

How to Meet the 10 mg/L Nitrate MCL in Treated Effluent

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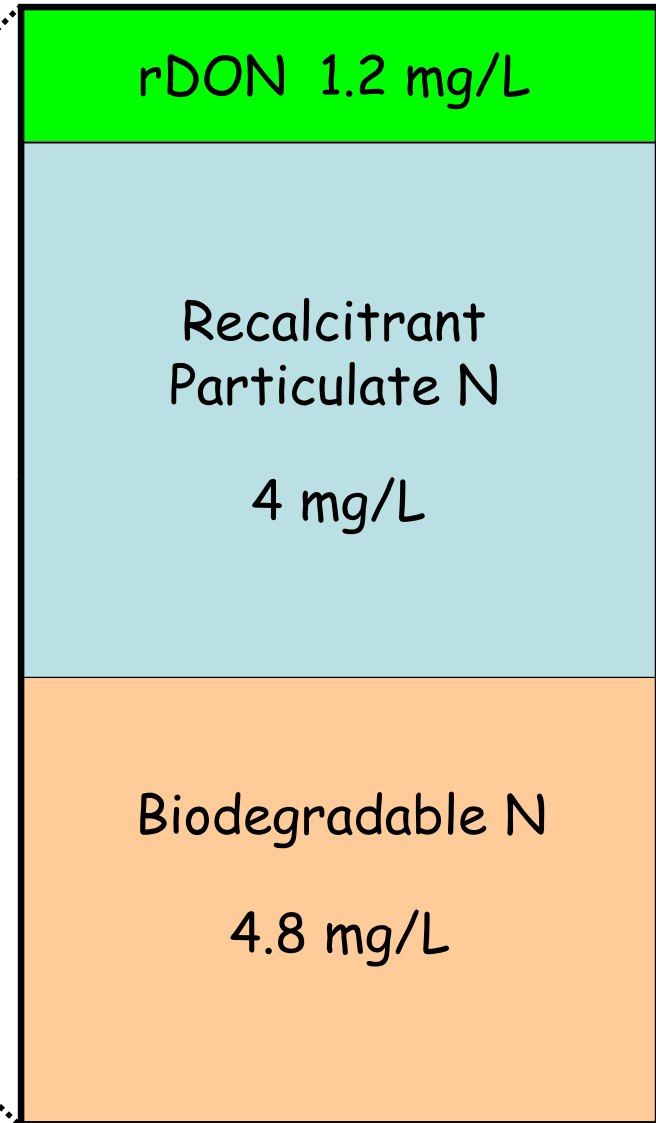
