

Nutrient Removal

*Presented to the West Virginia
Point Source Innovations Workgroup*

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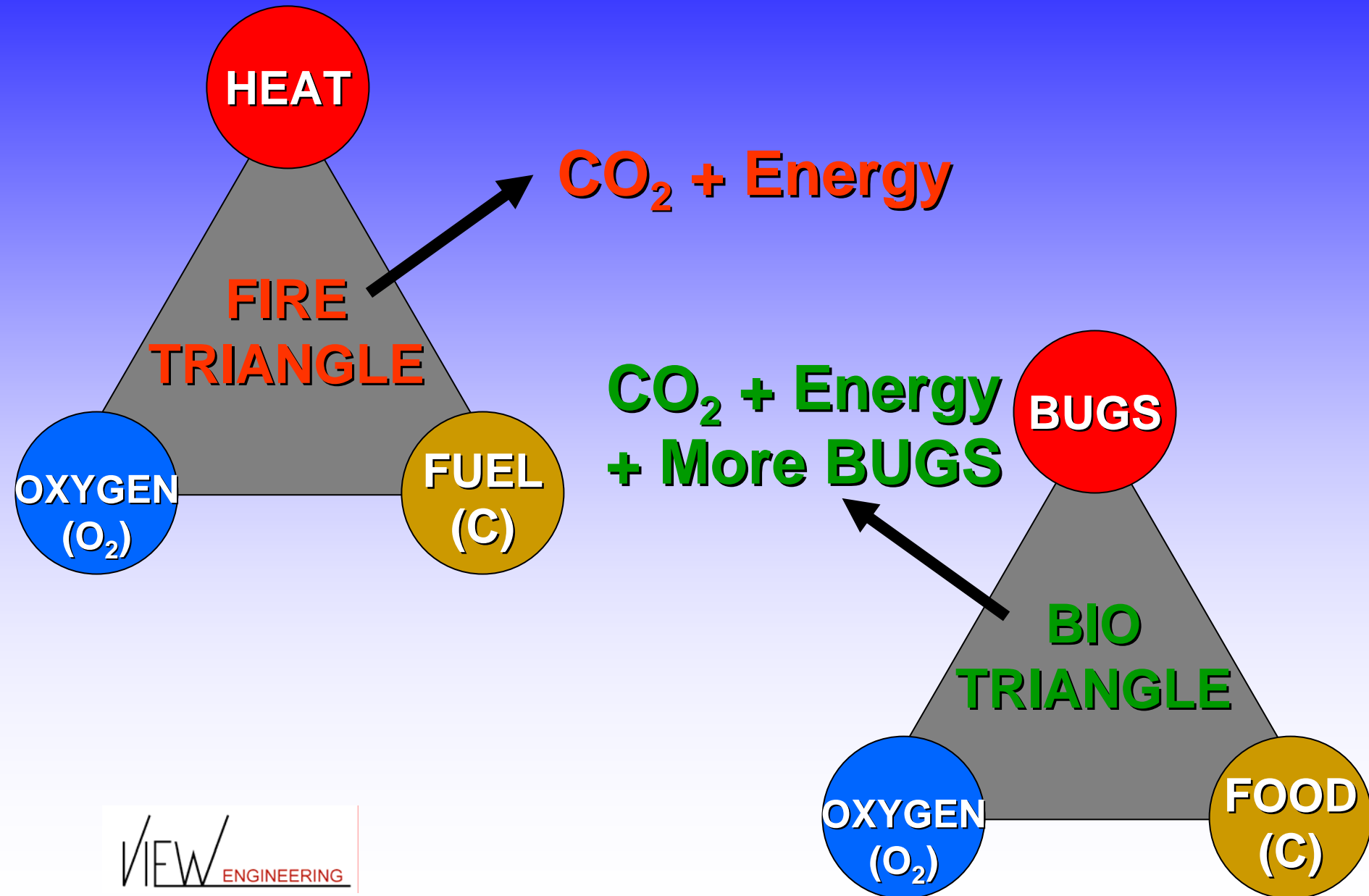
Overview

- **What are nutrients?**
 - Nitrogen and Phosphorus
- **Why do we want to remove them?**
 - They act as fertilizer and disrupt the ecological balance in the Chesapeake Bay
- **Outline**
 - How does nitrogen appear in wastewater?
 - How is nitrogen removed from wastewater?
 - How does phosphorus appear in wastewater?
 - How is phosphorus removed from wastewater?

