Biological Treatment Sequencing Batch Reactors (SBRs) - Chemical Analysis and Monitoring
Start-up, Operation and Maintenance

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Burns & McDonnell Engineering Co.

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Presentation Outline

1. Definitions of Key Parameters
2. Types of Biological Treatment
3. SBR Features
4. Example Wastewater Treatment Plant
5. Start-Up Considerations
6. O&M Considerations
7. Q/A
1. Definitions and Key Parameters

- Dissolved Oxygen - DO
- BOD - a measure of pollution
- COD – a measure of pollution
- pH
- Nutrients (P, N, others)
- Equalization (hydraulic and waste-strength)
- HRT – Hydraulic Retention Time
- MCRT
1. Definition of Key Parameters

**Feed Batch Reactor**

- Peristaltic feed pump and controller
- Mixer
- Sample flow
- Rotometer
- Lab air
- Graduated cylinder (feed)
- Fed batch reactor
- $V_0 = 2.01$
1. Definition of Key Parameters

Design Parameters

Aerobic Oxidation:

\[ S_R = \text{BOD Removal, mg/L} \]
\[ x_{vb} = \text{biological MLVSS} \]
\[ f_a = \text{biologically active fraction of the MLVSS} \]
\[ t = \text{detention time, days} \]
\[ S_e = \text{effluent soluble BOD, mg/L} \]

Anoxic Denitrification:

\[ S_o = \text{influent soluble BOD, mg/L} \]
\[ K_o = \text{aerobic reaction rate, days}^{-1} \]
\[ \text{NO}_3^-\text{N} = \text{Nitrate Reduced, mg/L} \]
\[ K_{DN} = \text{anoxic reaction coefficient, days}^{-1} \]
1. Definition of Key Parameters

**Nitrogen Transformations**

**Organic Nitrogen** → **NH₃-N**

\[
2\text{NH}_4^+ + 3\text{O}_2 \xrightarrow{\text{Nitrosomonas}} 2\text{NO}_2^- + 4\text{H}_2\text{O} + 4\text{H}^+ + \text{NEW CELLS}
\]

\[
2\text{NO}_2^- + \text{O}_2 \xrightarrow{\text{Nitrobacter}} 2\text{NO}_3^- + \text{NEW CELLS}
\]

For 1 g NH₃-N oxidized:

- 4.33 g of O₂ are consumed
- 7.15 g of alkalinity (as CaCO₃) are destroyed
- 0.15 g of new cells are formed
- 0.08 g of inorganic carbon are consumed
1. Definition of Key Parameters
Nitrogen Changes

- Organic Nitrogen
- NH$_4^+$ (Ammonium)
- NO$_3^-$ (Nitrate)
- NO$_2^-$ (Nitrite)
2. Types of Biological Treatment

- Aerated Lagoons
- Activated Sludge
- Pure-Oxygen activated sludge
- SBR
- Bio-towers
- Rotary fixed film bioreactors
- Membrane Bioreactor (MBR)
- Anaerobic and Aerobic Treatment
2. Aerated Lagoon

Aeration Basin
HRT = MCRT
TSS in Effluent Normally Increases
2. Types of Biological Treatment

• Activated Sludge
  – Flocculent Slurry of Microorganisms
  – Quiescent Settling at settling tanks
  – Return of Settled Solids (biomass) to Bioreactor
  – Excess Solids Wasted to Control SRT
2. Activated Sludge

Equalization → Return Solids → Waste Solids → Discharge
2. MBR - Activated Sludge

Equalization → RAS → Membrane → Discharge

Waste Solids → Liquid-solids separation
MBR – Activated Sludge
2. SBR-Activated Sludge

A – Fill / React
B - Settle
C - Draw

Equalization

Waste Solids

Discharge
SBR Treatment Conditions

- BOD load (g/D/m3)  80 to 240 and higher
- Cycle (hr)  3 to 12
  - Fill (aeration)  1-3
  - Settle  0.7 to 1
  - Draw  0.5 to 1.5
- MLSS (mg/L)  2,300 to 5,000
- MLVSS (mg/L)  1,500 to 3,500
- HRT (hr)  15 to 40
- MCRT (day)  20-40
- F/M (g BOD5/MLVSS/day)  0.05 to 0.20
Example Wastewater Treatment Plant Site

- Operating a groundwater extraction, treatment and reinjection system in northern IL
- Treatment system used SBRs to biologically treat organics, ammonia and phenols
- Arsenic treatment is conducted when needed with ferric chloride addition and ion exchange
- Treated water is re-injected into treatment cell.
Mass removal of ammonia, phenols, and arsenic from groundwater at a Superfund site, immediately west of Lake Michigan, was dictated by a 1999 USEPA Record of Decision. After extensive study and design, the pump-treat-reinjection system was turned over to Burns & McDonnell for startup and operations. Testing was required to determine the underperforming system’s actual limits. Through constant monitoring and adjustments, Burns & McDonnell achieved EPA criteria over a year in advance, with a perfect safety record and $6MM saved. The City has already rezoned this property, hopeful that 10,000 people will be living on the lakefront in 15-20 years.
Example Wastewater Treatment Plant Site
Example Wastewater Treatment Plant
Example Wastewater Treatment Plant Site

Groundwater Treatment Plant (GTP)

Extraction Cells
Example GW Contamination Plume
Example Wastewater Treatment Plant Site
Example Wastewater Treatment Plant Site
5. O&M Considerations – Startup

- Seed Sludge
- Chemical addition
  - PH Neutralization
  - Nutrient Addition (Phosphoric acid)
  - Polymer
  - Defoamer
  - Ferric Chloride
- Temperature, DO
- Other (As, NH₃)
- Test equipment
- Blowers
- Compressors
- Tanks
- Pumps
- SCADA
- Dry / wet runs
# 5. O&M Considerations – Startup

## NOVEMBER 2009 NORMAL PLANT OPERATIONS LOG
For TK-330

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Thanks for Your Time

Questions?

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