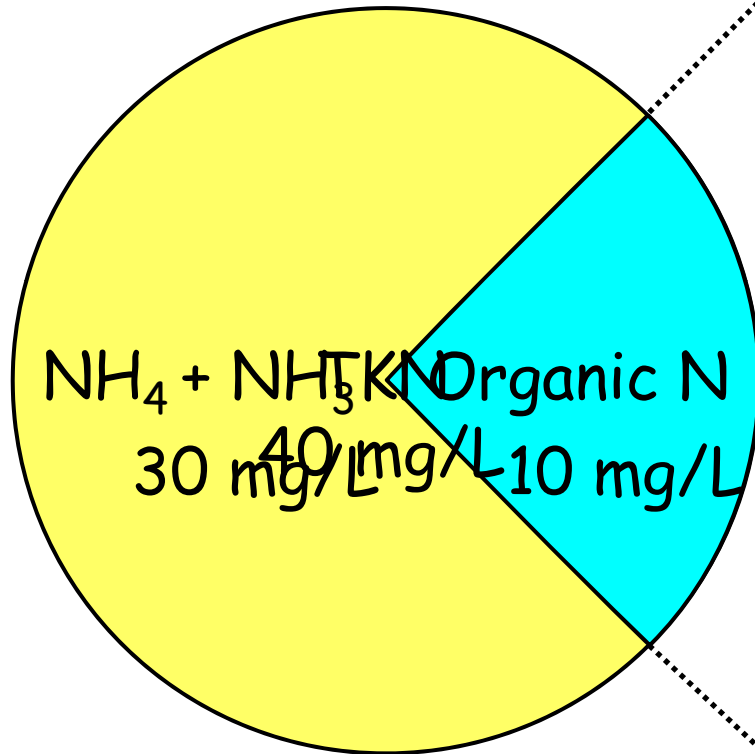
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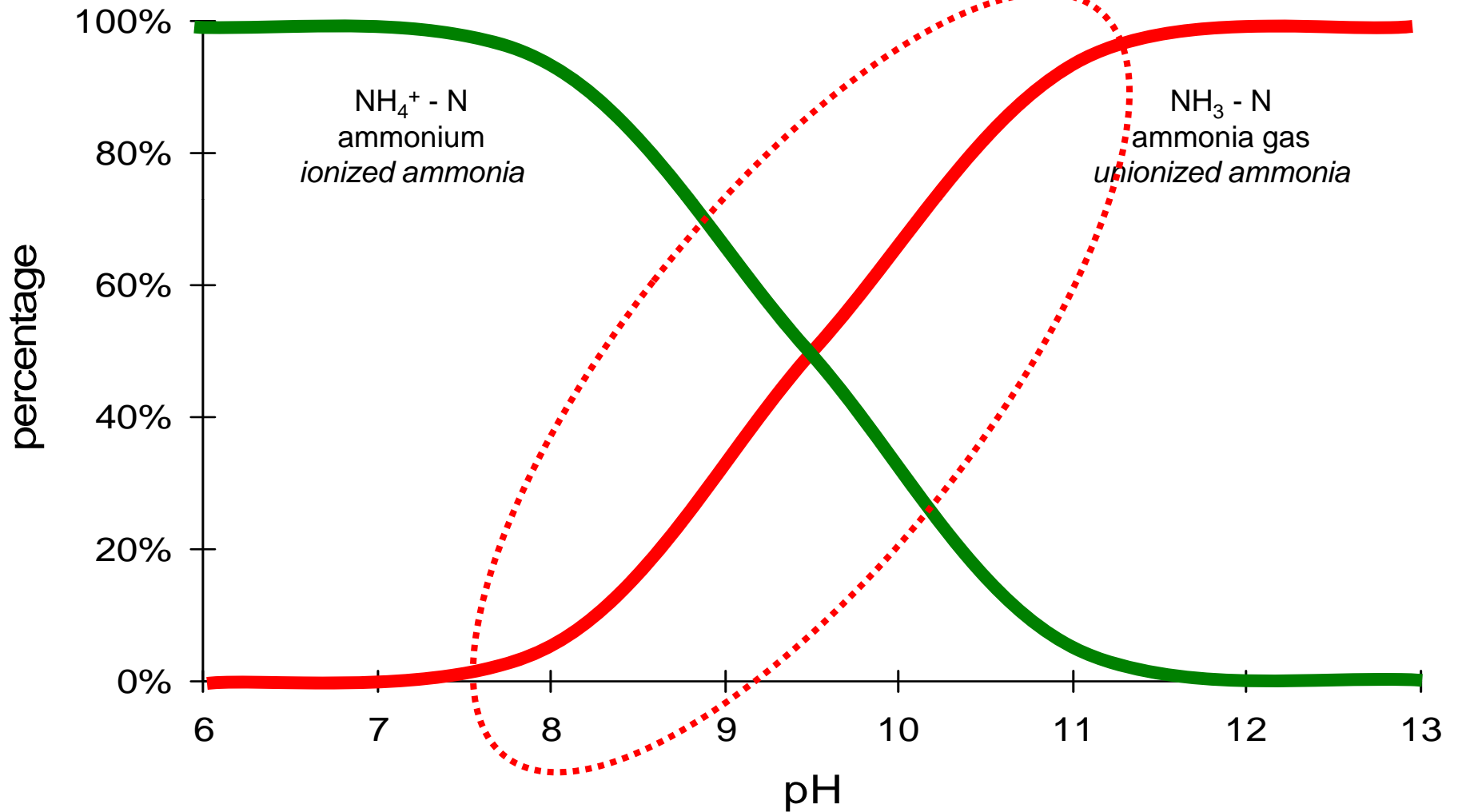
Forms of Nitrogen in Water

