Phosphorus in effluent from nutrient removal treatment facilities are like coconuts and bananas

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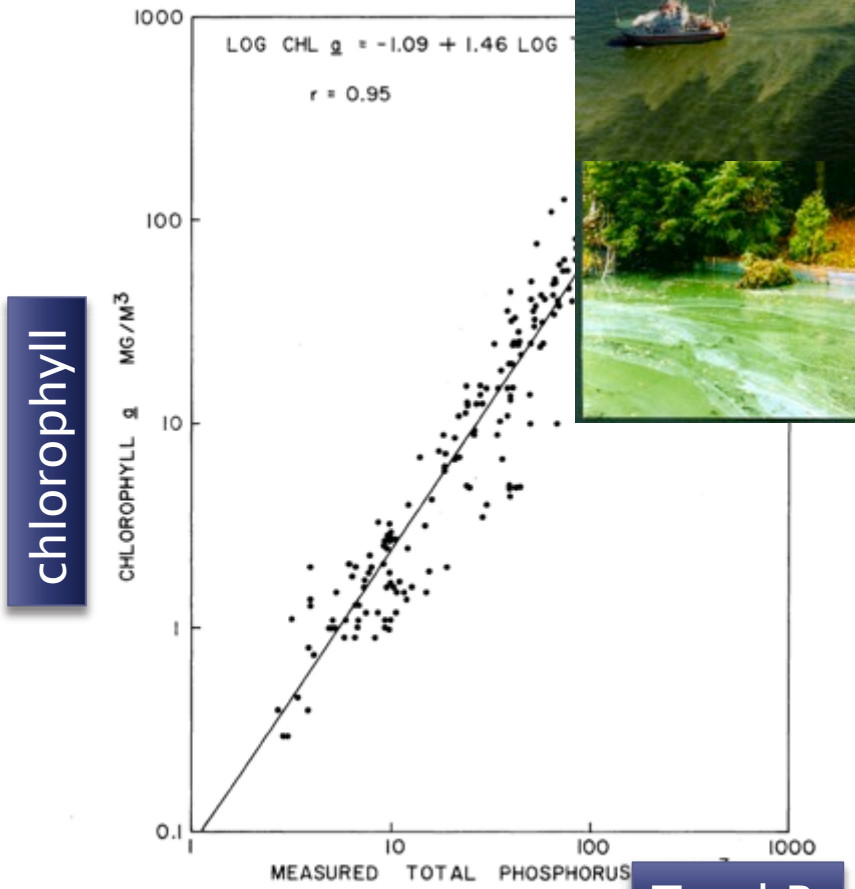
Phosph



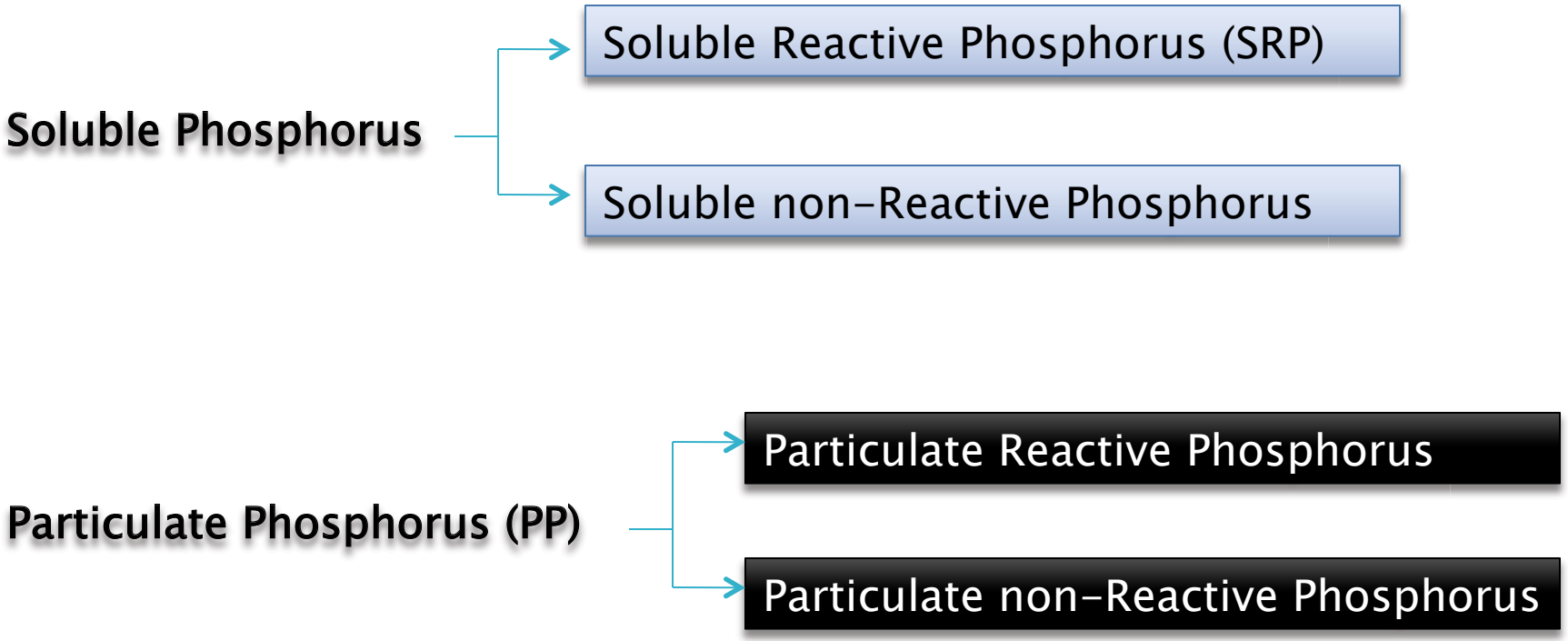
chlorophyll

Total P

FIGURE 1.—Relationship between summer
phyll *a* and measured total phosphorus concentration for 145
lakes.

Phosphorus

Operational Categories



Phosphorus

Operational Categories

≠

Bioavailability

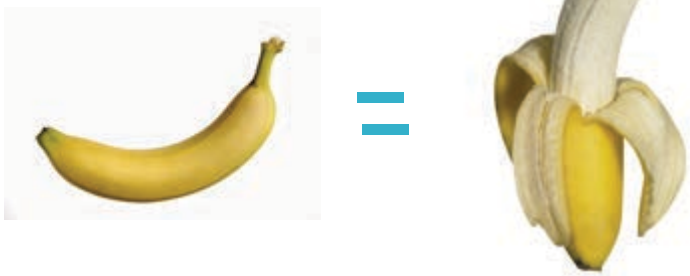
SRP ≠ phosphate = 100% bioavailable ?

BAP

- Bio-available Phosphorus
- phosphorus that can be utilized by plants and bacteria

BAP

- Bioavailable P
- Phosphate (PO_4^{-3})
- ….



