

Implementing and Troubleshooting Biological Phosphorus Removal

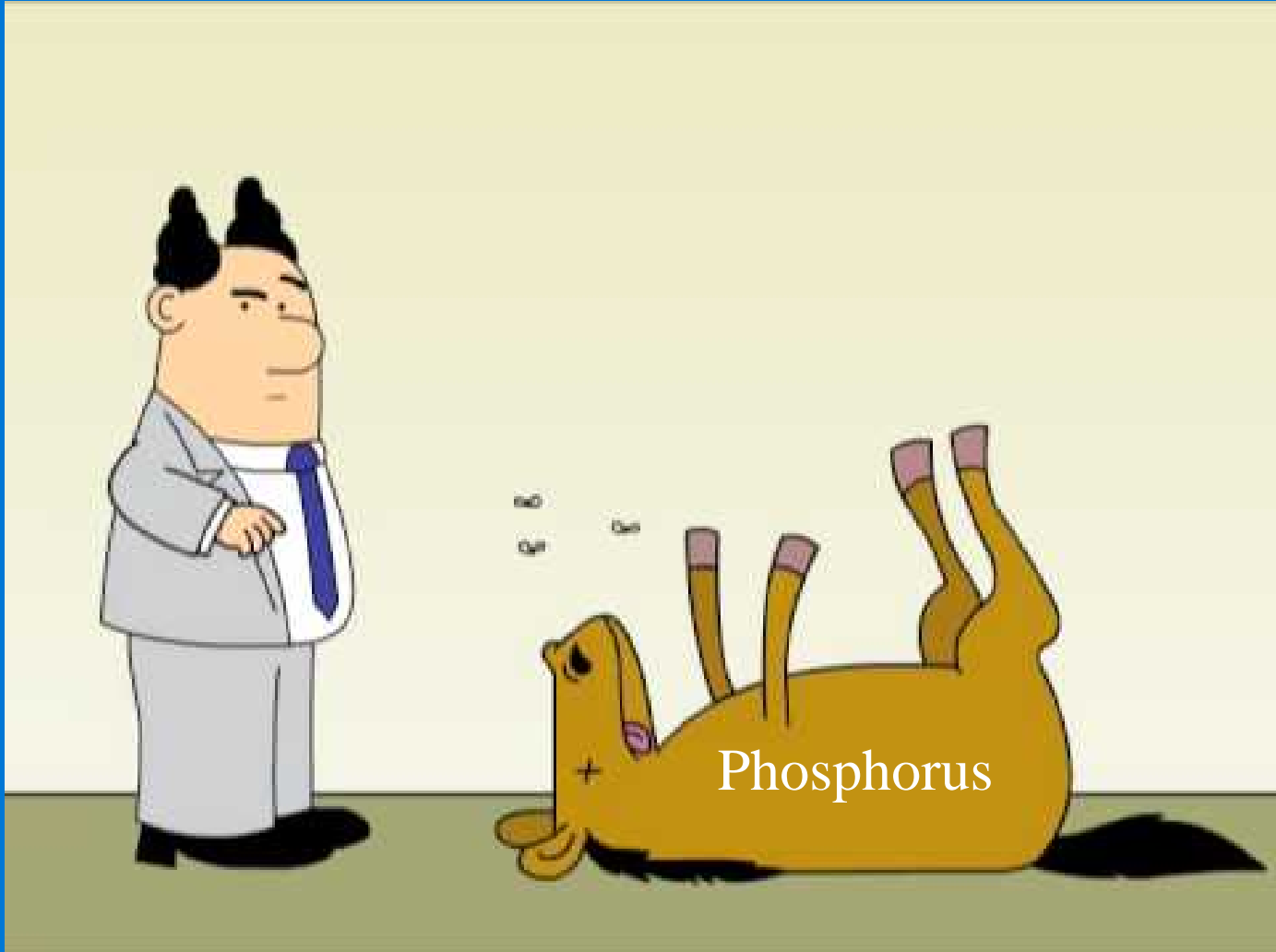
WWOA 46th Annual Conference

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But...



Warning: Don't dive into your Phosphorus selector tank

Overview

- Background
 - Activated Sludge
 - Biological Phosphorus Removal
- The Bio-P Process
 - The Phosphorus Selector
 - The Aerobic Zone
 - The Final Clarifier
- Implementing and Troubleshooting
 - Upstream
 - Midstream
 - Downstream
 - Sidestream