- Ammonium and Ammonia (NH_4^+ , NH_3)
(ionized, un-ionized)
- Organic Nitrogen (-N)
- Nitrite and Nitrate (NO_2^- , NO_3^-)
- Total Kjeldahl Nitrogen (TKN)
(ammonia forms + organic nitrogen)
- Total Inorganic Nitrogen (TIN)
(ammonia forms + nitrite + nitrate)
- Total Nitrogen

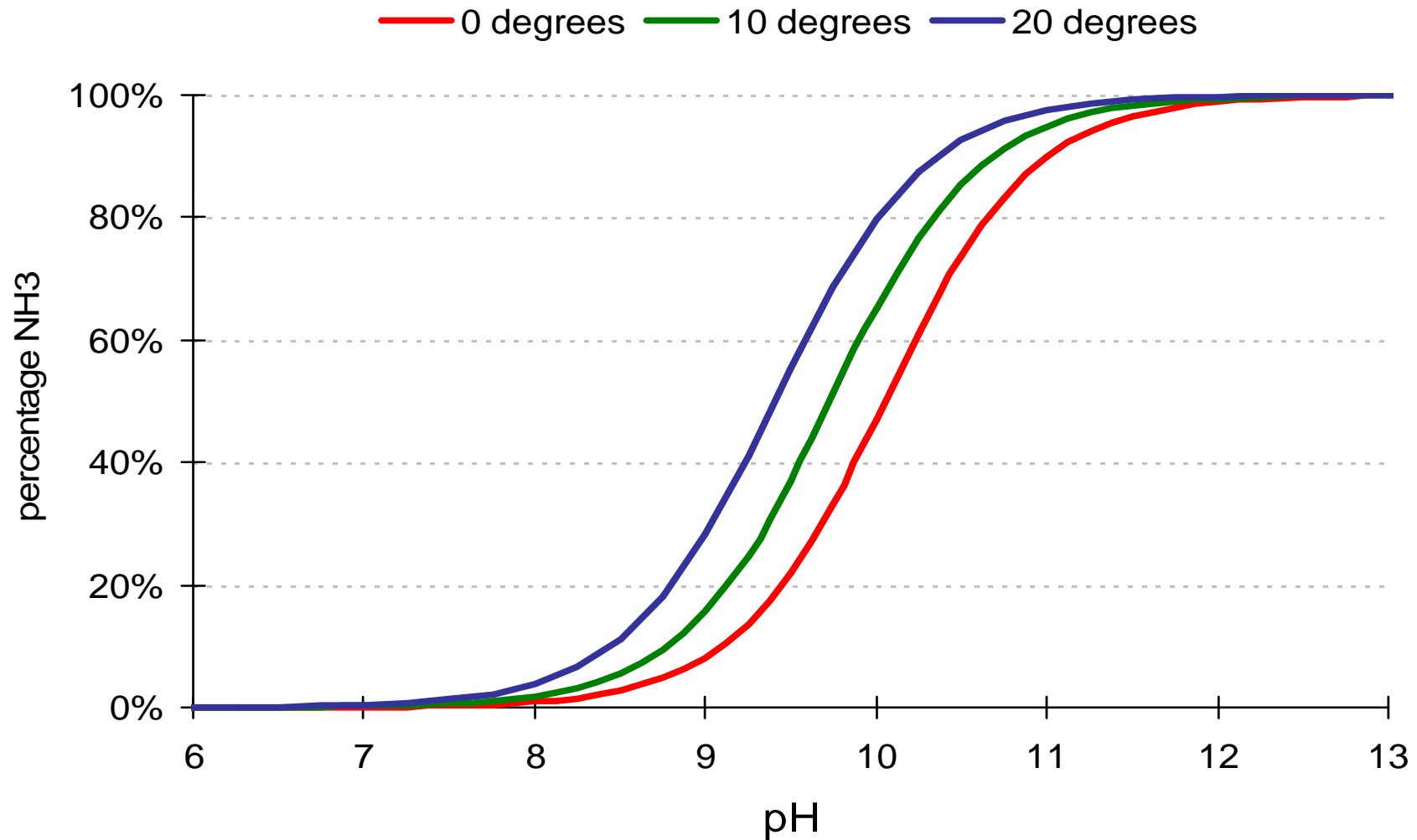
Fractionation TKN



Ammonia Form Depends on pH



Ammonia Curve depends on Temperature



Common Removal Methods

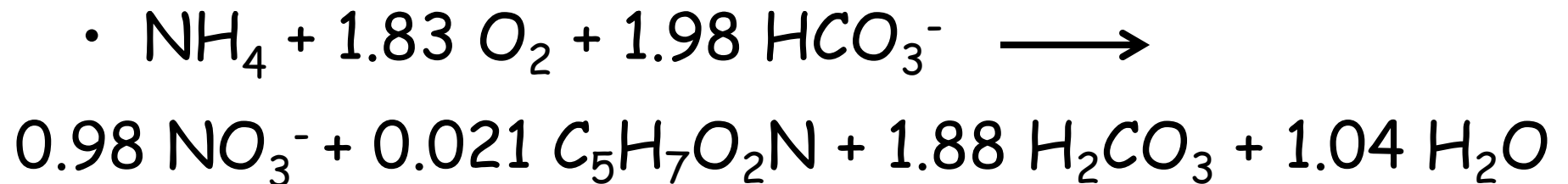
- Air Stripping
- Breakpoint Chlorination
- Ion Exchange
- Nitrification / Denitrification

Nitrification

- The major method for ammonia removal