Recalcitrant P

Inorganic P
- Apatite
- ($Ca_3(PO_4)_2$)
- $AlPO_4$
- $FePO_4$

Organic P
- Polyphosphate
- Inositol hexakisphophate
- L-α-phosphatidyl choline
- phosphoenol pyruvate
- glycerophosphate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Goals

- Evaluate effect of Tertiary Treatment Process on bioavailable P fraction in effluent

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Identify banana

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Identify banana

- Test Bioavailability of P species

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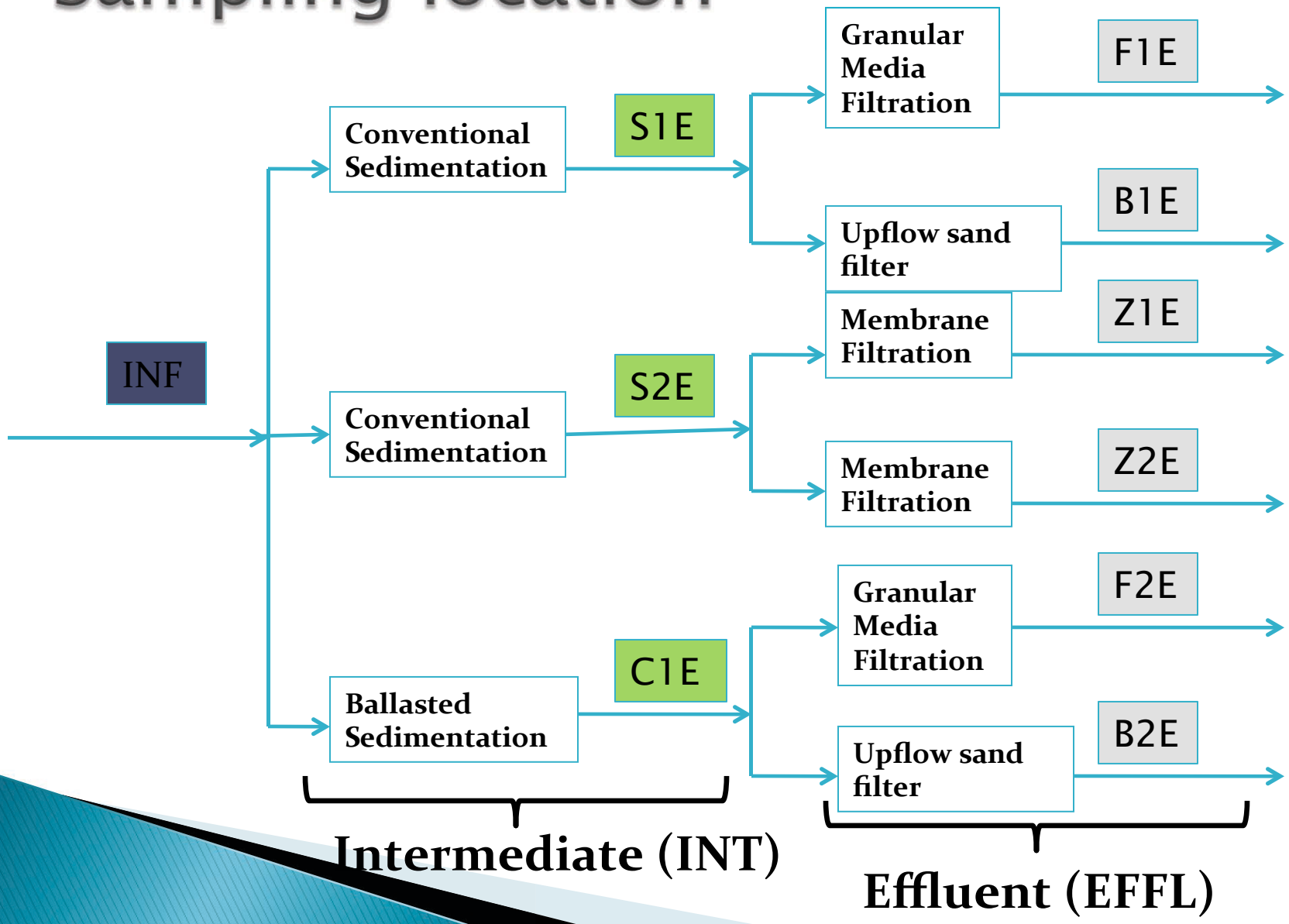
Identify banana

- Test Bioavailability of P species

Which species of banana will be more tasty?

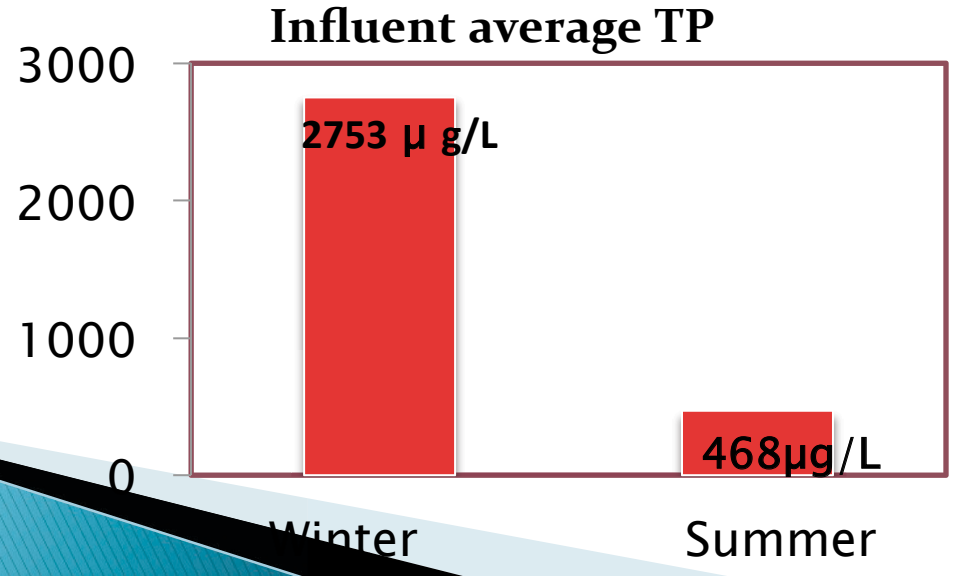
City of Spokane Pilot plant Sampling location



