Activated Sludge

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ENTECH ENGINEERING

READING | LITITZ | POTTSVILLE | MOUNTAINTOP | PITTSBURGH

PRESENTATION

Section 1: Activated Sludge Treatment Process

Section 2: Aerobic Process for BOD Removal

Section 3: Aerobic Process, Nitrification & Denitrification

Lightnin' Round Quiz

Section 4: Settleability of Activated Sludge

Section 5: Control Parameters for Activated Sludge

Section 6: Operational Changes by the operator

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Section 1

Activated Sludge Treatment Process

Just What is That Activated Sludge ?

The activated sludge process was developed in England in 1914 by Ardern and Lockett and was so named because it involved the production of an activated mass of microorganisms capable of aerobically stabilizing a waste.

In the activated sludge process, a waste, usually domestic sewage, is stabilized biologically in a reactor under aerobic conditions.

Just What is That Activated Sludge ?

While a Trickling Filter or Rotating Biological Contactor is an activate mass of microorganisms capable of aerobically stabilizing a waste,……

The activated sludge process, has the microorganisms suspended in the wastewater (MLSS) and all the microorganisms are in intimate contact with the waste.

Fixed Film microorganisms only contact the waste at the surface of the biological film.

Just What is That Activated Sludge ?

The activated sludge process, provides the operator with more options to control the biological processes stabilizing the waste than the Fixed Film Processes.

The knowledge and understanding of these controls ie: MLSS, SVI, Sludge Age, Dissolved Oxygen Conc., Return Sludge Rate, Sludge Wasting Rate, etc., will help the operator produce high quality effluent and……..

……its why we are all here today !

Section 2

Activated Sludge for BOD Removal

Aeration Tank and Clarifier

Aeration tank :

Contains the Biomass (Activated Sludge, MLSS).

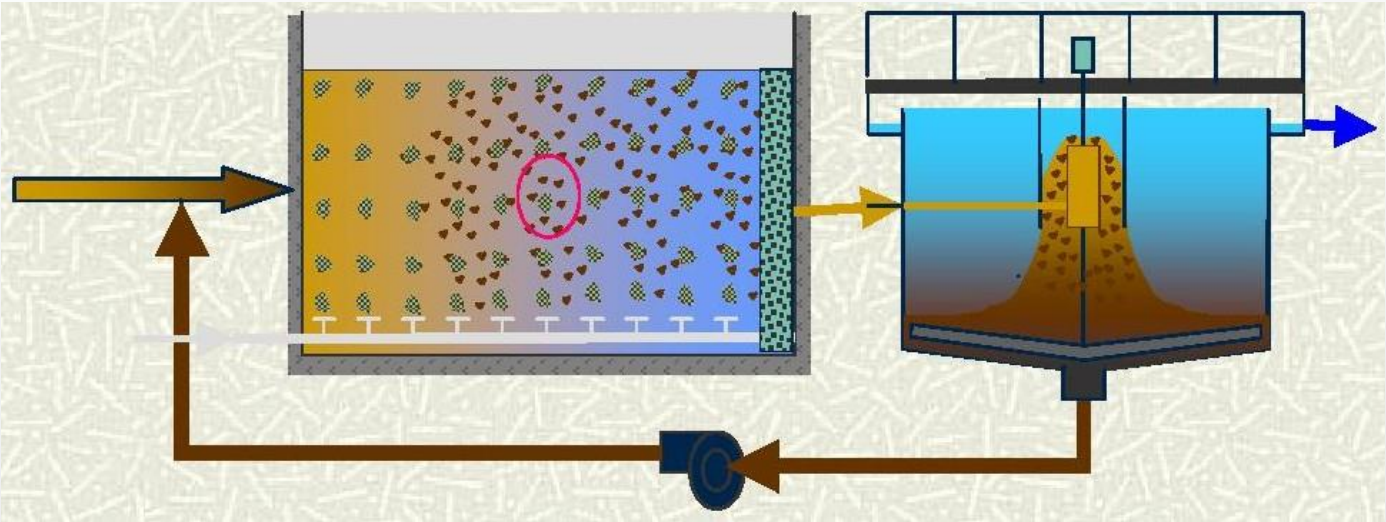
Add Air (Blowers), Add Wastewater

Removes the BOD, converts Ammonia to NOx

Clarifier :

MLSS Settles, Clear Wastewater discharged

RAS Returns Biomass to Aeration Tank



Types of Activated Sludge Process

Variations for Secondary Treatment - 85% Removal

Conventional	BOD Removal with 6-8 Hour Detention
Step Aeration	BOD Removal with 6-8 Hour Detention
Contact Stabilization	BOD Removal with 5 Hour Detention
Extended Aeration	BOD & Ammonia Removal, 12-24 hr.
Oxidation Ditch	BOD & Ammonia Removal, 18-24 hr.
Batch Process	18-24 detention, BOD & Ammonia Removal
	Sequential Batch Reactor (SBR)
	Intermittent Cycle Extended Aeration System (ICEAS)

Section 3

Activated Sludge for Nitrification & Denitrification

Nitrification & Denitrification

Nitrification

Aerobic process which converts Ammonia To Nitrates and Nitrites.

Denitrification

Anoxic process which converts Nitrates and Nitrites to Nitrogen gas.

Variations for Nitrification & Denitrification

Detention Times of 18-24 or more hours

- Sequential Batch Reactor (SBR)
- Intermittent Cycle Extended Aeration System (ICEAS)
- Vertical Loop Reactor (VLR)
- Orbal Process
- Modified Ludzak-Ettinger (MLE)
- Five Stage Bardenfo
- Membrane Biological Reactor (MBR)
- On and on ad-infinitum

What's the Difference ?

Activated Sludge Process for BOD & NH_3

- Strictly Aerobic (aeration) Process

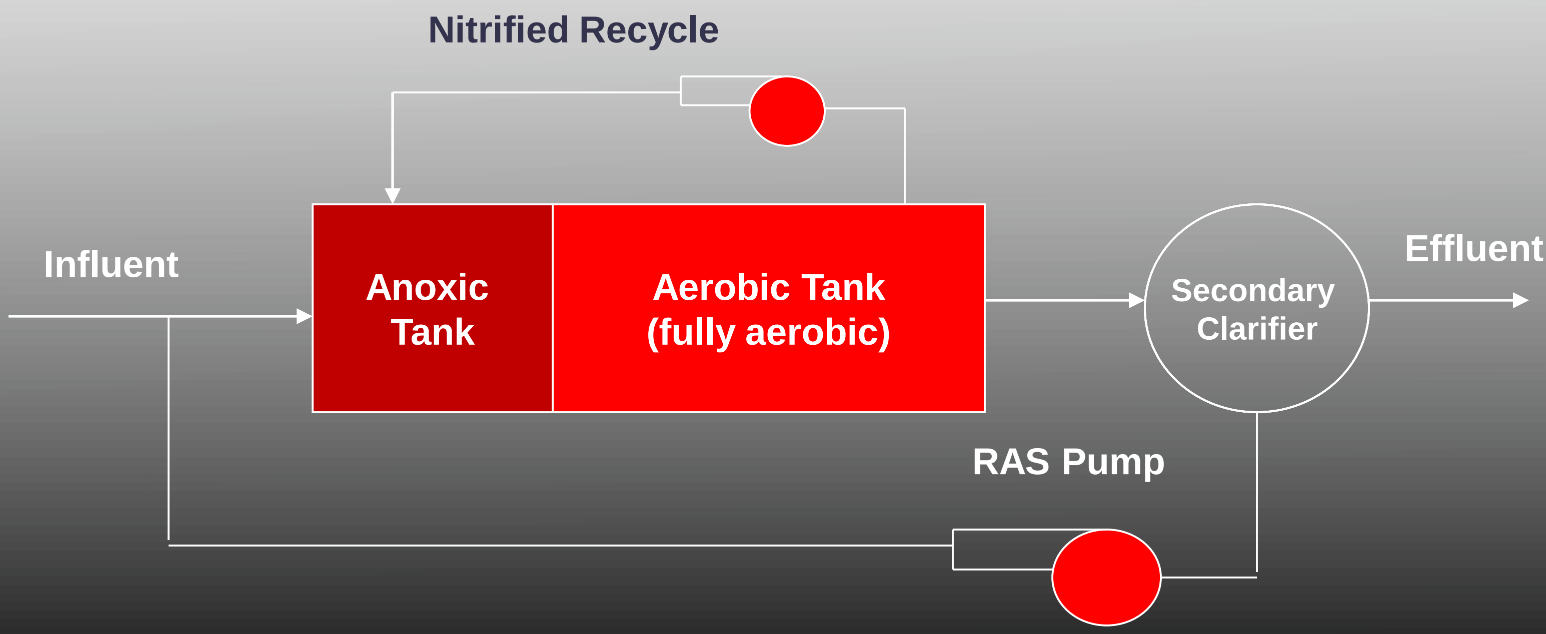
Activated Sludge Process for Nutrient Removal

- Aerobic Zones
- Anoxic Zones
- Anaerobic Zones

Activated Sludge For BNR

Modified Ludzack-Ettinger (MLE) Process

This process modifies the Ludzack-Ettinger process by adding a recirculation of mixed liquor recycle (MLR) from the end of the aeration tank to the beginning of the anoxic tank.



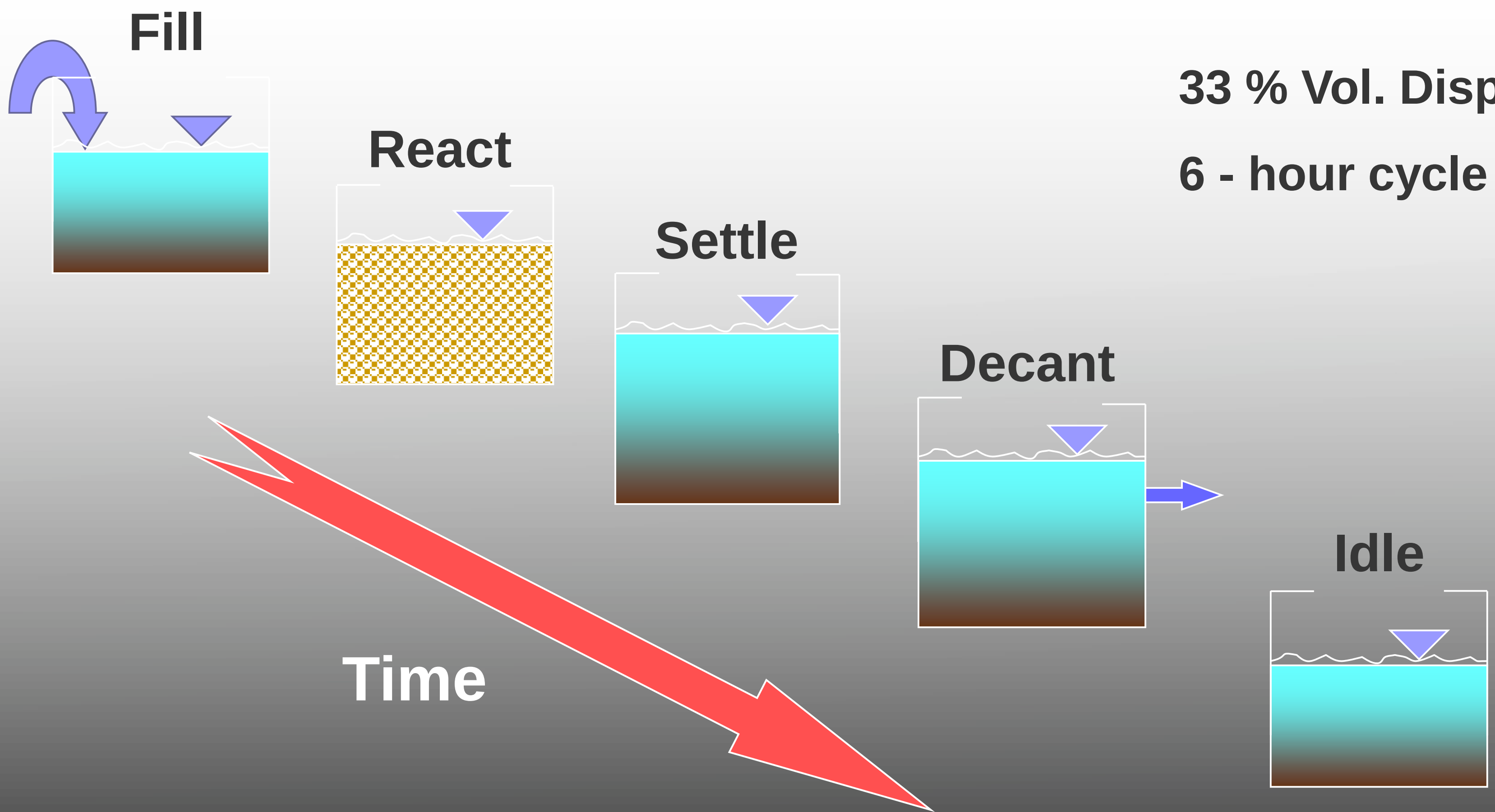
Activated Sludge For BNR

Bardenpho Process (Five-Stage)

Similar to Four Stage

RAS is returned to the Anaerobic Tank. The sludge is contacted with the plant influent to produce the a stress condition that allows phosphorus to be removed biologically in subsequent aerobic stages. Stress occurs in the absence of D.O. and NO_3.

The Sequencing Batch Reactor



33 % Vol. Disp.

6 - hour cycle

What is Nitrification ?

