Maximizing Your Aerobic Digester Performance

Op2Myz, LLC

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Who's/Why's and How's

- Who have aerobic digesters?
- Why do we stabilize sludge?
  - Reduce disease causing microbes
  - These guys are made of organic material including organic N
  - MAKE IT SO IT DOESN'T STINK!!
- How do we stabilize sludge transforming into Biosolids?
  - Biological/chemical/heat treatments
  - Focus – AEROBIC DIGESTION – Biological Treatment

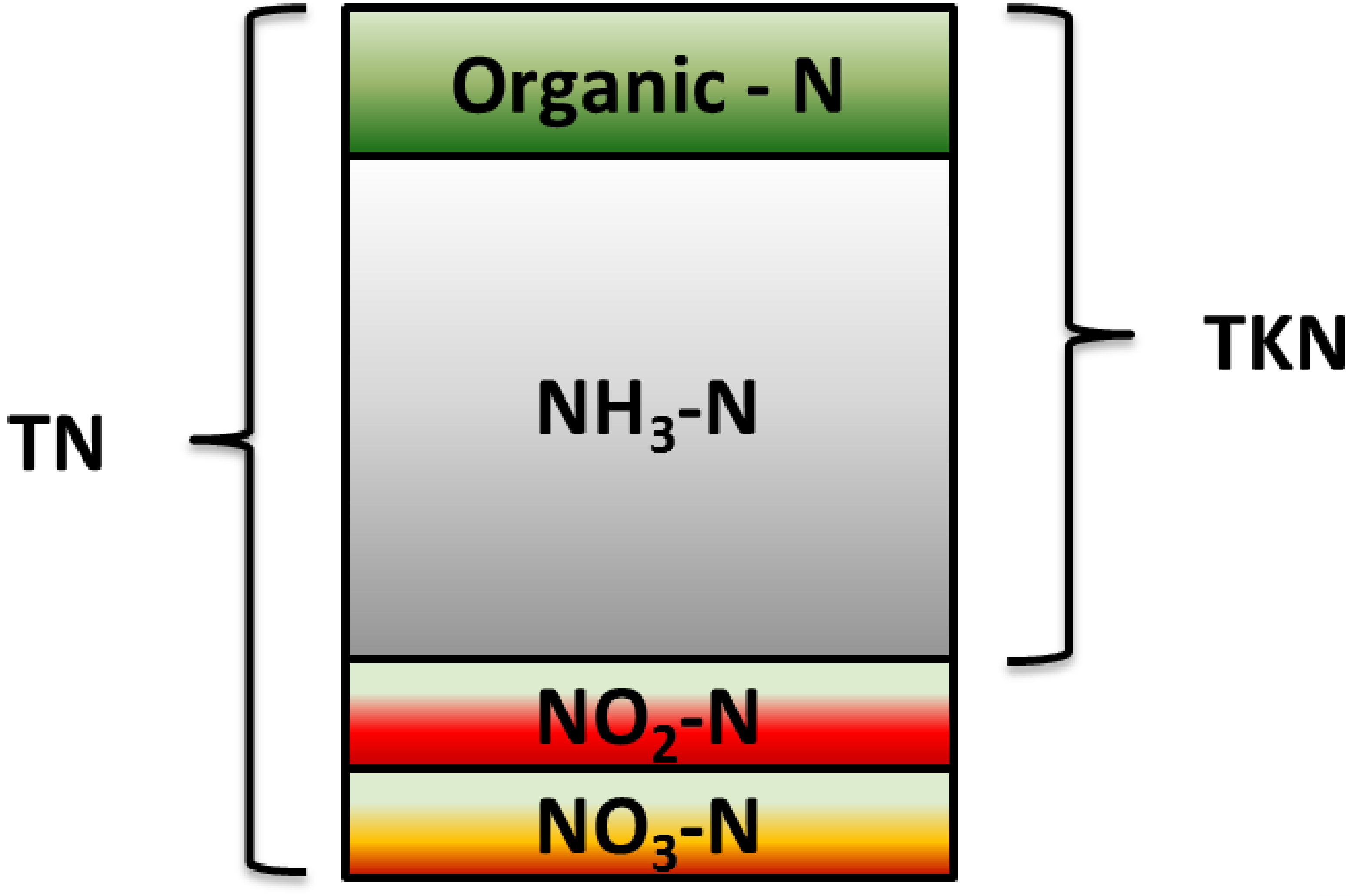
Main Goal

Reduce Nitrogen Content in Sludge

Forms Nitrogen

- Total Nitrogen – TN
- Total Kjeldahl Nitrogen – TKN – has 2 parts
  - Ammonia – NH_3-N
  - Organic nitrogen – Organic N
- Total Inorganic Nitrogen – TIN – has 3 parts
  - Ammonia – NH_3-N
  - Nitrite – NO_2-N
  - Nitrate – NO_3-N

Fractions of N



Nitrogen Degradation Process

1. **Organic N breaks down to ammonia**
   – Decomposers (fermenting microbes)
2. **Ammonia converts to nitrite/nitrate**
   – Nitrifying microbes (AOB & NOB)
3. **Denitrification of nitrate to N_2 gas**
   – Heterotrophic denitrifying microbes

Fermenters

1. **Organic N breaks down to ammonia**

   Decomposers (fermenting microbes

Ammonification

What happens?

