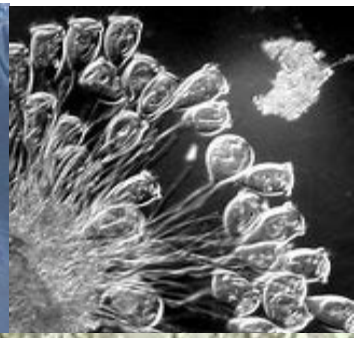
baywork

Bay area water/wastewater workforce reliability

BAY AREA CONSORTIUM FOR WATER & WASTEWATER EDUCATION

ACTIVATED SLUDGE



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AS Water/Wastewater Technology Solano College

Activated Sludge

Activated Sludge – consists of sludge particles produced in raw or settled wastewater (primary effluent) by the growth of organisms (including zoogleal bacteria) in aeration tanks in the presence of dissolved oxygen.

"Activated" – refers to the fact that the activated sludge particles are teeming with:

Bacteria – Fungi - Protozoa

Activated Sludge Process – a biological wastewater treatment process that uses MICROORGANISMS to speed up the decomposition of wastes.

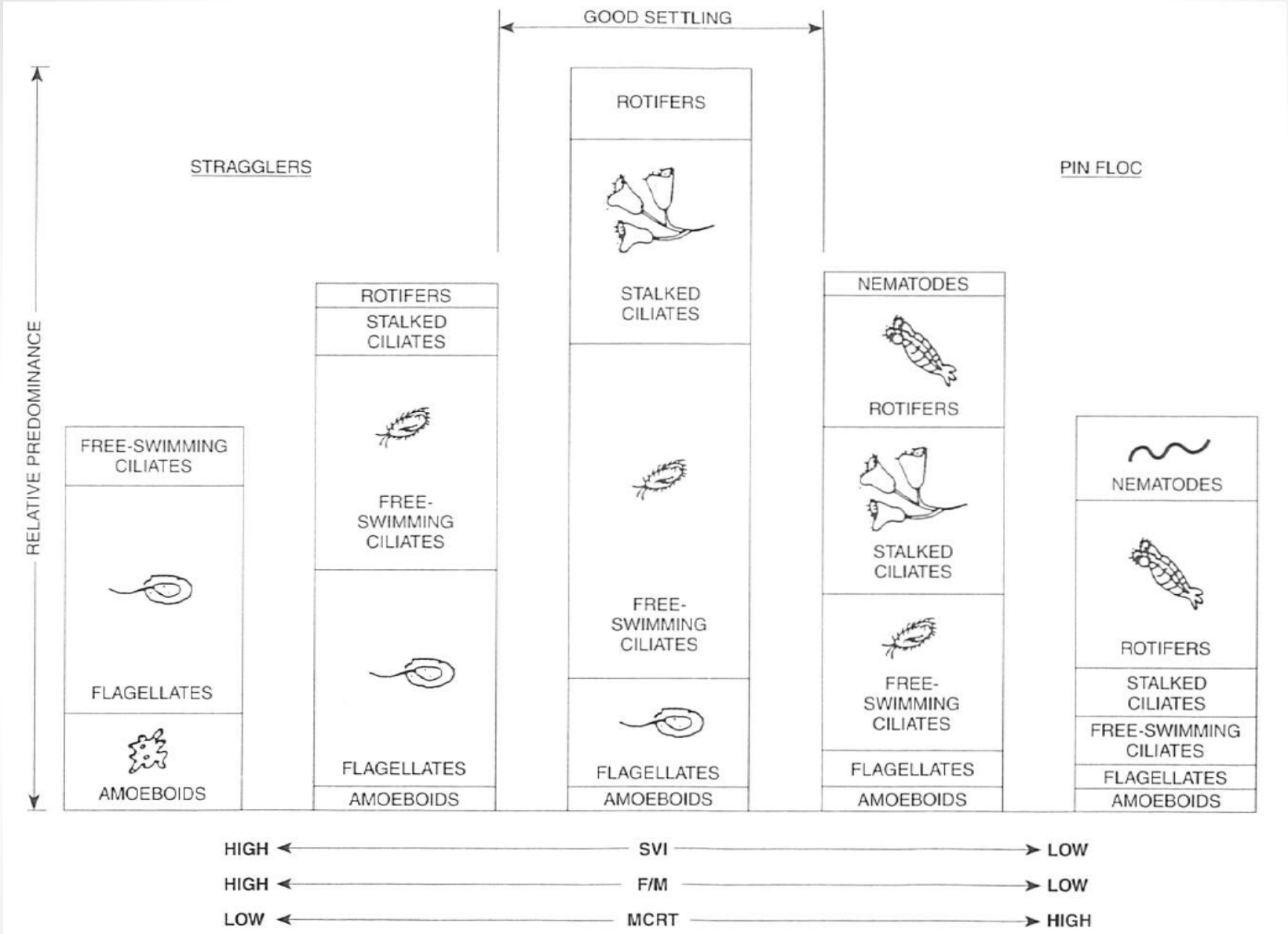
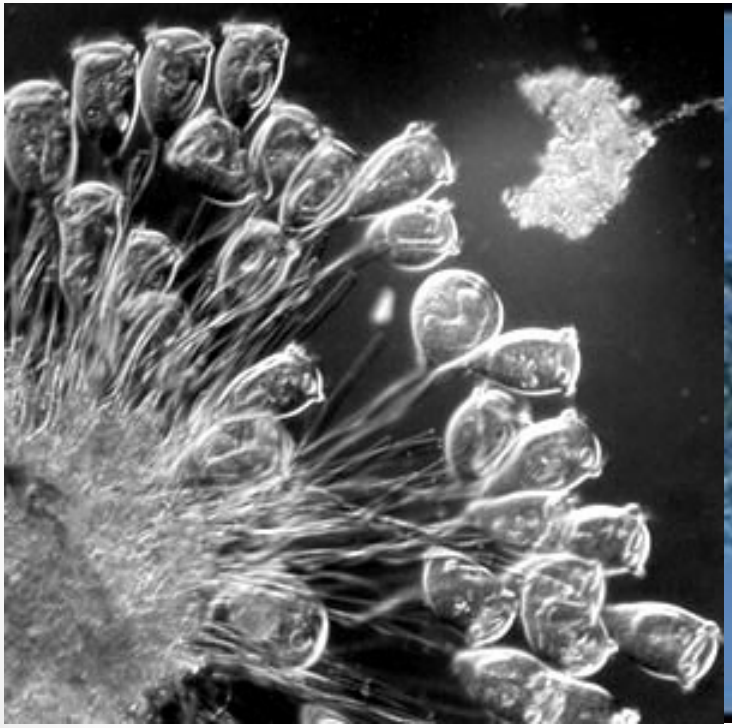