Conversion of Ammonia to Nitrate and Nitrite

It is the first step of B Nitrogen R

It is an Aerobic Process

Nitrification Process

Step 1: $NH_4^+ + 1.5\ O_2 \xrightarrow{\text{Nitrosomonas}} NO_2 + 2H^+ + H_2O$

Step 2: $NO_2 + 0.5\ O_2 \xrightarrow{\text{Nirtrobacter}} NO_3$

Overall Reaction: $NH_4^+ + 2\ O_2 \longrightarrow NO_3 + 2H^+ + H_2O$

- **4.6 lbs O_2 / lb NH3-N**
- **7.14 lbs alkalinity destroyed / lb NH3-N**
- **0.1 lbs VSS generated / lb NH3-N**

Temperature and Nitrification

Temperature, C	Effect on Nitrification
28 to 32	Optimal temperature range
15 to 16	Approximately 50% of maximum rate
10	Significant reduction in rate, approximately 20% of rate at 30☜
< 5	Nitrification ceases

Temperature and MCRT Required for Nitrification

Temperature, C	**MCRT (Mean Cell Residence Time), Days**
10	30
15	20
20	15
25	10
30	7

Oxygen Consumed (Theoretical) During Nitrification

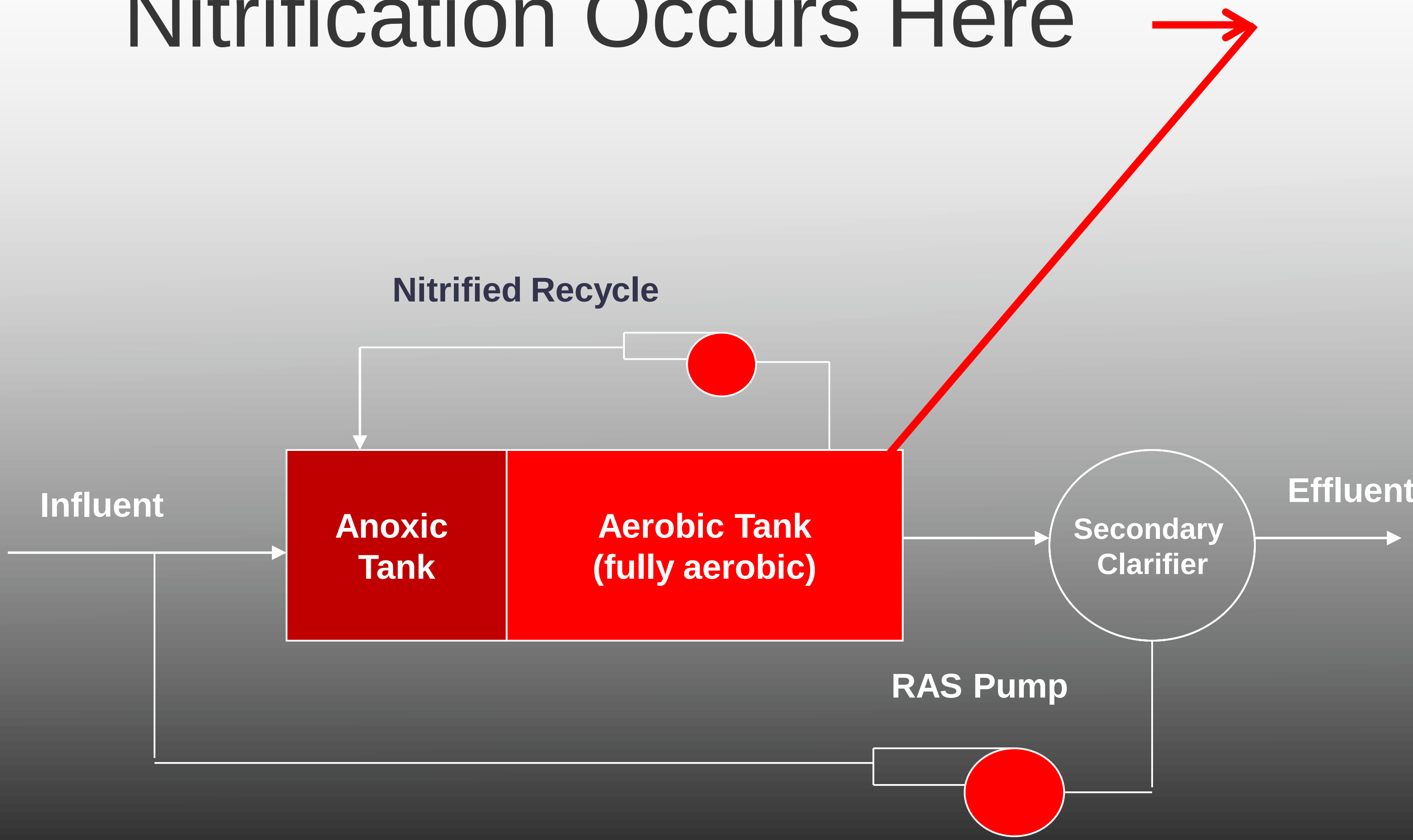
Biochemical Reaction	O_2 Consumed, lb
1 lb NH_4^+ to 1 lb NO_2^-	3.43
1 lb NO_2^- to 1 lb NO_3^-	1.14
1 lb NH_4^+ to 1 lb NO_3^-	4.57

DO Concentration and Nitrification Achieved (Laboratory)

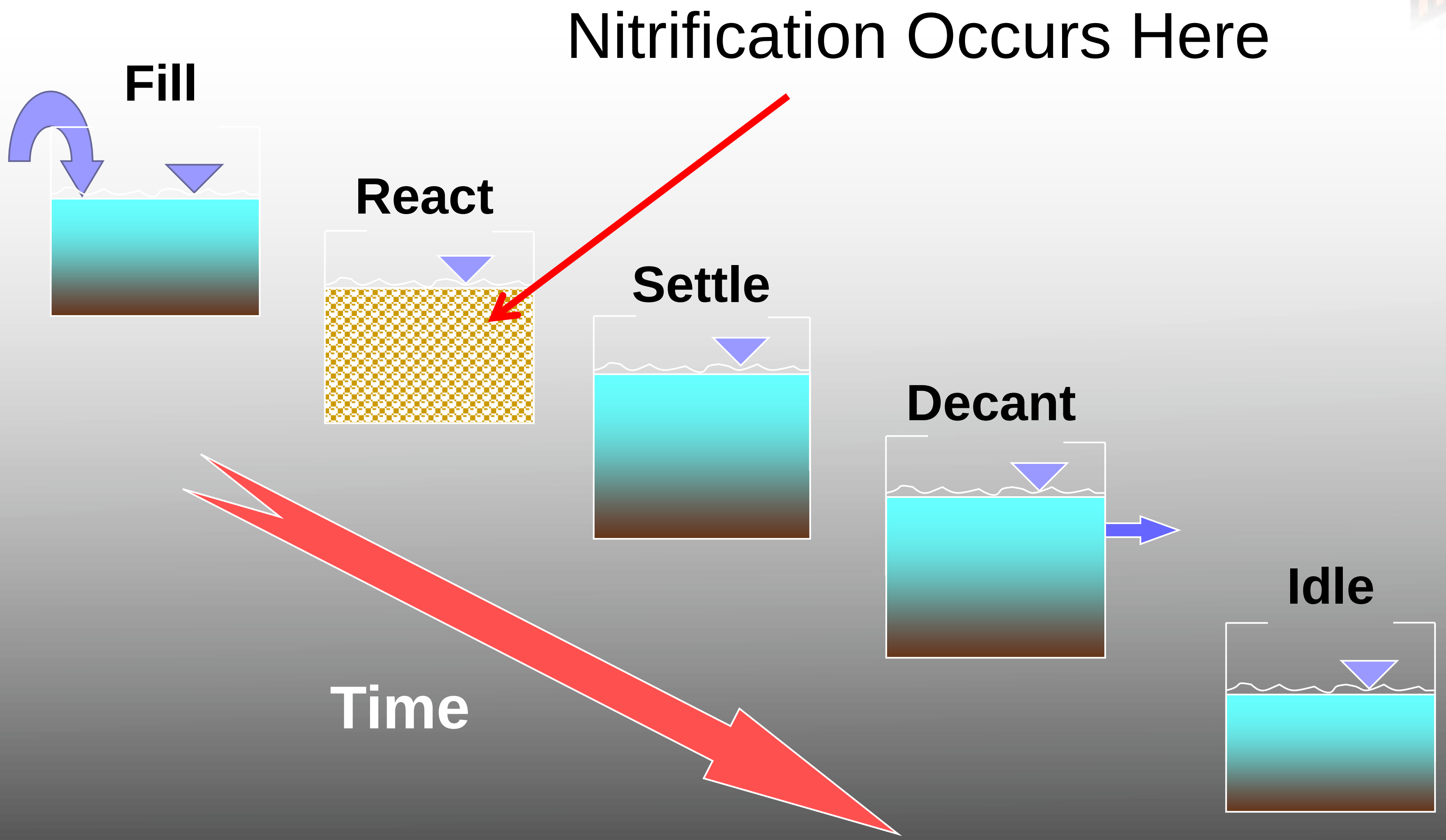
DO Concentration	Nitrification Achieved
< 0.5 mg/l	Little, if any, nitrification achieved
0.5 to 1.5 mg/l	Nitrification occurs, but inefficiently
2.0 mg/l	Significant nitrification occurs
3.0 mg/l	Maximum nitrification

Modified Ludzack-Ettinger (MLE) Process

Nitrification Occurs Here



The Sequencing Batch Reactor



What is Denitrification ?

Conversion of Nitrate and Nitrite to Nitrogen Gas

It is the second step of B Nitrogen R

It is an Anoxic Process

- No Dissolved Oxygen

Denitrification Process

Majority of denitrifying organisms consist of facultative anaerobic bacteria.

Approximately 80% of the bacteria in the activated sludge process are facultative anaerobic bacteria

Denitrification Process

$$NO_3^- + \text{organic carbon} \xrightarrow{\text{carb. bacteria}} N_2 + CO_2 + OH^- + H_20$$

$$CO_2 + OH \longrightarrow HCO_3^-$$

$$NO_3 \longrightarrow NO_2 \longrightarrow NO \longrightarrow N_2O \longrightarrow N_2$$

- **2.86 lbs oxygen recovered / lb NO_3-N**
- **3.57 lbs alkalinity recovered / lb NO_3-N**

Operational Factors Affecting Denitrification

Significant Operational Factors:

Presence of soluble cBOD

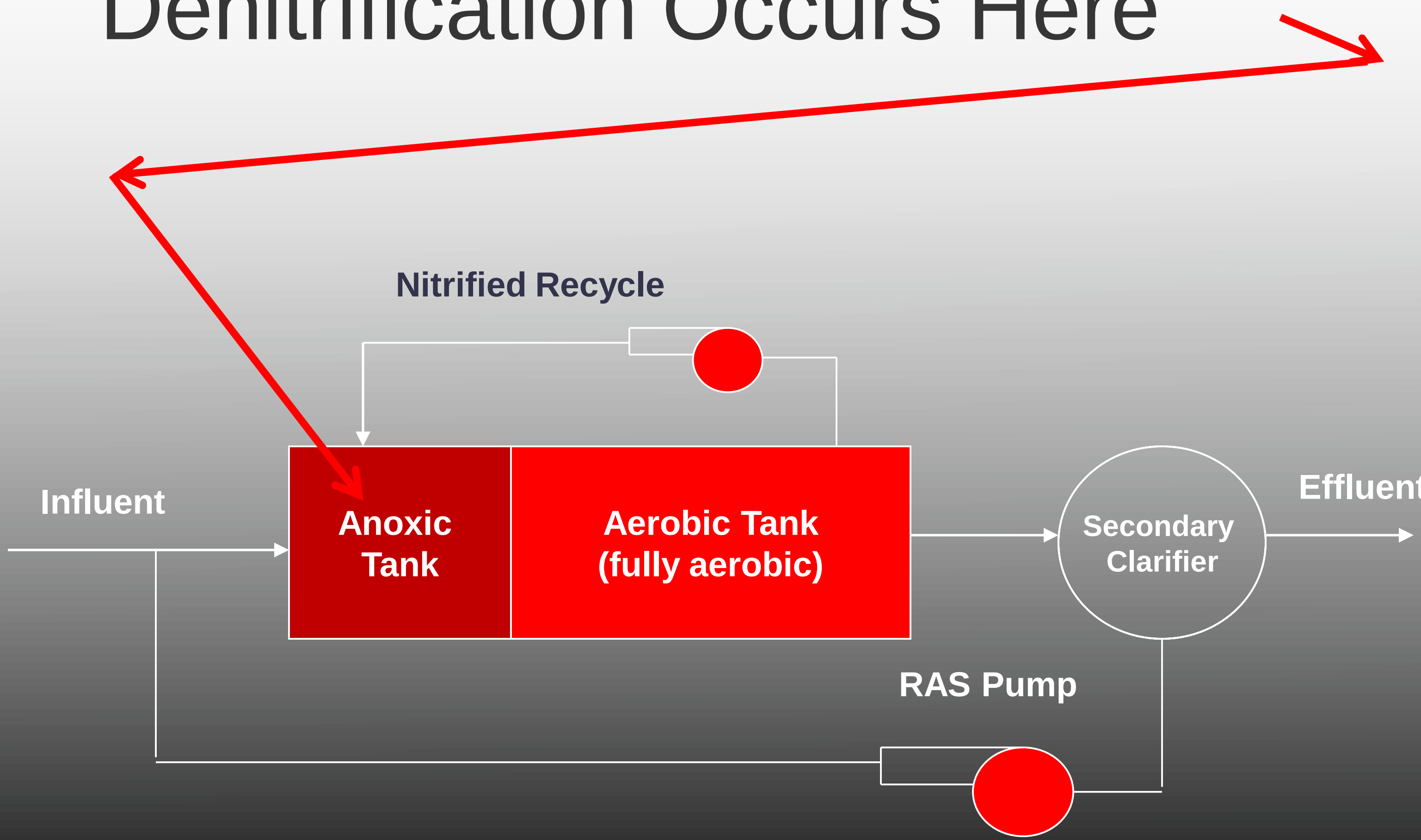
Absence of O_2 NO Dissolved Oxygen

Presence of NO_3^- or NO_2^-

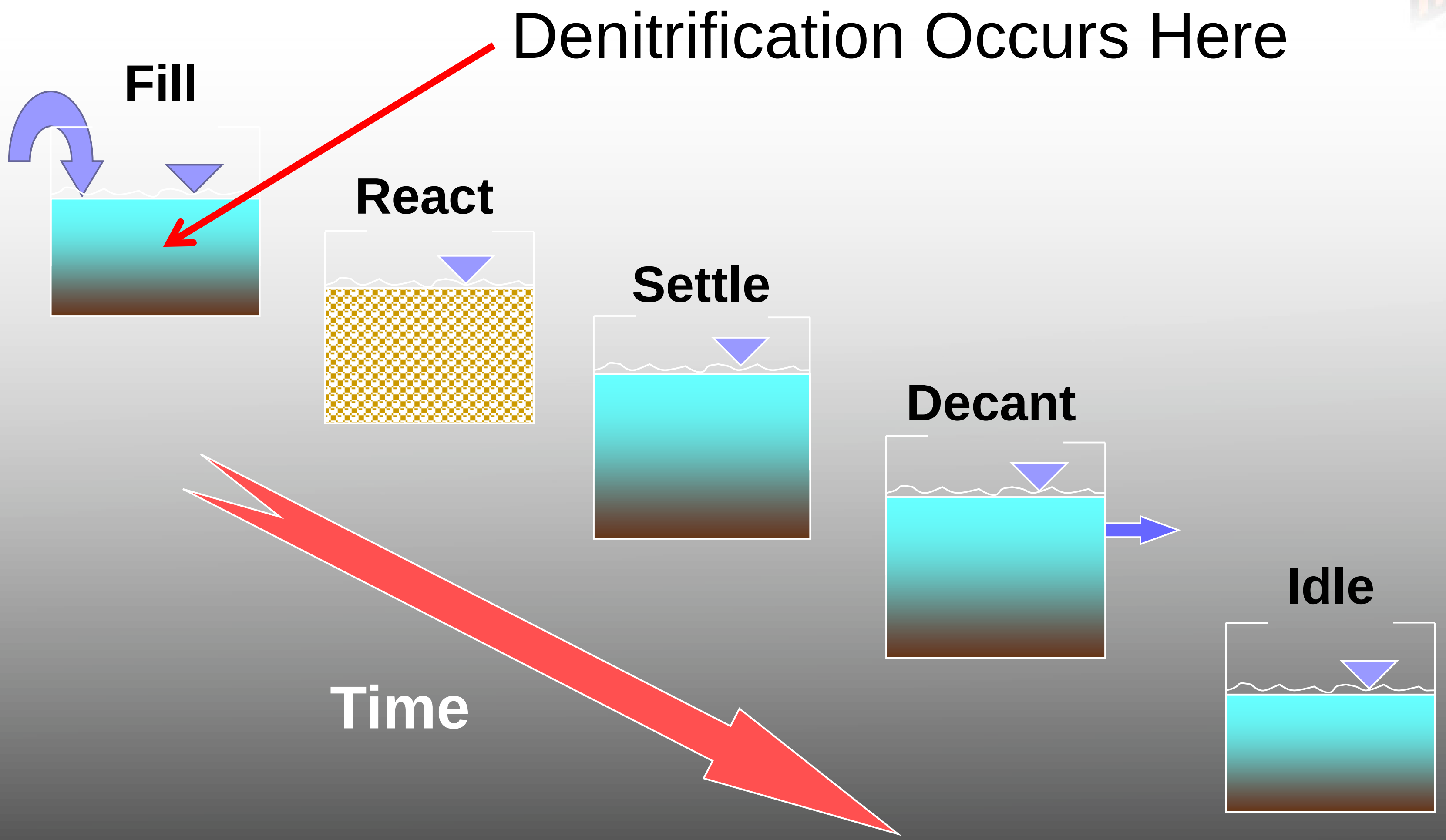
Active population of denitrifiers

Modified Ludzack-Ettinger (MLE) Process

Denitrification Occurs Here



The Sequencing Batch Reactor



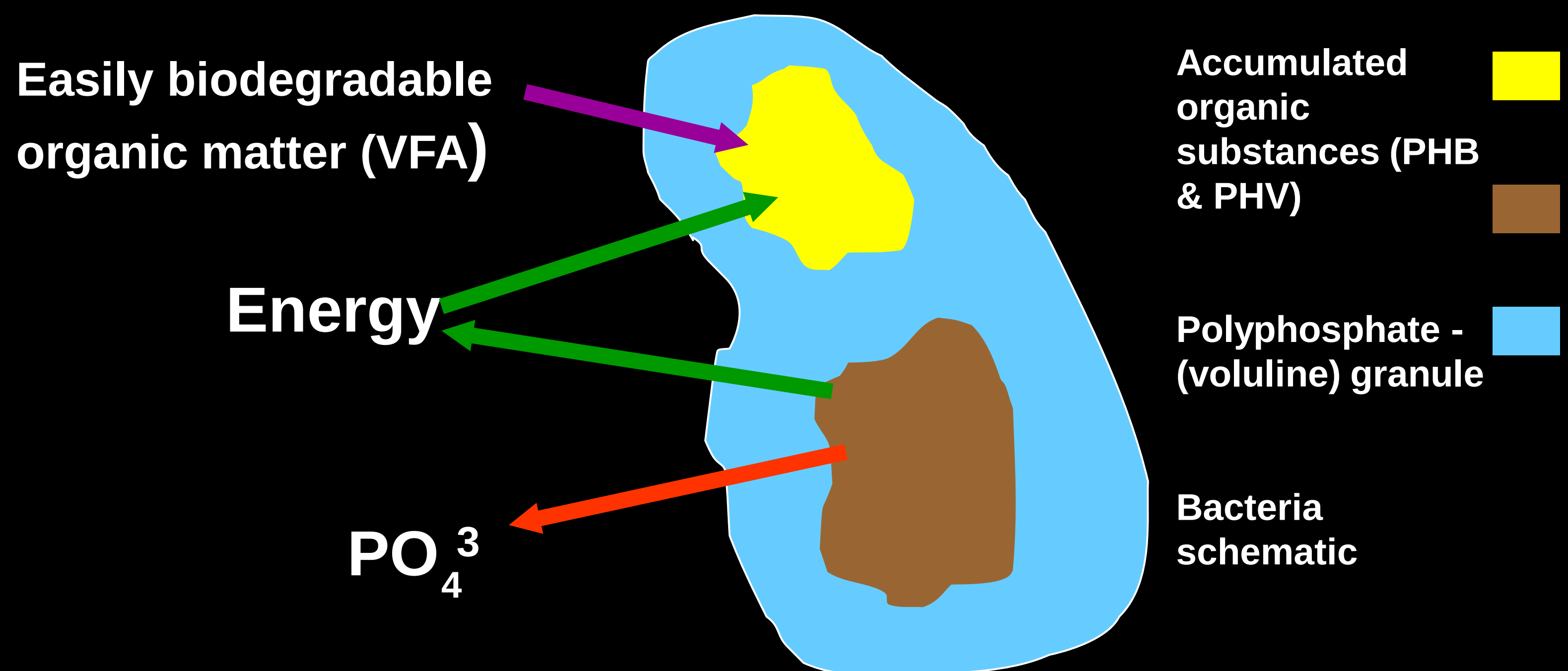
What is Bio-Phosphorus Removal ?

Removal of Phosphorus by bacteria rather than chemicals

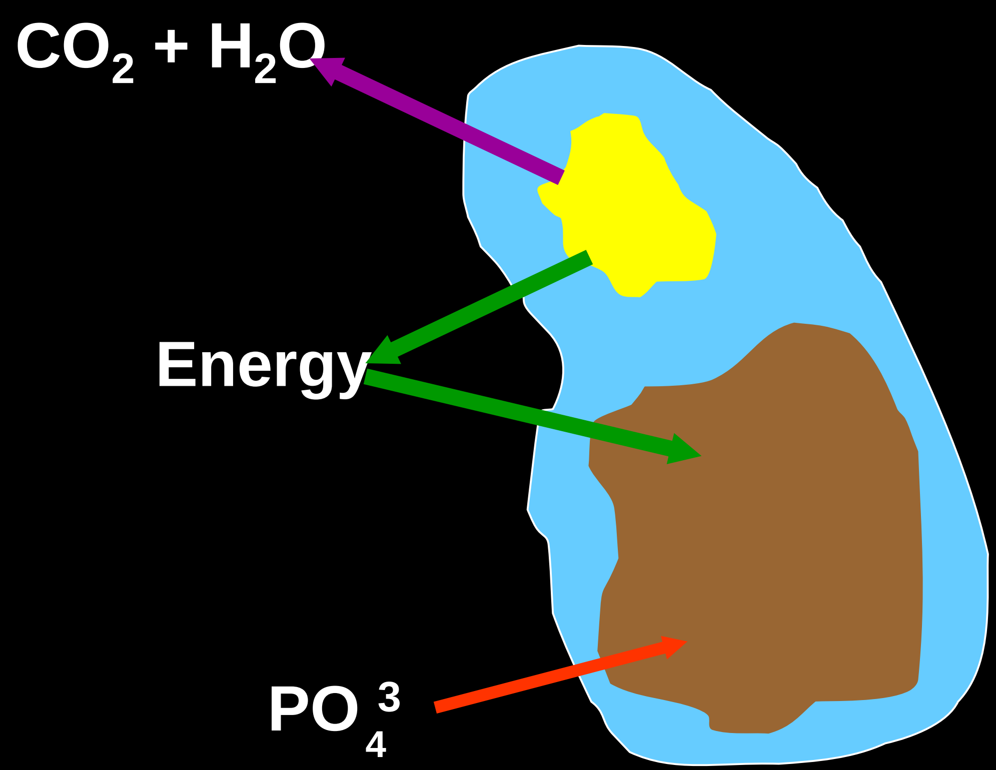
It’s a 2 step process

- Anaerobic Stressing is First
- Aeration the second step of B Phosphorus R

Phosphorous Release Anaerobic Zone



Phosphorus Uptake Aerobic Zone



Accumulated organic substances (PHB & PHV)

Polyphosphate - (voluline) granule

Bacteria schematic

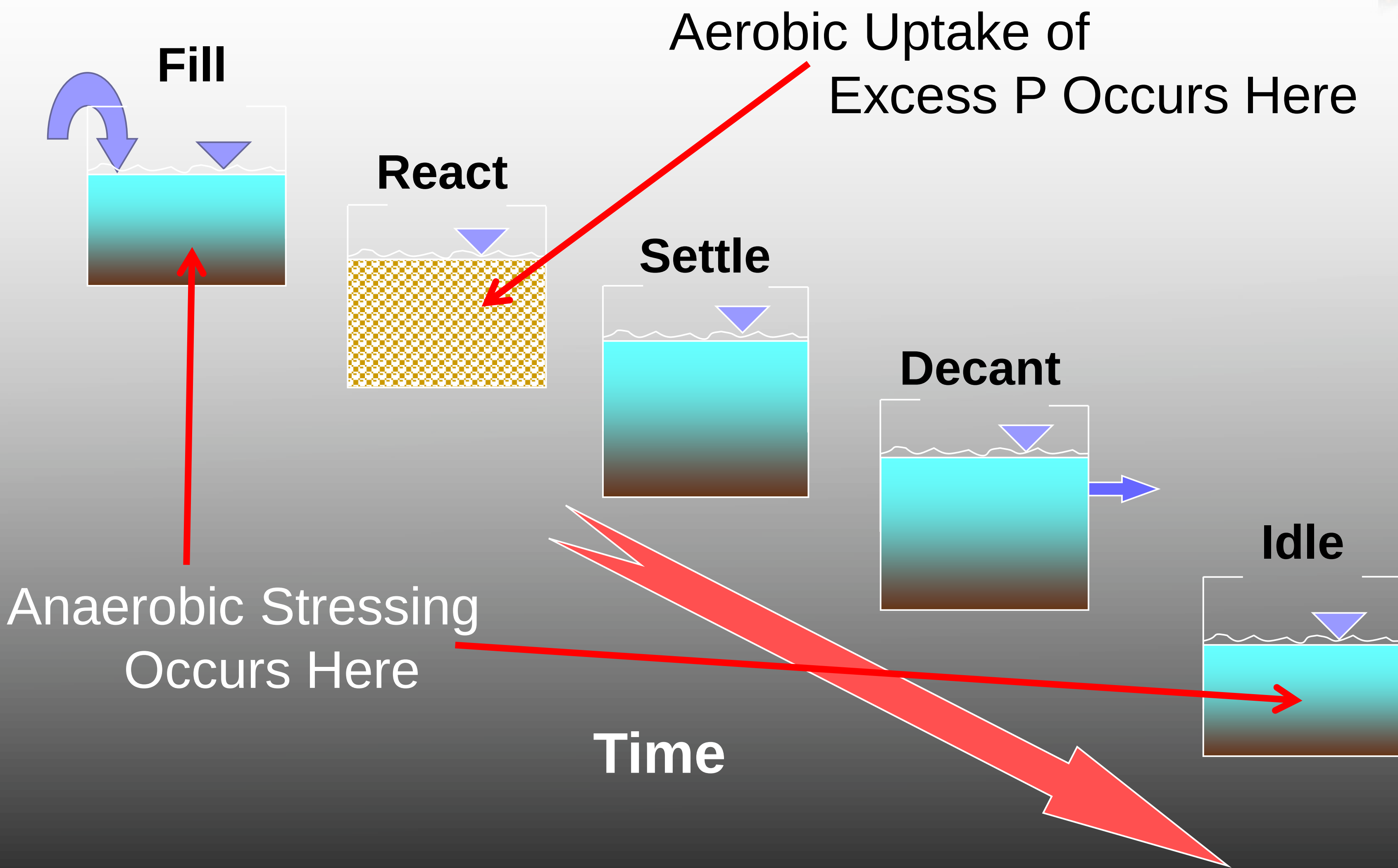
Cell contains
5 to 10% P

Bardenpho Process (Five-Stage)

Anaerobic Stressing Occurs Here

Aerobic Uptake of Excess P Occurs Here

The Sequencing Batch Reactor



Lightnin' Round Quiz

VERBAL QUESTION, SOMEONE STAND AND ANSWER :

1. Which of the following is an Activated Sludge Process which can remove BOD and Ammonia?

   a. Rotating Biological Contactor
   b. Oxidation Ditch
   c. Sequential Batch Reactor
   d. Rock Media Trickling Filter

When student answers, all who agree to stand up.
If answer correct, all people standing may leave on Break.
Incorrect answer, everyone sits down, go to question 2

Lightnin' Round Quiz

VERBAL QUESTION, SOMEONE STAND AND ANSWER :

1. Is the Modified Ludzak-Ettinger (MLE) Process an Activated Sludge System?

   1. A. Yes B. No

When student answers, all who agree to stand up.
If answer correct, all people standing may leave on Break.
Incorrect answer, everyone sits down, go to question 3