- Protein (organic material) is broken down into **AMMONIA**

What microbes perform ammonification?

- *Decomposers* – fermenting microbes

What do Decomposers/Fermenter Like?

- Very low or **NO D.O**. (Low ORP)
  - Continuous Low D.O.
  - Cycling Air ON/**OFF**
- Low pH
- Organic material to feed on

AOB (ammonia oxidizing bacteria)

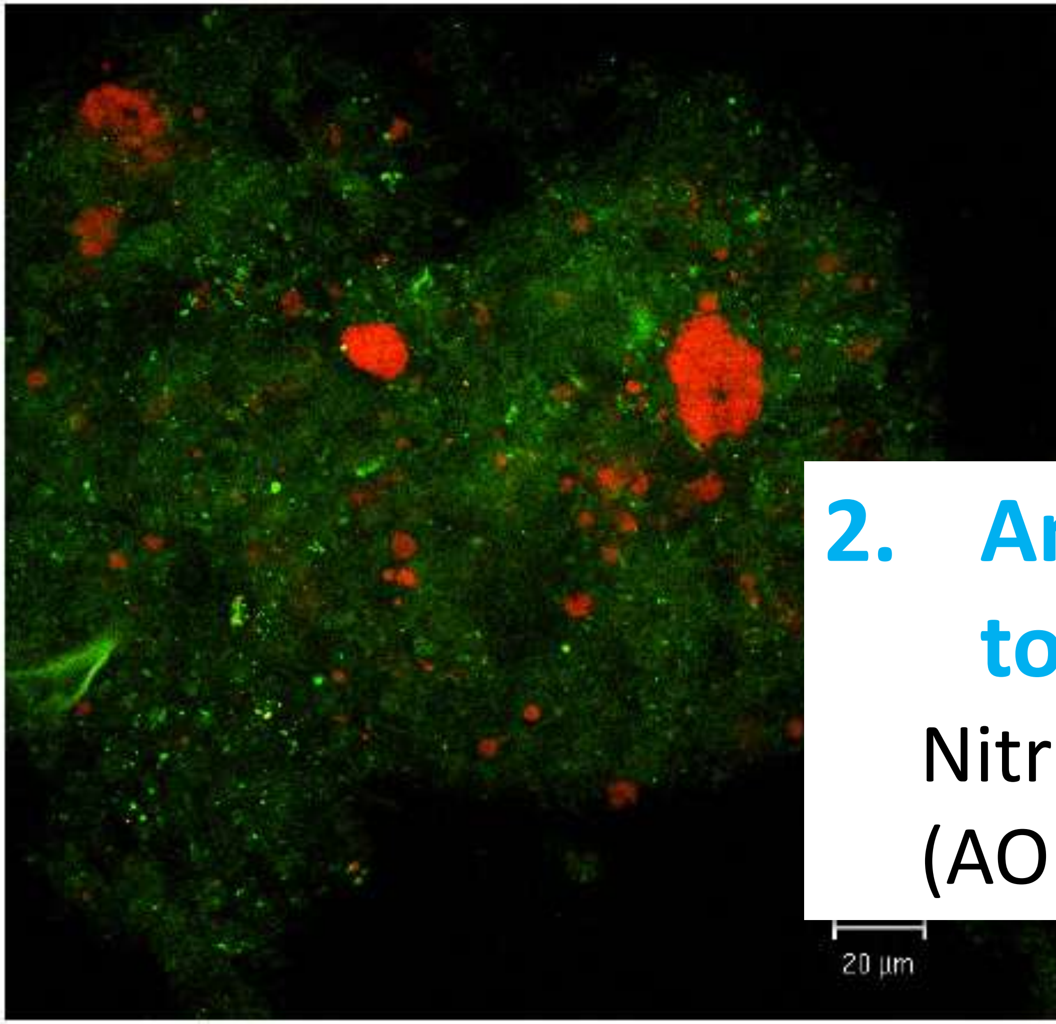
http://garciajeanlouis9051.perso.neuf.fr/aaBXIII2_O2_7.html

Nitrosospira Conversion NH_3-N to NO_2-N

2. **Ammonia converts to nitrite/nitrate**

Nitrifying microbes (AOB & NOB)

NOB (nitrite oxidizing bacteria).



Nitrospira-like nitrite-oxidizers detected by probe Ntspa662 in Phoenix WWTP

Nitrospira
Conversion
NO_2-N to NO_3-N

2. **Ammonia converts to nitrite/nitrate**

Nitrifying microbes (AOB & NOB)

Nitrification

- Nitroso-bacteria
  - **Ammonia** (NH_3-N) → **Nitrite** (NO_2-N)
- Nitro-bacteria
  - **Nitrite** → **Nitrate** (NO_3-N)

What do Nitrifying Bugs Like?