Fig. 11.49 Population predominance versus operational guidelines (Bar graph taken from EPA PROCESS CONTROL MANUAL FOR AEROBIC BIOLOGICAL WASTEWATER TREATMENT FACILITIES, 1977)

Activated Sludge

- Activated Sludge (Good Microorganisms)



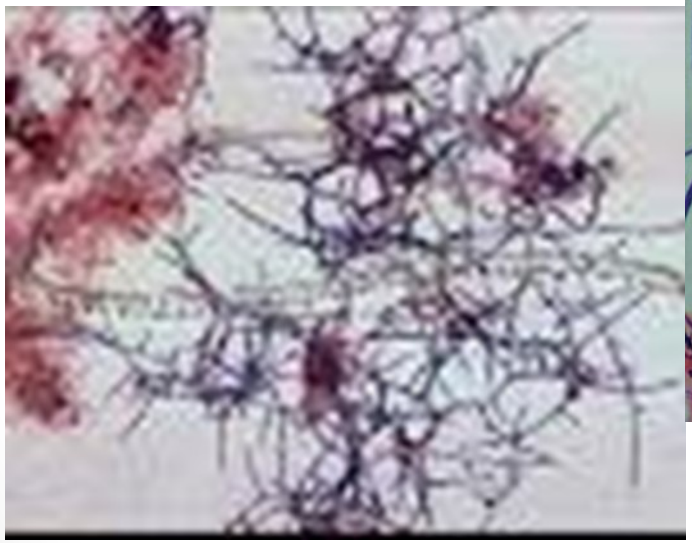
Stalked Ciliates

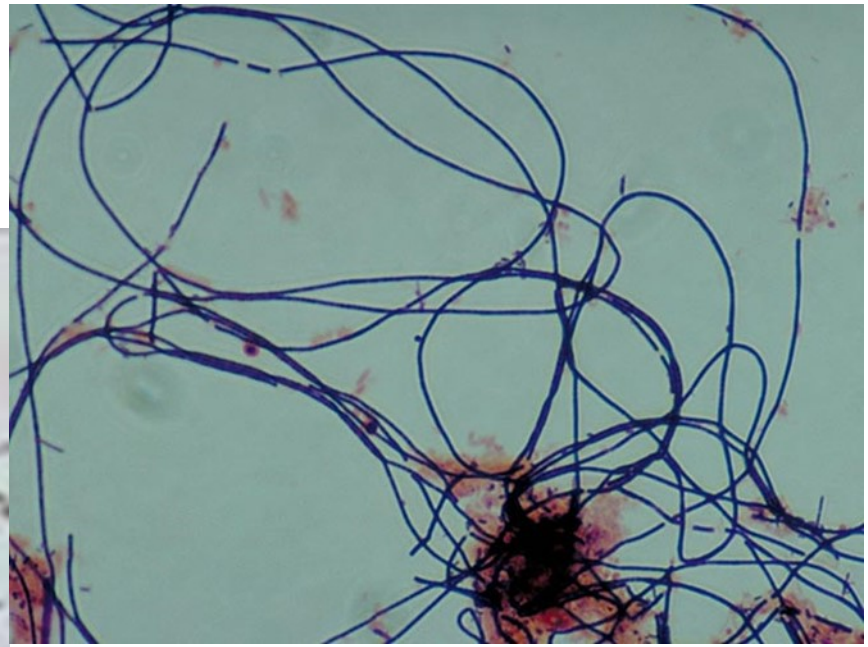
Rotifers

Activated Sludge

- Activated Sludge (Bad Microorganisms)