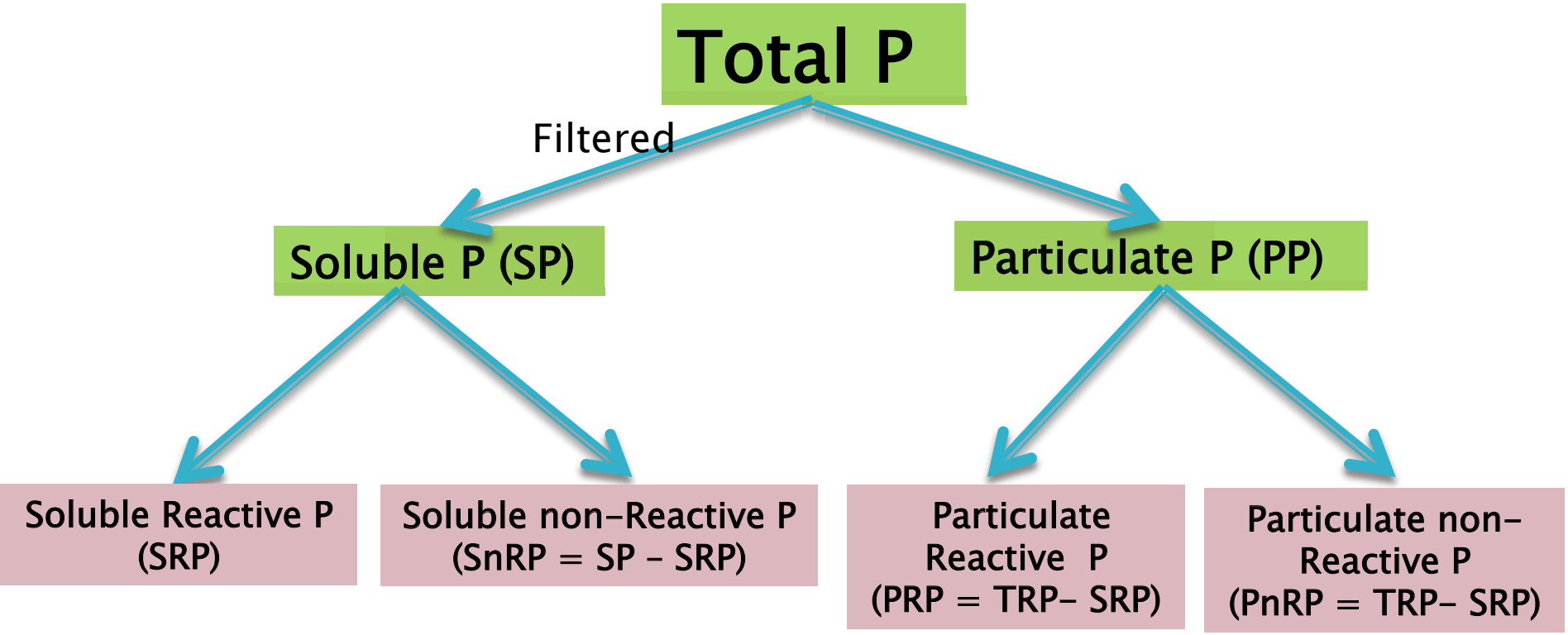
Sampling (from August 2009 to April 2010)

- **Winter Scenario:**
- *without* alum addition in secondary WWTP

- **Summer Scenario:**
- *with* alum addition in secondary WWTP



Chemical Analysis

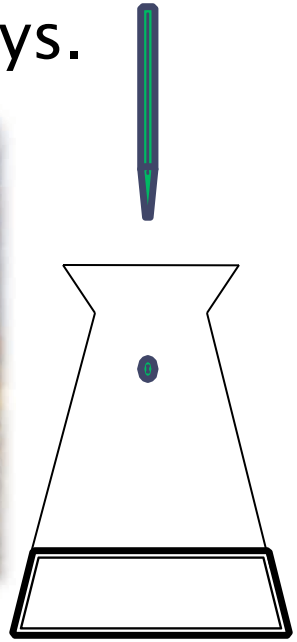


Bioassay Method

Selenastrum capricornutum

Initial concentration:10,000 cells/ml

Incubate for 14 days.



Culturing condition:

1.Continuous Illumination

2.Temperature: 24 ± 2°C

3. shake at 110 rpm.

Bioassay Method

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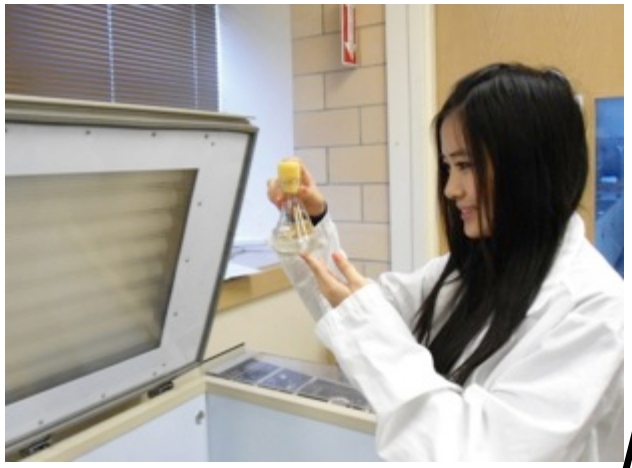
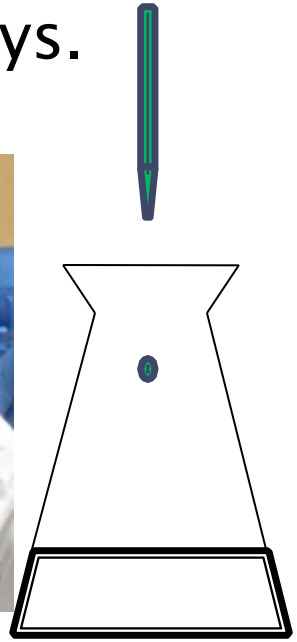
Incubate for 14 days.





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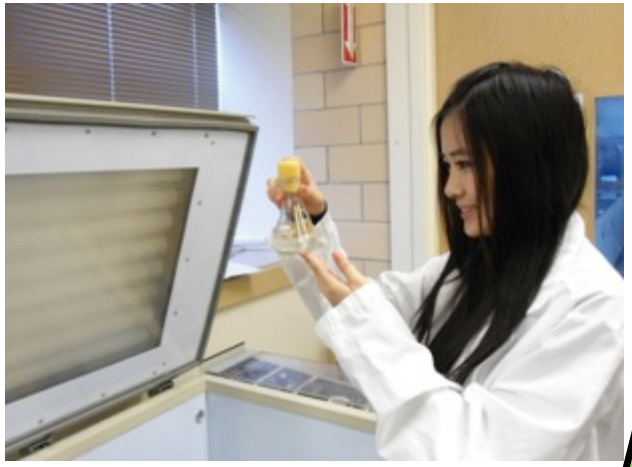