- Conversion of ammonium to nitrite and nitrate by autotrophic bacteria
- Is an AEROBIC process (Oxygen needed)

Some Chemistry

- Complete nitrification balance



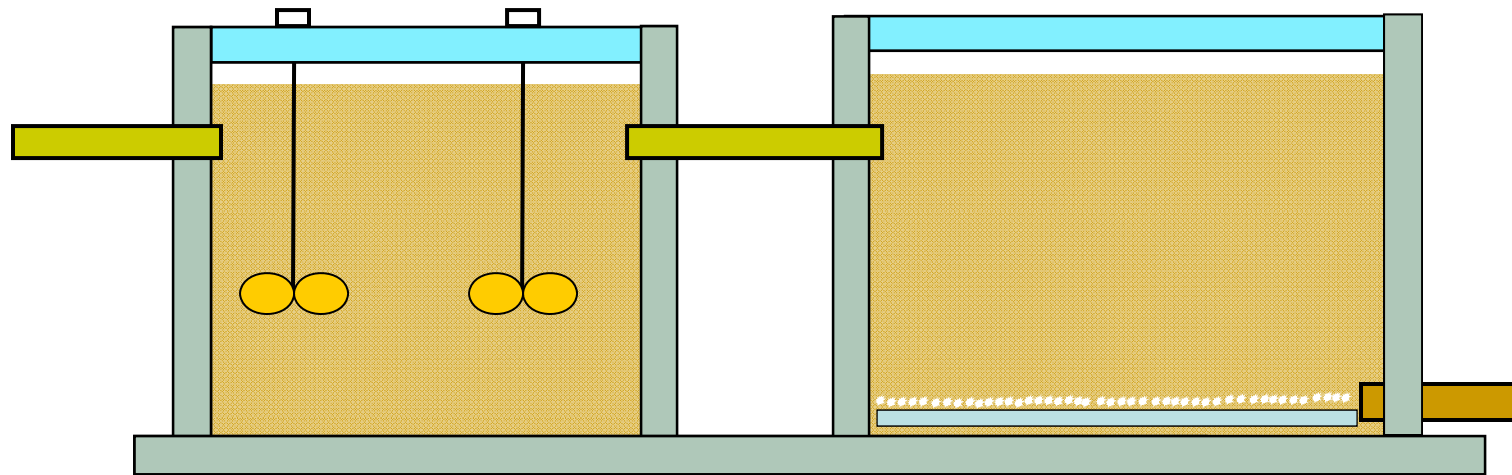
- The carbonic acid produced reduces the alkalinity by about 7.1 lbs per lbs of NH_4^+

Some Chemistry

- Typically a 2 step process (peel the orange!)
- Nitrite formation (Nitroso-bacteria)
- $2 \text{NH}_4^+ + 3 \text{O}_2 \longrightarrow 2 \text{NO}_2^- + 4 \text{H}^+ + 2 \text{H}_2\text{O}$
- Nitrate formation (Nitro-bacteria)
- $2 \text{NO}_2^- + \text{O}_2 \longrightarrow 2 \text{NO}_3^-$