The Miracle of Activated Sludge

- Oxidation:
$$\text{COHNS} + \text{O}_2 + \text{nutrients} \xrightarrow{\text{bacteria}} \text{CO}_2 + \text{NH}_3 + \text{C}_5\text{H}_7\text{NO}_2$$
- Endogenous Respiration:
$$\text{C}_5\text{H}_7\text{NO}_2 + 5\text{O}_2 \xrightarrow{\text{bacteria}} 5\text{CO}_2 + 2\text{H}_2\text{O} + \text{NH}_3 + \text{energy}$$
- Nothing miraculous there, but:
 - Make conditions favorable for the “right” bacteria
 - Interrupt the process at the “right” time
- And 99% of the organic matter settles out
- Bonus: the process is very forgiving
- Phosphorus bonus: 1 mg/L removed for every 100 mg/L BOD

Biological Phosphorus Removal

- Not quite the miracle that activated sludge is:
 - The process is less forgiving
 - The organisms are less robust
 - The operator attention is more substantial
- But, the concept is similar:
 - Make conditions favorable for the “right” bacteria
 - Interrupt the process at the “right” time
- And the phosphorus will settle out.

The Right Bacteria

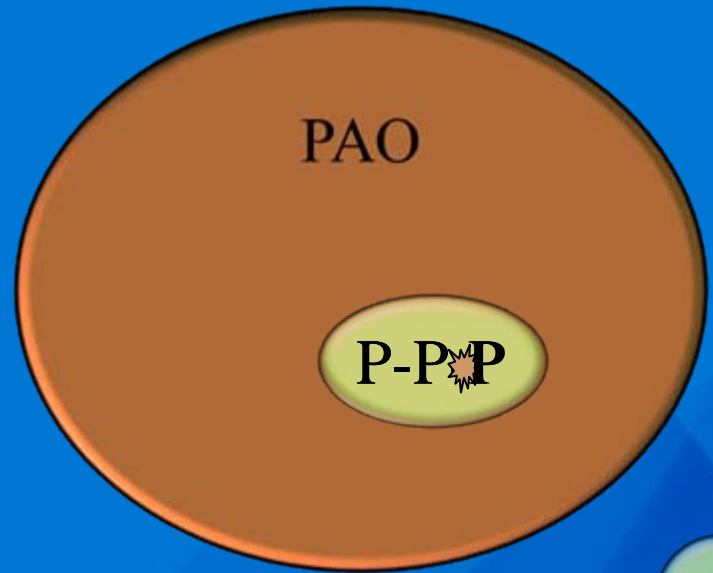
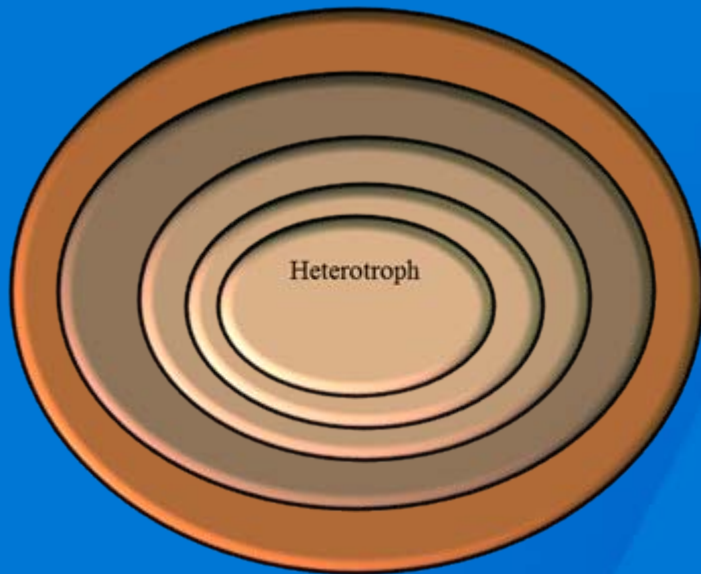
- Phosphorus Accumulating Organisms (PAOs)
- In order to increase the PAOs, we make it hard for other organisms to thrive.
- Thus, the “Phosphorus Selector Tank”



The Phosphorus Selector Tank

- An anaerobic tank with a detention time of 0.5 – 1 hr where RAS and influent are mixed prior to the activated sludge process.
- What happens in there?
 - bsCOD (or VFA) is fermented to form acetate, which PAOs love.
 - PAOs use the phosphorus that they brought with them to produce energy that allows them to assimilate the acetate, and the other organisms have no mechanism to do this.

