oz container treats 1600 gallons on www.123ponds.com

Products

Phosclear

It's an Alum product that binds phosphate and acts like a flocculent.

This is a powder blended with sodium carbonate to buffer the water against PH swings. It will not affect PH, if dosed correctly. The manufacturers recommend that pH be between 6.5 and 8.2. The reason is that – in very alkaline ponds (above pH 8.2) the aluminum in these products can react with the alkaline groups to form Aluminum Hydroxide which can be toxic to fish.

Application: 4 oz (1/2 cup) per 1000 gallons of water
Cost: $38.09 for 16,000 gallon treatment.
http://www.phosclear.com/html/pond-treatment.html

Phosclear recommended process for a green pond:

First, use an algaecide. When the algae dies off in a couple days, it will release its phosphorus making it bio–available for a rebound algae bloom. Apply the phosphorus binder three days after the algaecide to bind the phosphorus prior to the rebound algae bloom.

Products
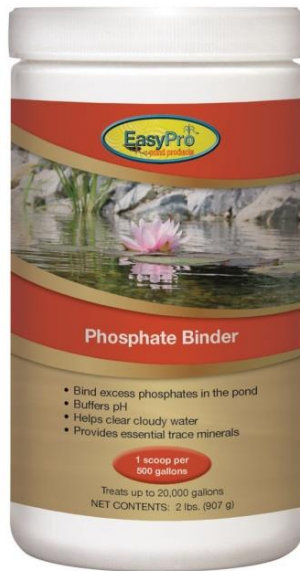
	EasyPro Phosphate Binder
	Binds phosphate. Provides approximately 70 beneficial trace minerals. Buffers pH. Provides minor flocculation (settling) of suspended particles 1 oz per 500 gallons. 5 lbs for $91.13 at www.thepondoutlet.com, treats 40,000 gallons

Products

The Pond Zinger by APS

The Pond Zinger was <mark>Pond Trade Magazine Product of the Year</mark> in 2011. It uses an anionic polyacrylamide that acts as both a binder AND a flocculant. It improves water quality in terms of clarity, reduced phosphates, odor control, decreased suspended solids, and metal discoloration removal.

Slow Release

Developed by Applied Polymer Systems, these pond pucks are derivatives of product used for 20 years to control waste water runoff from construction sites.

Sample LOG on display

This product is NOT supposed to alter the pH of your water. This I want to confirm.

Application: <u>Install above an aerator, under a floating fountain, on the steps of a waterfall or with any circulation mechanism</u>.

Pond size: 500-12,000 gallons

Life expectancy: 1- 2 months

Price: $29.99 on Amazon or $23.99 at

www.store.lakeandpondsolutions.com/pond-zinger.html.

http://www.northcoastpets.com/pond_conditioning.htm

http://www.koiphen.com/forums/archive/index.php/t-137600.html

Products

24 hours using Pond Zinger

SAMPLE ANALYSIS PROCEDURE

International Sampling has specific guidelines, please view them here

We are happy to offer an analysis of a sample from your job site to determine exactly which blend of polymer will be most effective with your specific soil lithology.

For **free** sample analysis at our lab, please include:

- 200g of soil and/or 500mL of water

- Your name, company name, and contact information (phone number, fax number and email)

- Job specifications (i.e. what are you looking at using the polymer for?)

We usually have one day turn-around on sample analysis, meaning that we try to return the lab results to you within **one day** from the time we receive your samples.
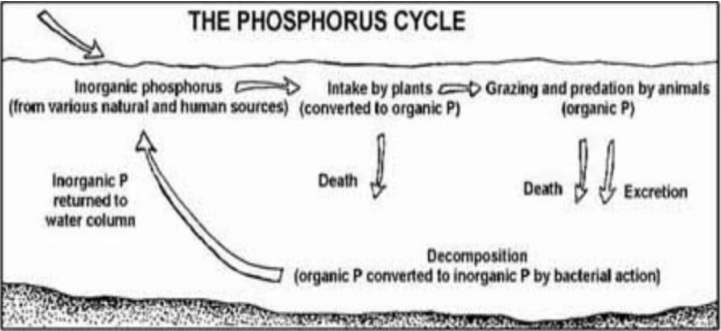
Please send the samples to:

**Applied Polymer Systems, Inc.
ATTN: Lab
519 Industrial Drive
Woodstock, GA 30189**

Please send the **Mining** samples to:

**Applied Polymer Systems, Inc.
Iwinski
4253 KCB Road/Lighthouse Road
Big Bay, Michigan 49808**

TAKEAWAYS

THE PHOSPHORUS CYCLE

Inorganic phosphorus → Intake by plants → Grazing and predation by animals
(from various natural and human sources) (converted to organic P) (organic P)

Inorganic P returned to water column

Death   Death   Excretion

Decomposition
(organic P converted to inorganic P by bacterial action)

Phosphates can cause trouble with algae in ponds. <u>Phosphates are a limiting nutrient for algae</u>. Reduce P and reduce algae.   Orthophosphates, those that are available for plant growth, cause the immediate trouble. <u>Orthophosphates are consumed by algae and then they are not detectable using common methods.</u>   A professional lab is your answer for a total phosphorus reading. Orthophosphates get into your pond from pond waste. So keep it clean. They can ALSO come from your source water so know your source water.
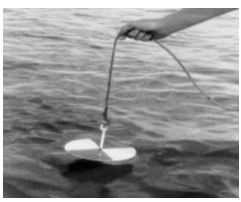
Measuring P & Phosphate:
Phosphorus is measured in PPB and Phosphate is measured in PPM.
Don't be fooled by dip sticks. Look closely at your measuring devices and understand their accuracy and resolution.
These checkers measure <u>bioavailable</u> PO_4^{-3} / P.

The two Checker devices from Hanna are about the only reasonably priced option for regular monitoring of P and PO_4^{3-}

Secchi disks are EASY!
5.5'ft is approx 30 PPB
phosphorus

P (PPB)	PO4 (PPM)	Trophic State
5	0.015	Oligotrophic
10	0.031	
15	0.046	Mesotrophic
20	0.061	
25	0.077	
30	0.092	
35	0.107	
40	0.122	
45	0.138	
50	0.153	Eutrophic
60	0.184	
70	0.214	
80	0.245	
90	0.275	
100	0.306	
105	0.321	Hypereutrophic
110	0.337	

Healthy levels

Runaway algae likely

Phosphorus Target: < 30 PPB
Phosphate (PO_4^{-3}) Target: < 0.10 PPM

Treatments:
Phosphorus can be bound and made bio-unavailable. There are many products.

Pond zinger (shown) is a slow release product & doesn't affect PH.

Microbe Lift Phosphate Binder is fast acting. I am intrigued by it because it advises treatment to be metered according to the levels of PO_4^{3-} level in your water. Watch your pH.

3-step approach:
1) Use algaecide.
2) After algae dies and releases the now inorganic PO_4^{-3}, (3-4 days) apply fast acting PO_4^{-3} binder. (Some binders also use flocculent to accelerate filtration)
3) Use slow release PO_4^{-3} binder for maintenance.

Q & A