Lightnin' Round Quiz

VERBAL QUESTION, SOMEONE STAND AND ANSWER :

1. Approximately 80% of the bacteria in the Activated Sludge Process are:

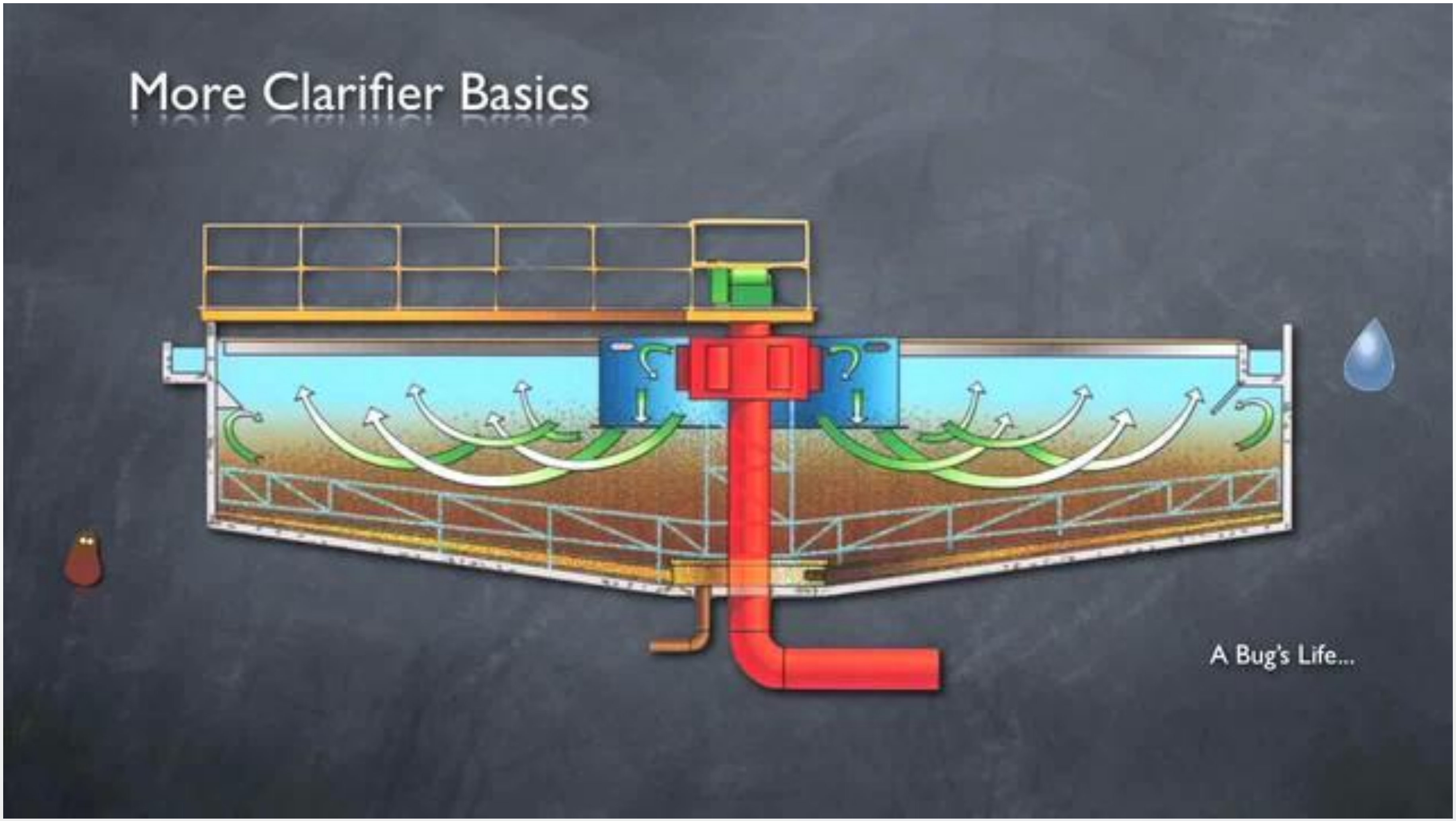
   a. Nitrifying Bacteria
   b. Mixed Liquor Suspended Solids – MLSS
   c. Facultative Anaerobic Bacteria
   d. Nitrosomonas
   e. Denitrifying organisms

When student answers, all who agree to stand up.
If answer correct, all people standing may leave on Break.
Incorrect answer, everyone sits down, go to question 2

Section 4

Settleability of Activated Sludge

Clarification is Biomass Separation



Biomass Separation

Sludge Volume Index

- The Guidepost for how the Biomass settles in the Clarifier.
- Must be periodically computed by operator.
- Requires a 30 Settling test.
- Requires Total Suspended Solids of Aeration Tank Contents
  - MLSS= Mixed Liquor Suspended Solids

SVI Calculation

$$SVI = \frac{\text{Milliters Settled Sludge X 1,000}}{\text{MLSS, mg/l}}$$

$$SVI = \frac{\text{400 ml settled sludge X 1,000}}{\text{3,000 mg/l MLSS}}$$

SVI = 133

SVI Calculation

$$SVI = \frac{\text{Milliters Settled Sludge X 1,000}}{\text{MLSS, mg/l}}$$

$$SVI = \frac{\text{400 ml settled sludge X 1,000}}{\text{1,800 mg/l MLSS}}$$

SVI = 222

SVI Calculation

$$SVI = \frac{\text{Milliters Settled Sludge X 1,000}}{\text{MLSS, mg/l}}$$

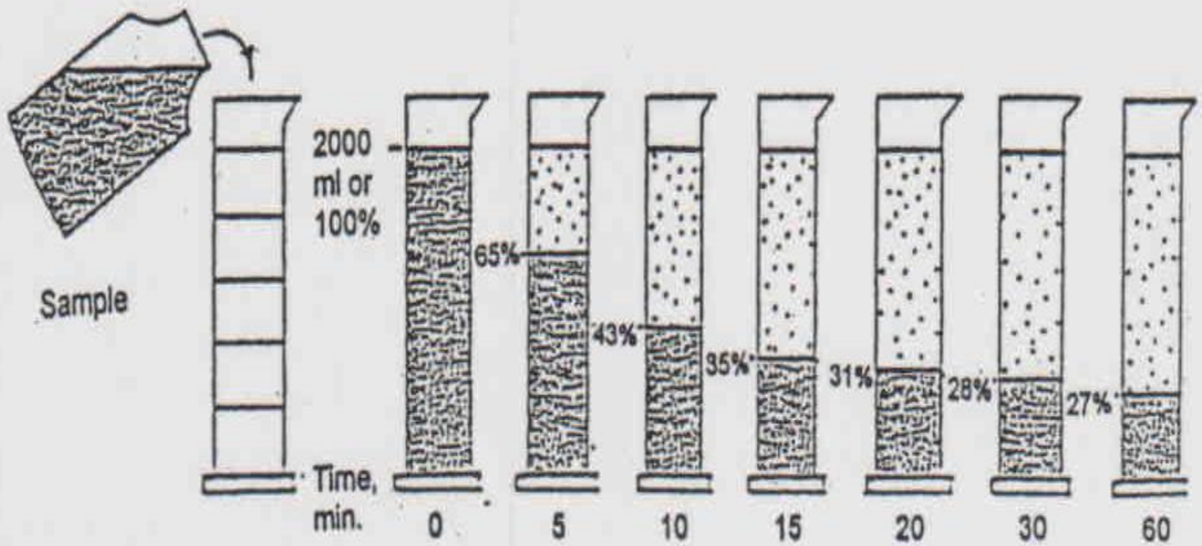
$$SVI = \frac{\text{190 ml settled sludge X 1,000}}{\text{3,000 mg/l MLSS}}$$

SVI = 63

30 Minute Settling Test - Outline of Procedure

1. Mix sample and pour into 2000 ml graduate

2. Record settleable solids, %, at regular intervals.



1. Collect a sample of mixed liquor or return sludge.

2. Carefully mix sample and pour into 2000 ml graduate. Vigorous shaking or mixing tends to break up floc and Procedures slower settling or poorer separation.

NOTE: If a 1000 ml graduate is used, the percent settleable solids is easier to record.

30 Minute Settleometer Test

Settle Test – 1 Minute

Sampled
2nd Half
React

Sampled
During
Mixed Fill

30 Minute Settleometer Test

Settle Test – 1 Minute

Sampled

2^{nd} Half

React

30 Minute Settleometer Test

Settle Test – 5 Minutes

Sampled

2^{nd} Half

React

Sampled

During

Mixed Fill

30 Minute Settleometer Test

Settle Test – 10 Minutes

Sampled 2nd Half React

Sampled During Mixed Fill

30 Minute Settleometer Test

Settle Test – 20 Minutes

Sampled

2nd Half

React

Sampled

During

Mixed

Fill

Note Clear

Water at

Bottom

30 Minute Settleometer Test

Settle Test – 30 Minutes

Sampled
2nd Half
React

Sampled
During
Mixed
Fill

Note
Clear
Water at
Bottom

30 Minute Settleometer Test

Settle Test – 30 Minutes

Sampled 2nd Half React

-Clear Decant
-Low Floating Scum
-Tight Solids
-400 ml Sludge Volume

30 Minute Settleometer Test

Settle Test – 30 Minutes

Sampled During Mixed Fill

-Note Clear Water on Bottom

-Large Sludge Volume

-Denitrified in Settleometer

Return Sludge Rate

Its how we return the settled biomass from the Clarifier to the Aeration Tank

Control with :