Forms of Nitrogen

- Ammonia = NH_3 (Soluble only)
- Organic Nitrogen = CHON (Soluble and Particulate)
 - Total Kjeldahl Nitrogen (TKN) = Ammonia + Organic Nitrogen
- Nitrogen Gas = N_2 (Gas only)
- Nitrate/Nitrite = NO_3/NO_2 (Soluble only)

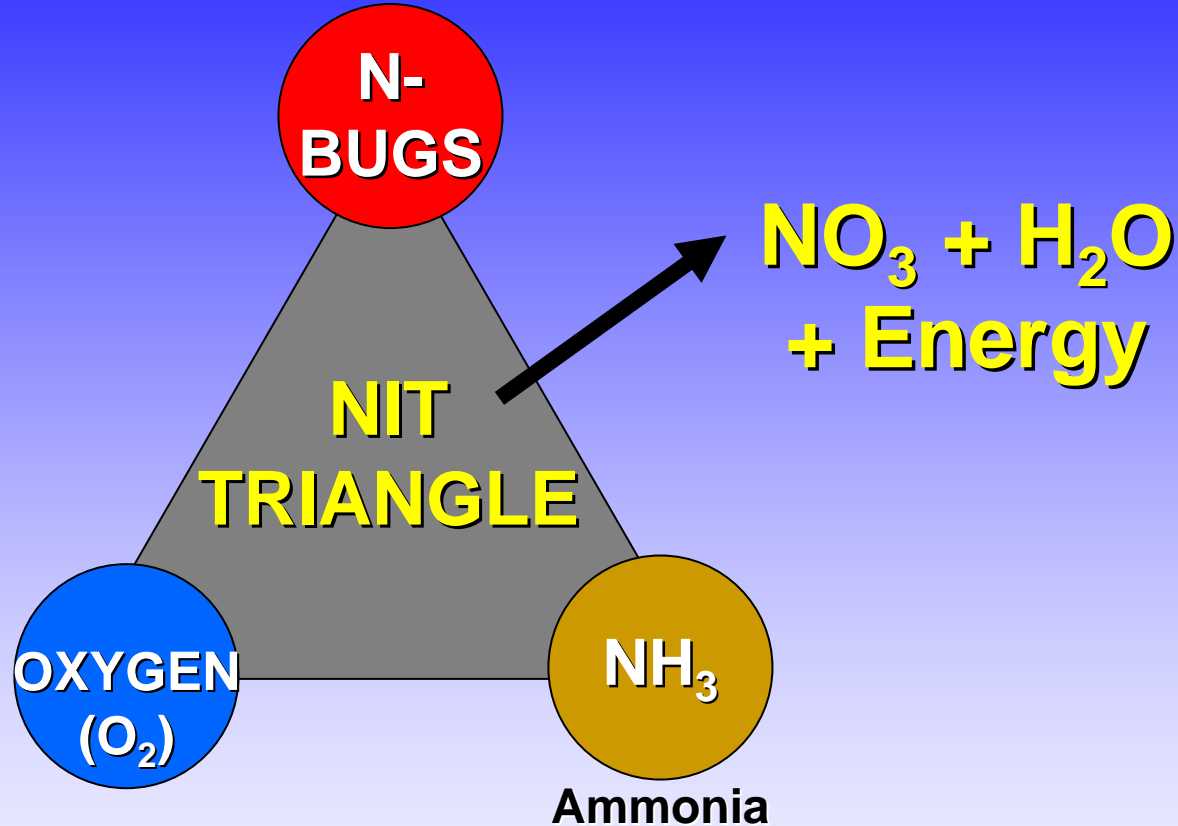
Biological Reactions are like Fire



Biological Nitrogen Removal

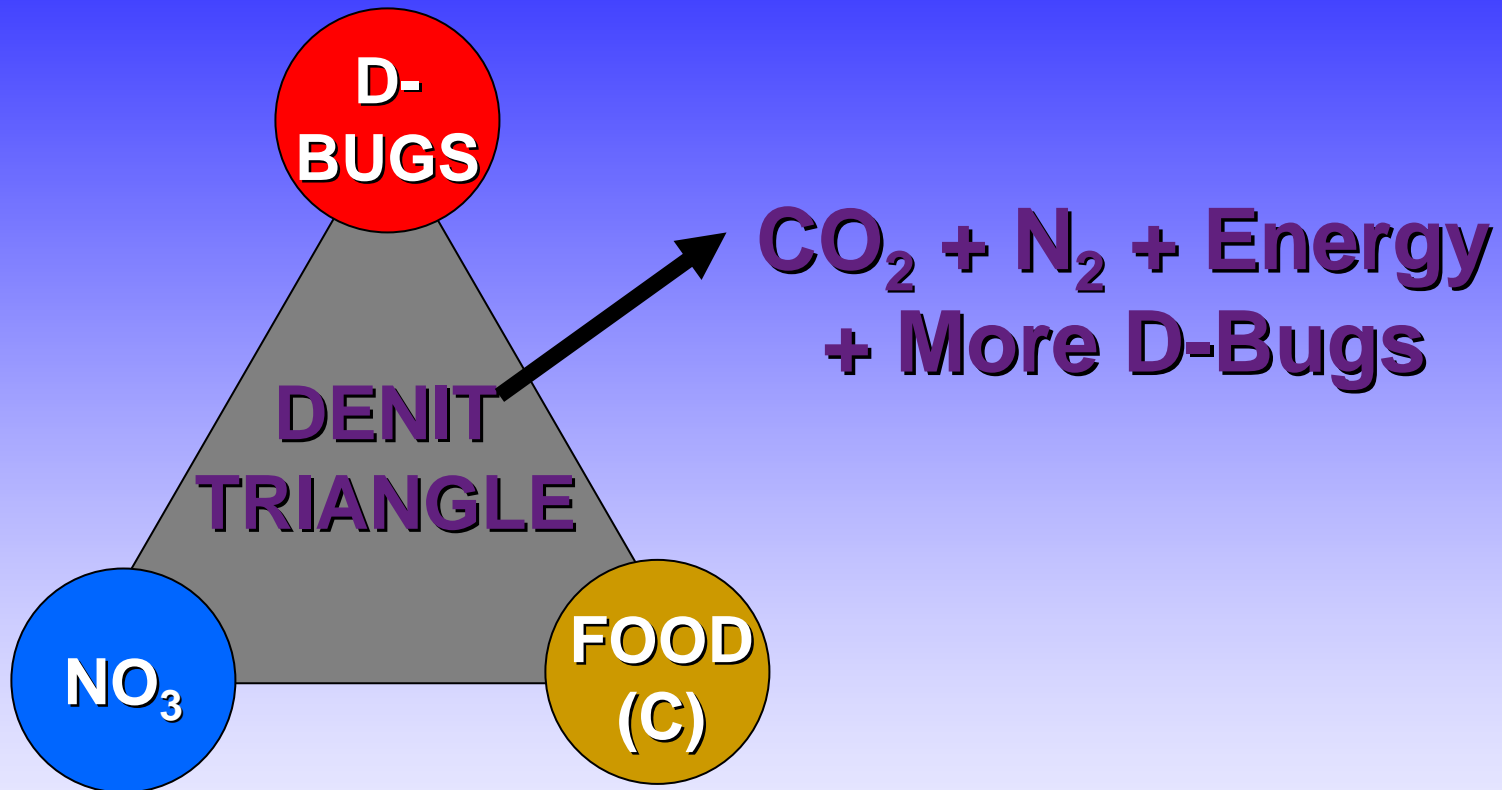
- Nitrogen Removal is a Two Step Biological Process
- Nitrification – TKN to NO_3
- Denitrification – NO_3 to N_2 gas

Nitrification



- Can occur in aeration basins – requires more air
- Requires a longer sludge age because nitrifying bacteria are slower growing
- Nitrifying bacteria are more sensitive to temperature

Denitrification



- Must have Nitrate (NO₃) and NO OXYGEN (O₂) = Anoxic conditions
- Denitrifying bacteria are extremely sensitive to temperature
- Denitrification (anoxic treatment) occurs slower than normal biological treatment (aerobic treatment)

Forms of Phosphorus in Sewage

- Orthophosphate = PO_4 (Soluble only)
- Polyphosphate = chemicals with multiple orthophosphate groups, like sodium hexametaphosphate, $\text{Na}_3(\text{PO}_3)_6$ (Soluble only)
 - Polyphosphates gradually breakdown into orthophosphate
- Organic Phosphorus = incorporated into cell mass, CHON_p (Soluble and Particulate)

Phosphorus Removal

- Phosphorus can be removed chemically or biologically
