Module 16: The Activated Sludge Process – Part 2

Wastewater Treatment Plant Operator Certification Training

Unit 1–Process Control Strategies

Learning Objectives

- List the key monitoring points within the activated sludge process and explain what to look for at those points.
- List five key process control parameters and for each parameter, explain what it is, why it is used and how it is calculated.
- List the daily process control tasks that need to be accomplished and explain how to perform them.

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Key Monitoring Points

- Plant influent
  - check for an increase in flow
    - In general, activated sludge treatment plants are designed to handle peak flow rates.
    - If a plant's hydraulic capacity is exceeded, it may result in reduced detention time in the aeration tank and the loss of sludge from the secondary clarifiers.
    - Excessive influent flow may be due to stormwater infiltration or unusual industrial discharges.

Key Monitoring Points

- Plant influent
  - check for an increase in influent solids
    - The mixed liquor volatile suspended solids (MLVSS) is the organic or volatile suspended solids in the mixed liquor of an aeration tank. This volatile portion is used as a measure of the bugs present.
    - If the solids loading exceeds the plant's design capacity, the MLVSS may need to be adjusted.
    - Biochemical Oxygen Demand (BOD) is the rate at which organisms use the oxygen while stabilizing decomposable organic matter.

Key Monitoring Points

- Plant influent
  - check for an increase in influent solids
    - If the influent solids increase results in increased BOD loading, then you may need to increase the MLVSS in the aeration tank by reducing the sludge wasting rate.
    - A shock load may result in a decrease in the MLVSS-to-MLSS ratio. The typical optimum MLVSS-to-MLSS ratio in activated sludge plants is between 0.7 and 0.8.

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Key Monitoring Points

- Plant influent
  - monitor treatment plant capacity
    - Flow, BOD, TSS, ammonia, total Kjeldahl nitrogen (TKN) are the parameters typically used to characterize influent loadings.
    - Process upsets and permit violations may result when the plant is overloaded. Monitor the influent loadings to avert overloaded conditions.

Key Monitoring Points

- Primary clarifier
  - BOD/COD
    - Well designed and operated primary clarifiers should remove 20 to 40 percent of BOD.
  - TSS
    - Well designed and operated primary clarifiers should remove 50 to 70 percent of TSS.
  - Nutrients
    - General rule of thumb for the ratio of BOD-to-nitrogen-to phosphorus in the primary effluent is 100:5:1.

Key Monitoring Points

- Primary clarifier
  - If the influent particle sizes are small and colloidal (non-settleable suspended solids), addition of flocculants may be needed to improve BOD and TSS removal efficiencies.
  - Malfunctioning or improperly operated sludge removal equipment may be responsible for poor clarifier performance.

Key Monitoring Points

- Aeration tank
  - Monitoring of the following process control parameters is required to optimize the treatment process:
    - MLSS/MLVSS
    - residual DO
    - pH and total alkalinity
    - Specific oxygen uptake rate (SOUR)

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Key Monitoring Points

- Aeration tank process control parameters
  - MLSS/MLVSS
    - MLSS concentration is a measure of the total concentration of solids in the aeration tank.
    - Typical MLSS concentrations for conventional plants range from 2,000 to 4,000 mg/L.
    - MLVSS is an indirect measure of the concentration of microorganisms in the aeration tank and should be between 70 and 80 percent of the MLSS.

Key Monitoring Points

- Aeration tank process control parameters
  - Residual Dissolved Oxygen (DO)
    - Microorganisms in the aeration tank require oxygen to oxidize organic waste.
    - A DO concentration between 2 to 4 mg/L is usually adequate to achieve a good quality effluent.

Key Monitoring Points

- Aeration tank process control parameters
  - pH and Total Alkalinity
    - In general, the optimum pH level for bacterial growth ranges between 6.5 and 7.5.
    - Low pH values may inhibit the growth of nitrifying organisms and encourage the growth of filamentous organisms.
    - The optimum pH range for nitrification is 7.8 to 8.2

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Key Monitoring Points

- Aeration tank process control parameters
  - Specific Oxygen Uptake Rate (SOUR)
    - SOUR is a measure of the quantity of oxygen consumed by the bugs and is a relative measure of the rate of biological activity.
    - As microorganisms become more active, the SOUR increases and vice versa.
    - SOUR is measured in mg O_2/g MLVSS-hr.

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Key Monitoring Points

- Aeration tank process control parameters
  - Specific Oxygen Uptake Rate (SOUR) continued
    - The SOUR and final effluent COD can be correlated. Therefore, changes in the SOUR can be used to predict final effluent quality.
    - If SOUR increases it is indicative of an increase in the MLSS respiration rate and may require additional oxygen to stabilize.

Key Monitoring Points

- Aeration tank
  - Color
    - If there is white, crisp foam present on the surface of the aeration tank, decrease the sludge wasting rate as needed.
    - A thick, dark brown or gray, greasy foam indicates the presence of a slow-growing filamentous organism, usually of the *Nocardia* genus.

Key Monitoring Points

- Aeration tank
  - Microscopic examination of the biomass (mixed liquor)
    - Recording observations, such as size and nature of floc particles and the type and number of organisms, will enable you to make qualitative assessments.

Key Monitoring Points

- Secondary clarifier
  - sludge blanket
    - Monitor the thickness of the sludge blanket to avoid wash-out of solids from the clarifier.
    - The sludge blanket level must be determined by experience and must provide adequate settling depth and sludge storage.
    - Typically, secondary clarifiers allow for 2-3 ft of depth for thickening, 3 ft for a buffer zone between the thickened sludge and the clarification zone, and 8 ft for clarification.