Filamentous Bacteria





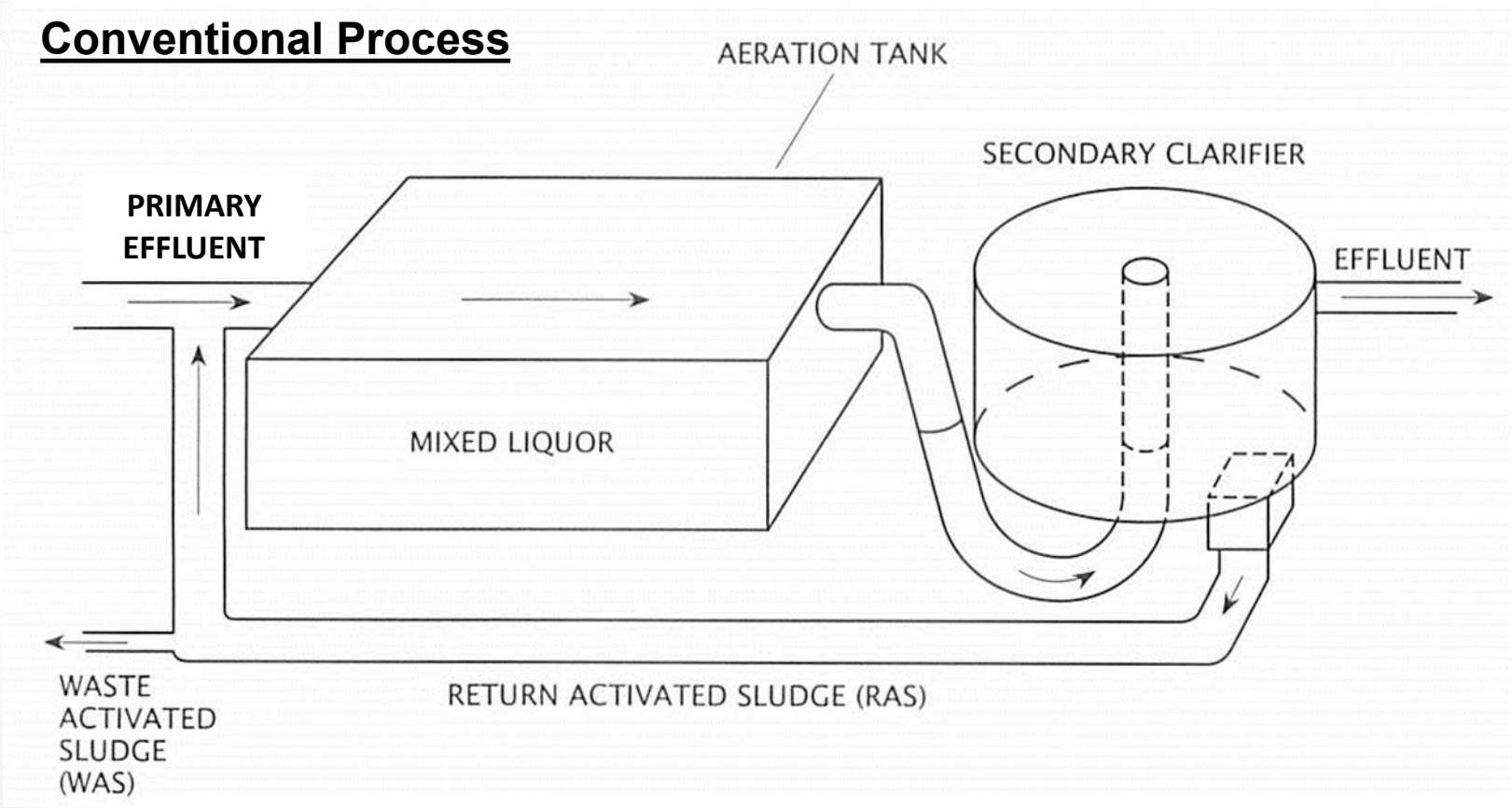
Nocardia

Activated Sludge

Basic Needs of a Healthy Activated Sludge:

- Food in the form of BOD that the microorganisms can readily assimilate
- Ample supply of oxygen
- Good mixing to create a homogeneous solution of the food-air-microorganisms
- Ability to maintain the desired activate sludge inventory

Activated Sludge



Activated Sludge

MLSS – The concentration of suspended solids (mg/L) in the mixed liquor of an aeration tank

MLVSS – The concentration of organic or volatile suspended solids (mg/L) in the mixed liquor of an aeration tank. Usually equivalent to concentration of microorganisms in an aeration tank.

FOOD / MICROORGANISM RATIO (F/M Ratio)

- A measure of food provided to the Activated Sludge in an aeration basin

$$\text{F/M Ratio} = \frac{(\text{Flow, MGD})(\text{BOD mg/L})(8.34\ \text{lbs/gal})}{(\text{Aeration Basin Vol, MG})(\text{MLVSS, mg/L})(8.34\ \text{lbs/gal})} = \frac{\text{BOD, lbs/day}}{\text{MLVSS, lbs}}$$

Activated Sludge

SLUDGE AGE

An indicator of the length of time a pound of solids is kept under aeration in the activated sludge process.

$$\text{Sludge Age, Days} = \frac{(\text{MLSS, mg/L})(\text{Aeration Basin Vol, MG})(8.34\ \text{lbs/gal})}{(\text{TSS in Primary Effluent, mg/L})(\text{Flow, MGD})(8.34\ \text{lbs/gal})}$$

$$= \frac{\text{Suspended Solids Under Aeration, lbs}}{\text{Suspended Solids Added, lbs/Day}}$$

Activated Sludge

Sludge Age

- HIGH RATE: 0.5 to 2.0 days
  - Operates at the highest loading of food to microorganisms.
- CONVENTIONAL: 3.5 to 7.0 days
  - Most common operation. Approximately 50% of the food to microorganism ratio as the High Rate.
- EXTENDED AERATION: >10.0 days
  - Popular in small package plants, most stable due to light loads and low food to microorganism ratios

Activated Sludge

MEAN CELL RESIDENCE TIME (MCRT)

an expression of the average time (days) that a microorganism will spend in the activated sludge process.

$$\text{MCRT, Days} = \frac{\text{Total Suspended Solids (MLVSS) in Activated Sludge , lbs}}{\text{Total Suspended Solids Removed from Process, lbs/day}}$$

$$\text{MCRT, Days} = \frac{\text{(MLVSS Aeration, lbs) + (MLVSS Secondary Clarifiers, lbs)}}{\text{(MLVSS removed WAS, lbs/day) + (TSS lost in Effluent, lbs/day)}}$$

SOLIDS RETENTION TIME (SRT)

an expression of the average time (days) that the solids will spend in the activated sludge process.