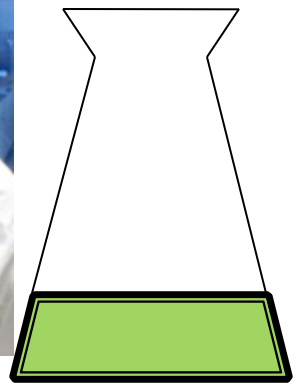

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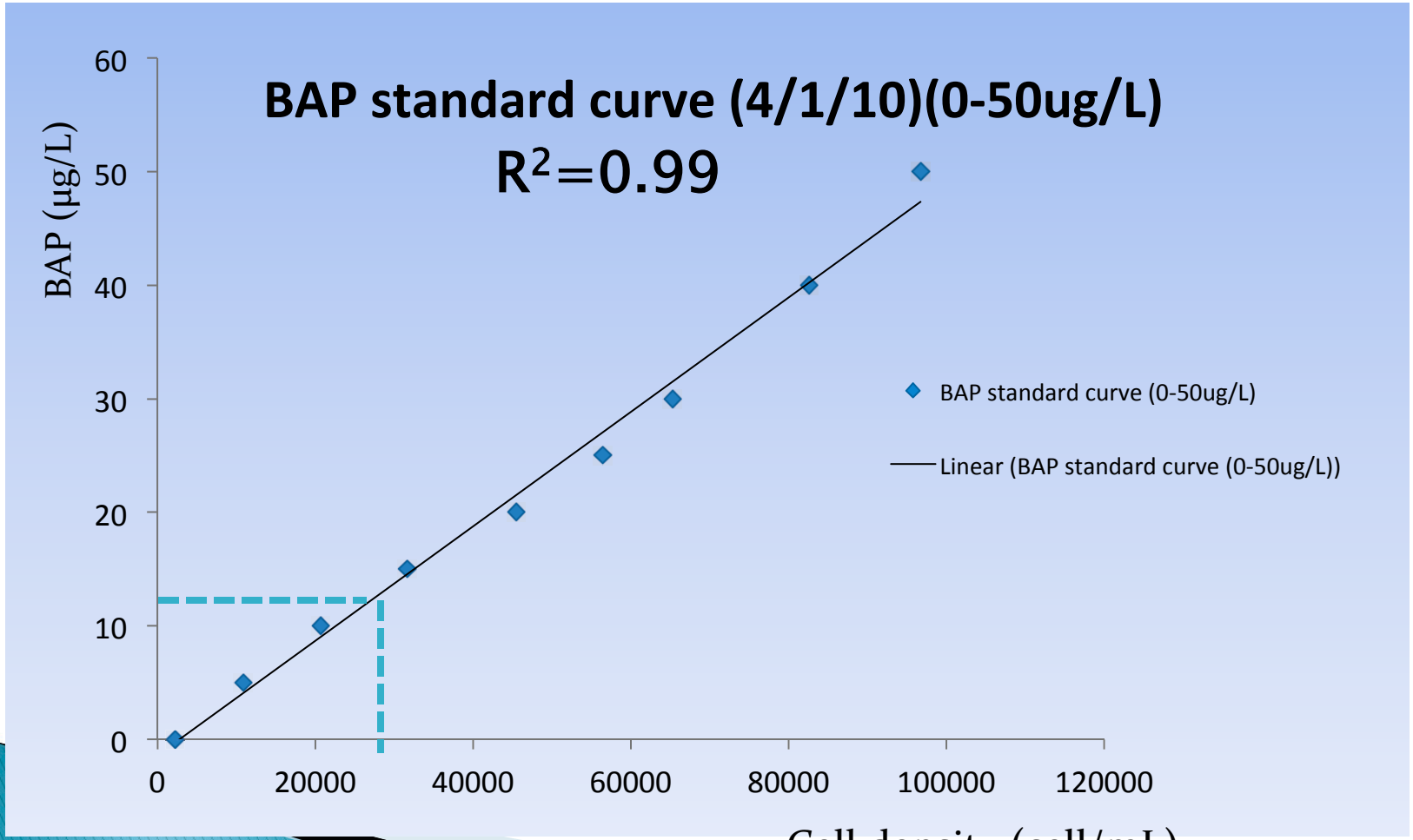
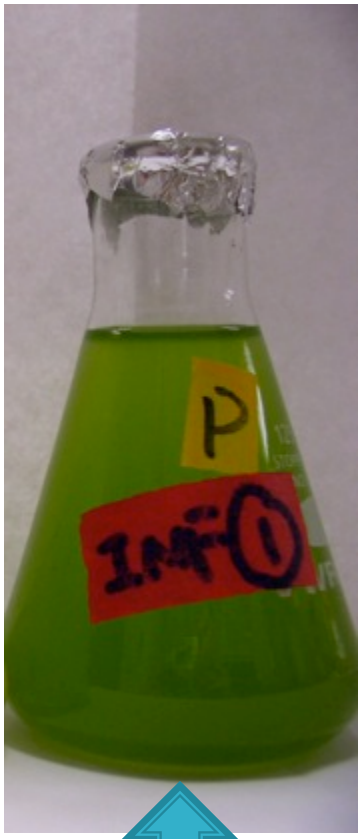
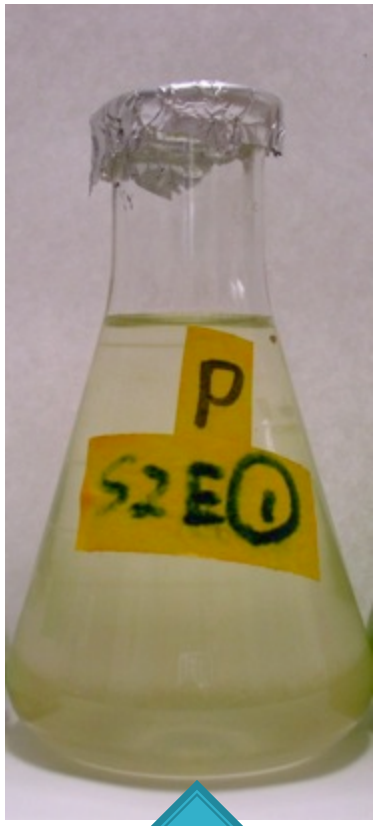