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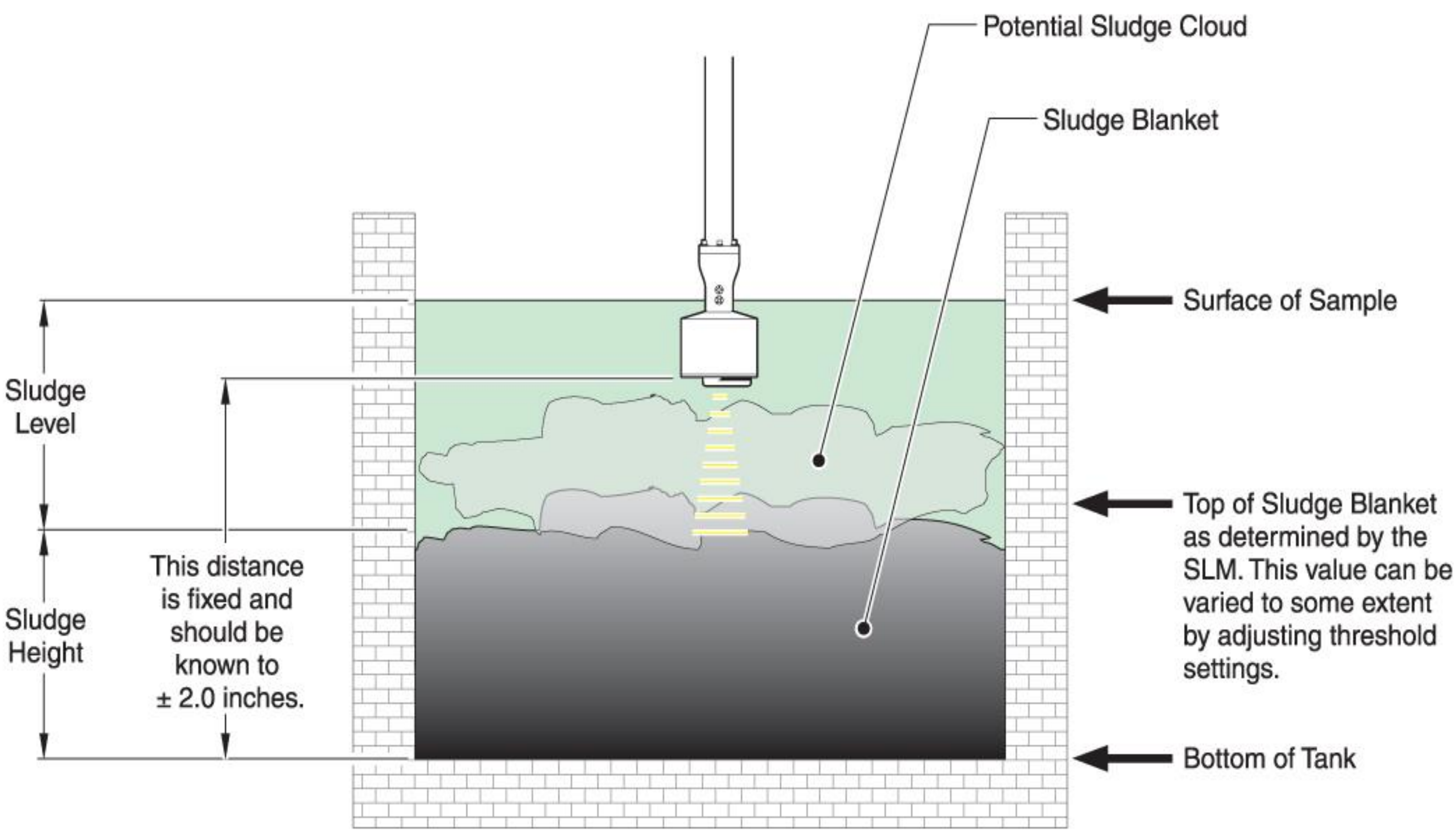
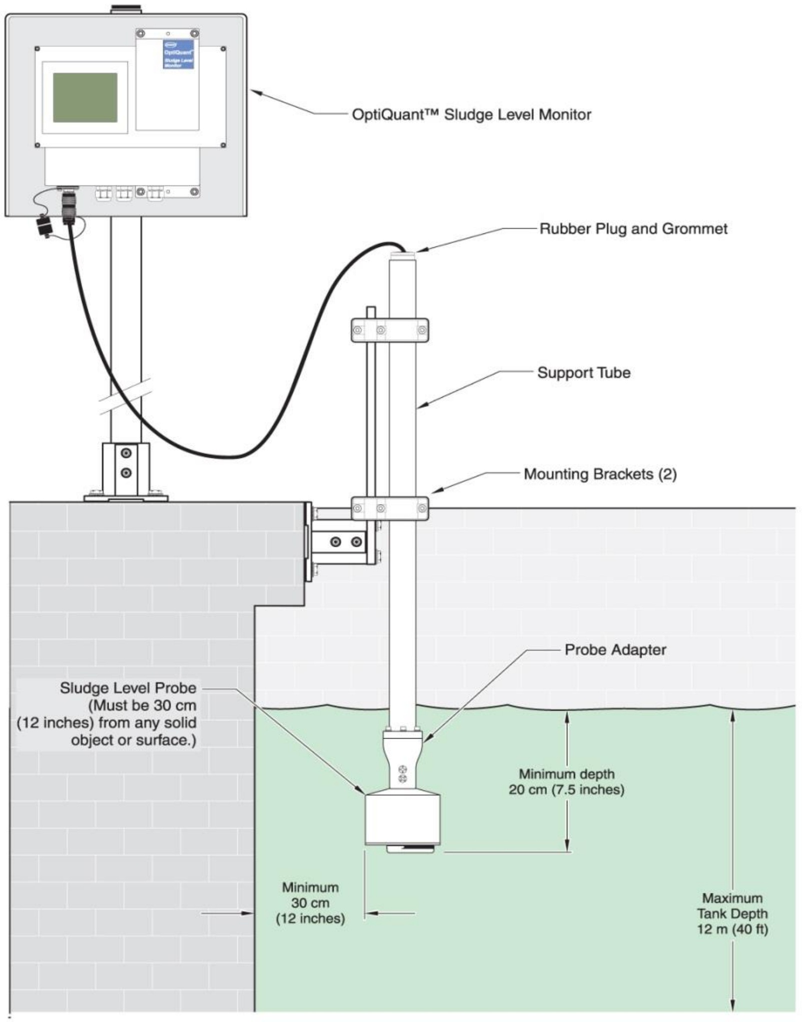
Manual Sludge Judge

Ex. 1 Ultrasonic Automated Sludge Blanket Monitor



Ex. 2 Ultrasonic Automated Sludge Blanket Monitor



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Key Monitoring Points

- Secondary clarifier
  - sludge return rate
    - Important in controlling and maintaining an adequate MLSS concentration in the aeration tank.
    - Pumping rates are typically 50 to 100 percent of the wastewater flow rate for large plants and up to 150 percent for small plants.
    - Inadequate RAS pumping rates can result in a rising sludge blanket.
    - The return-sludge flow rate should be adjusted to maintain the sludge blanket as low as possible.

Key Monitoring Points

- Secondary clarifier
  - floating solids on clarifier surface
    - Floating solids on the clarifier surface are an indication of a problem called "rising sludge."
    - Rising sludge occurs when the DO concentration in the secondary clarifier drops resulting in an anoxic, or oxygen deficient, condition.
    - Under anoxic conditions, nitrifying bacteria convert nitrate to nitrogen gas. The nitrogen gas bubbles adhere to floc particles, causing them to rise to the surface.