$$\text{SRT, Days} = \frac{\text{Total Suspended Solids (MLSS) in Activated Sludge , lbs}}{\text{Total Suspended Solids Removed from Process, lbs/day}}$$

$$\text{SRT, Days} = \frac{\text{(MLSS Aeration, lbs) + (MLSS Secondary Clarifiers, lbs)}}{\text{(MLSS removed WAS, lbs/day) + (TSS lost in Effluent, lbs/day)}}$$

Activated Sludge

- 30-Minute Settleometer (Settling Test)
  - Simulates the behavior of the activated sludge in the Secondary Clarifiers

Good Settling
Dense blanket, clear supernate

Medium Settling
Uniform blanket, PIN-FLOC

POOR Settling
Sludge blanket split,
DENITRIFICATION

Activated Sludge

SLUDGE VOLUME INDEX (SVI)

An indicator of the settleability characteristics of the MLSS. An SVI below 150 indicates a good settling activated sludge.

$$SVI = \frac{\text{(Volume 30 min settleability, mL) / (Volume of sample, L)}}{\text{(MLSS mg/L)}} \times \frac{\text{(1,000 mg)}}{\text{g}}$$

Activated Sludge

Activated Sludge

- **"RAS" (Return Activated Sludge)** – Activated Sludge that is returned from the Secondary Clarifiers to the influent of the Aeration Basin
- **"WAS" (Waste Activated Sludge)** – Activated Sludge wasted or removed from the Activated sludge System. This is how operators control the microorganism population needed to treat the flow from the Primary Treatment Process (BOD & TSS). WAS is generally thickened and sent to the Digestion Process.

Activated Sludge

- Activated Sludge Operation
  - Waste Activated Sludge (WAS)
  - If your PCMP use MCRT to control the Activated Sludge Process:

$$\text{MCRT, Days} = \frac{\text{(MLVSS Aeration, lbs) + (MLVSS Secondary Clarifiers, lbs)}}{\text{(MLVSS removed WAS, lbs/day) + (TSS lost in Effluent, lbs/day)}}$$

$$\text{WAS Lbs/Day} = \frac{\text{(Total MLVSS in Activated Sludge , lbs)}}{\text{MCRT, Days}} - \text{(TSS lost in Effluent, lbs/day)}$$

Activated Sludge

Activated Sludge

There are two (2) main processes Activated Sludge microorganisms use to bind-up their food:

1. ADSORPTION – the gathering of gas, liquid, or dissolved substances on the surface or interface zone of another material. (stick to the surface of the organism)
2. ABSORPTION – The taking in or soaking up of one substance into the body of another by molecular or chemical action. (goes into the body of the organism)

Activated Sludge

Activated Sludge

- **OXIDATION**
  - **Oxidation and Reduction in terms of oxygen transfer**
    The terms **oxidation** and **reduction** can be defined in terms of the adding or removing oxygen to a compound. while this is not the most robust definition, as discussed below, it is the easiest to remember.
  - Definition: Oxidation and Reduction with respect to Oxygen Transfer

Oxidation is the **gain** of oxygen.

Reduction is the **loss** of oxygen.

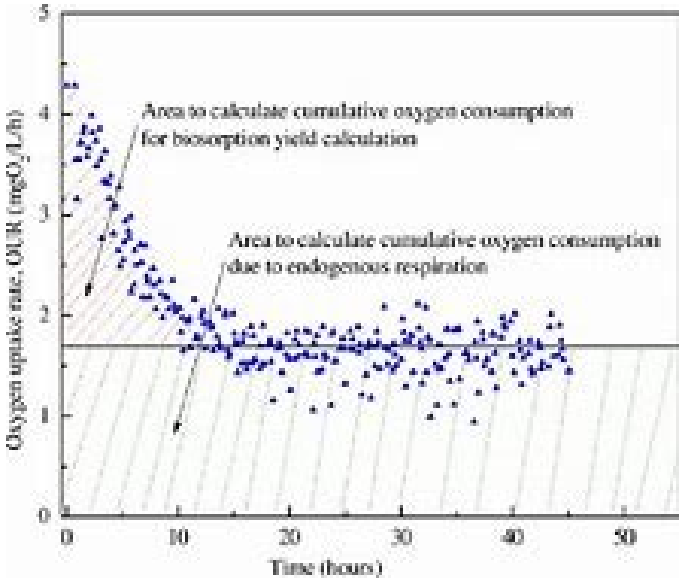
Activated Sludge

Activated Sludge

OXYGEN UPTAKE RATE (OUR)

The rate at which micro-organisms use oxygen while consuming food (BOD) from the wastewater.

Dissolved Oxygen Uptake
(DOUR) Test



Activated Sludge

Activated Sludge Operation

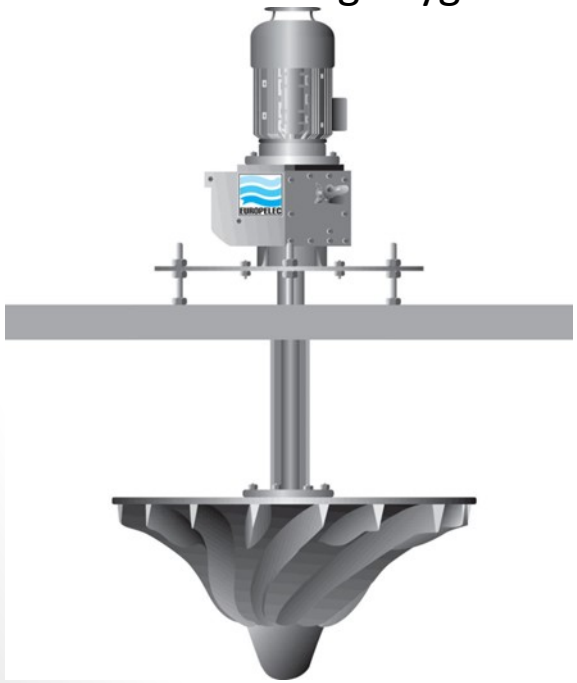
- Activated Sludge process is generally robust and can handle periodic “shock loads” of food (BOD).
- When the F/M Ratio is low indicating a low food concentration for the microorganisms, the microorganisms can enter **ENDOGENOUS RESPIRATION**.