Nitrification Designs

Separate Stage



Carbon (BOD) Removal

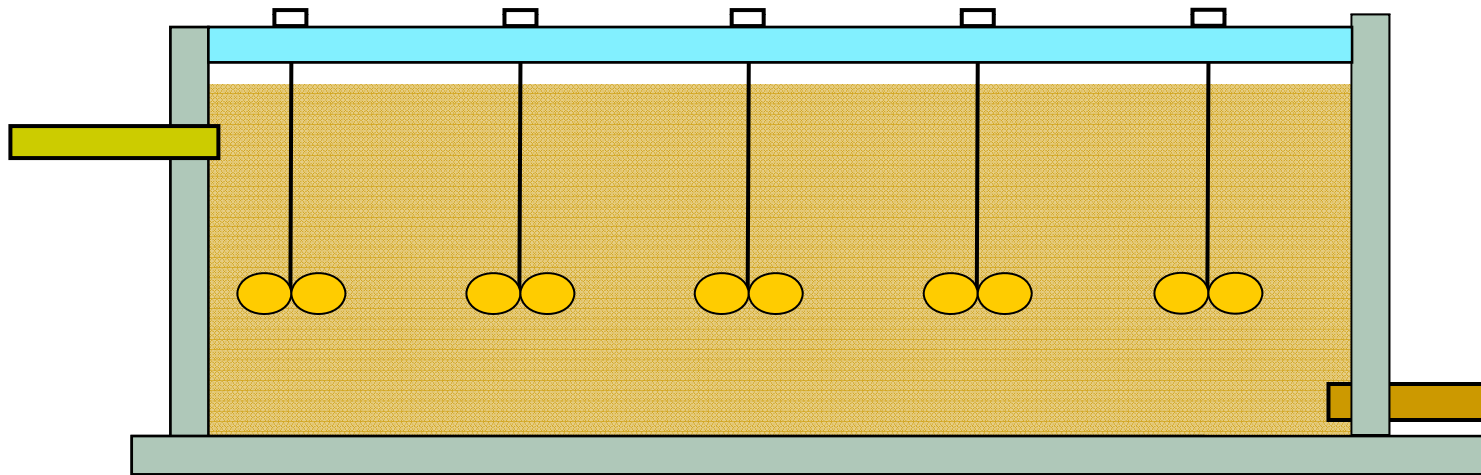
Ammonia Removal

Separate Stage



Nitrification Designs

Combined Stage



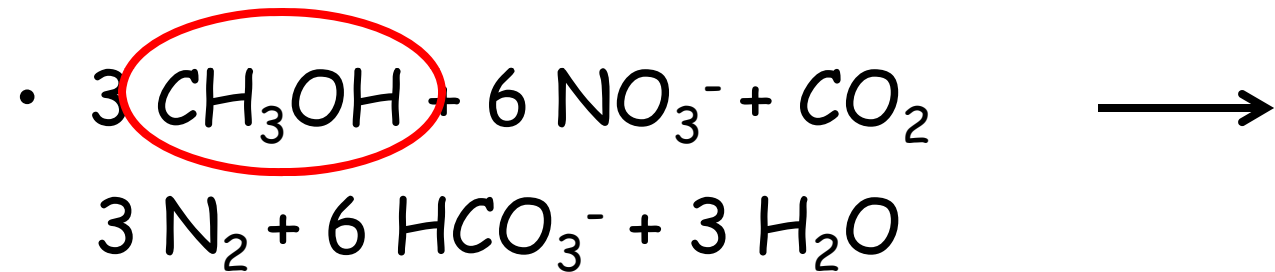
Carbon (BOD) Removal + Ammonia Removal

Combined Stage

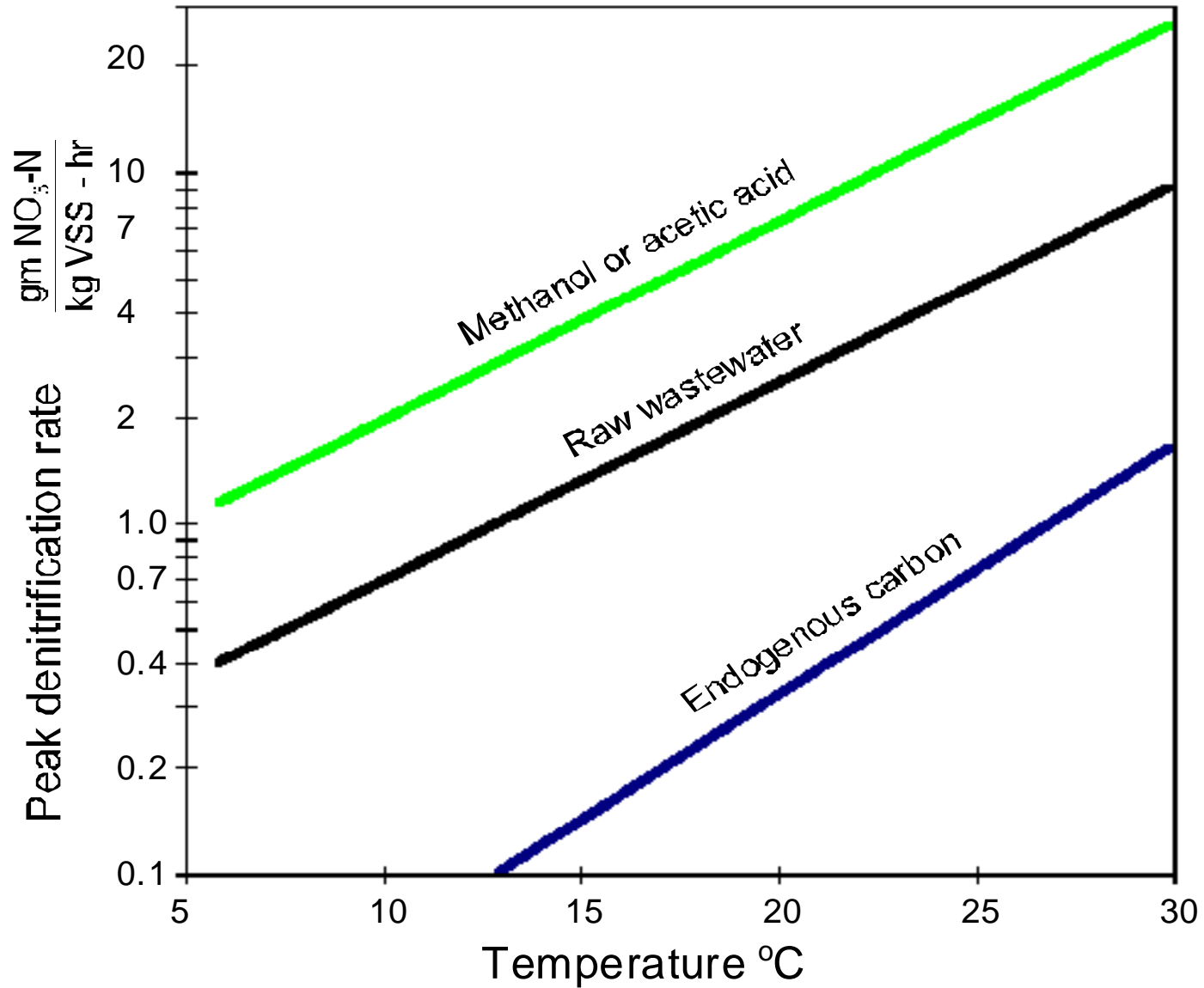


Some Chemistry

- Simple de-nitrification balance