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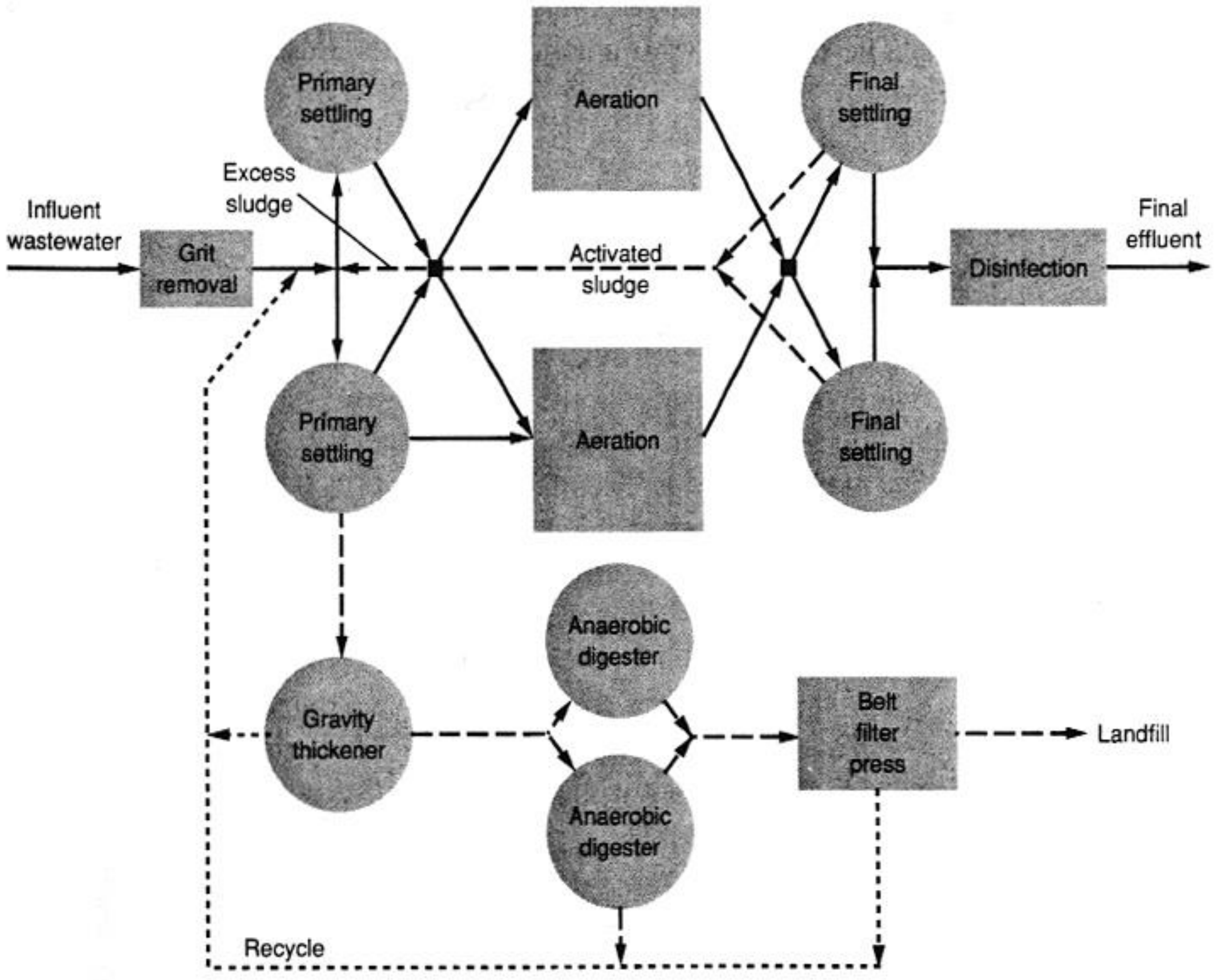
Key Monitoring Points

- Internal plant recycles
  - Supernatant from anaerobic digesters or sludge holding tanks and the clarified water from sludge dewatering process or thickening processes are typically recycled back to the primary clarifiers.
  - It is important to monitor the solids levels in these recycled streams to avoid the buildup of excessive levels of inert solids in the secondary treatment system.

Typical Internal Plant Recycles



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Key Monitoring Points

- Plant effluent
  - check turbidity
    - Turbidimeters measure the amount of light scattered by the suspended particles and give a qualitative measure of the TSS concentration.
    - Turbidimeters may be real-time or bench-top units for testing grab samples.
    - Turbidity is measured in nephalometric transfer units (NTU).

Key Monitoring Points

- Plant effluent
  - NPDES permit requirements may vary from one plant to another. See the typical permit requirements on the following slide.
  - EPA has established the following minimum national standards for secondary treatment plants.

Parameter	Units	30-day Average Concentration	7-day Average Concentration
BOD_5	mg/L	30	45
Suspended Solids (TSS)	mg/L	30	45
pH	pH units	must be between 6.0 and 9.0	
$CBOD_5$	mg/L	25	40

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Key Monitoring Points

Typical Permit Parameters

Parameter	Typical Discharge Limitation
flow rate	varies
BODs	30 mg/L monthly avg., 45 mg/L weekly avg.
TSS	30 mg/L monthly avg., 45 mg/L weekly avg.
pH	6.0 to 9.0
total residual chlorine	0.038 mg/L daily max., 0.08 mg/L weekly avg.
fecal coliform	400#/100 mL daily max.
total recoverable metals	varies
hardness (as $CaCO_3$)	no limit, just monitor
total phosphorus	1 mg/L monthly avg
ammonia nitrogen	no limit, just monitor
acute whole effluent toxicity (WET)	Toxic Unit – Acute (TU_a) must be <1
chronic WET (must be negative) Relative	Toxic Unit – Chronic (rTU_c) must be <1

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Checkpoint

- What are the six key monitoring points within the activated sludge process?
  - plant influent
  - primary clarifier effluent
  - aeration tank
  - secondary clarifier
  - internal plant recycles
  - plant effluent

Checkpoint

- What are the key characteristics you should look for at each of the monitoring points?
  - plant influent – check for flow increase and influent solids increase
  - primary clarifier effluent – check BOD/COD, TSS and nutrients
  - aeration tank – check MLSS/MLVSS, residual DO, pH and total alkalinity, SOUR, color and the biomass
  - secondary clarifier – check sludge blanket level, sludge return rate and floating solids on clarifier surface
  - internal plant recycles – check digester or sludge holding tank supernatant and sludge dewatering or thickening process recycle

5 Key Process Control Parameters

- Mean Cell Resident Time (MCRT)
- Food-to-Microorganism (F/M) ratio
- Sludge Volume Index (SVI)
- Specific Oxygen Uptake Rate (SOUR)
- Sludge (Solids)Wasting

5 Key Process Control Parameters

- Mean Cell Resident Time (MCRT)
  - Is an average measure of how long the bugs remain in contact with the substrate (food source) and is also known as solids retention time (SRT).
  - Used to control the mass of MLVSS in the aeration tank.
  - The desired MCRT is achieved by adjusting the sludge wasting and return rates.
  - MCRTs ranging from 3 to 15 days are typical for conventional activated sludge plants.
  - MCRTs less than 3 days will produce a sludge that is young and slow settling and produce a turbid effluent.