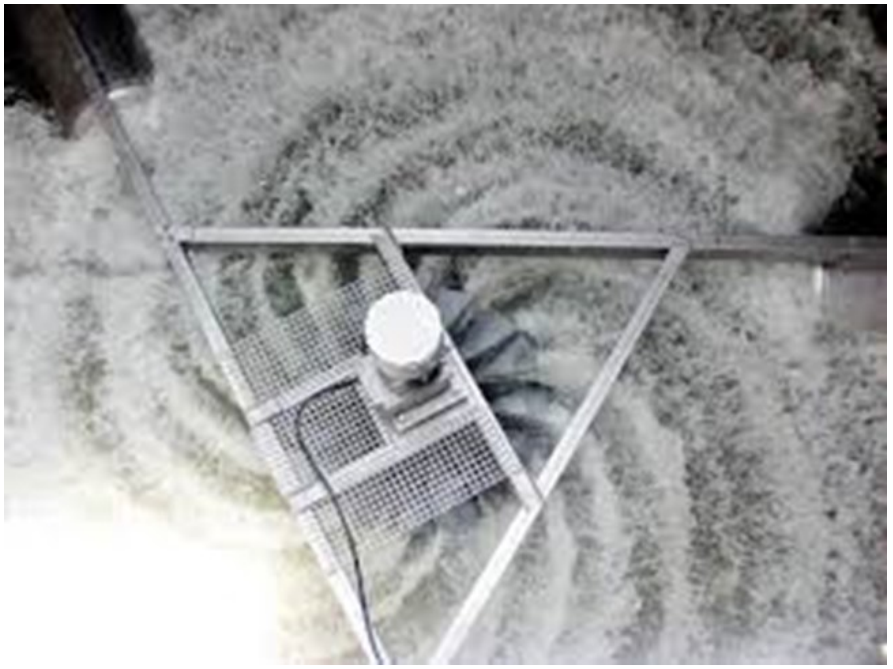
- **ENDOGENOUS RESPIRATION:** a situation in which living organisms oxidize some of their own cellular mass instead of new organic matter they adsorb or absorb from their environment

Activated Sludge

Activated Sludge - Aeration

- Three (3) methods to supply dissolved oxygen to the activated sludge microorganisms
    1. **Mechanical Aeration** – utilizes a mechanical mixer to agitate the water resulting in a spray or waves that splash water into the air absorbing oxygen.





Activated Sludge

Activated Sludge - Aeration

2. **Diffused Air Aeration** – utilizes a diffuser to break up air supplied from a blower into fine bubbles for greater oxygen transfer

Ceramic Head Diffusers

Membrane Sock Diffusers

Activated Sludge

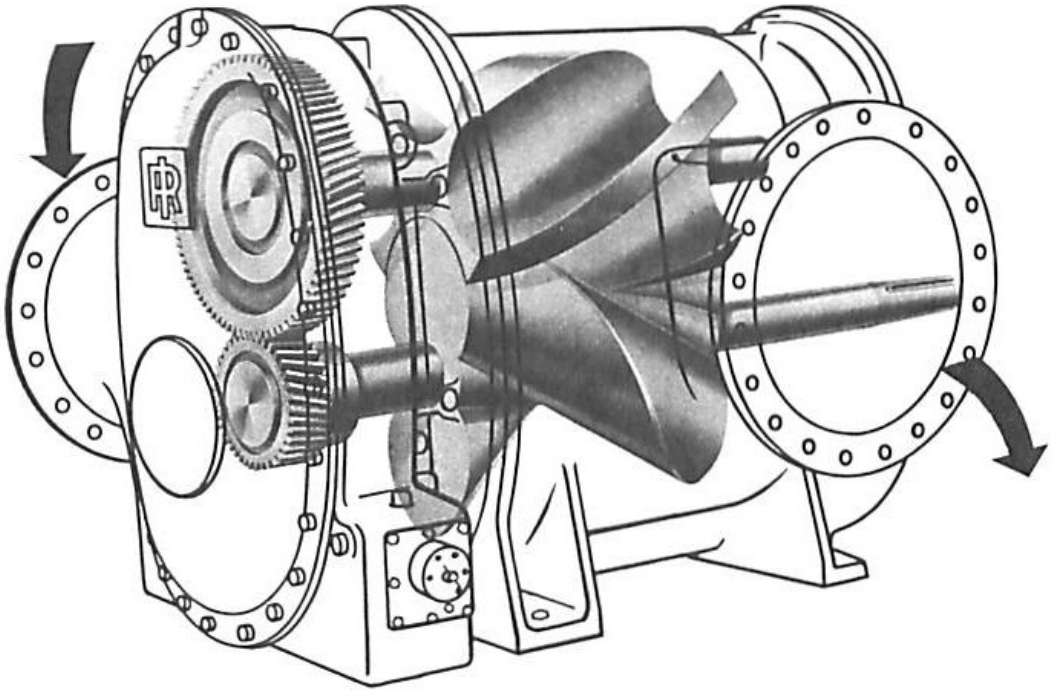
Activated Sludge - Aeration

3. Hybrid Mechanical Aeration + Diffused Air – utilizes a mechanical mixer to agitate the water dispersing diffused air in the aeration basin.