- Alkalinity – CO_3 (of $CaCO_3$) as **FOOD**
- Ammonia for an **ENERGY** source
- D.O.
- Long sludge age – or long time in tank
- pH above 7.0
- **NOTE** - These guys make water acidic

Denitrification

- Heterotrophic bacteria - FACULTATIVE Microbes
  - Live with or without D.O.
- Use Oxygen (of NO_3-N) to SURVIVE
- Need BOD
- Produce alkalinity – give back about half of the alkalinity needed for nitrification
- **NOTE** – These guys neutralize the acid

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OVIVO
0:00 / 4:57

Operation

- Feeding
- Decanting
- D.O. control
  - Continuous 0.5 mg/l D.O. **OR**
  - ON/OFF air flow cycle
  - Air flow ON approx. 25% of the time
  - Air flow OFF approx. 75% of the time

D.O. Control

– Continuous 0.5 mg/l D.O.
  - SND (Simultaneous Nitrification Denitrification)

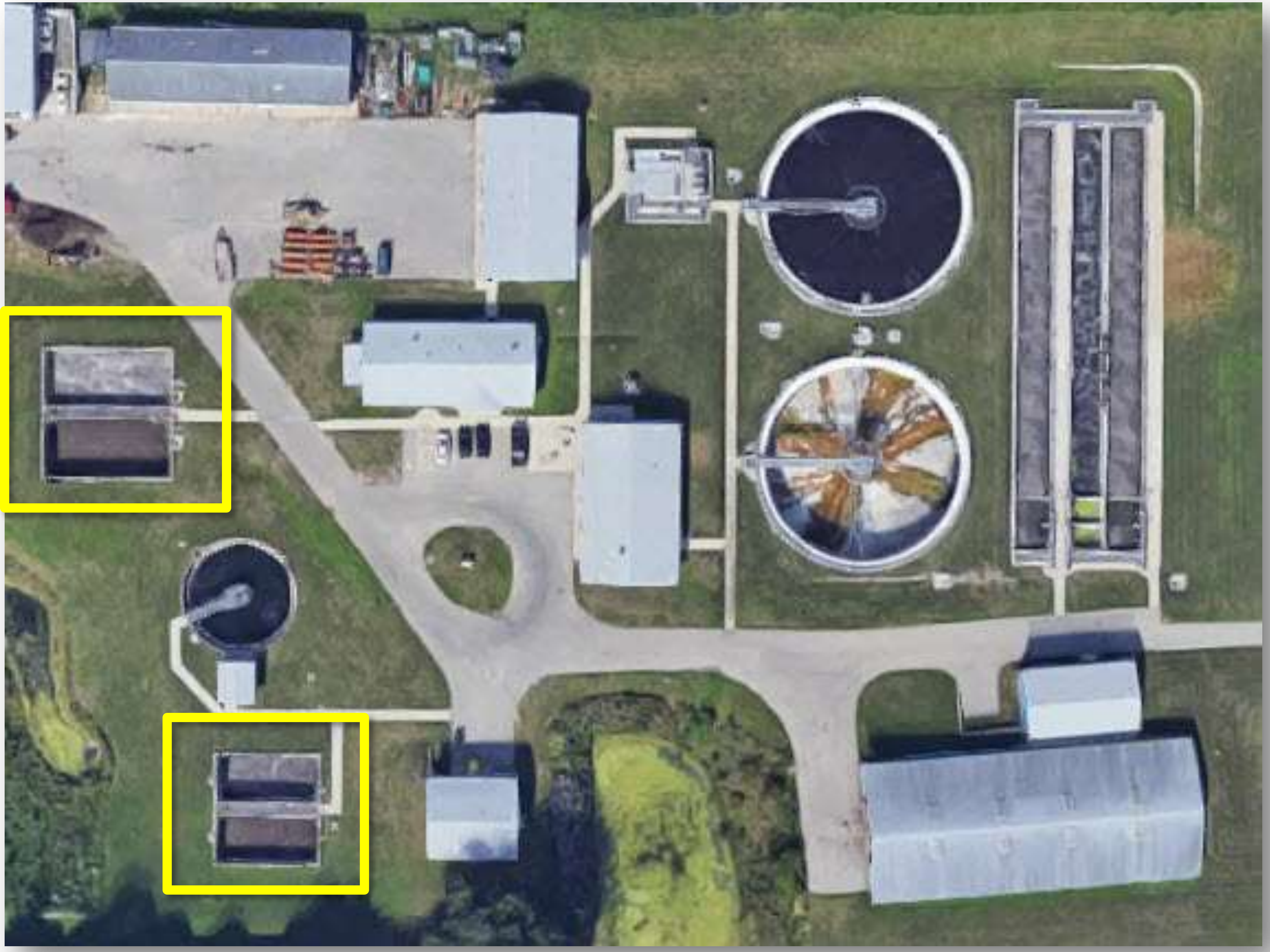
OR

– ON/OFF air flow cycle
  - Air ON - **nitrification**
  - Air OFF – **decomposing & denitrification**