5 Key Process Control Parameters

- Mean Cell Resident Time (MCRT)
  - $$\text{MCRT, days} = \frac{\text{SS in aeration system, lbs}}{\text{SS lost from the aeration system, lbs/day}}$$

OR

  - $$\text{MCRT, days} = \frac{\text{SS in aeration tank, lbs}}{\text{SS in the effluent, lbs/day} + \text{solids wasted, lbs/day}}$$

5 Key Process Control Parameters

- Calculate the MCRT assuming the following:
  - Aeration Tank Volume is 1,000,000 gal
  - Wastewater flow to aeration tank is 4.0 mgd
  - Sludge wasting rate = 0.075 mgd
  - MLVSS = 2,000 mg/l
  - Waste sludge VSS = 6,200 mg/l
  - Final effluent VSS = 10 mg/l

5 Key Process Control Parameters

- SS in the aeration tank, lbs = 2,000 mg/l x 1.0 mil. gal. x 8.34 = 16680 lbs
- SS lost from the aeration system, lbs/day = effluent SS lbs/day + WAS SS lbs/day
  - Effluent SS lbs/day = 10 mg/l x 4.0 mgd x 8.34 = 333.6 lbs/day
  - WAS SS lbs/day = 6,200 mg/l x 0.075 mgd x 8.34 = 3878.1 lbs/day

Substituting into the MCRT equation:

$$\text{MCRT, days} = \frac{16680 \text{ lbs}}{(333.6 + 3878.1) \text{ lbs/day}} = 3.96 \text{ days}$$

Checkpoint

- Calculate the MCRT assuming the following:
  - Aeration Tank Volume is 250,000 gal
  - # of aeration tanks = 4
  - Wastewater flow to each aeration tank = 1.25 mgd
  - Sludge wasting rate = 0.1 mgd
  - MLVSS = 2,000 mg/l
  - Waste sludge VSS = 8,000 mg/l
  - Final effluent VSS is negligible

Checkpoint

- Step 1: Calculate the total aeration tank volume
  - Total volume = 250,000gal x 4 = 1 mgal
- Step 2: Calculate total wastewater flow
  - Total flow = 1.25mgd x 4 = 5 mgd
- Step 3: Calculate MCRT

$$\frac{1 \text{ mgal} \times 2000 \text{ mg/l} \times 8.34}{(0.1 \text{ mgd} \times 8000 \text{ mg/l} \times 8.34) + (5 \text{ mgd} \times 0 \text{ mg/l} \times 8.34)} = 2.5\text{days}$$

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5 Key Process Control Parameters

- Food-to-Microorganism (F/M) ratio
  - is a measure of the mass of food available in the primary effluent per unit mass of MLVSS per unit time and has units of lb BOD or COD/lb MLVSS-day.
  - Food-to-Microorganism (F/M) ratio is calculated as follows:

$$F/M = \frac{\text{Influent BOD (or COD) lbs/day}}{\text{MLVSS in aeration, lbs/day}}$$

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5 Key Process Control Parameters

- Food-to-Microorganism (F/M) ratio
  - The MLVSS represents the concentration of organisms in the aeration tank.
  - COD is often used instead of BOD because test results are available four hours after sample collection instead of five days for BOD test results.
  - The F/M ratio can be used to control the concentration of MLVSS in the aeration tank.
  - To maintain a MLVSS concentration, the sludge wasting rate will need to be adjusted.

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5 Key Process Control Parameters

- Calculate the F/M given the following:
  - Influent flow rate = 10 mgd
  - Primary effluent COD = 200 mg/l
  - MLVSS = 1550 mg/l
  - # of aeration tanks in parallel = 4
  - Aeration tank dimensions:
  - Depth of water = 20 ft
  - Length = 120 ft
  - Width = 24 ft

5 Key Process Control Parameters

- Influent COD lbs/day = (200 mg/l) x (10 mgd) x 8.34
  = 16680 lbs/day COD

- Volume of aeration tanks = 4 x (20' x 120' x 24') x 7.48 gal/ft^3
  = 1,723,392 gal or 1.72 mgal

- MLVSS, lbs = (1.72 mgal) x (1550mg/l MLVSS) x 8.34
  = 22240 lbs MLVSS

- F/M = $\frac{\text{16680 lbs/day COD}}{\text{22240 lbs MLVSS-day}}$ = 0.75

Checkpoint

- Calculate the F/M given the following:
  - Aeration Tank Volume is 500,000 gal
  - Influent BOD_5 = 200 mg/l
  - Influent flow = 1.0 mgd
  - MLVSS = 2,000 mg/l

Checkpoint

- Step 1: Calculate the influent BOD_5
  - Influent BOD_5 = (200 mg/l) x (1.0 mgd) x 8.34 = 1668 lbs/day
- Step 2: Calculate the lbs of MLVSS in aeration
  - MLVSS in aeration = (0.5 mgd) x (2000 mg/l) x 8.34 = 8340 lbs MLVSS-day
- Step 3: Calculate F/M ratio

$$F/M = \frac{1668 \text{ lbs/day } BOD_5}{8340 \text{ lbs MLVSS-day}} = 0.2$$

5 Key Process Control Parameters

- Sludge Volume Index (SVI)
  - Is the volume in mL occupied by one gram of MLSS after 30 minutes of settling in a 1,000 mL graduated cylinder and has units of mL/g.
  - The SVI is a measure of the settleability of the activated sludge in a secondary or final clarifier.
  - Lower values of the SVI indicate better sludge *s*ettleability.
  - The preferable range for the SVI is 50 to 150 mL/g.