Activated Sludge

Activated Sludge - Aeration

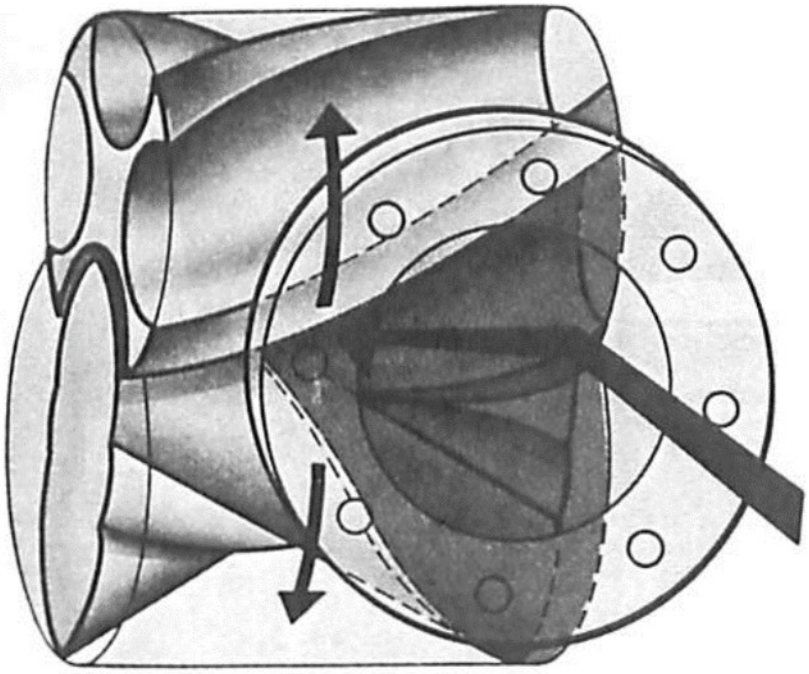
- Positive Displacement Blowers



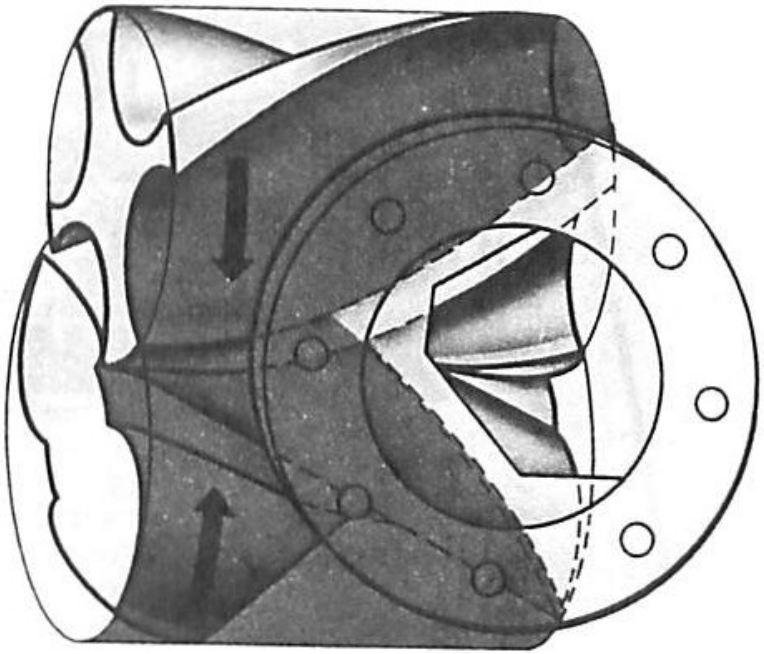
1. Air enters the compressor at the left and leaves at the right.

Activated Sludge

Activated Sludge - Aeration



2. As the rotors turn away from each other on the inlet side, air is drawn into pockets formed between the rotors and the casing wall.