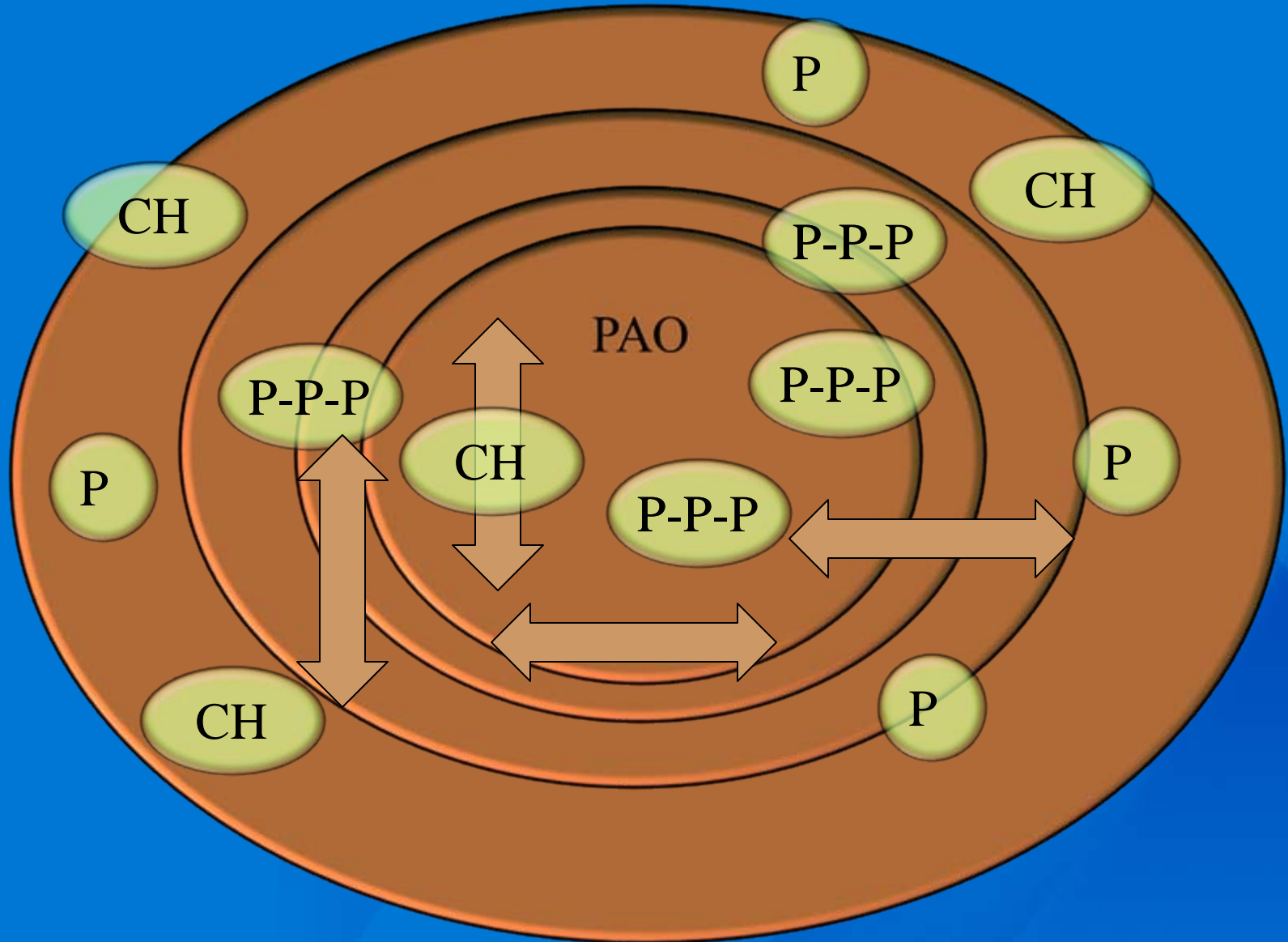
The Phosphorus Selector Tank



The Aerobic Zone

- Now that we've increased our population of PAOs and held the other organisms at bay, we're ready to turn them all loose.
- Heterotrophic organisms go about their activated sludge business
 - Composed of 1.5-2.0% P
- PAOs reverse the process from the anaerobic zone, but now take up more P as the cells are growing
 - Composed of 20-30% P