5 Key Process Control Parameters

- Sludge Volume Index (SVI)
  - SVI, mL/g =

$$\frac{\%\ \text{settleable solids} \times 10{,}000}{\text{MLSS (mg/L)}}$$

OR

  - SVI, mL/g =

$$\frac{\text{settled sludge volume/sample volume (mL/L)}}{\text{MLSS (mg/L)}} \times \frac{1{,}000\ \text{mg}}{1\text{gm}}$$

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Checkpoint

- Calculate the SVI for an activated sludge sample given the following:
  - 30-minute settleable solids volume = 150 mL
  - MLSS = 3,000 mg/L

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Checkpoint

- $$\text{SVI, mL/g} = \frac{\text{\% settleable solids x 10,000}}{\text{MLSS (mg/L)}}$$

  - Step 1: Calculate the % settleable solids

    % settleable solids = (150/1000) x 100 = 15 mL/g

  - Step 2: Calculate the SVI

    $$\text{SVI} = \frac{15 \text{ x } 10{,}000}{3{,}000} = 50 \text{ mL/g}$$

Checkpoint

- SVI, mL/g =

$$\frac{\text{settled sludge volume/sample volume (mL/L)}}{\text{MLSS (mg/L)}} \times \frac{1{,}000\text{mg}}{1\text{gm}}$$

$$\text{SVI} = \frac{150 \text{ mL/1L}}{3{,}000 \text{ mg/L}} \times \frac{1{,}000 \text{ mg}}{1 \text{ gm}} = 50 \text{ mL/g}$$

Checkpoint

- Calculate the SVI for an activated sludge sample given the following:
  - 30-minute settleable solids volume = 200 mL
  - MLSS = 2,000 mg/L

Checkpoint

- SVI, mL/g = $\frac{\text{\% settleable solids x 10,000}}{\text{MLSS (mg/L)}}$

  - Step 1: Calculate the % settleable solids

    % settleable solids = (200/1000) x 100 = 20 mL/g

  - Step 2: Calculate the SVI

    $$\text{SVI} = \frac{20 \times 10{,}000}{2{,}000} = 100 \text{ mL/g}$$

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5 Key Process Control Parameters

- Specific Oxygen Uptake Rate (SOUR)
  - SOUR is a measure of the quantity of oxygen consumed by microorganisms and is a relative measure of the rate of biological activity.
  - As microorganisms become more active, the SOUR increases and vice versa.
  - Changes in the SOUR can be used to predict final effluent quality.

5 Key Process Control Parameters

- Specific Oxygen Uptake Rate (SOUR)
  - SOUR is determined by taking a sample of mixed liquor, saturating it with oxygen, and measuring the decrease in oxygen with a DO probe with time.
  - The results of that test, Oxygen Uptake Rate (OUR), measured in mg O_2/L-min, is divided by the MLVSS to yield the SOUR, measured in mg O_2/g MLVSS-hr.
  - Refer to Method 2710 B. “Oxygen-Consumption Rate” in Standard Methods for the Examination of Water and Wastewater for details on SOUR determination.

5 Key Process Control Parameters

- Sludge (Solids)Wasting
  - Solids in waste activated sludge (WAS) come from two sources.
    - The primary source of WAS is from the growth of new bacterial cells in the aeration tank.
    - The second source is from organic and inorganic solids in the raw wastewater that pass through the primary clarifiers.
  - Sludge is wasted to maintain the desired mass of microorganisms in the aeration tank. It's typically wasted when the actual MCRT is higher than the target value.

5 Key Process Control Parameters

- Sludge (Solids)Wasting
  - Typical secondary clarifiers thicken the activated sludge to three to four times the concentration in the aeration tank.
  - WAS (and return activated sludge, RAS) MLSS concentrations may range from 2,000 to 10,000 mg/l (0.2 to 1.0 percent).
  - Waste sludge on a continuous basis, changing the WAS rate as needed by no more than 10 to 15 percent from one day to the next.

5 Key Process Control Parameters

Typical Unit Sludge Production Values for Suspended Growth POTWs

Process Type	lb TSS (sludge)/lb BOD_5 removed
Primary Clarification	1.7
Activated Sludge w/primary clarification	0.7
Activated Sludge w/o primary clarification	
Conventional[a]	0.85
Extended Aeration[b]	0.65
Contact Stabilization	1.0

[a]Includes tapered aeration, step feed, plug flow and complete mix with wastewater detention times <10 hours

[b]Includes oxidation ditches

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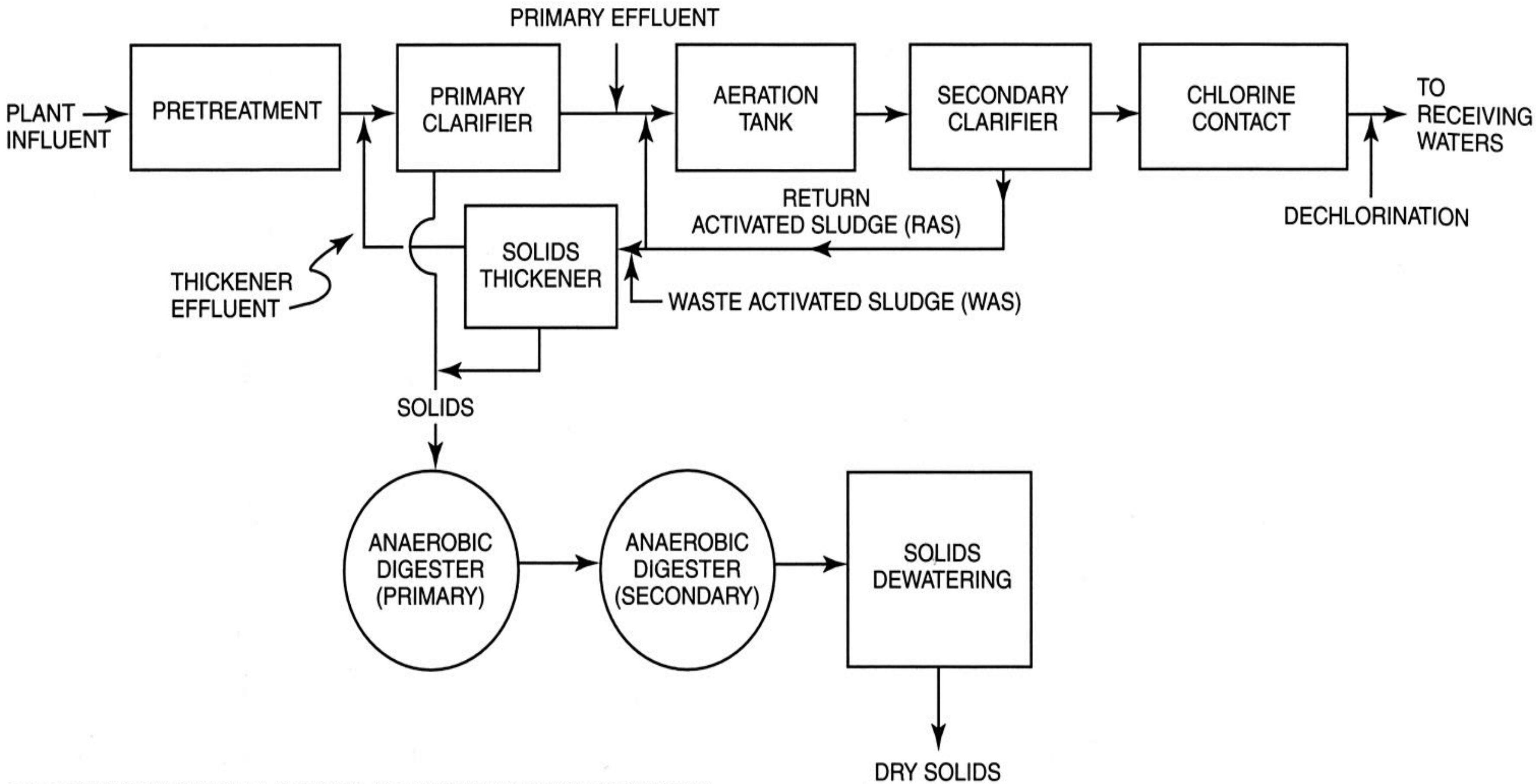
5 Key Process Control Parameters