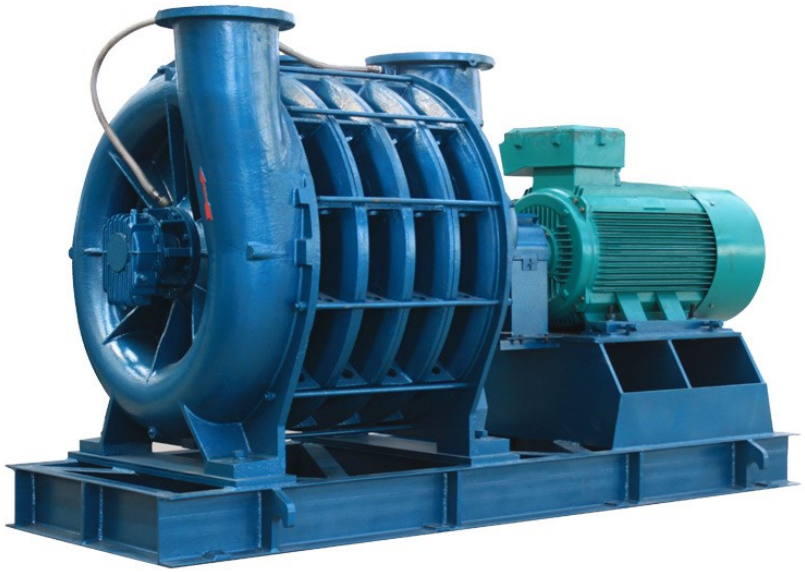


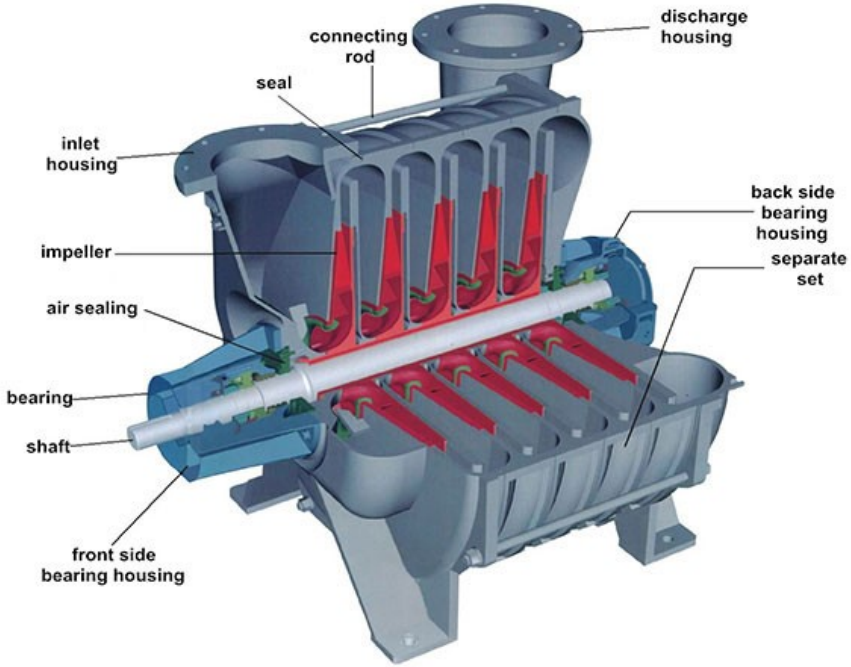
3. The pockets of air move along and around the rotor axes, then join and diminish in volume, thus compressing the air. The air flow is smooth and continuous, without pumping or surging.

Activated Sludge

Activated Sludge - Aeration

- Centrifugal Blowers

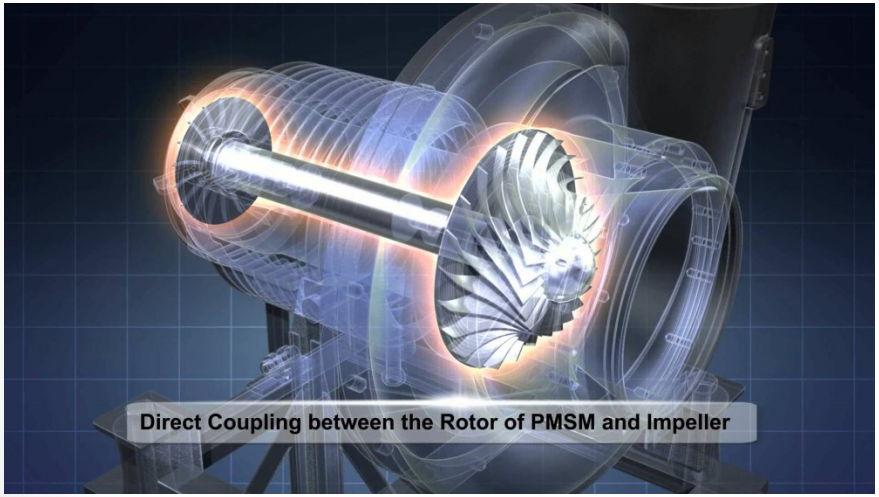


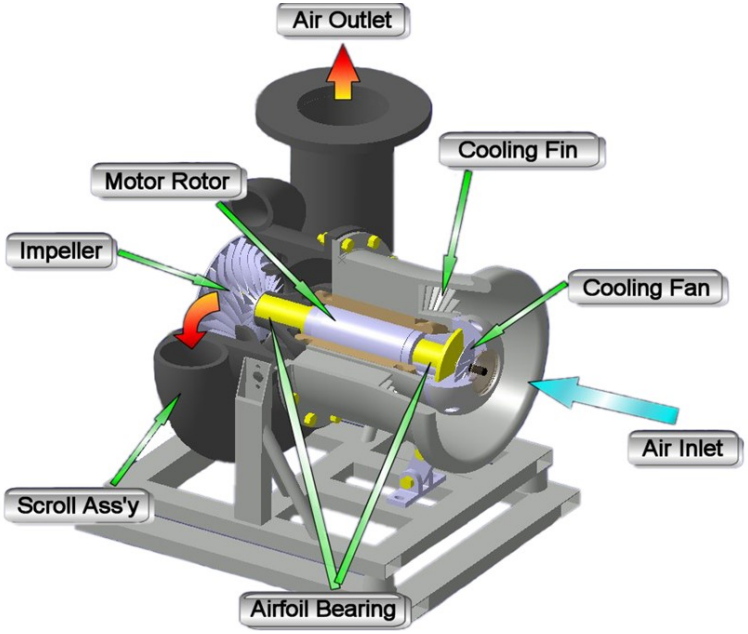


Activated Sludge

Activated Sludge - Aeration

- Turbine Blowers





Activated Sludge

Activated Sludge Operation

(3) Three areas of major concern for an Operator of an Activated Sludge process:

1. What enters the plant (Influent)
2. The environment for treating waste (Process)
3. What leaves the plant (Effluent)

Activated Sludge

TABLE 11.1 TYPICAL LAB RESULTS

Test	Location	Common Range	
COD	Influent	250–1,000	mg/L
	Primary Effluent	200–400	mg/L
	Final Effluent (Conv. Act. Sl.)	30–70	mg/L
BOD	Influent	150–400	mg/L
	Primary Effluent	100–280	mg/L
	Final Effluent (Conv. Act. Sl.)	10–20	mg/L
SUSPENDED SOLIDS	Influent	150–400	mg/L
	Primary Effluent	60–160	mg/L
	Mixed Liquor	1,000–4,500	mg/L
	Return Sludge	2,000–10,000	mg/L
	Final Effluent (Conv. Act. Sl.)	1–20	mg/L
DISSOLVED OXYGEN	Mixed Liquor	0.5–4	mg/L
	Final Effl. (Outfall)	2–6	mg/L
CHLORINE RESIDUAL (30 min.)	Final Effluent	<0.1–2.0[a]	mg/L[b]
COLIFORM GROUP BACTERIA, MPN	Final Effluent (Chlorinated)	2–700/100 mL	
CLARITY (Secchi Disc)	Final Effluent	3–8 ft	
TURBIDITY (Turbidimeter)	Final Effluent	1–3 NTU	
pH	Influent	6.8–8.0	
	Effluent	6.9–8.5	