Settleometer

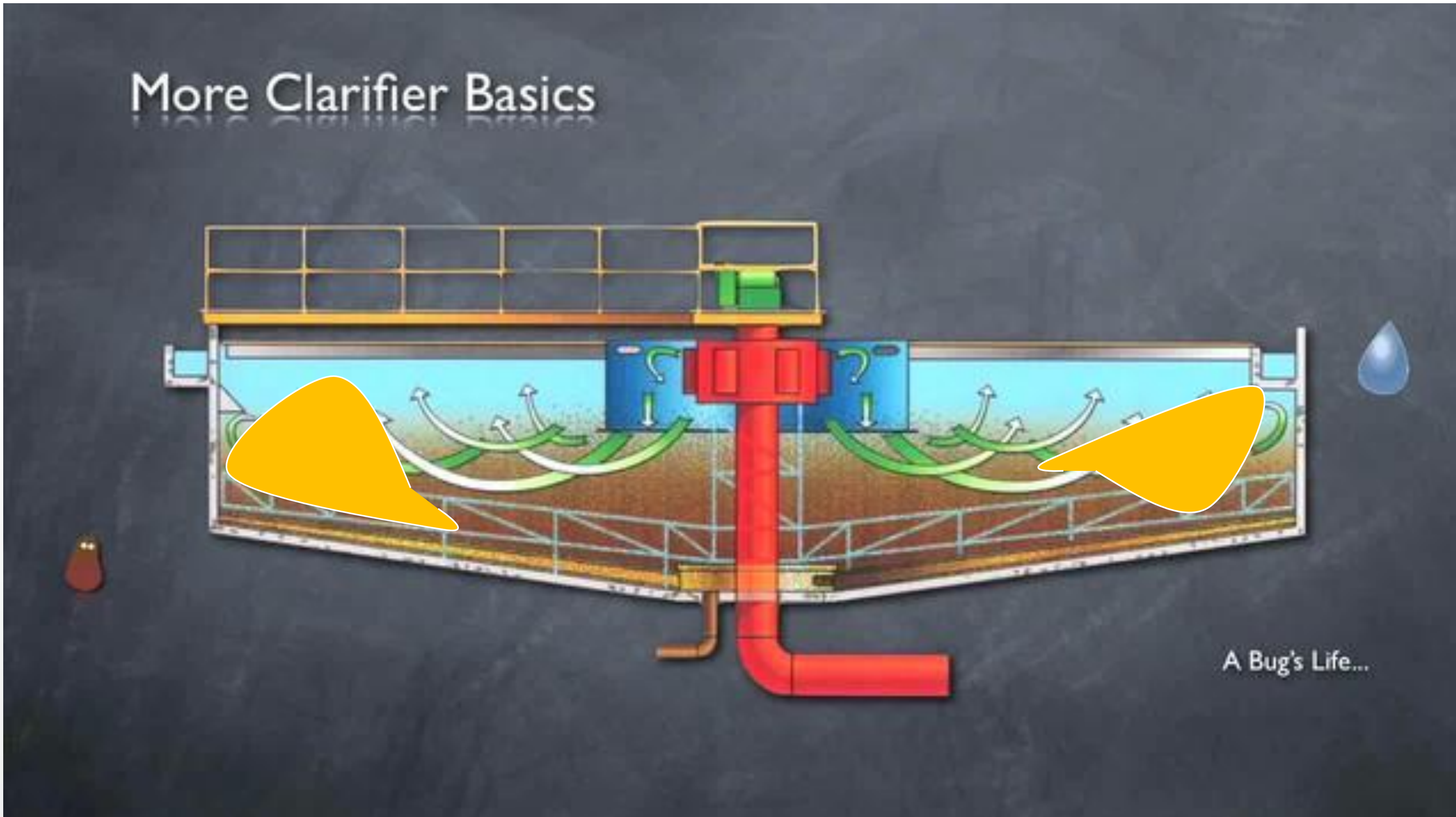
Sludge Judge

SVI

Return Sludge Rate

Sludge Judge

Biomass Separation in a Perfect World



SVI Calculation

$$SVI = \frac{\text{Milliters Settled Sludge X 1,000}}{\text{MLSS, mg/l}}$$

$$SVI = \frac{\text{400 ml settled sludge X 1,000}}{\text{3,000 mg/l MLSS}}$$

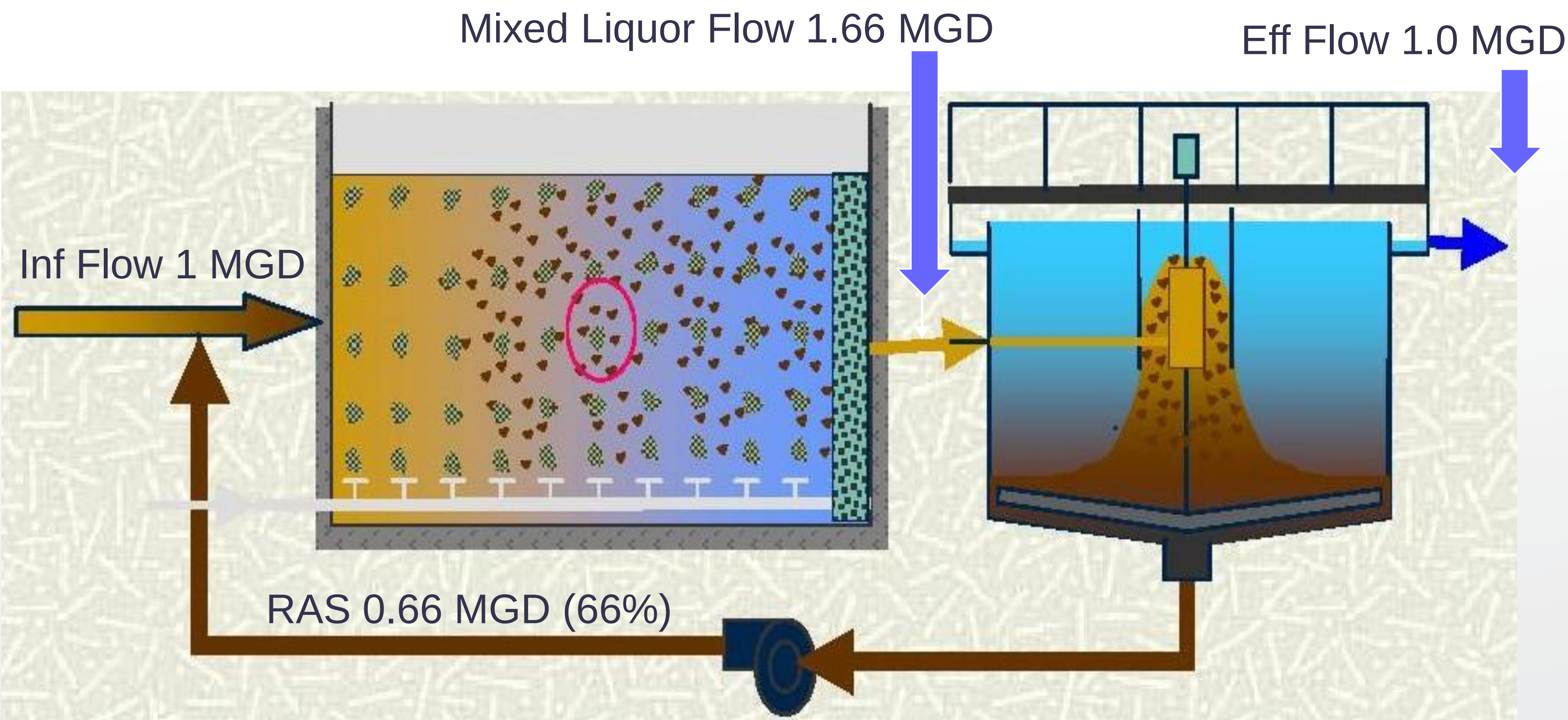
SVI = 133

30 Minute Settleometer Test

Settle Test – 30 Minutes

- **Return Rate is a % of**
  Influent Flow Rate
- **Settled Sludge Volume**
  400 or 40%
- **What is Return Rate ?**
- **400 / 1000 = 40% ?**
- **400 / 600 = 66% ?**
- **66% is RAS Rate**

Aeration Tank and Clarifier



Section 5

Control Parameters for Activated Sludge

Sequential Batch Reactors

Standard Operating Procedures

Routine Process Control Measurements

Parameter	Chemical formula	Location of sample	Frequency of sample	Recommended range	Corrective Action level	Corrective Actions
Ammonia	NH3-N	Effluent	Twice per week	< 1mg/1	1.5 mg/1	1. Low DO level in aeration tank 2. Low MLSS in aeration tank 3. Low alkalinity in effluent 4. Low temperature of effluent
Nitrite	NO2-N	Effluent	Twice per week	< 1mg/1	1.5 mg/1	1. Low DO level in aeration tank 2. Low MLSS in aeration tank 3. Low alkalinity in effluent 4. Low temperature of effluent
Nitrate	NO3-N	Effluent	Twice per week	>1<10mg/l	> 8 mg/1	1. High DO level during Anerobic / Anoxic Cycles. 2. Low MLSS in aeration tank
Alkalinity	CaC03	Effluent	Twice per month	> 100 mg/1	< 100 mg/1	1. Add Alkalinity with Chemical to influent or Anoxic Tank
pH	Units	Effluent	Daily	6.9-7.2	< 6.9	1. Add Alkalinity with Chemical to influent or Anoxic Tank
Temperature	ºC	Influent	Daily			
Temperature	ºC	Effluent	Twice per week		< 14"C	1. Adjust MLSS to higher level as temperature drops seasonaly
Temperature	ºC	Effluent	Twice per week		< IO"C	1. Continue Adjusting MLSS to higher level as temperature drops.
Dissolved Oxygen	mg/l	SBR during Anoxic Cycles		< 0.3 mg/1	> 0.3 mg/1	1. Reduce DO (reduce air volume)at end aeration, prevent DO carryover. 2. Increase MLSS to raise Biomass DO Demand
Dissolved Oxygen	mg/l	SBR during React Fill		> 1mg/1	>3 mg/1	1. Reduce DO (reduce air volume)at end of aeration to prevent high DO. 2. Increase MLSS to raise Biomass DO Demand
Dissolved Oxygen	mg/l	SBR during React		>2<3mg/l	>3 mg/1	1. Reduce DO (reduce air volume)at end of aeration to prevent high DO. 2. Increase MLSS to raise Biomass DO Demand
MLSS	mg/l	SBR 5 minutes prior to Settle	Once per week	3,000- 3,500 mg/1 Range is Plant Specific		1. Increase Rate of sludge wasting for high MLSS. 2. Reduce Rate of sludge wasting for low MLSS
Settled Sludge Volume	SSV_{30}	SBR 5 minutes prior to Settle	Twice per week (each tank)	350 ml/liter		1. Increase Rate of sludge wasting for high SSV. 2. Reduce Rate of sludge wasting for low SSV. 3. Sludge Bulking (high SSV) indicates overation or possible filaments.
Microscopic Examination of MLSS sample		SBR 5 minutes prior to Settle	Once per week			Look for good active population of free Swimmers, Stalked Ciliates and a few rotifers. Define population at best performance.

What's the Most Listed Control ?

Low MLSS	10	
High DO	4	
Sludge Wasting	4	
Low Alkalinity	4	
Low DO	2	
High MLSS	2	
Low Temperature	2	You can't fix that !
SVI	1	
Microscopic Biology	1	
Total of List	30	

Bacteria As A Component Of MLVSS

Nitrifiers are approximately 3 to 10% of MLVSS bacterial population

Majority of denitrifying organisms consist of facultative anaerobic bacteria.

Approximately 80% of the bacteria in the activated sludge process are facultative anaerobic bacteria

Food/microorganism ratio (F/M)

Organic loading rate of a wastewater treatment system.

The ratio of daily BOD load (FOOD) and the quantity of activated sludge (Microorganisms) in the system (MLVSS).

The F/M ratio is a process control which determines the proper number of microorganisms for your system.

How to Measure F / M

DATA: Influent Flow, MGD and Influent CBOD, mg/l

FORMULA FOR FOOD !

Food = Inf. Flow (MGD) X Inf. CBOD (mg/l) X 8.34

Food = Inf. CBOD pounds / day

How to Measure F / M

DATA:

Mixed Liquor Suspended Solids (MLVSS), mg/l

Volume (in million gallons) of your aeration tanks

FORMULA FOR MICROORGANISMS !

Micro. = Aeration Volume (MG) X MLVSS X 8.34

Microorganisms = MLVSS Pounds

How to Measure F / M

FORMULA FOR F/M !

$$\frac{\textbf{Food, pounds}}{\textbf{Microorganisms, pounds}} = \textbf{F/M Ratio}$$

Activated Sludge F/M, RAS Rates

Activated Sludge Operational Parameters - Typical Ranges

Activated Sludge Process	SRT days	MLSS mg/L	F:M lb BOD/day / lb MLVSS	Q_r / Q_o %
Conventional Plug Flow	3 - 15	1000 - 3000	0.2 - 0.4	25 - 75
Complete Mix	3 - 15	1500 - 4000	0.2 - 0.6	25 - 100
Extended Aeration	20 - 40	2000 - 5000	0.04 - 0.1	50 - 150

Which Tanks to Sample MLSS?

Which Tanks to Sample MLSS ?

Example Problem for F:M

Facility Flow = 1.2 MGD
Influent CBOD= 230 mg/l

1.2 X 230 X 8.34 = 2,302 Lbs FOOD

Aeration Vol. 250,000 gal / 1,000,000 = 0.25MG

Don’t Count the off-line tanks.

MLVSS = 2,500mg/l

0.25 X 2,500 X 8.34 = 5,215 Lbs. Micro.

2,301 F / 5,212 M = 0.44 F/M Ratio

F:M Really Controls MLVSS

Influent BOD typically cannot be controlled. Rearrange the formula to determine required MLVSS.

$$MLVSS = \frac{BOD,\ lbs.}{F:M}$$

Also, MLSS is acceptable when MLVSS does not vary significantly.

Example Problem for MLVSS

Facility Flow = 1.2 MGD

Influent CBOD= 230 mg/l = 2,302 Lbs FOOD

Aeration Vol. = 0.25MG

Target F:M = 0.075

Mass Lbs. = $\frac{\text{2,302 Lbs. F}}{\text{0.075 F/M}}$ = 30,693 Lbs. M

MLVSS mg/l = $\frac{\text{30,693 Lbs. Micro.}}{0.25 \times 8.34}$

MLVSS mg/l = 14, 720 mg/l

The Problem with 14,720 MLVSS

IT WON'T SETTLE !

Facility Flow = 1.2 MGD

Influent CBOD= 230 mg/l = 2,302 Lbs FOOD

Aeration Vol. = 0.25MG   Need 1.25 MG

$$\text{Mass Lbs.} = \frac{2{,}302 \text{ Lbs. F}}{0.075 \text{ F/M}} = 30{,}693 \text{ Lbs. M}$$

$$\text{MLVSS mg/l} = \frac{30{,}693 \text{ Lbs. Micro.}}{1.25 \times 8.34}$$

MLVSS mg/l = 2,944 mg/l

Note: This can be a design problem or not enough tanks online.

What's the best MLVSS & F:M ?

The one that works for you !

- Record Load & Effluent Results on Spreadsheet
- Calculate F:M for each record
- The best F:M will have the best results !
- Generally Speaking :
  - If the BOD is good but NH_3 or NO_2 is high
    - Lower F:M i.e.: 0.075 lowered to 0.06 (Raise the MLVSS)
  - As the wastewater temperature drops
    - Raise the MLVSS (Lower the F:M)

Sludge Wasting

Sludge Wasting Controls MLVSS

- Waste More……..MLVSS goes down
- Waste Less………MLVSS goes up

Waste Too much

- No Microorganisms….No Treatment !

Don’t Waste Enough

- Solids will go out in the effluent
- Probably see Turbidity & High TSS first

D.O. High? Low? Make up your Mind !

High D.O.

Removes BOD

Converts NH3 to NO2

Converts NO2 to NO3

Assimilates P

- after Anaerobic Stress

Keeps the Odors down

Low D.O.

Anoxic Treatment

- Denitrification
- DO< 0.5
- Converts NO3 to N gas
- Takes the N out of the water

Anaerobic Treatment

- 0.0 DO & 0.0 NOx
- Stresses Poly P Bacteria
- P release Anaerobic Zone
- No Anaerobic Odor

How to Control D.O.

- Best with in Tank Probe & SCADA Trend
  - Manual measurements miss too much
- Blowers on VFD
  - Automatic Adjustment of DO Level
  - Best in MLE & Bardenpho
- Blower Timers work well on SBR
  - Can also work on Extended Air

Measure Nitrification/Denitrification to Balance DO

Form	ML Effluent Filtrate Concentration, mg/l		
	NH_4^+	NO_2^-	NO_3^-
Complete	< 1	< 1	>1<7
More DO	< 1	> 1	< 1
More DO	> 1	< 1	> 1
Less DO, Carryover to Anoxic Zone	< 1	< 1	> 10

Standard Operating Procedures

Routine Process Control Measurements

Parameter	Chemical formula	Location of sample	Frequency of sample	Recommended range	Corrective Action level	Corrective Actions
Ammonia	NH_3-N	Clarifier effluent	Twice per week	< 1 mg/l	1.5 mg/l	1. Low DO level in aeration tank 2. Low MLSS in aeration tank 3. Low alkalinity in effluent 4. Low temperature of effluent
Nitrite	NO_2-N	Clarifier effluent	Twice per week	< 1 mg/l	1.5 mg/l	1. Low DO level in aeration tank 2. Low MLSS in aeration tank 3. Low alkalinity in effluent 4. Low temperature of effluent
Nitrate	NO_3-N	Clarifier effluent	Twice per week	> 1 < 10 mg/l	> 8 mg/l	1. High DO level at aeration tank outlet weir. 2. High DO in Anoxic Tank 3. Low MLSS in aeration tank
Alkalinity	$CaCO_3$	Clarifier effluent	Twice per month	> 100 mg/l	< 100 mg/l	1. Add Alkalinity with Chemical to influent or Anoxic Tank
pH	Units	Clarifier effluent	Daily	6.9 - 7.2	< 6.9	1. Add Alkalinity with Chemical to influent or Anoxic Tank
Temperature	°C	Influent	Daily			
Temperature	°C	Primary Clarifier effluent	Twice per week			
Temperature	°C	Clarifier effluent	Twice per week		< 14°C	1. Adjust MLSS to higher level as temperature drops seasonaly
Temperature	°C	Clarifier effluent	Twice per week		< 10°C	1. Continue Adjusting MLSS to higher level as temperature drops.
Dissolved Oxygen	mg/l	Last Anoxic Tank		< 0.3 mg/l	> 0.3 mg/l	1. Reduce DO (reduce air volume)at end of aeration to prevent DO carryover in Recycle
Dissolved Oxygen	mg/l	First Aeration Tank		> 1 mg/l	> 3 mg/l	1. Reduce DO (reduce air volume)at end of aeration to prevent high DO.
Dissolved Oxygen	mg/l	Middle Aeration Tank		> 2 < 3 mg/l	> 3 mg/l	1. Reduce DO (reduce air volume)at end of aeration to prevent high DO.
Dissolved Oxygen	mg/l	Aeration tank outlet weir		> 2 < 3 mg/l	> 3 mg/l	1. Reduce DO (reduce air volume)at end of aeration to prevent high DO.
MLSS	mg/l	Aeration tank outlet weir	Once per week	3,000 - 3,500 mg/l		1. Increase Rate of sludge wasting for high MLSS. 2. Reduce Rate of sludge wasting for low MLSS
Settled Sludge Volume	SSV_{30}	Aeration tank outlet weir	Twice per week (each tank)	350 ml/liter		1. Increase Rate of sludge wasting for high SSV. 2. Reduce Rate of sludge wasting for low SSV. 3. Sludge Bulking (high SSV) indicates overation.
Microscopic Examination of MLSS sample		Aeration tank outlet weir	Once per week			