- Sludge (Solids)Wasting
  - Two means of wasting sludge are through the primary clarifier or through a solids thickener.
  - WAS is typically wasted from the return activated sludge (RAS) line to either the primary clarifier or a solids thickener to reduce the water content prior to anaerobic digestion, as shown in the next slide.

Solids Wasting



SOLIDS WASTING WITH A GRAVITY, BELT, OR FLOTATION THICKENER

Solids Wasting

- Calculating Sludge Wasting Rates (WAS)
  - WAS rates may be calculated based on several different parameters such as:
    - F/M ratio
    - Target MCRT

Checkpoint

- Calculate the WAS in mgd given the following:
  - MCRT = 3.96 days
  - Aeration Tank Volume is 1,000,000 gal
  - Wastewater flow to aeration tank is 4.0 mgd
  - MLVSS = 2,000 mg/l
  - Waste sludge VSS = 6,200 mg/l
  - Final effluent VSS = 10 mg/l

Checkpoint

- Calculate the WAS in mgd given the following:
  - Volume of aeration tank = 1.7 Mgal
  - MLVSS = 1,600 mg/L
  - plant effluent flow = 10 mgd
  - VSS in effluent = 10 mg/L
  - MCRT = 5 days
  - VSS in WAS = 8,000 mg/L

Daily Process Control Tasks

- Record Keeping
  - Raw data such as meter readings and visual observations are typically recorded in some type of log book while lab data are typically kept in a separate file.
  - The raw data recorded in the log book and the lab files can be used to create summary data sheets.
  - Maintaining consistent records will help you develop an understanding of the activated sludge process and determine the optimal ranges for process parameters, as well as, enable you to identify potential plant upset conditions before they impact the plant's effluent quality.

Example 1 of Monthly Data Sheet

MONTHLY LAB DATA FOR EXAMPLE ACTIVATED SLUDGE PLANT

Date	Day	Flow, MGD	BOD		COD	Suspended Solids		Suspended Solids		Volatile Solids		Total Vol, lbs [b]	F/M Ratio	Waste, lbs [c] / day	Air, MCF [d] / day	SVI
			Infl, mg/L	Effl, mg/L	Infl, mg/L	Infl, mg/L	Effl, mg/L	Reaer, mg/L	Aer, [a] mg/L	Reaer, %	Aer, [a] %					
1	W	19.9	440	8	992	446	8	8060	2150	83	82	95786	.43	44298	80.2	270 [e]
2	T	22.3	430	11	957	540	18	8860	2160	80	80	98453	.66	50544	80.2	384
3	F	29.2	580	9	1420	682	11	9830	2510	81	80 [f]	109930	.38	59929	64.8	295
4	S	24.0	270	12	838	542	27	7930	2170	77	74	87353	.60	53041 [g]	51.2	248
5	S	18.8	280	10	770	586	16	8880	2380	73	72	98932	.17	39474	39.0	109
6	M	20.0	360	12	894	456	12	9470	2140	72	72	91818	.38	59156	56.6	98
7	T	20.0	380	8	992	502	26	6090	3050	71	72	85877	.56	36112	61.8	125
8	W	21.7	350	6	881	476	11	8690	2180	74	77	91710	.75	50152	72.5	92
9	T	20.0	340	8	770	380	14	8370	1750	75	79	83716	.44	42931	66.3	–
10	F	25.0	360	9	846	430	16	6070	2040	76	78	74570	.56	24350	68.2	98
11	S	19.9	400	6	710	476	16	8580	2390	76	79	97214	.38	33130	43.7	106
12	S	17.1	210	6	650	380	6	7820	1790	77	75	80672	.25	21131	32.0	156
13	M	21.3	380	9	930	424	6	8220	1990	76	78	87313	.45	23720	65.8	106
14	T	21.2	400	9	920	430	8	8960	2160	78	82	94866	.47	38335	72.4	113
15	W	20.9	440	16	1000	472	21	8720	2680	80	67 [h]	98913	.49	44798	77.5	101
16	T	19.1	380	8	927	450	12	8410	2080	81	84	96448	.43	46362	75.3	135
17	F	16.3	350	6	907	428	11	7070	1950	82	87	86835	.38	34965	66.0	133
18	S	16.5	320	5	720	418	14	6120	1830	84	89	79820	.31	23785	42.0	131
19	S	15.4	200	6	620	360	11	5460	1800	84	85	72937	.25	15665	36.4	138
20	M	16.3	400	9	1040	470	8	5430	1590	82	84	67433	.54	13812	51.5	151
21	T	15.4	460	14	1080	416	8	6300	1940	84	86	81982	.50	20176	71.4	155
22	W	15.8	420	6	986	432	9	6620	2120	85	86	88288	.37	28213	69.4	189 [e]
23	T	15.1	400	6	888	418	12	6410	1990	85	85	83811	.33	29510	62.2	347
24	F	14.8	360	8	848	414	13	5940	1900	86	90	81395	.21	22689	57.5	289
25	S	16.2	220	8	797	400	14	5490	1800	85	84	73218	.30	15567	42.0	183
26	S	14.2	260	8	700	396	14	5850	1710	84	85	74451	.22	14442	38.4	292
27	M	20.3	420	16	1010	489	14	6330	1510	83	93	75674	.54	18530	58.9	152
28	T	20.4	440	7	961	428	12	6960	1770	85	88	84673	.52	25889	82.1 [i]	158
29	W	20.3	480	7	1120	438	8	7180	1810	86	85	86398	.63	30360	94.2	138
30	T	20.8	500	8	1200	616	7	7870	1880	86	88	93977	.54	40300	97.1	144
31	F	21.9	410	7	952	320	10	7710	1870	87	91	74545	.60	38709	92.0	128
Avg		19.4	375	9	914	455	13	7410	2035	81	82	86536	.44	33551	63.5	172

[a] Middle of three aeration tanks.
[b] Multiply lbs x 0.454 to obtain kg.
[c] Multiply lbs/day x 0.454 to obtain kg/day.
[d] Multiply MCF/day x 0.0283 to obtain Million cu m/day.
[e] Filamentous growths. Increase chlorine dose to return sludge.
[f] Drop in percent volatile matter due to storm.
[g] Carefully decrease solids wasting rate due to storm.
[h] Lab error.
[i] Increased air requirements and increased solids wasting due to industrial dump of methanol.