Activated Sludge

Process Control Management Plan (PCMP)

Activated Sludge - Unit Process Report

Start Date: **02/01/21**
End Date: **02/28/21**
Forecast (Days) : 20

Rpt Date: **03/29/21**

#	Parameter	Units	Total	Average	Min	Max	Trend	Flag	LCL	LWL	Target	UWL	UCL	# Samples
4340	AERATION BASINS 16 AS Average MLSS SCADA	mg/L	31,241	1,116	981	1,333	8		950	1,000	1,100	1,300	1,400	28
4342	AERATION BASINS 16 AS Average MLVSS Manual	mg/L	4,982	996	855	1,088	38		700	800	1,000	1,050	1,100	5
4380	AERATION BASINS 16 AS Inventory MLSS SCADA	lbs	639,235	22,830	18,884	29,383	163		18,000	20,000	24,000	26,000	30,000	28
4381	AERATION BASINS 16 AS Inventory MLVSS SCADA	lbs	434,148	15,505	8,538	19,572	72		13,000	15,000	17,000	20,000	22,000	28
4343	AERATION BASINS 16 AS Average DO SCADA	mg/L	68	2.4	1.6	3.4	-0	UCL	0.9	1.1	1.5	1.8	2.0	28
4345	AERATION BASINS 16 AS Average OUR	mg/L/Hour	538	19	12	37	0		12	15	20	25	35	28
4347	AERATION BASINS 16 AS Average SSV30	ml/L	500	125	100	200	30		100	125	150	200	250	4
4348	AERATION BASINS 16 AS Average SVI	Ratio	440	110	90	167	23		75	80	120	150	170	4
4350	AERATION BASINS 16 AS Average F:M	Ratio	30	1.1	0.6	1.8	-0	UCL	0.2	0.5	0.7	0.8	1.0	28
4385	AERATION BASINS 16 AS MCRT	Days	37	1.3	0.5	3.9	-0	LCL	1.7	1.8	2.0	2.2	2.3	28
4351	AERATION BASINS 16 AS Average Load	lbs/KFT3	1,765	63.0	36.6	88.4	-1.8	UCL	15.0	20.0	25.0	35.0	40.0	28
4360	AERATION BASINS 16 AS WAS Q	MGD	15	0.553	0.475	0.648	0		0.400	0.500	0.700	0.800	0.900	28
4389	AERATION BASINS 16 AS MCRT - Using Lab WAS TSS	Days	30	1.1	0.6	1.5	0	LCL	1.50	1.60	1.75	2.00	2.20	28
4660	SECONDARY CLARIFICATION 17 SCs Average Blanket	Feet	31	1.1	0.6	2.0	-0		0.5	1.0	2.0	2.5	3.0	28
4358	AERATION BASINS 16 AS RAS Q	MGD	273	9.8	8.8	11.8	0		5.0	7.0	10.0	11.0	12.0	28
4359	AERATION BASINS 16 AS RAS Q %	%	2,080	74	66	81	1		30	50	85	90	92	28
4895	SECONDARY EFFLUENT 17Turbidity Daily Average SCADA	ntu	174	6.2	4.1	7.7	-0		2.0	3.0	5.0	7.0	8.0	28
4900	SECONDARY EFFLUENT 17 TSS SCADA	mg/L	352	12.6	10.0	15.0	-0		5.0	7.0	10.0	14.0	20.0	28
4810	SECONDARY EFFLUENT 17 BOD	mg/L	34	11.3	11.0	12.0	1		8.0	11.0	15.0	18.0	20.0	3

Activated Sludge

ABNORMAL OPERATIONS

- **Rising Sludge/Bulking**
  - Denitrification (Low DO)
  - Septic sludge in clarifier (Low RAS rate)

Activated Sludge

ABNORMAL OPERATIONS

- **Toxic Loads**
  - Toxic material dumped into the collection system that enters the treatment plant
  - Toxic to Activated Sludge
  - Acid, Caustic, Solvents, Poisons

Activated Sludge

ABNORMAL OPERATIONS

- **Foaming/Frothing**
  - Nocardia
  - Surfactant dump
  - High MCRT

Activated Sludge

FOOD / MICROORGANISM RATIO (F/M Ratio)

- Example:

$$\text{F/M Ratio} = \frac{\text{BOD, lbs}}{\text{MLVSS, lbs}}$$

- Known:
  - Flow = 10.0 MGD F/M Ratio
  - BOD = 120 mg/L
  - Aeration Basin Volume = 1.0 MG
  - MLVSS = 1,500 mg/L
  - Pounds Formula = (Flow, MGD)(Conc., mg/L)(8.34)

Activated Sludge

FOOD / MICROORGANISM RATIO (F/M Ratio)

BOD, Lbs = (10.0 MGD)(120 mg/L)(8.34)

= 10,008 lbs

MLVSS Lbs = (1.0 MG)(1,500 mg/L)(8.34)

= 12,510 lbs

$$F/M = \frac{10{,}008 \text{ lbs}}{12{,}510 \text{ lbs}}$$

F/M = **0.8**

Activated Sludge

Process Control Management Plan (PCMP)

Activated Sludge - Unit Process Report

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4810	SECONDARY EFFLUENT 17 BOD	mg/L	34	11.3	11.0	12.0	1		8.0	11.0	15.0	18.0	20.0	3

WISHING YOU THE BEST OF LUCK