Results



Influent



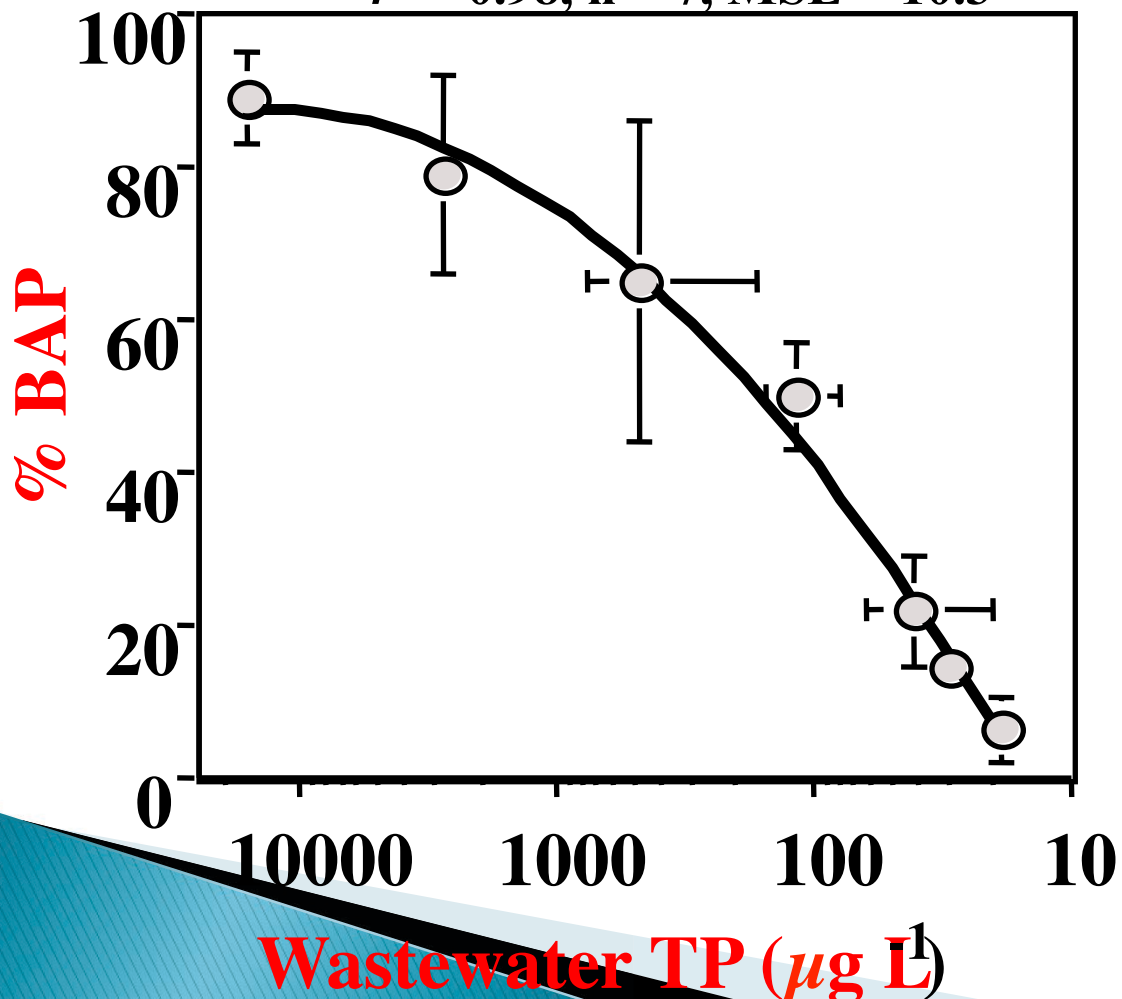
Intermediate

Effluent

BAP% vs. TP in alum treatment process

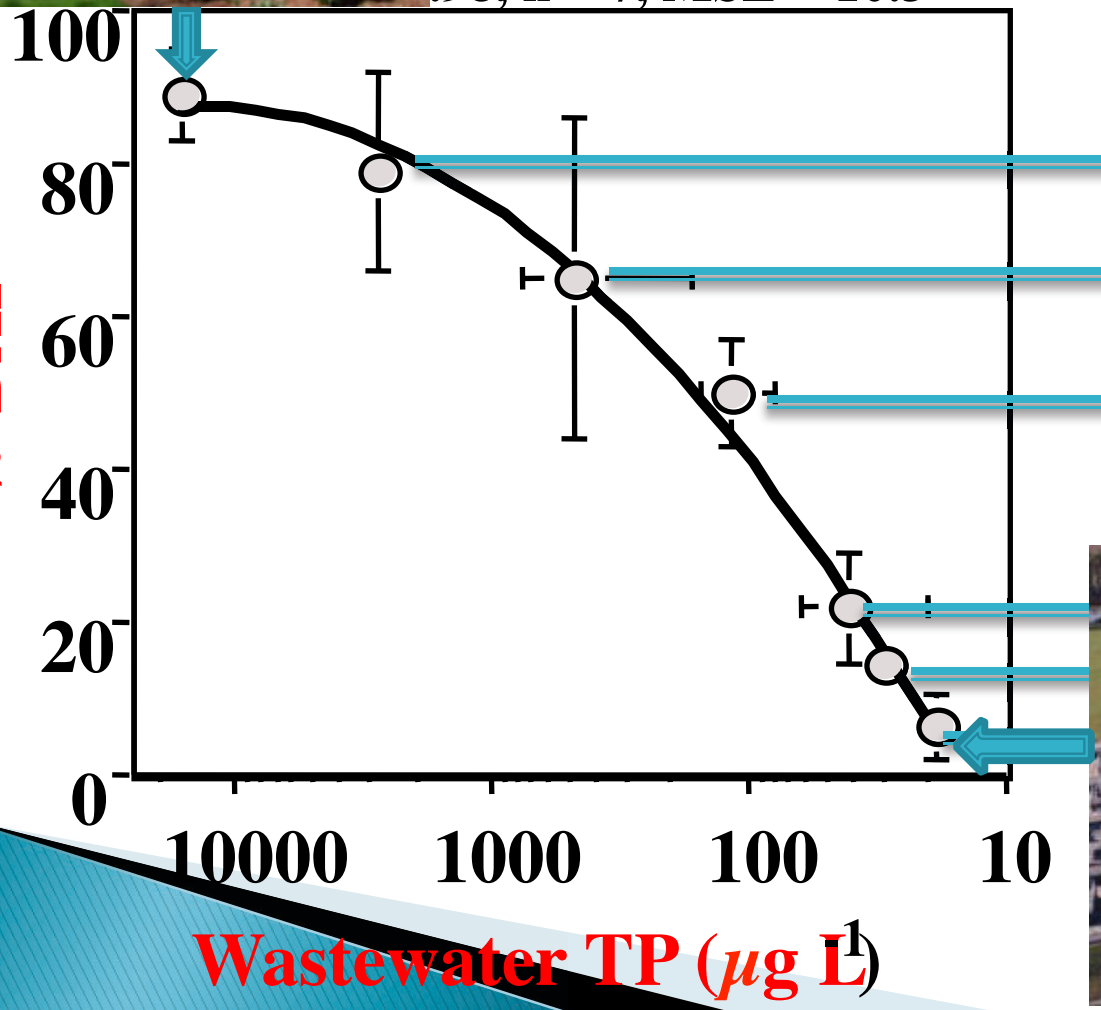
$\%BAP = -12.19*\log(TP)^2 + 92.03*\log(TP) + 94.17;$

$r^2 = 0.98$, n = 7, MSE = 10.3



P in alum treatment process

P = -12.19*log (TP)^2 + 92.03*log(TP) + 94.17;
.98, n = 7, MSE = 10.3



Bioavailability of P species

Category	Chemical Name	Molecular Formula
Inorganic P	Aluminum phosphate (Al-P)	$AlPO_4$
	Calcium Phosphate (Ca-P)	$CaHPO_4$
	Ferric Pyrophosphate (Pyro-P)	$Fe_4(P_2O_7)_3$
	sodium tripolyphosphate (Tripoly-P)	$Na_5P_3O_{10}$
	Phosphorus Pentoxide (P_4O_{10})	P_4O_{10}
	Apatite	$Ca_5(PO4)_3(OH,F,Cl)$
	Ca-hydroxypatite	$Ca_5(PO4)_3(OH)$