Example 2 of Monthly Data Sheet

CLEANWATER, U.S.A.

WATER POLLUTION CONTROL PLANT

MONTHLY RECORD ________ 19__ OPERATOR: ____________

				RAW WASTEWATER					PRIM. EFF.			FINAL EFFLUENT					AERATION SYSTEM									
DATE	DAY	WEATHER	FLOW — MGD	TEMP.	pH	SETT. SOLIDS	B.O.D.	SUSP. SOLIDS	B.O.D.	SUSP. SOLIDS	D.O.	pH	B.O.D.	SUSP. SOLIDS	D.O.	CL_2 RES.	LBS. VOL. SOLIDS	SUSP. SOLIDS	% VOL.	30 MIN. SETT.	S.V.I.	D.O.	RETURN SUSP. SOLIDS	RETURN-MGD	WASTE GAL. X 1000	WASTE LBS./DAY
1	S	CLEAR	1.782	75	7.2	14			118	84	0.6	6.9	19	18	0.9	2.7	6746	2036	78.9	150	73	2.5	5961	0.702	70	3480
2	M	CLEAR	2.347	74	7.3	13	218	150	156	84	0.3	6.8	19	15	1.0	2.8	6859	2078	78.6	150	72	1.4	4683	0.711	72	2812
3	T	CLEAR	2.165	74	7.3	8			109	66	0.8	6.8	14	9	1.2	8.8	7224	2211	77.8	170	76	2.1	6625	0.708	71	3922
4	W	CLEAR	2.012	74	7.3	12			135	74	0.5	6.8	16	14	0.8	4.4	7305	2213	78.6	180	81	2.0	6641	0.712	70	3877
5	T	CLEAR	2.483	74	7.2	13	189	138	134	62	0.3	6.8	9	11	1.7	5.2	7014	2106	79.3	170	80	2.6	6098	0.722	78	3966
6	F	CLEAR	2.386	74	7.2	13			112	60	0.4	6.8	18	6	2.6	6.0	6754	2069	79.0	160	77	3.5	5862	0.700	80	3911
7	S	CLEAR	2.131	75	7.3	13			89	66	0.7	6.9	14	7	1.2	4.4	6296	1905	78.7	150	78	2.6	5564	0.706	80	3712
8	S	CLEAR	1.867	76	7.4	12	174	134	84	74	0.9	6.9	9	15	0.8	4.2	7057	2138	78.6	180	84	0.9	6758	0.703	72	4058
9	M	CLEAR	2.634	75	7.3	14			117	68	0.3	6.9	11	11	1.6	3.5	6767	2037	79.1	160	78	2.5	6022	0.712	70	3515
10	T	CLEAR	2.307	76	7.3	18			120	66	0.3	7.1	8	8	1.5	6.6	6119	1861	78.3	170	91	2.8	6135	0.705	64	3274
11	W	CLEAR	2.198	76	7.3	18	192	142	111	68	0.4	7.0	9	10	1.1	6.6	7035	2123	78.9	200	94	1.7	6183	0.700	70	3609
12	T	CLEAR	2.202	76	7.3	11			99	72	0.4	7.0	11	9	2.0	3.8	6352	1954	77.4	190	97	3.0	6027	0.704	70	3518
13	F	CLEAR	2.178	77	7.3	11			81	58	0.6	7.0	15	18	3.5	4.0	6313	1937	77.6	170	87	4.8	5542	0.689	72	3327
14	S	CLEAR	2.006	78	7.3	12	155	156	105	76	0.3	6.9	12	8	3.1	3.8	6335	1929	78.2	160	82	4.3	4856	0.703	70	2834
15	S	CLEAR	1.942	78	7.2	12			113	74	0.4	6.9	9	9	1.3	4.4	6873	2090	78.3	180	86	2.2	5753	0.711	73	3502
16	M	CLEAR	2.464	78	7.2	11			128	74	0.3	6.9	10	10	1.8	3.0	7082	2162	78.0	200	92	2.5	6852	0.723	76	4343
17	T	CLEAR	2.321	78	7.1	8	168	144	110	64	0.4	6.8	10	11	1.9	6.6	6215	1937	76.4	190	98	2.8	6654	0.698	74	4106
18	W	CLEAR	2.611	78	7.3	15			105	64	0.2	6.9	11	7	2.2	4.4	6227	1923	77.1	190	98	3.3	5767	0.717	83	3992
19	T	CLEAR	2.457	78	7.3	12			87	72	0.5	6.9	10	7	2.9	6.2	4844	1534	75.2	170	110	4.5	4762	0.721	25	992
20	F	CLEAR	2.498	79	7.3	11	193	118	105	66	0.7	6.9	18	12	3.1	4.4	5846	1822	76.4	190	104	4.1	5123	0.719	0	0
21	S	CLEAR	2.213	76	7.1	12			109	76	0.6	7.1	10	9	1.2	4.2	6892	2096	78.3	200	95	2.6	5928	0.706	35	1730
22	S	CLEAR	1.878	76	7.3	12			131	78	0.4	6.9	14	10	0.5	4.2	7518	2263	79.1	260	114	1.8	3894	0.703	35	1136
23	M	CLEAR	2.901	77	7.3	12	187	142	133	89	0.2	6.9	13	13	0.3	2.5	8388	2541	78.6	310	121	1.9	8396	0.741	70	4901
24	T	N.M. CLEAR	2.340	78	7.3	13			114	56	0.3	6.9	14	10	2.2	4.2	7962	2409	78.7	230	95	3.6	8824	0.700	71	5225
25	W	CLEAR	2.421	78	7.3	13			89	56	0.4	7.0	12	8	2.8	4.0	7688	2332	78.5	230	98	4.1	7382	0.713	72	4432
26	T	CLEAR	2.562	79	7.3	12	212	170	143	87	0.6	7.0	10	6	1.7	4.3	6697	2047	77.9	210	102	2.6	6867	0.698	70	4008
27	F	CLEAR	2.428	79	7.3	10			128	84	0.5	6.8	15	10	0.5	3.8	6923	2103	78.2	200	94	1.2	7436	0.702	64	3969
28	S	CLEAR	2.149	78	7.3	12			84	66	0.9	6.9	16	5	0.6	3.5	7169	2180	78.3	200	91	1.7	8412	0.706	68	4770
29	S	CLEAR	1.862	79	7.3	7	176	102	117	60	0.5	6.9	14	8	0.5	3.9	7852	2397	78.0	230	95	1.0	7117	0.700	66	3917
30	M	CLEAR	2.746	79	7.3	13			107	73	0.2	6.8	8	8	1.6	3.5	7688	2335	78.4	220	94	2.9	7735	0.713	70	4515
31																										
MAX			2.901	79	7.4	18	218	170	156	89	0.9	7.1	19	18	3.5	8.8	8388	2541	79.3	310	121	4.8	8824	0.741	83	5225
MIN			1.782	74	7.1	7	155	102	84	56	0.2	6.8	8	5	0.5	2.5	4844	1534	76.4	150	72	0.9	4683	0.698	0	0
AVG			2.283	77	7.3	12	186	139	112	70		6.9	12	10	1.6	4.4	6868	2092	78.1	192	91	2.6	6328	0.708	65	3511

