A Mathematical Model Describing Nitrogen Removal in Alternative Wastewater Treatment Systems

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Diagram of Solar Aquatic System
Basic Equations

\[ \frac{dB}{dt} = B[1 - \frac{B}{N_{in}}] \]

\[ N_{out}(t) = N_{in}(t) - B(t) \]
What About Backflow?

\[
\frac{dB}{dt} = B[1 - \frac{B}{N}]
\]

\[
N(t) = \frac{N_{in}(t) + N_{out}(t - \delta) \frac{F}{I}}{1 + \frac{F}{I}}
\]

\[
N_{out}(t) = N_{in}(t) - B(t)
\]
[N] Backflow Delay 1 Day, Feedback: Inflow 1:2
What about Buffering?

- Physical definition
- Implemented as a averaging
[N] 1 Day Buffering

**Output Nitrogen Concentration**

- Input N Concentration
- Output N Concentration

**Bacterial Consumption Nitrogen Concentration**

- Input + Feedback N Concentration
- Bacterial Consumption N Concentration
1 Day Buffering

Output Nitrogen Concentration

Nitrogen Concentration (mg/L)

Time (days)

Bacterial Consumption Nitrogen Concentration

Nitrogen Concentration (mg/L)

Time (days)
What if you combine buffering and feedback?

Buffer + Feedback = ??
1 Day Buffering, 1 Day Feedback Delay, Feedback: Inflow 1:1

Output Nitrogen Concentration

Bacterial Consumption Nitrogen Concentration
Numerical Solver

- RK4
  - Description
  - Why?
- Coding
  - feedback delay
  - buffering averaging
Know your system!

- The ideal feedback:inflow ratio is 1:1
- The ideal feedback rate is a half integer of the period of the system
- How to optimize buffering
  - Determine highest peak (ex: 100x normal peak)
  - Determine tolerance (ex: 40x normal or 10x normal)
  - Determine buffering time (ex: 40x -> 7 day buffer, 10x -> 20 day buffer)
  - Be reasonable (ex: wastewater goes “bad” quickly)
Any Questions?