# Energy Savings Through Denitrification

## If Your Plant Nitrifies, Why Not Make it Denitrify

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# Nitrate, $NO_3$

- The discharge of Nitrate from a wastewater plant, either in the effluent or in sludge or biosolids represents potential electrical savings.

# Electrical Savings

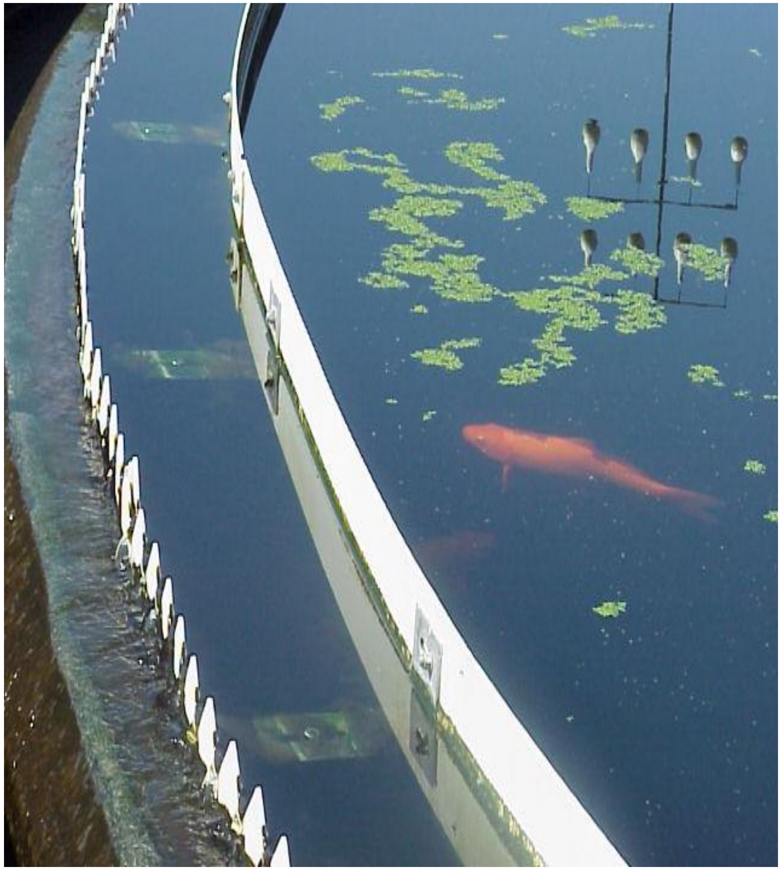
- The savings occur when operators are able to turn aeration equipment “off” for short periods of time, allow the aeration basin to denitrify, then restart aeration.

# Why Denitrify?

- Required
  - New NPDES Permit Limits
    - Total Nitrogen
    - Nitrate
- Desired
  - Activated Sludge Improvements
  - Reduced Electrical Usage

# Denitrification Benefits

- Meet the Permit
- Recycle Oxygen
- Recover Alkalinity/pH
- Improve Effluent
- Select against Filaments
- Improved Solids Proc.
- Save Dollars



# Total Nitrogen Limits

- Total Nitrogen

  $TN = TKN + NO_2 + NO_3$

  TKN = Organic Nitrogen + Ammonia

  Nitrification: Ammonia to Nitrate

  Nitrite($NO_{2)}$: generally low

  Organic Nitrogen : generally low ~ TSS

- Nitrate, $NO_3$ parameter of concern

# Removing Nitrate Through Biological Denitrification

- Create the needed environment
  - Nitrate must be present
  - Anoxic, Dissolved Oxygen < 0.3 mg/L
  - BOD or food must be available
  - BOD organisms must be present

# Speed of Denitrification

## Fast

- DO = 0.0 mg/L
- Soluble BOD available

## Slow

- DO > 0.3 mg/L
- Little Food
  - Endogenous Respiration
    - Extended Aeration
    - Digester

# Making Your Plant Denitrify

- Locate the basin which best meets the denitrification requirements.
  - Primary clarifier, depends of piping
  - Aeration basin, perhaps
  - Final clarifier, no way!
  - Other basins, what do you have?