Process Kinetics

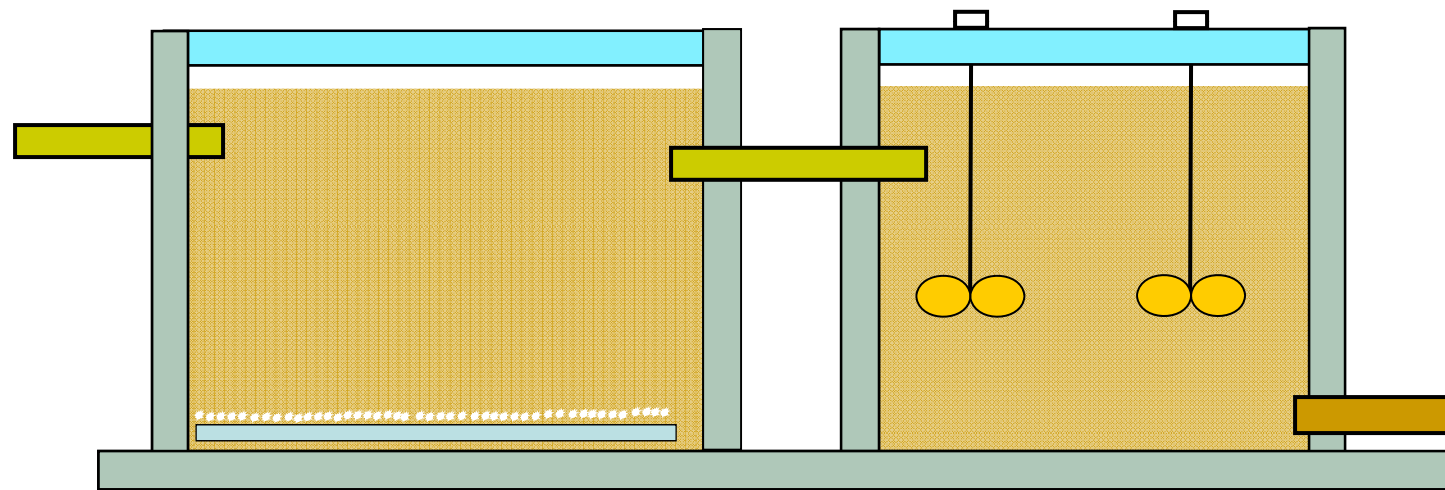


De-nitrification

- Oxygen equivalent of NO_3^- is 2.86 mg
- Alkalinity produced due to the consumption of the nitric acid
- Alkalinity equivalent of NO_3^- is 3~3.2 mg

De-nitrification Designs

Separate Stage



Ammonia Removal

Nitrate Removal

Separate stage (de-nite filters)