Bioavailability of P species

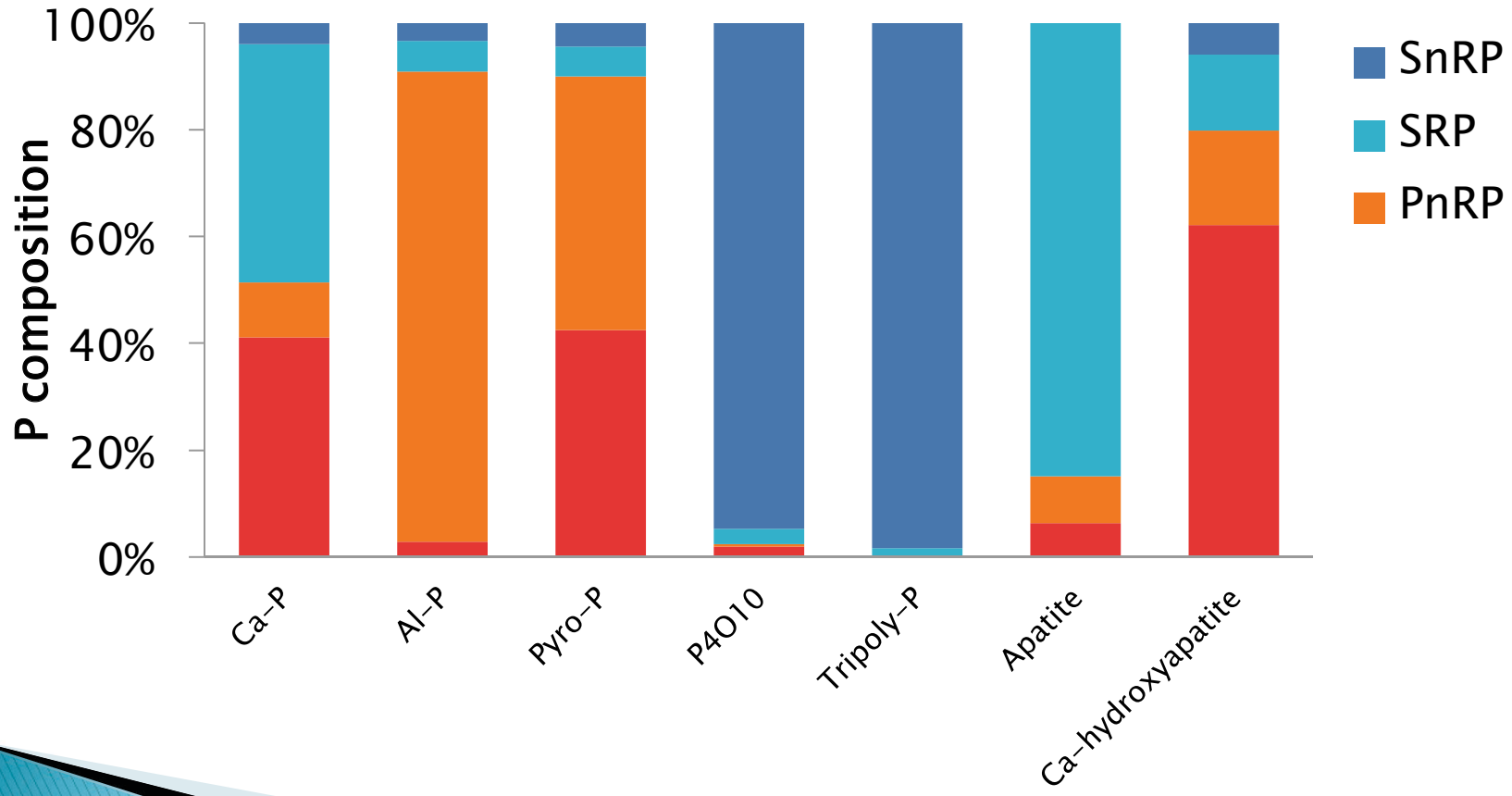
Category	Chemical Name	Molecular Formula
Organophosphate	Adenosine 5'Monophosphate (AMP)	$C_{10}H_{14}N_5O_7P$
	guanosine diphosphate (GDP)	$C_{10}H_{15}N_5O_{11}P_2$
	uridine diphosphate (UDP)	$C_9H_{14}N_2O_{12}P_2$
	Adenosine-5'-triphosphate (ATP)	$C_{10}H_{14}N_5O_{13}P_3Na_2 \cdot {}_3H_2O$
	Deoxyribonucleic acid (DNA)	
	Ribonucleic acid (RNA)	
	Lecithin	
	Liposome	

Bioavailability of P species

Category	Chemical Name	Molecular Formula
Humic Substance	Elliott Soil humic acid standard	
	Wackish Peat humic acid reference	
	Leonardite humic acid standard	
	Pahokee Peat humic acid standard	
	Pahokee Peat humic acid reference	