Equipment

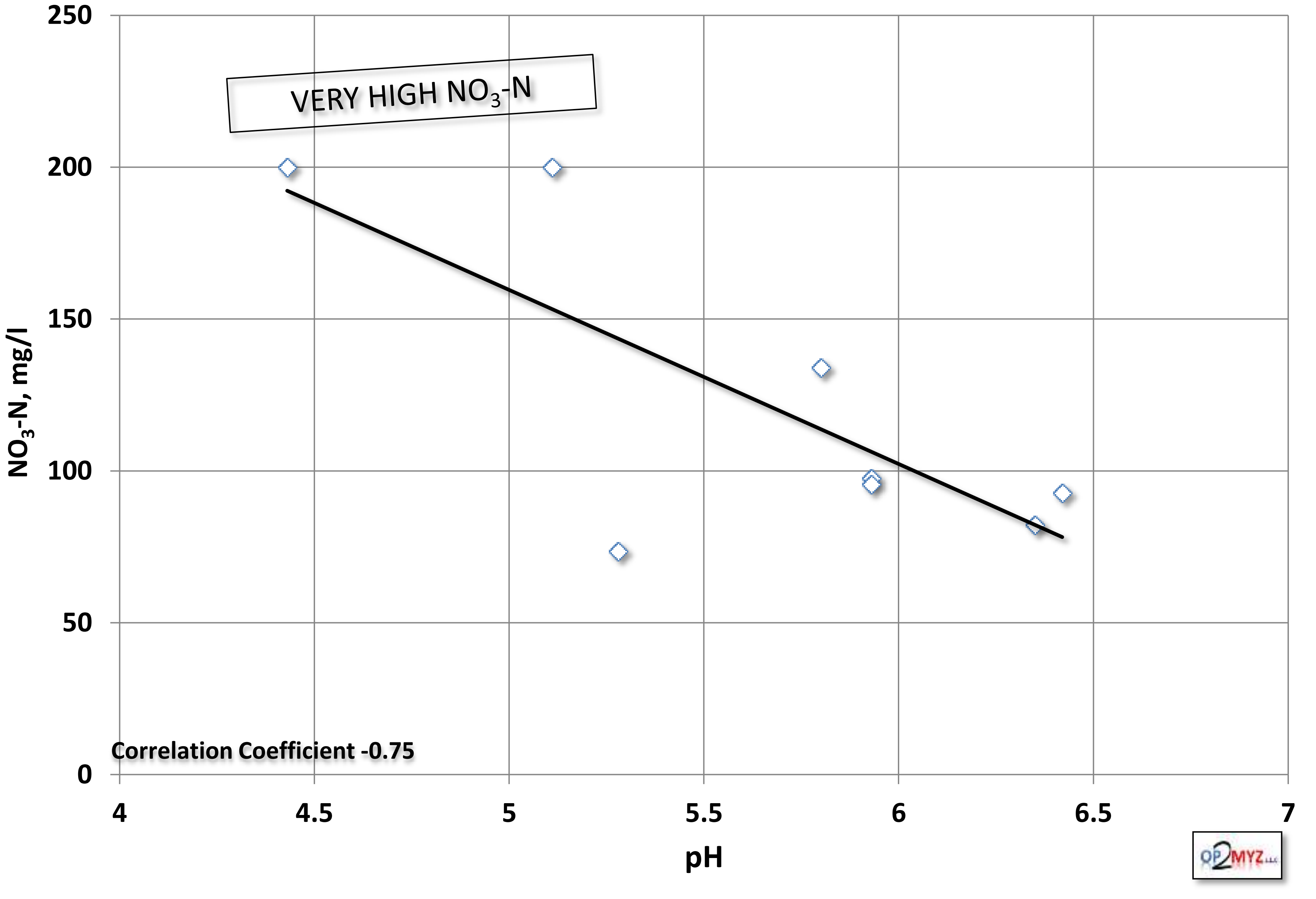
- **Tank** - The aerobic digester's tank is either rectangular or circular and below ground or insulated from the cold. The tanks may be covered to provide more protection from the cold.
- **Aeration system** - The purpose of the aeration system is to supply oxygen to microbes and provide mixing. This can be either submerged air (usually coarse-bubble diffusers to avoid plugging), surface-mechanical aeration, or submerged-mechanical aeration.
- **Decant system** - In the decant system, the aeration is turned off periodically (in many plants daily) to allow solids to settle and to then remove clear water from the surface. The decant process thickens the biosolids. The decanted waters are then run back through the treatment plant.