Section 6

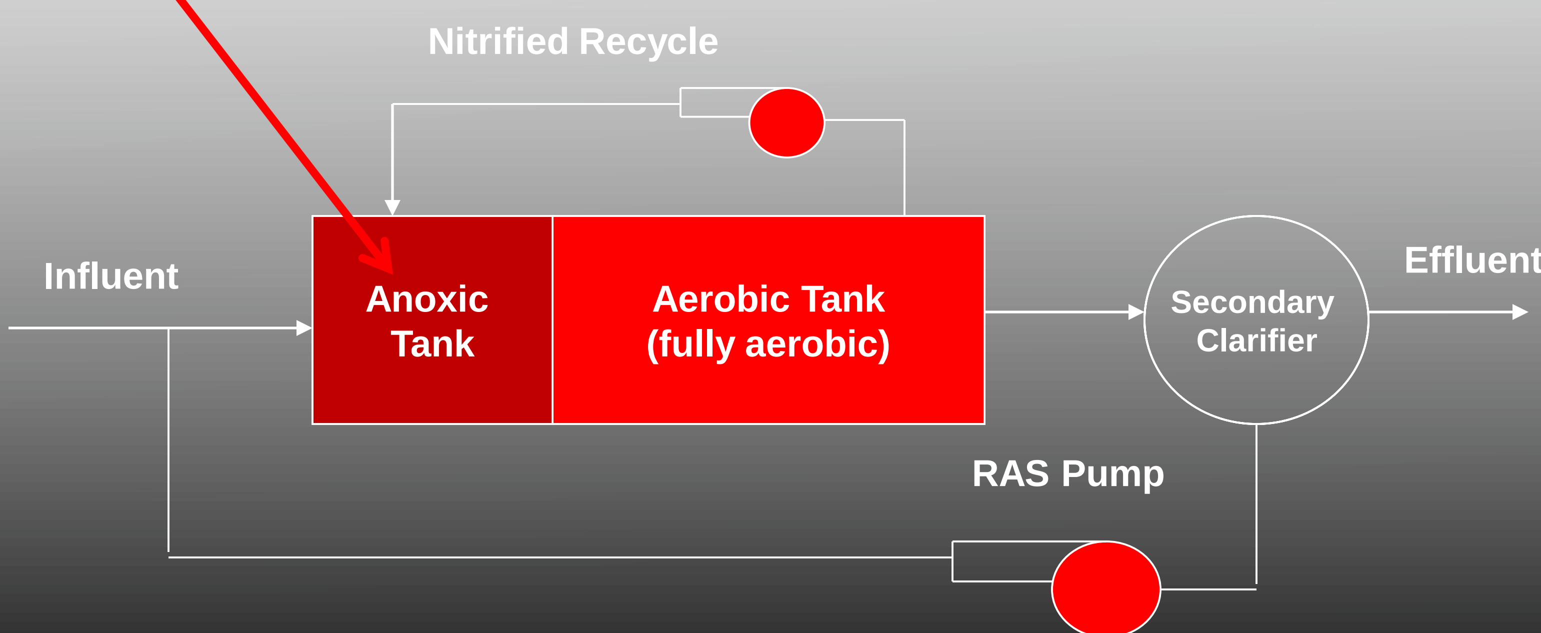
Operational Changes by the operator

What is Nitrified Recycle ?

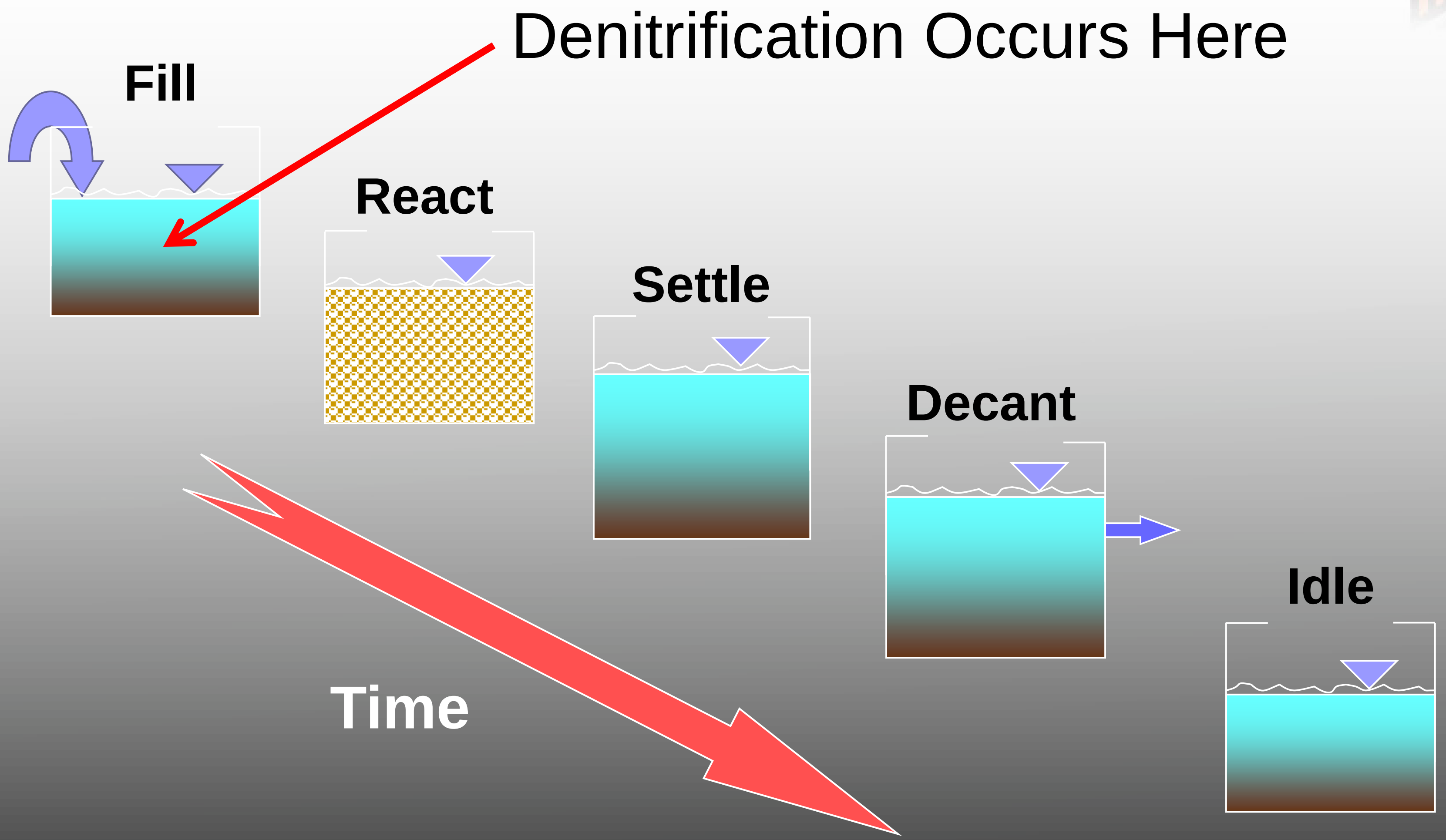
- This BNR Treatment is Backwards
  - First, NH_3 goes to NO_3 in the Aeration Tank
  - Second, NO_3 goes to N gas in the Anoxic Tank
  - Anoxic Tank is First, Aeration Tank is second
- Recycle Brings the NO_3 back to Anoxic
  - WHY ? Denitrification needs BOD from influent
  - In the SBR, it’s the Large Volume remaining after decant

Modified Ludzack-Ettinger (MLE) Process

Denitrification Occurs Here



The Sequencing Batch Reactor



Adjusting Nitrified Recycle

- Typically 200% to 400% of Influent Rate
  - Over 500% has no benefit
  - Can return DO to Anoxic Tank
    - Keep end of Aeration at a low DO
- Recycle Brings the NO3 back to Anoxic
  - If NO3 is high in effluent
    - Increase NIR
    - NO3 will equalize when Soluble BOD utilized
  - If NO3 is low
    - Reduce NIR, it will save energy

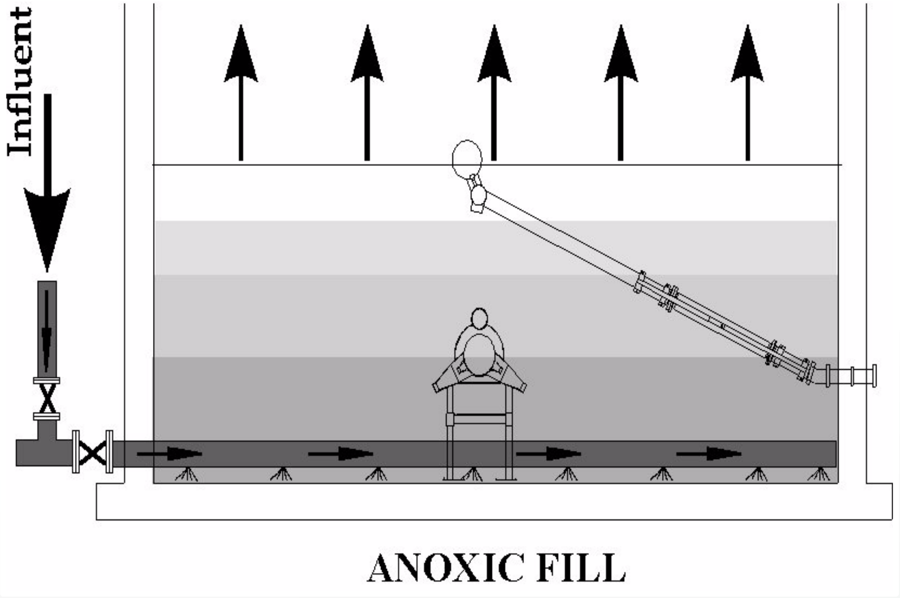
NO3 Reduction in SBR

- NIR is fixed at minimum decant volume
  - It’s a design feature the operator can’t change
  - That’s why an SBR has limited NO3 removal
- Insure SBR isn’t over aerated
  - Add a blower off time period during React Fill
  - Will remove some NO3 created with aeration

Phosphorous Removal

- Its all about Anaerobic Action
  - STRESS THE BACTERIA
- Bacteria Use P as a nutrient
  - Consume 1 part P for every 100 parts BOD
- Anaerobic Stressing changes the ratio
  - Consume 2 to 5 parts P for every 100 parts BOD
- Can Remove P to Levels below 0.5 mg/l

Anaerobic/Anoxic Fill

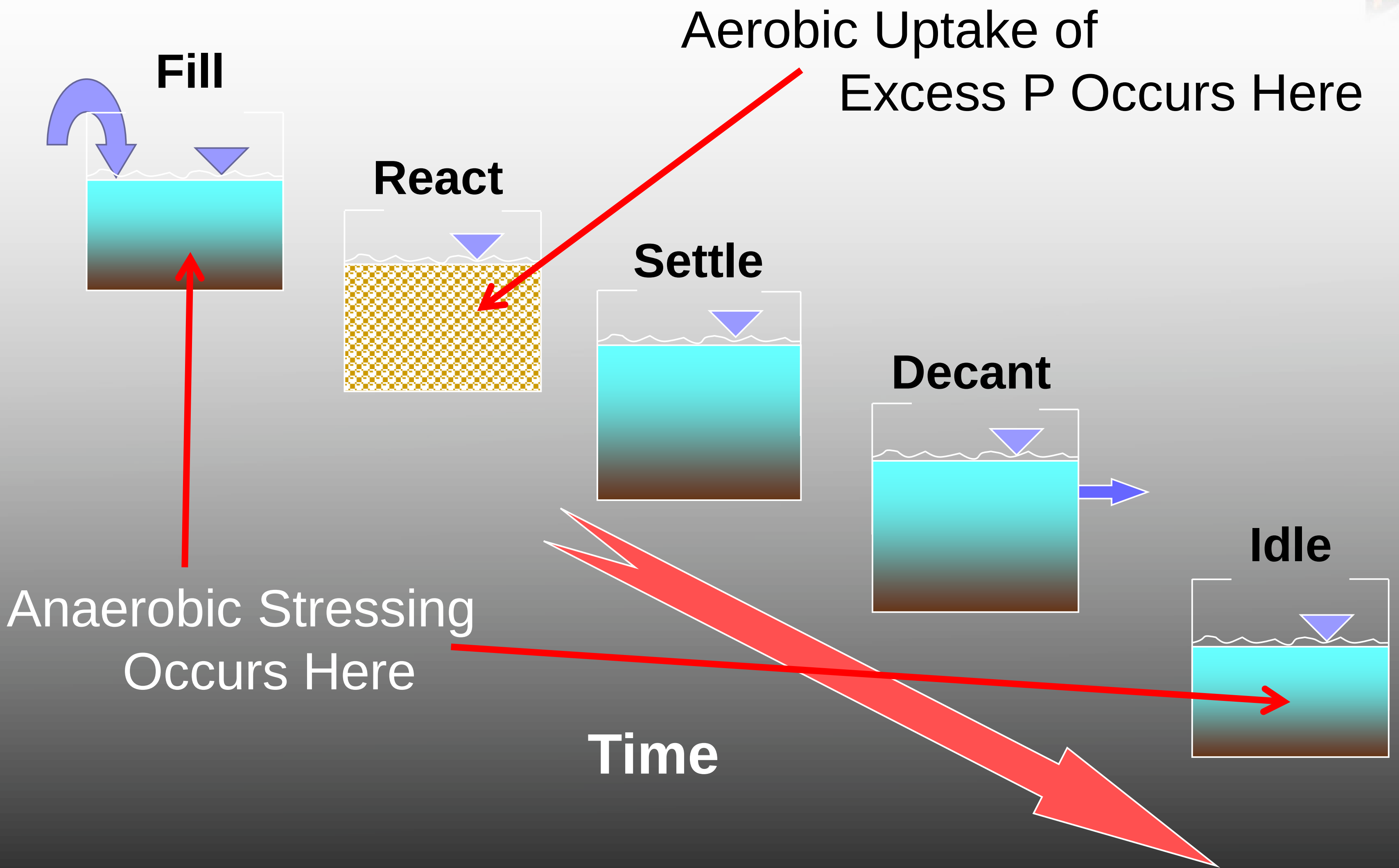


To remove nitrate, promote VFA production & growth of Bio-P bacteria, and to control aerobic filamentous organisms.