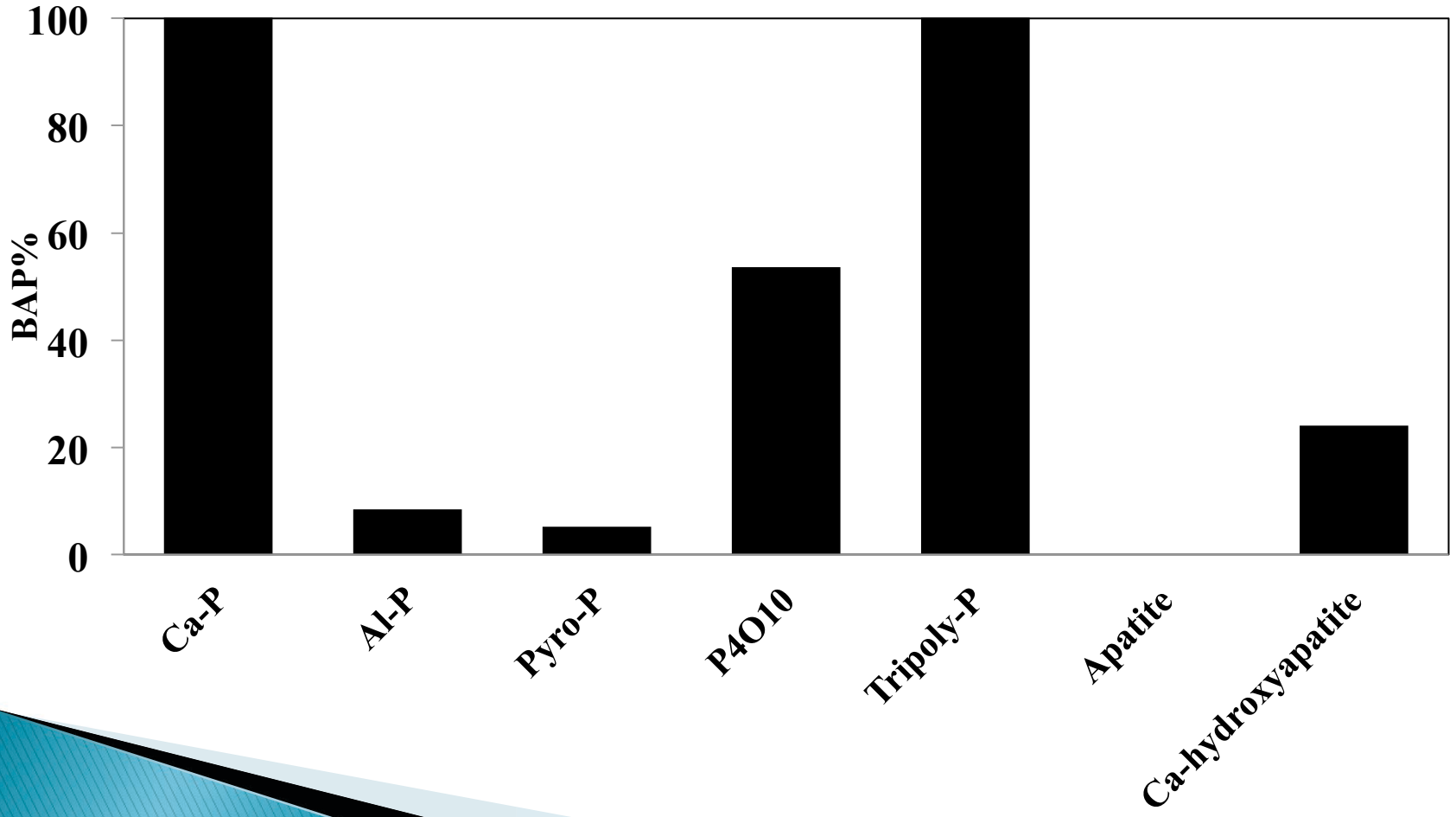
Bioavailability of P species

- Inorganic P



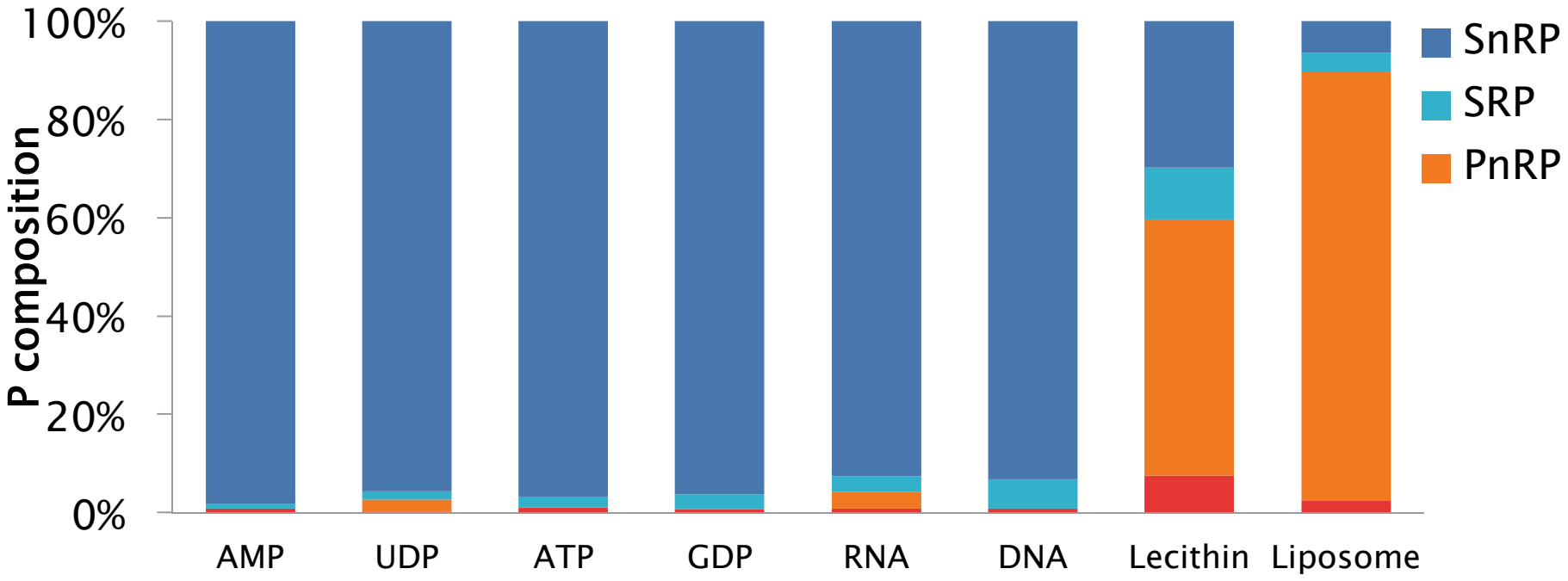
Bioavailability of P species

- Inorganic P



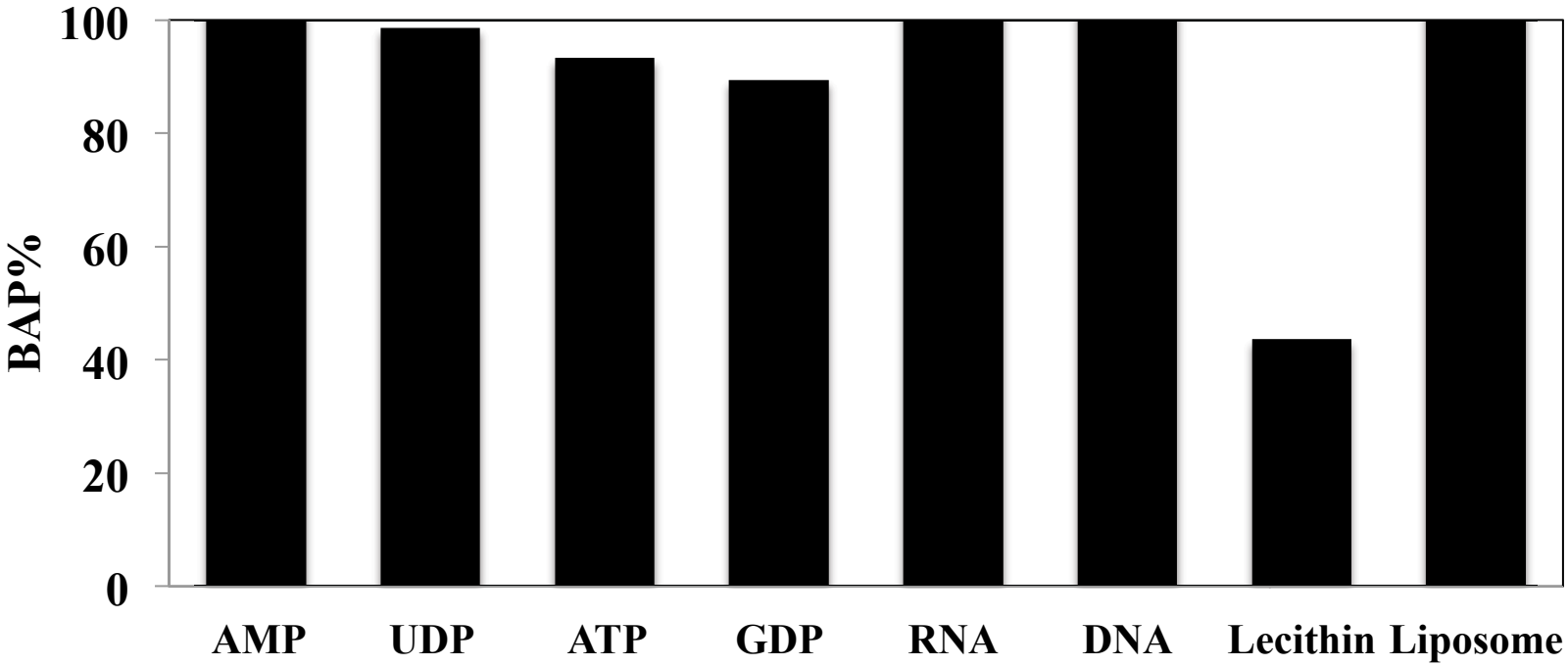
Bioavailability of P species

- Organic P



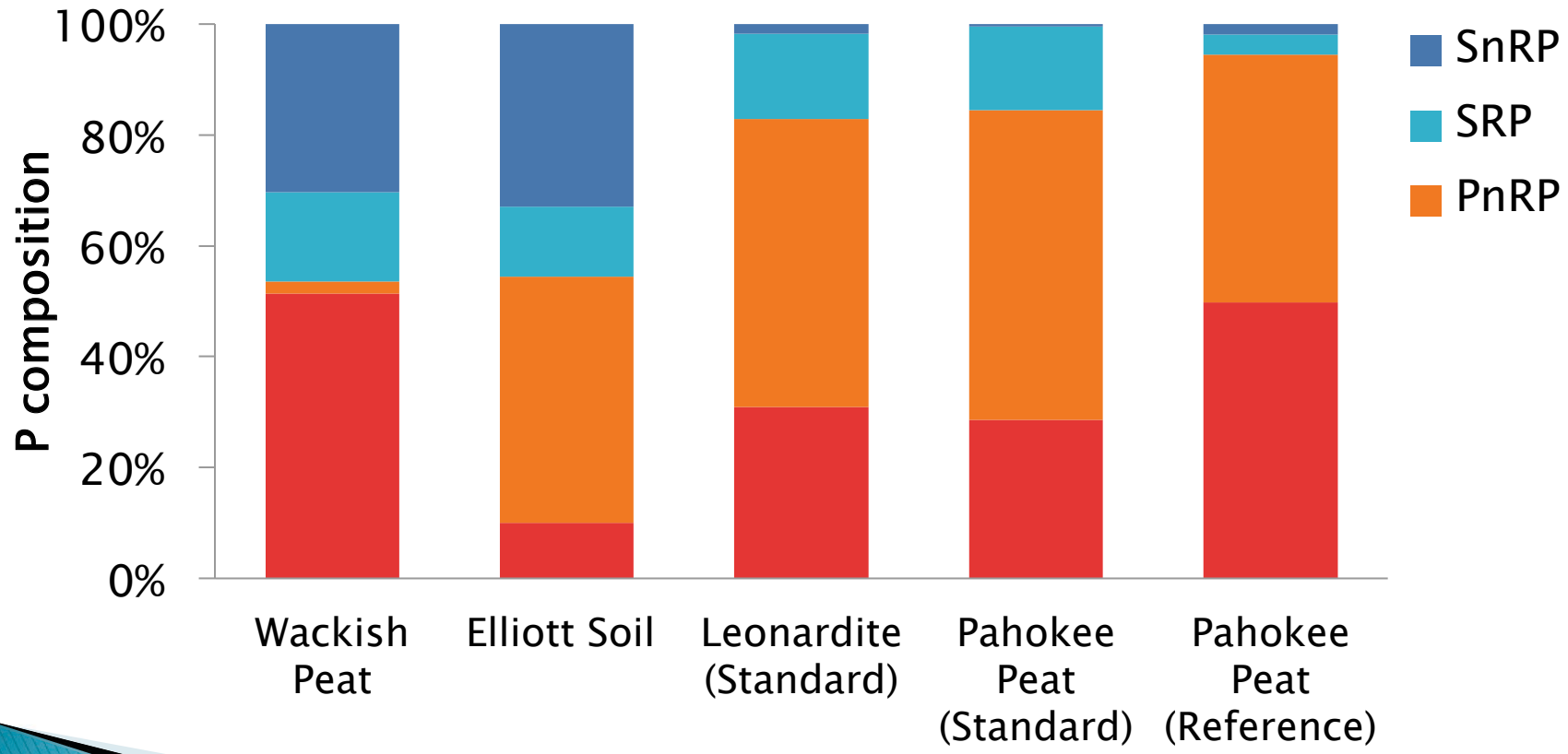