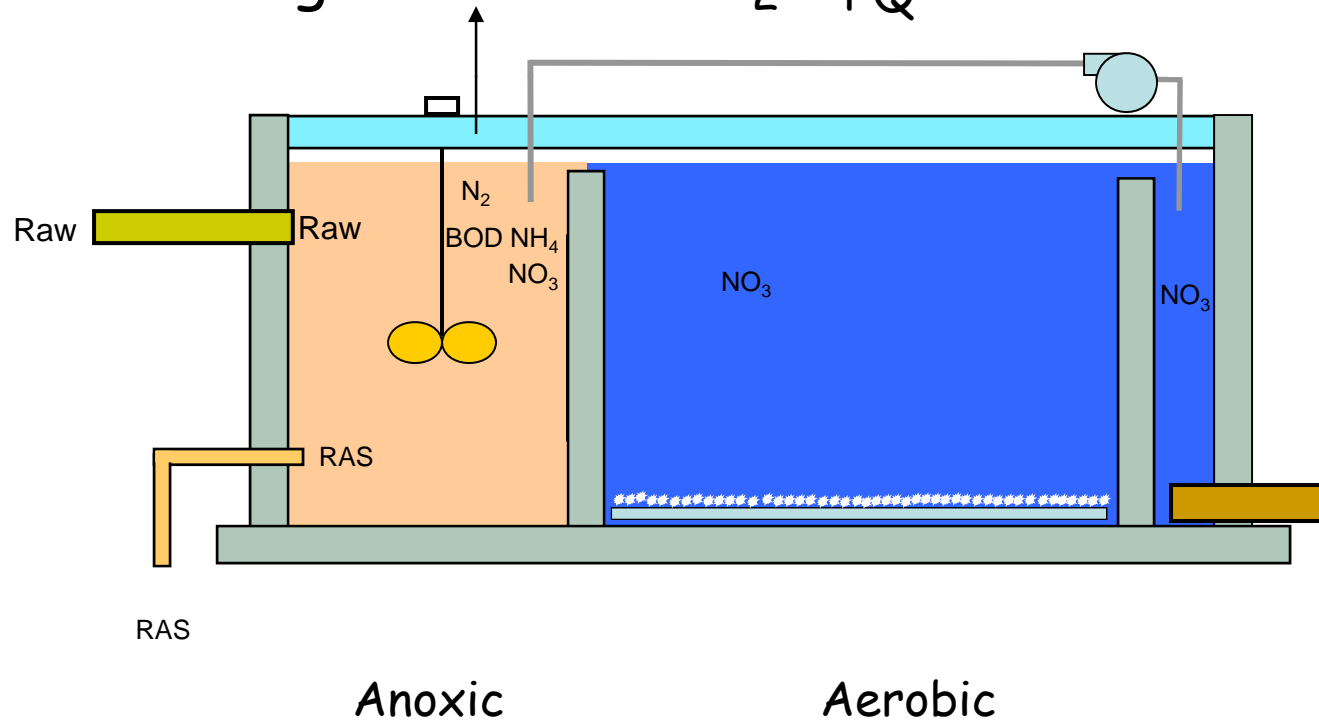


De-nitrification Designs

Modified Ludzack-Ettinger Process - 1970

TN - 5-10 mg/L

2 - 4 Q



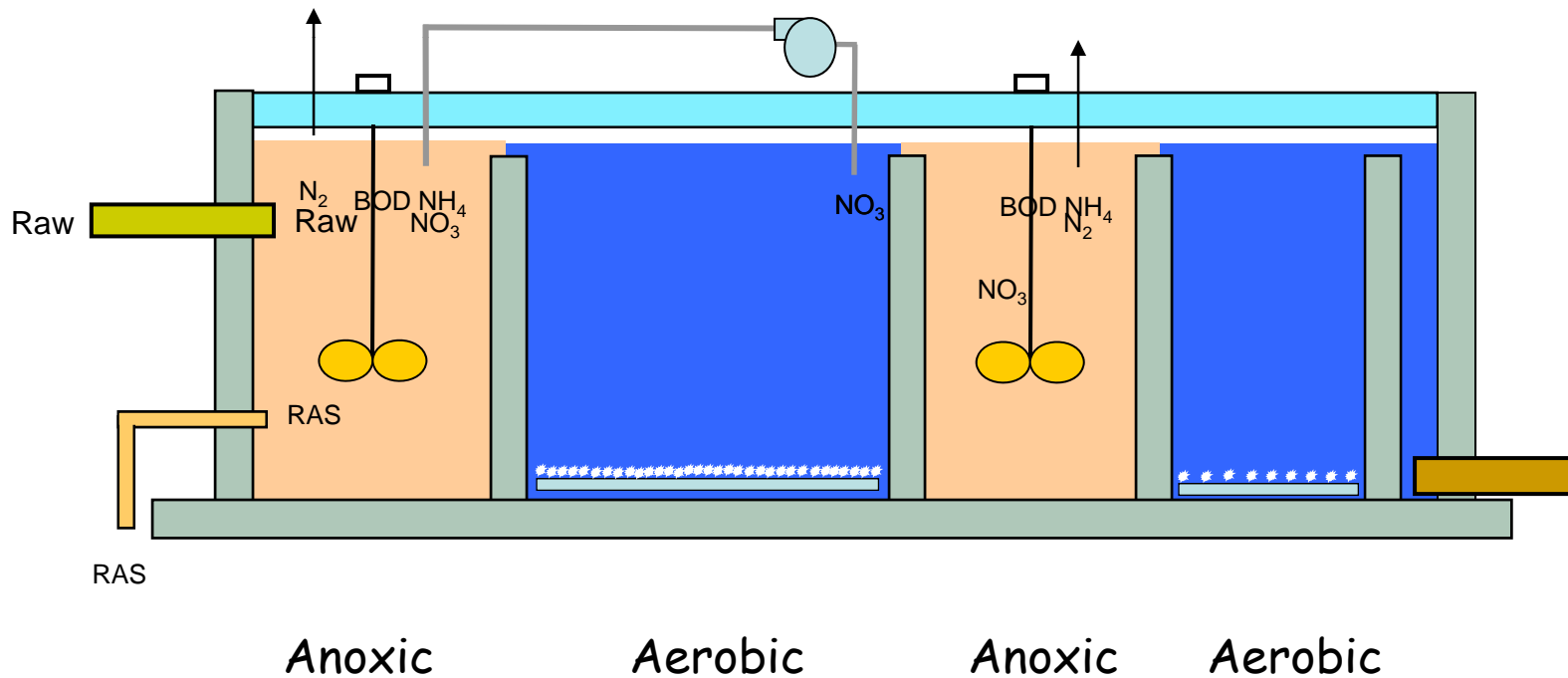
MLE process



De-nitrification Designs

4-Stage Bardenpho Process - 1971

TN - 3-4 mg/L 2 - 4 Q



Bardenpho



Take Home Message

- 10 mg/L Nitrate can be reliably met
- Look at Total Inorganic Nitrogen (TIN)
(ammonia forms + nitrite + nitrate)
- Performance is limited by Carbon
- Three proven designs
 - Separate stage De-Nitrification
 - Modified Ludzack-Ettinger Process (MLE)
 - 4-Stage Bardenpho Process



Questions ?