- **Static Fill**
- **Mixed Fill**
- **Design Time = 50% to 100% of Fill Time**

Design time is a function of BOD & TKN loads, BOD: P ratio, temperature & effluent requirements

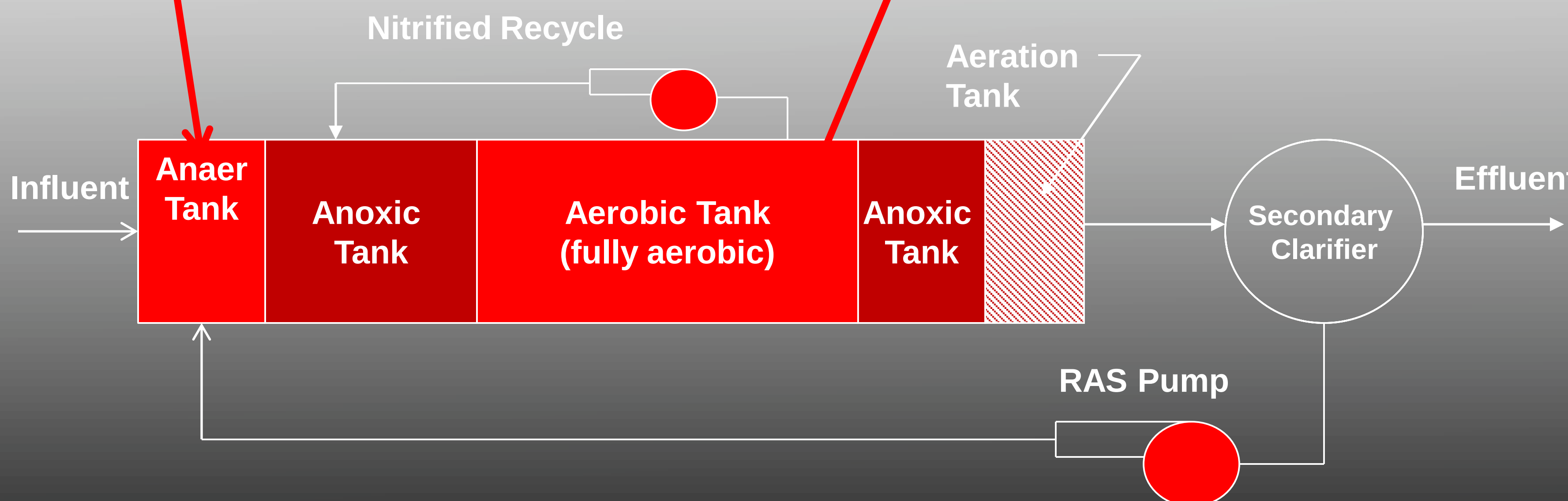
The Sequencing Batch Reactor



Bardenpho Process (Five-Stage)

Anaerobic Stressing Occurs Here

Aerobic Uptake of Excess P Occurs Here

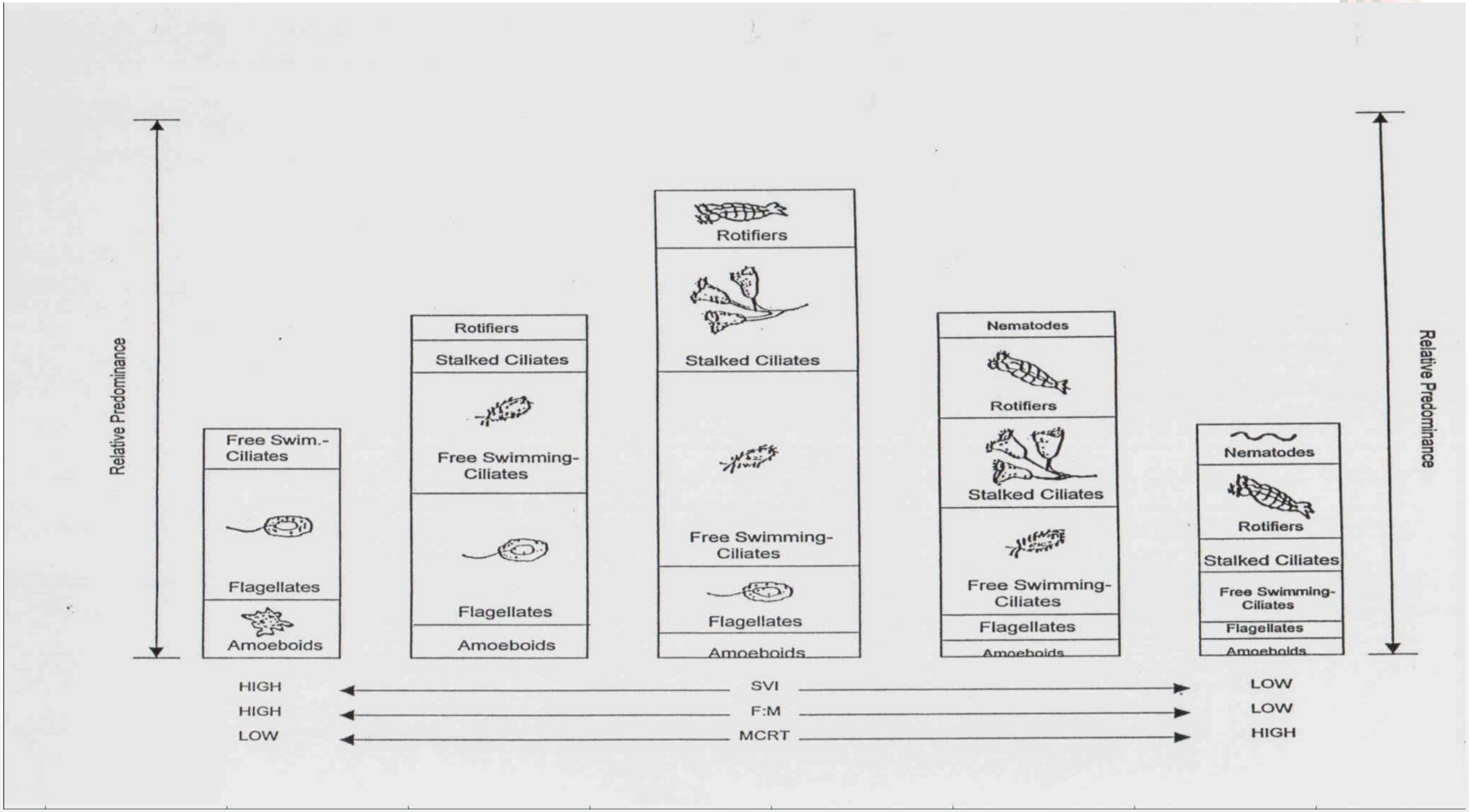


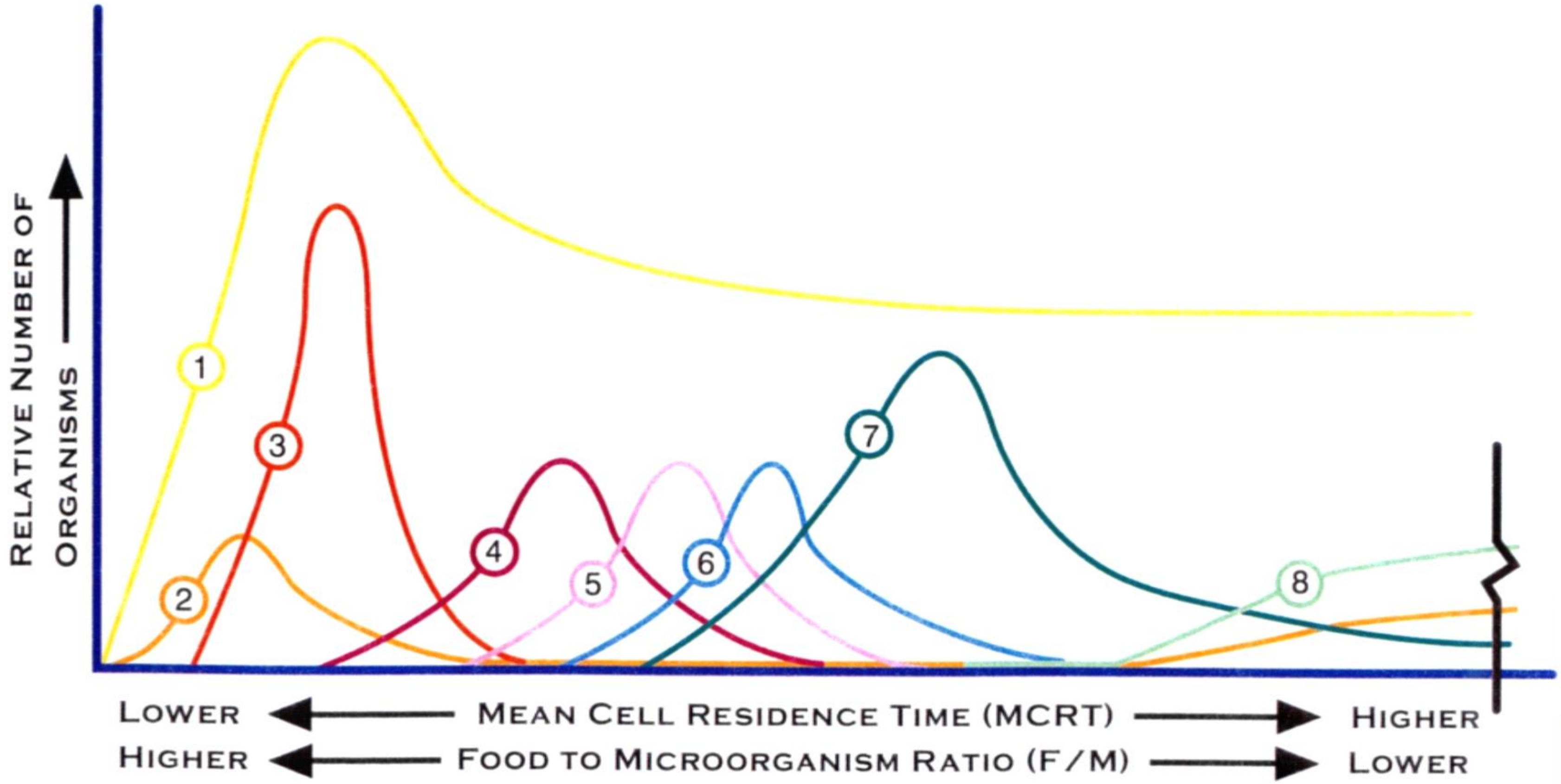
Questions?