# Aerator is Common Choice

- Turn the air “OFF”,
- Denitrify
- Turn the air back “ON”

# #1 Activated Sludge Myth

- Aeration basin Dissolved Oxygen must be maintained at a set levels continuously. Dan Miklos, Advanced Treatment Science, Columbus, Ohio

- Biological treatment is more flexible than this!
  - Treatment and odor prevention will continue as long as there is $O_2$ or $NO_3$

# Oxygen Usage Hierarchy

| | |
|---|---|
| Free Dissolved Oxygen | Aerobic or Oxic Treatment |
| Little or No free Oxygen, but $NO_3$ present | Anoxic Treatment |
| Sulfate, $SO_4$ is the next choice of the Bugs | Anaerobic conditions are beginning. ODORS fm. $H_2S$ |

# “Off – On” Aeration

Wastewater Treatment Plant
Examples

# Prison Wastewater Treatment

Operational Problems

- Low pH
- Bloodworms

- 1 Caustic feed added
- 2 OFF/ON
  - 3hr ON/ 3hr Off
  - Recycled alkalinity
  - pH maintained
  - Caustic eliminated
  - Bloodworms gone

Aerators with air "off"

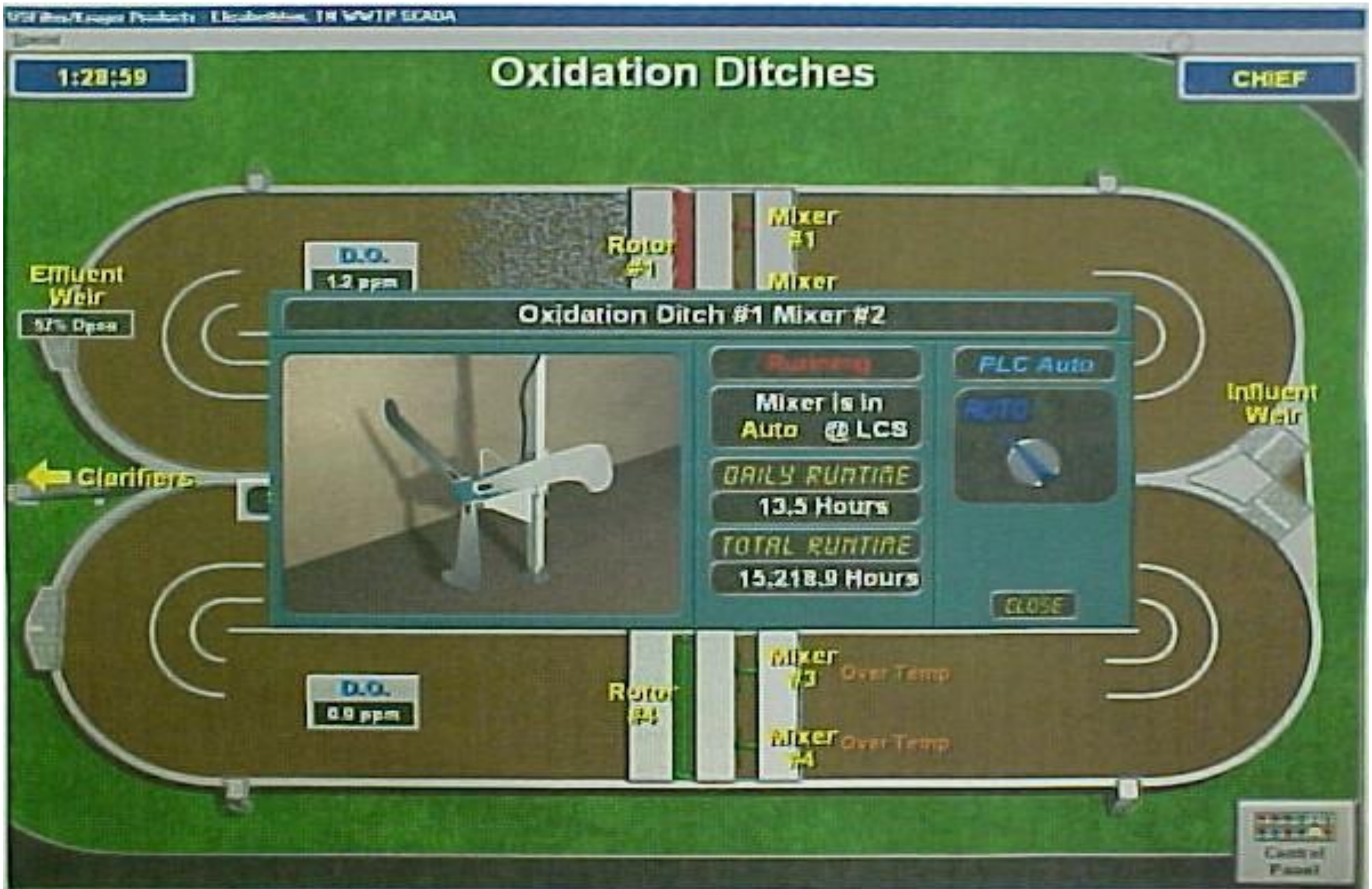
# Prison Wastewater Treatment

- Current Data, EFF.
  - BOD ~1-2 mg/L
  - TSS ~1-2 mg/L
  - $NH_4$ ~0.3 mg/L
  - $NO_3$, 1-4 mg/l
  - pH ~7.0
- Aerator
  - pH 6.2-6.8
  - Alkalinity ~80 mgL

# Small Oxidation Ditch

- 30 min. Settlometer =1000
- Microscopic evaluation = filaments
- History of low eff. pH
- Eff Alkalinity ~ 0.0mg/L
- Off/ On
  - 5hr ON/ 3hr off
- Best effluent ever and 30% electricity savings