- Most small plants use chemical phosphorus removal with alum or ferric chloride
 - $\text{PO}_4 \text{ (a)} + \text{Al (a)} = \text{AlPO}_4 \text{ (s)}$
 - $\text{PO}_4 \text{ (a)} + \text{FeCl}_3 \text{ (a)} = \text{FePO}_4 \text{ (s)} + 3 \text{ Cl (a)}$
- Chemical can be added before a clarifier and precipitate can be settled out to get phosphorus <1.0 mg/L
- To get phosphorus <0.5 mg/L, filtration may be required

Biological Phosphorus Removal

- Waste sludge contains organic phosphorus, 1.5% to 2.0% phosphorus by dry weight
- Biological Phosphorus Removal increases the organic phosphorus concentration to 3% to 5% by dry weight by growing special Phosphorus Accumulating Organisms (PAOs)
- To grow PAOs, first create a “selector zone” with food (C), bugs (PAOs), and NO OXYGEN OR NITRATES
 - The PAOs will grab food and release phosphorus
- Next, create an “aeration zone” with bugs (PAOs) and oxygen, but less food
 - The PAOs will consume the food and grab more phosphorus

Recap

- **Nitrogen is removed biologically**
 - **First step is Nitrification, TKN to NO_3 in aerobic treatment with a long sludge age**
 - **Second step is Denitrification, NO_3 to N_2 in anoxic treatment**
- **Phosphorus is usually removed chemically with alum or ferric chloride**
 - **Filtration may be necessary to achieve 0.5 mg/L total phosphorus**

Questions?

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