BIOLOGY

OPERATOR
Guidelines

Microorganism Activity and Predominance in Activated Sludge

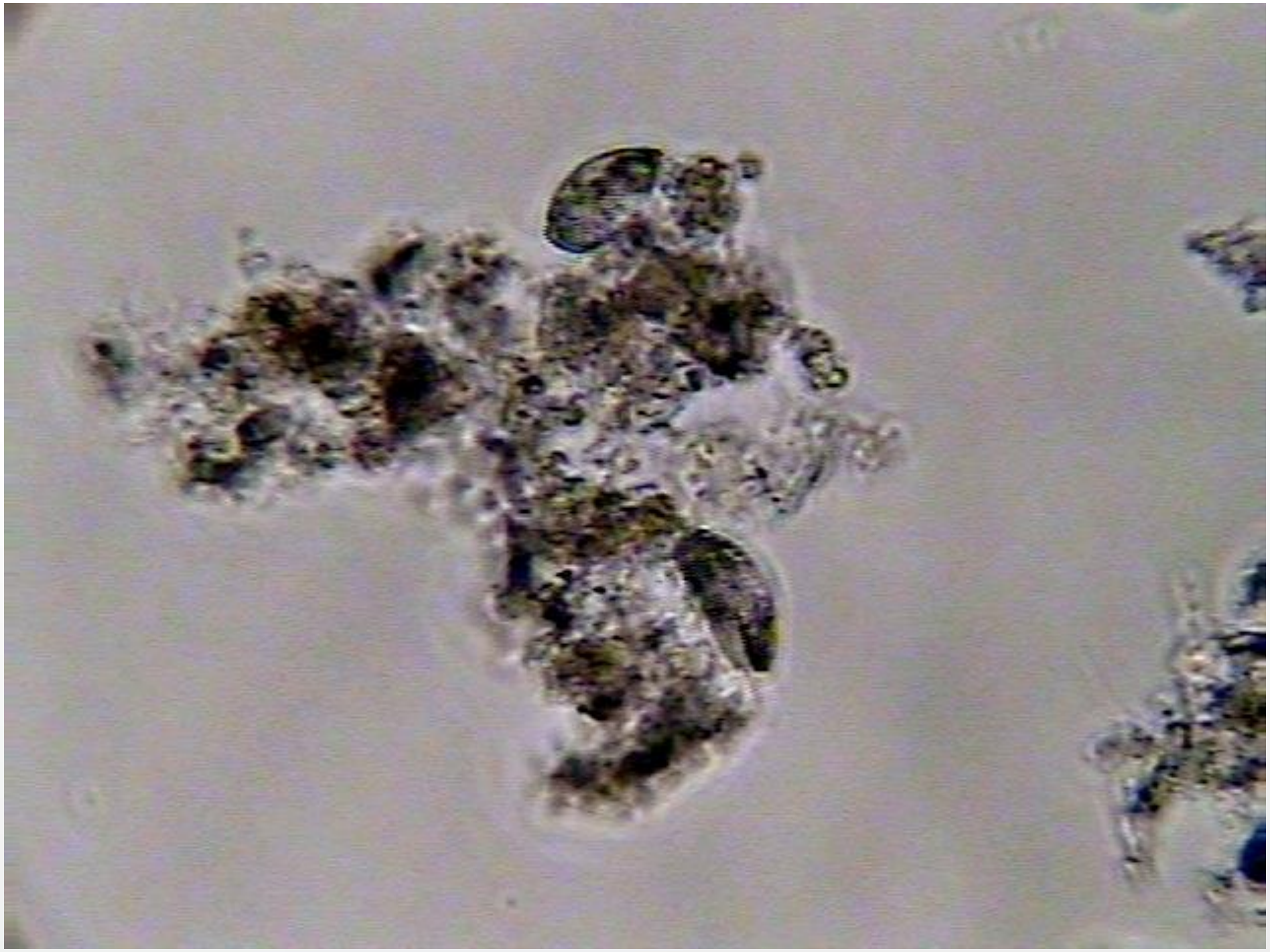




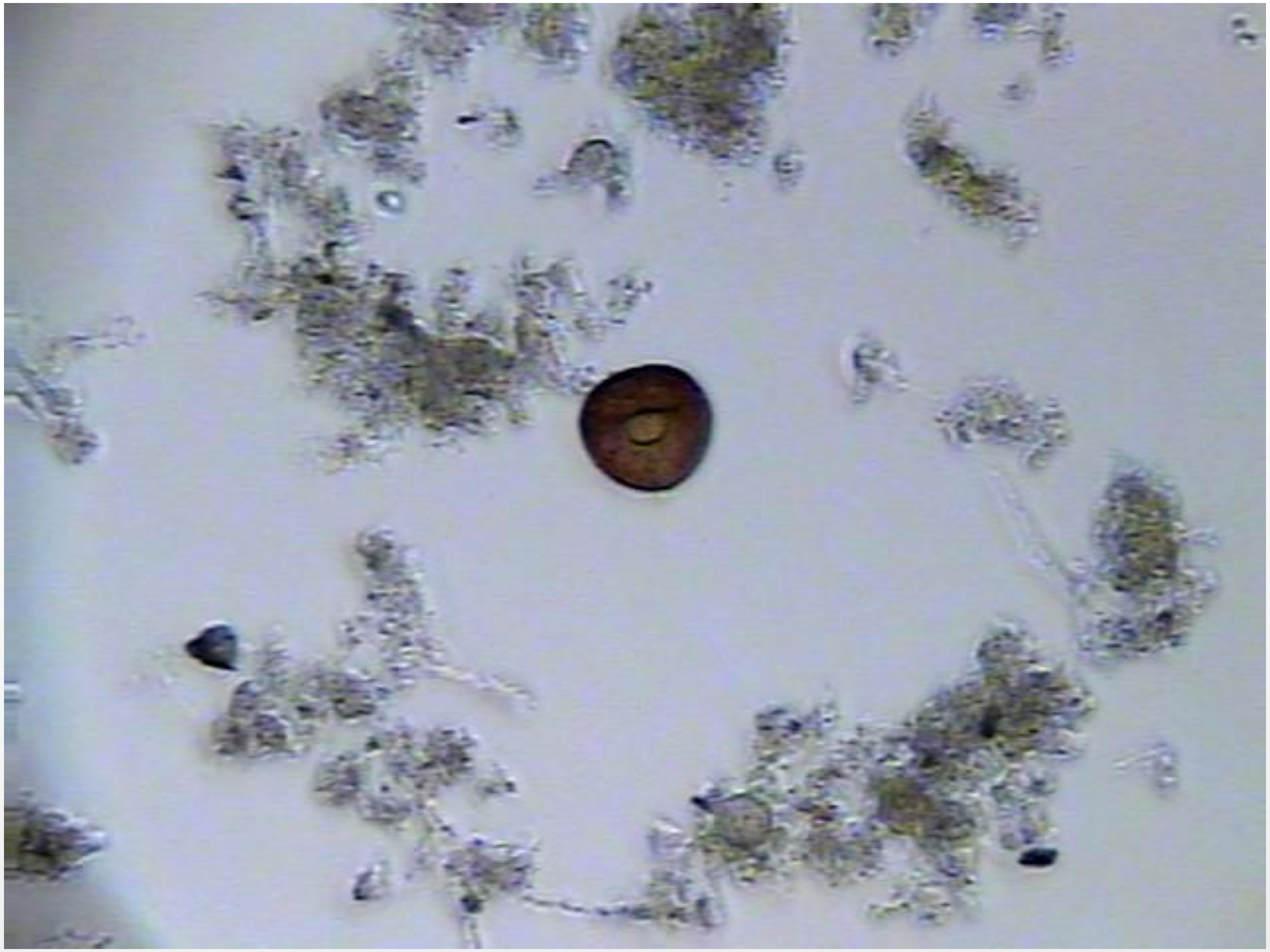
Relative Number of Organisms
1
2
3
4
5
6
7
8
Lower
Mean Cell Residence Time (MCRT)
Higher
Higher
Food to Microorganism Ratio (F/M)
Lower

1. **Bacteria** - Feed on soluble materials directly and solublize organic particles
2. **Amoeba Protozoa** - Primarily feed on solid particles and soluble organics, but some are photosynthestic
3. **Flagellated Protozoa** - Primarily feed on bacteria, solid particles and soluble organics, but some are photosynthestic
4. **Free-Swimming ciliated protozoa** - Feed primarily on dispersed bacteria, either individual cells or small clumps
5. **Crawling ciliated protozoa** - Feed on individual bacterial cells or small clumps dislodged from bacterial flocs
6. **Carnivorous free-swimming ciliated protozoa** - Feed on other protozoa
7. **Stalked ciliated protozoa** - Feed primarily on individual bacterial cells, but may be carnivorous such as *Suctoria*
8. **Metazoa (Phylum listed)** - Feed on detritus and small plankton organisms

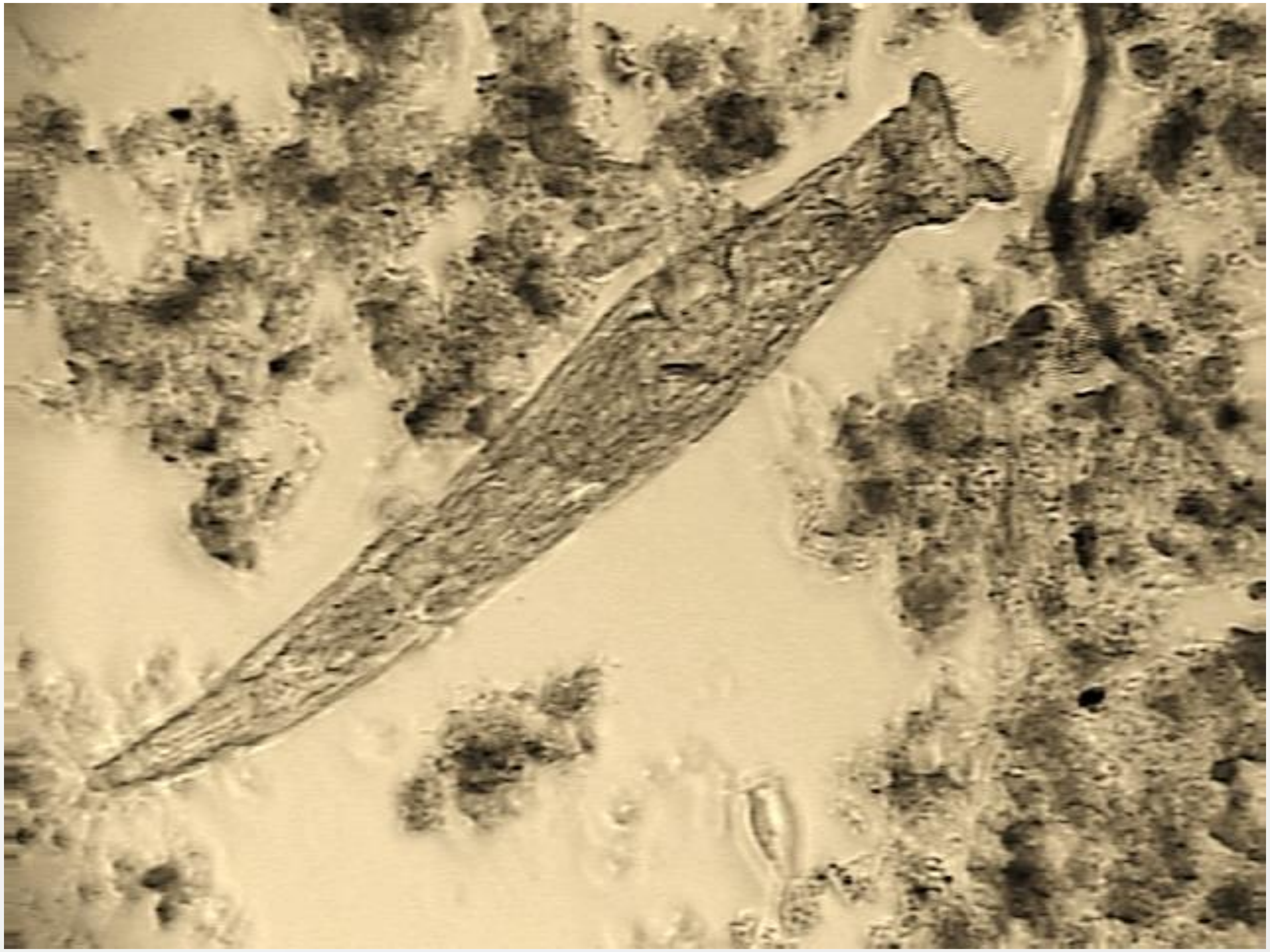
Crawling Ciliates



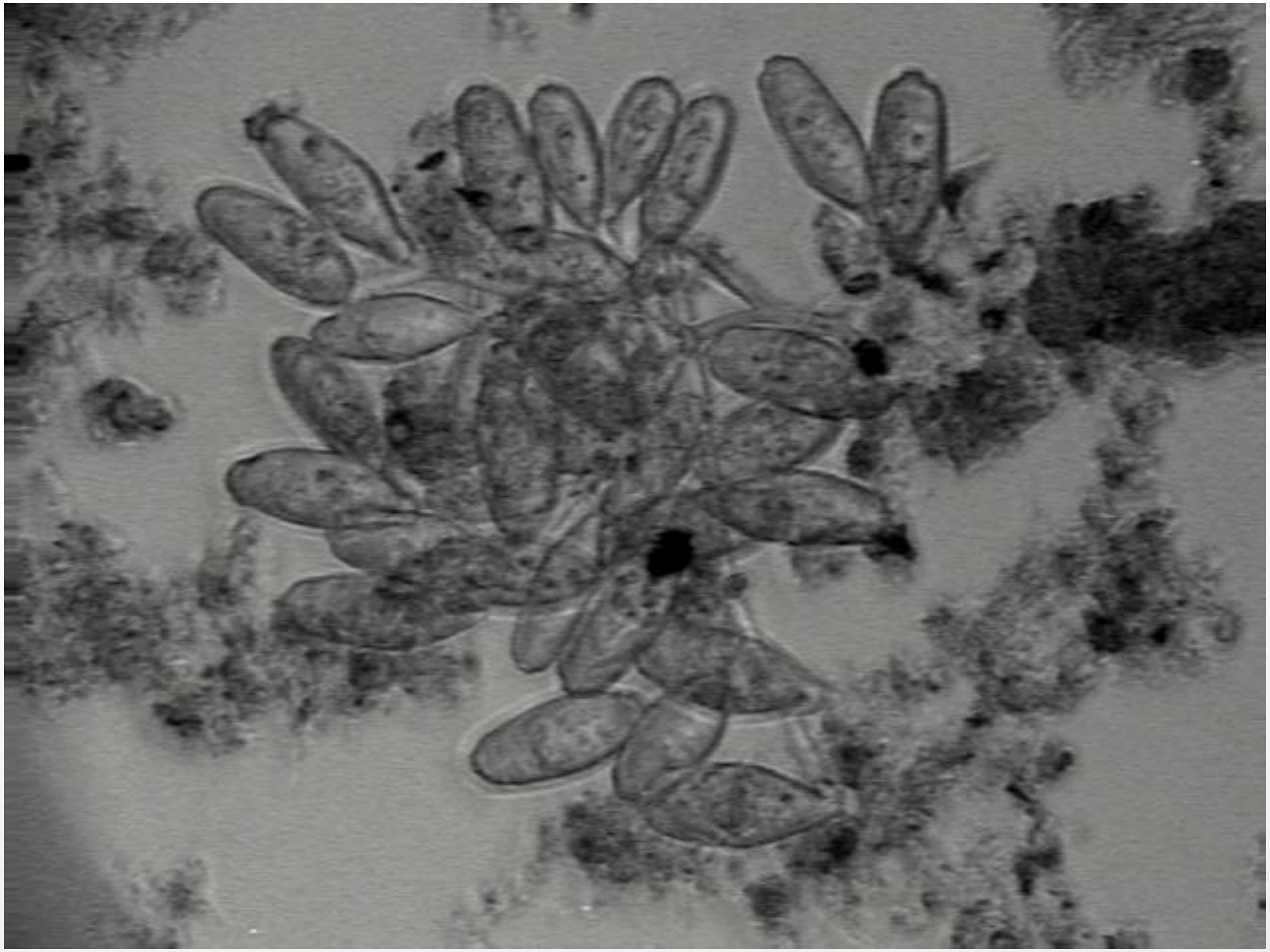
Testate Shelled Amoeba



Bdelloid Rotifer



Stalked Ciliate Cluster



Nocardia Filaments within Floc Particle