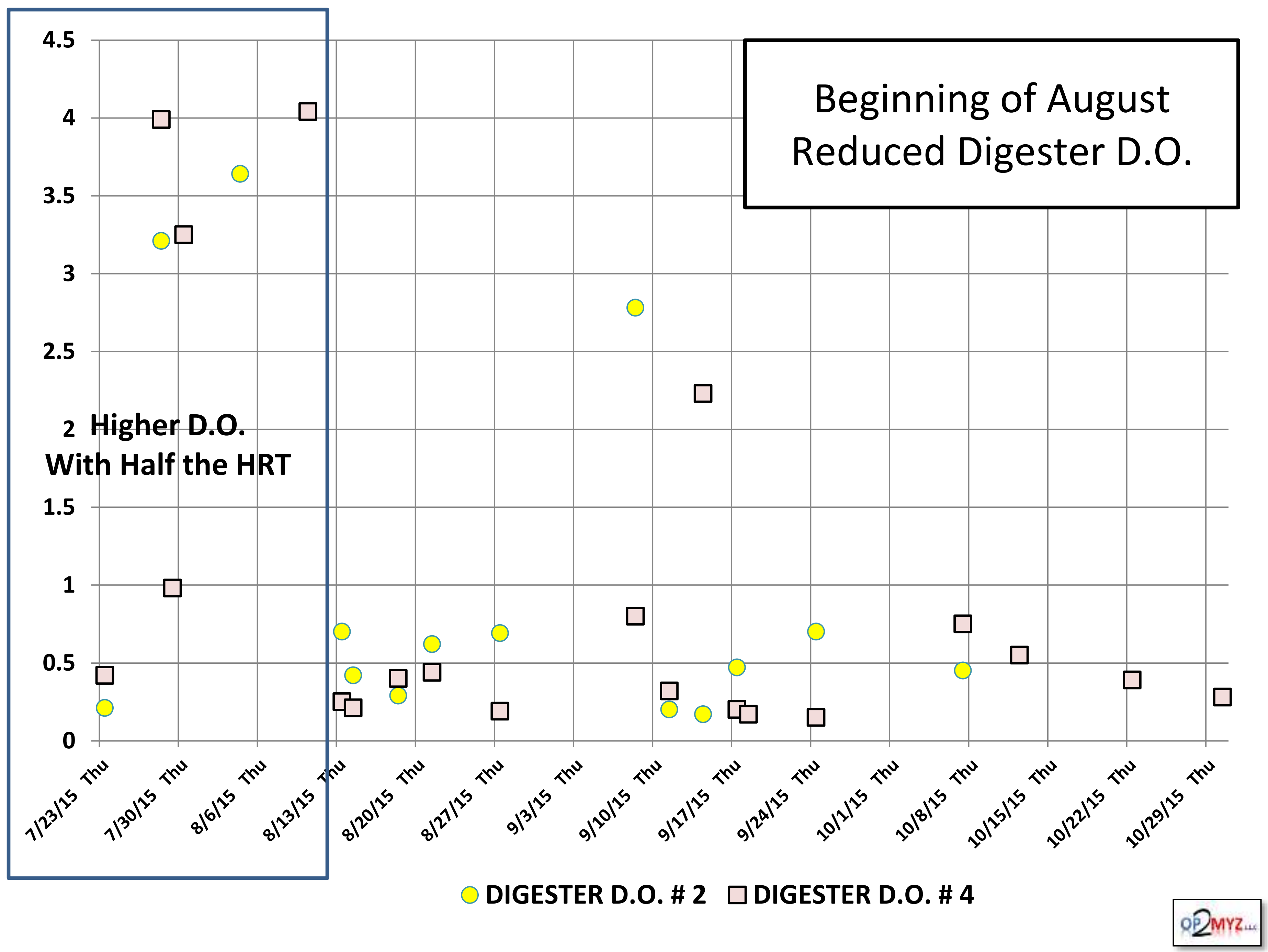
Antioch



Antioch

Aerobic Digester - Nitrates vs. pH



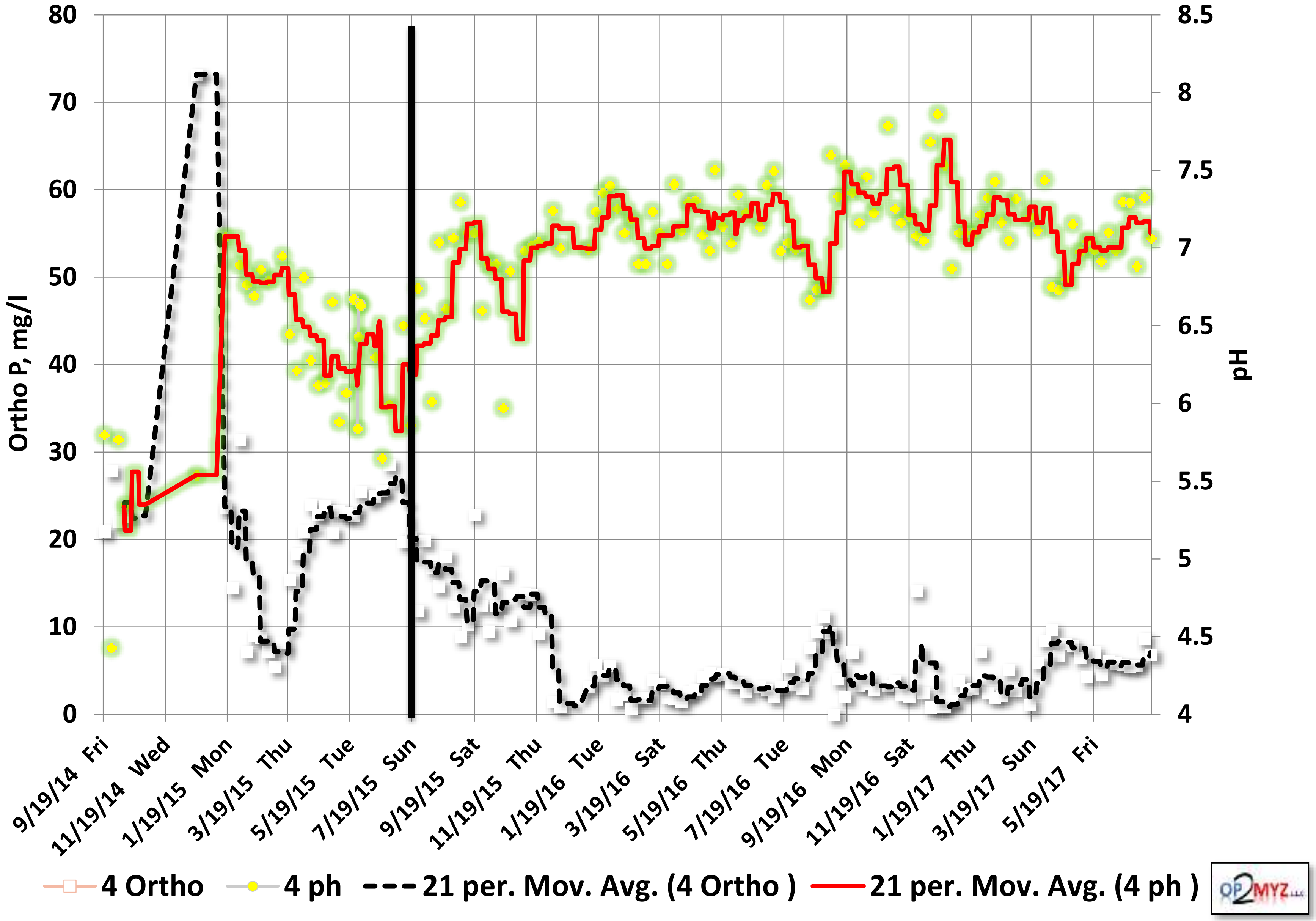


Beginning of August
Reduced Digester D.O.
Higher D.O.
With Half the HRT
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
7/23/15 Thu
7/30/15 Thu
8/6/15 Thu
8/13/15 Thu
8/20/15 Thu
8/27/15 Thu
9/3/15 Thu
9/10/15 Thu
9/17/15 Thu
9/24/15 Thu
10/1/15 Thu
10/8/15 Thu
10/15/15 Thu
10/22/15 Thu
10/29/15 Thu
DIGESTER D.O. # 2
DIGESTER D.O. # 4