Bioavailability of P species

- Organic P



Bioavailability of P species

- Humic Substances



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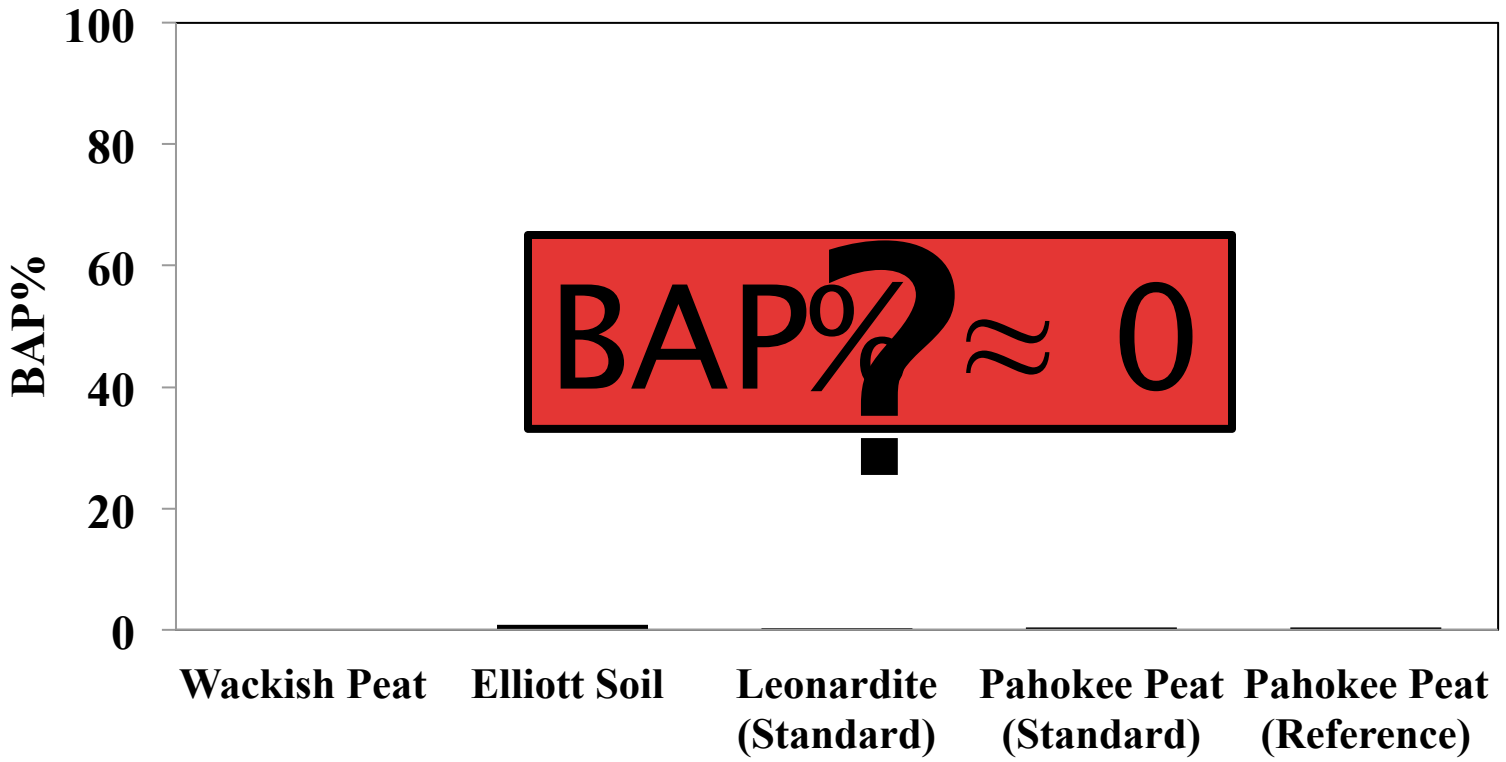

Acknowledgement

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QUESTIONS?