# Large Oxidation Ditch



# Large Oxidation Ditch

- Kruger system
- Computer controlled Dissolved Oxygen

  Range

  0.2 to 1.5 mg/L

- $N0_3$ < 1.0 mg/L
- TSS ~ 1.0 mg/L
- BOD < 5.0 mg/L

# Extreme Cycles

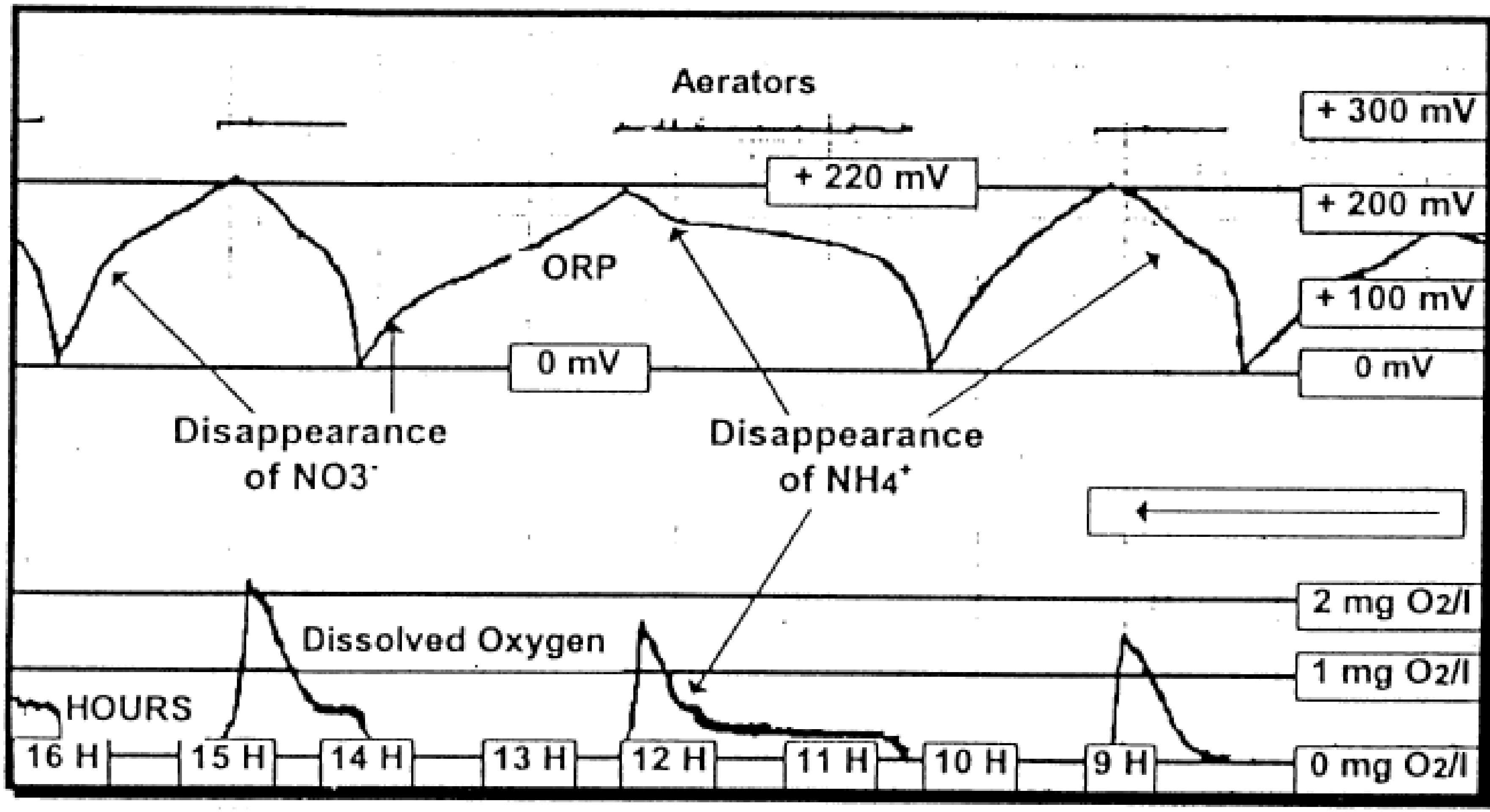
- Complete Mix /Plug Flow AS
- Basic Cycle
  - Off 2-6 pm
  - Off 12-6 am
- BOD ~ 3.0
- TSS ~ 1.0
- $NH_4$ <0.2
- $NO_3$ ~5.0

# Determine “Off” Time

- ORP, Oxidation Reduction Potential
  - Common cycle
    - Aerate to + 200 mV
    - Air “off” to – 50 mV
  - Theoretical beginning of Sulfate reduction
    - -50 mV, Goronszy
    - -100 to –200mV Optimum range for $H_2S$ creation
    - Odors will depend on concentration of $H_2S$ & pH
  - Measure in the settled Biomass

# ORP & DO Graph

Charpentier, et.al. Water Science & Tech. 1998



# Determine "Off" Time

- Oxygen Uptake Rate, OUR
  - $$\frac{O_2 \text{ mg/L} + (2.86 * NO_3 \text{ mg/L})}{\text{OUR mg/L/ Hr}} = \text{Hours "Off"}$$
- Monitor
  - pH, Alkalinity , Nitrate
  - Enzyme Fluorescence, more direct measure of biological metabolism.
- Trial and Error

# Items of Concern

- Aeration Capacity to raise DO after "Off" cycle.
- Diffuser Type
- Mixing
- Switch Control
  - Manual, Timers, Computer
- Different Flows & Loads

# If you nitrify, Why not denitrify?

- Benefits
  - Meet permit limits
  - Save money
  - Recycle oxygen and alkalinity
  - Select against filaments
  - Be a better operator!