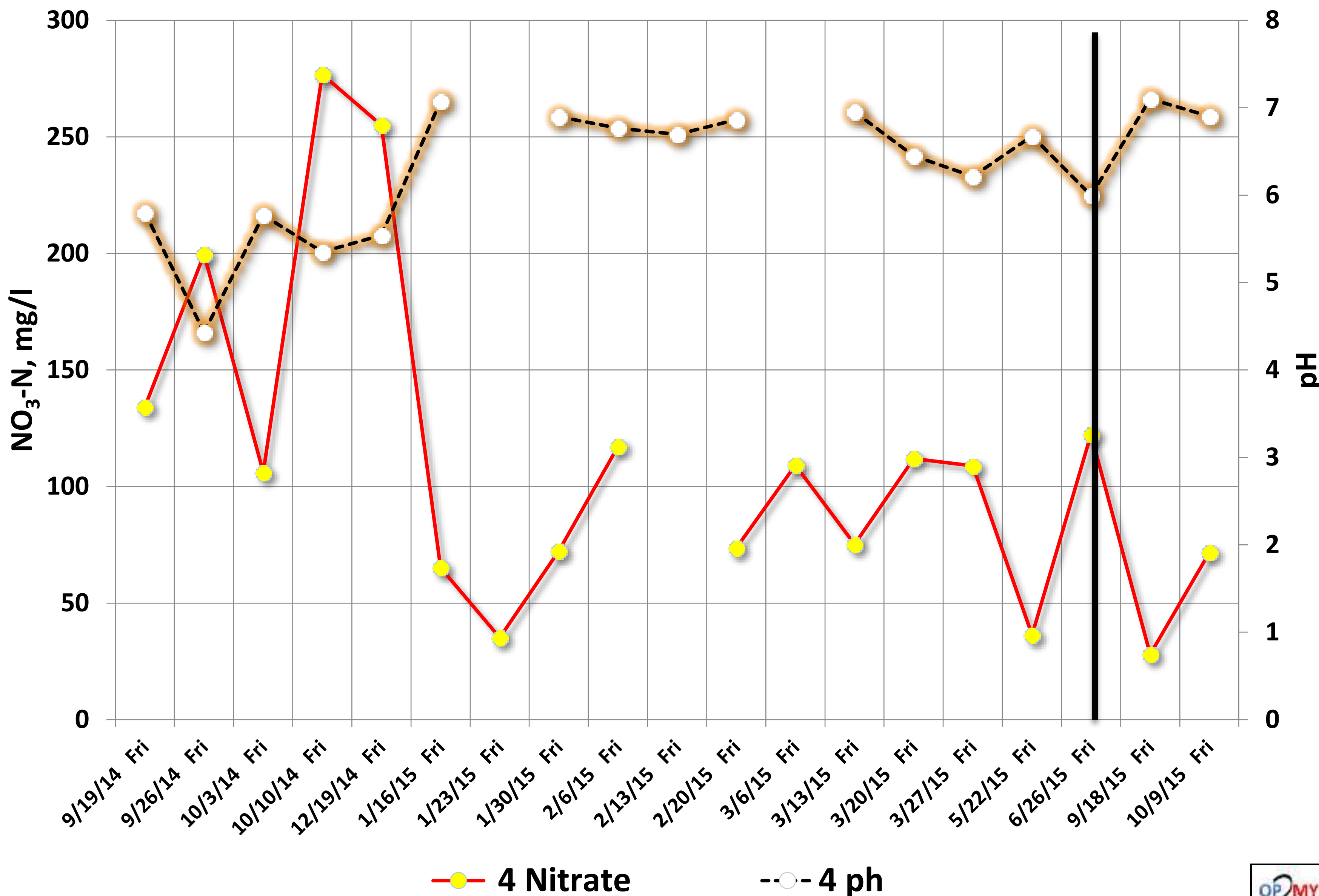
Antioch - Issue

- **Issue** – VERY High side stream lbs./hr. **NO_3-N & sRP** (soluble Reactive P) in decant & belt press filtrate from aerobic digester + very low pH
- Decants were done very **quickly**, high gal/hr. with as high as 200 mg/l NO_3-N, 80 mg/l sRP and **4.4 pH**
- This combination created the VERY high lbs./hr. condition

Antioch Aerobic Digestion – Ortho-P & pH



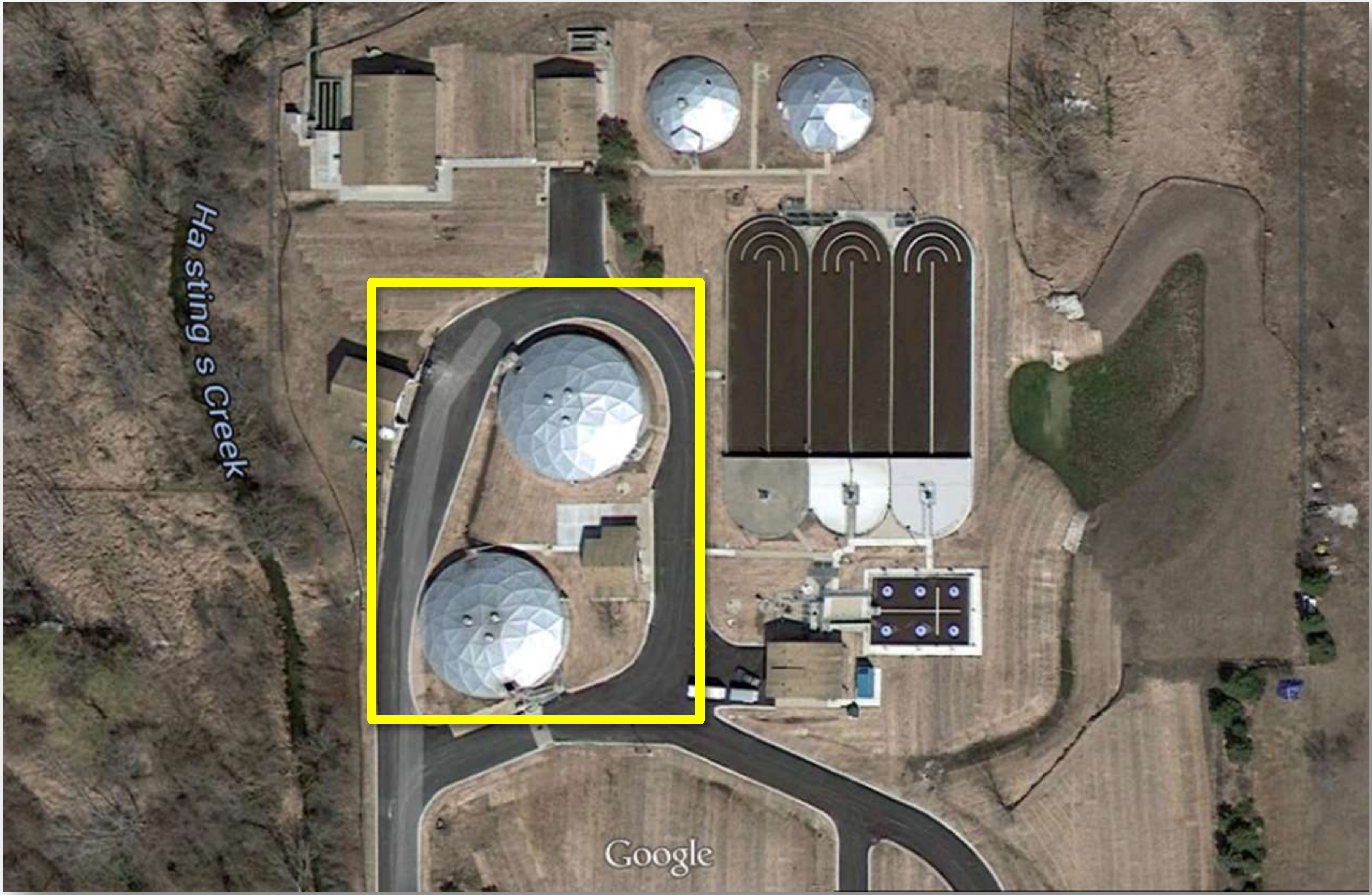
Antioch Aerobic Digestion – Nitrate & pH