The Aerobic Zone



The Final Clarifier

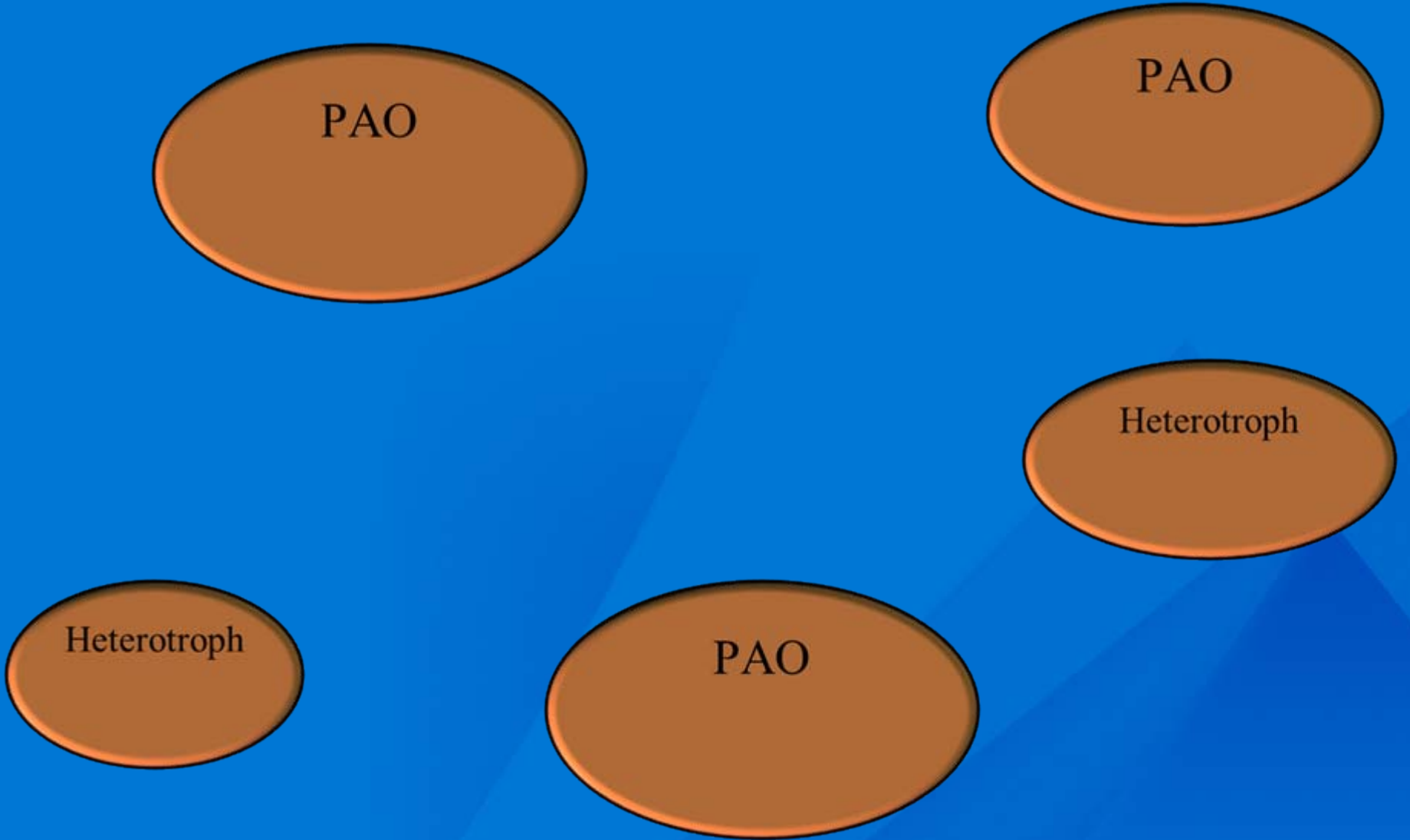
PAO

PAO

Heterotroph

Heterotroph

PAO



Implementing/Troubleshooting

Upstream Issues

- First, let's make sure the influent has what it takes to perform bio-P.
 - Characterize the influent COD (or BOD)
 - The key component is the bsCOD. Other classifications or approximations include:
 - rbCOD
 - sBOD
 - VFA
 - We need approximately 10 g of bsCOD to remove 1 g of P.
 - We need the influent stream to provide a relatively consistent stream of bsCOD
 - If conditions are unfavorable, constructing a primary sludge fermentation tank is an option.

Upstream Issues

- The biological phosphorus removal process is not as robust as the activated sludge process.
- If there is a problem, bio-P (or other BNR) will likely be the first to go.
 - pH variations (<6.5)
 - Temperature variations
 - Toxic loads
 - Variable influent loadings
- Bio-P also requires the presence of Mg (0.56 g/g P), K (0.63 g/g P) and Ca (0.32 g/g P)

Midstream Issues

- Next, let's make sure we have a properly functioning P selector
 - Detention time should be 0.5 – 1.0 hours
 - The zone must be truly anaerobic
 - No dissolved oxygen
 - No nitrates
 - If PAOs are functioning, the orthophosphate concentration in the selector should be significantly higher than in the influent.

Downstream Issues

- The overall SRT of the system may be a factor, even if P selector is properly sized.
 - Minimum SRT is in the range of 2.5-4 days.
 - SRT over 8 days may cause problems.
 - Less wasting of PAOs
 - Less production of PAOs
 - Longer endogenous state
 - Less storage ability
 - Just like activated sludge, we want to interrupt the process at the right time.
- After sludge is removed from the system, aerobic conditions must be maintained.

Sidestream Issues

- Potential sidestreams:
 - Supernatant
 - Filtrate/Pressate/Centrates
 - Hauled Waste
 - Holding Tank
 - Septage
 - Centrate
- Generally high in nutrients
 - Is P being accounted for in influent loading to bio-P system?
 - Is ammonia nitrifying and carrying nitrates into P selector?

Questions?