Antioch - FIX

- **FIX** – Improved aerobic digester operation/performance
- Operating with a **low D.O.** approx. 0.5 mg/l and reducing the time period the sludge stayed in digester – **reduced** hydraulic retention time **(HRT)**
- **Reduced** both **NO_3-N/sRP** levels, increased pH & alkalinity

Lindenhurst



Lindenhurst

Lindenhurst - Issue

- **High** sRP in decant
- **High** NO_3-N in decant
- Digester air OFF too long during decant
  - Longer the air OFF the higher the sRP

Lindenhurst - FIX

- Decanting improvements
  - Installed **LARGE DECANT PUMP** decrease the time the air was off in aerobic digester which reduced the sRP concentrations
  - **Improved ON/OFF** aeration time of aerobic digesters **decreasing nitrate and sRP** concentration in decant
  - Change in ON/OFF operation improved performance so it made it possible to settle and decant within an 8 hour period vs. 24 hours
  - **DECREASE** amount of **SOLIDS** in digester to improve settling

Specific Oxygen Uptake Rate (SOUR).

- The oxygen uptake rate (OUR) measures the oxygen used per hour by the microorganisms while breaking down the sludge volatile organic matter.
- The specific uptake rate (SOUR) divides the oxygen uptake rate (mg O_2/hr.) by the grams (g) of total solids in the sample (mg O_2/hr./g TS).
- From DNR Study Guide

Specific Oxygen Uptake Rate (SOUR).

- A SOUR from a well-operated aerobic digester sludge process will range **between 0.1 and 1.0 mg 02/hr./g TS**.
- For a Class B sludge to meet the vector attraction reduction requirement, the SOUR must be
  - less than or equal to 1.5 mg/02/hr./g TS.
- From DNR Study Guide

Specific Oxygen Uptake Rate (SOUR).

OXYGEN used in **ONE** hour by **ONE** gram of sludge (BUGS)

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Calculating SOUR

6.2.8 Given data, determine the oxygen uptake rate (OUR) (mg/L of DO/min) and specific oxygen uptake rate (SOUR) (mg/L of DO/hr./mg)

Calculating SOUR

Initial DO = 2.5 mg/L

Final DO = 1.7 mg/L

Time = 15 mins

Aerobic digester total solids = 2.5 g/L

FORMULAS AND SOLUTION:

OUR = [initial DO (mg/L) - final DO (mg/L)] ÷ time (mins)

= (2.5 mg/L - 1.7 mg/L) ÷ 15 mins

= 0.8 mg/L ÷ 15 minutes

= 0.053 mg/L of DO/min

SOUR = [**OUR** (mg/L of DO/min) × 60 mins/hr.] ÷ solids (g/L)

= (0.053 mg/L of DO/min × 60 min/hr.) ÷ 2.5 g/L

= 3.18 mg/L of DO/hr./mg/L ÷ 2.5 g/L

= 1.27 mg/L of DO/hr./mg

HISTORY

Aerobic Digestion evolved from the extended aeration version of activated sludge

Credits

- Wisconsin DNR Biological Solids and Sludges – Handling, Processing, and Reuse Study Guide


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Thank You
Any Discussion,
Comments or
Questions
• Op2Myz, LLC
• Providing a "bridge" between WWTP operators in understanding, troubleshooting and optimizing their biological phosphorus & nitrogen removal systems.