SUMMARY DATA		
% REMOVAL	B.O.D.	S.S.
INF — PRI	39.7	49.6
INF — EFF	93.5	92.8
SLUDGE DATA		
% SOLIDS — AVG.		5.6
LBS. DRY SOLIDS / DAY		5579
% VOL. SOLIDS — AVG.		79.8
LBS. VOL. SOLIDS / DAY		4452
LBS. VOL. SOL./1000 FT^3/DAY		67.5
GALS. SLUDGE TO BEDS		28,000
CU. YDS. CAKE REMOVED		63
FT^3 GAS / LB. VOL. SOLIDS		6.8
FT^3 GAS / LB. MG FLOW		14,286
COST DATA		
MAN DAYS 63 PAYROLL		2,325.78
POWER PURCHASED		520.32
OTHER UTILITIES (GAS, H_2O)		NONE
GASOLINE, OIL, GREASE		108.56
CHEMICALS AND SUPPLIES		547.25
MAINTENANCE		238.48
VEHICLE COSTS		NONE
OTHER		NONE
TOTAL		$ 3,740.39
OPER. COST/MG TREATED		$ 54.62
OPER. COST/CAPITA/MO.		$ 0.158

FLOW METER:
LAST 222046
1st 153549
TOTAL 68.497 MG

ELECTRIC METER:
LAST 7838
1st 5670
TOTAL 2168
MULT 40 X 2168 = 86,720 KWH

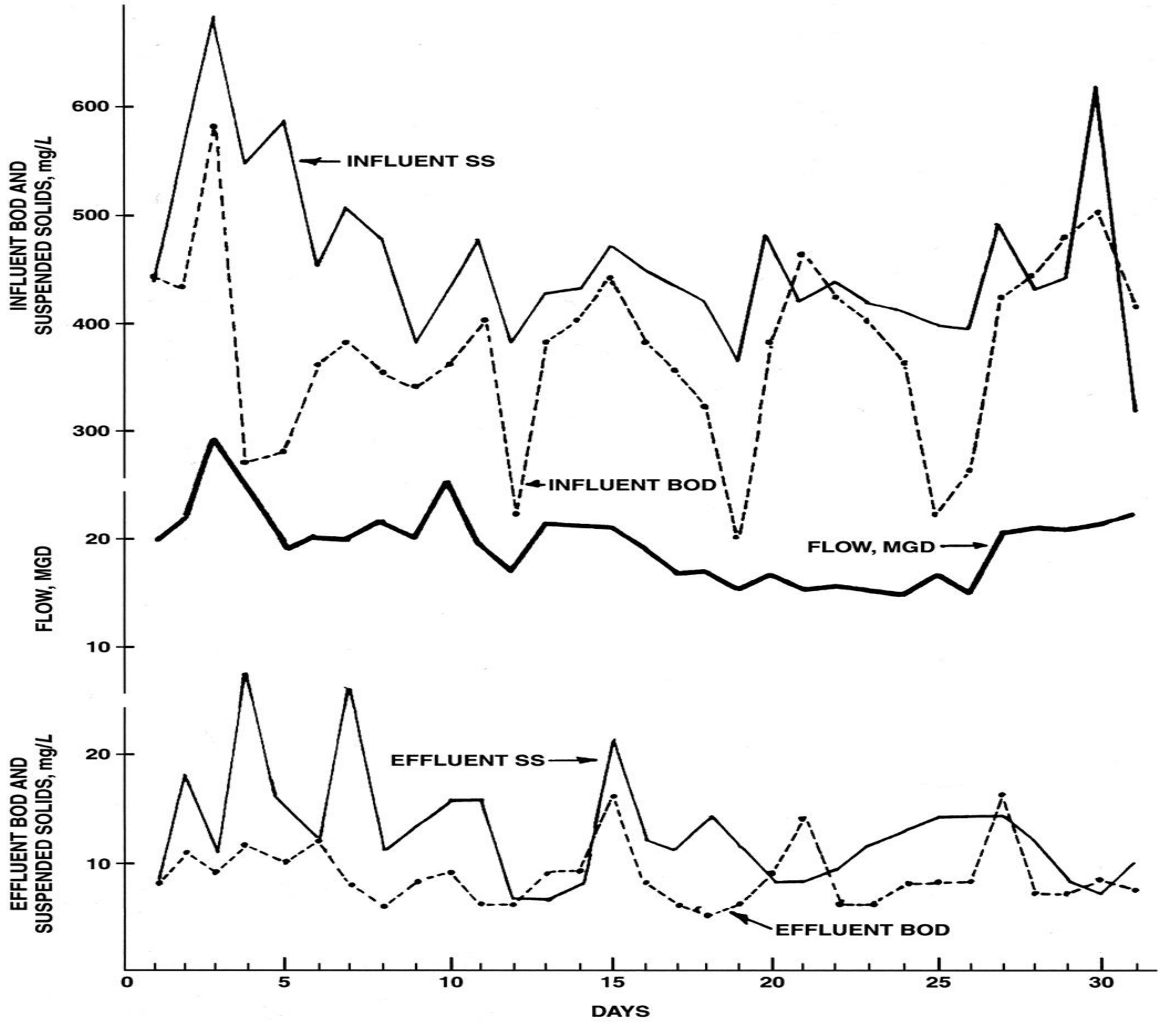
RAW SLUDGE:
LAST 798324
1st 432984
STROKES 365340
TOTAL 365340 X 1.0 = 365,340 GALS

GAS METER:
LAST 2181110
1st 1265230
TOTAL 915,880 FT^3

RETURN SLUDGE:
LAST 67635048
1st 67613800
TOTAL 21.248 MG

WASTE SLUDGE:
LAST 134251
1st 132560
TOTAL 1961 x 1000 MG

Example 1 of Process Parameter Plot



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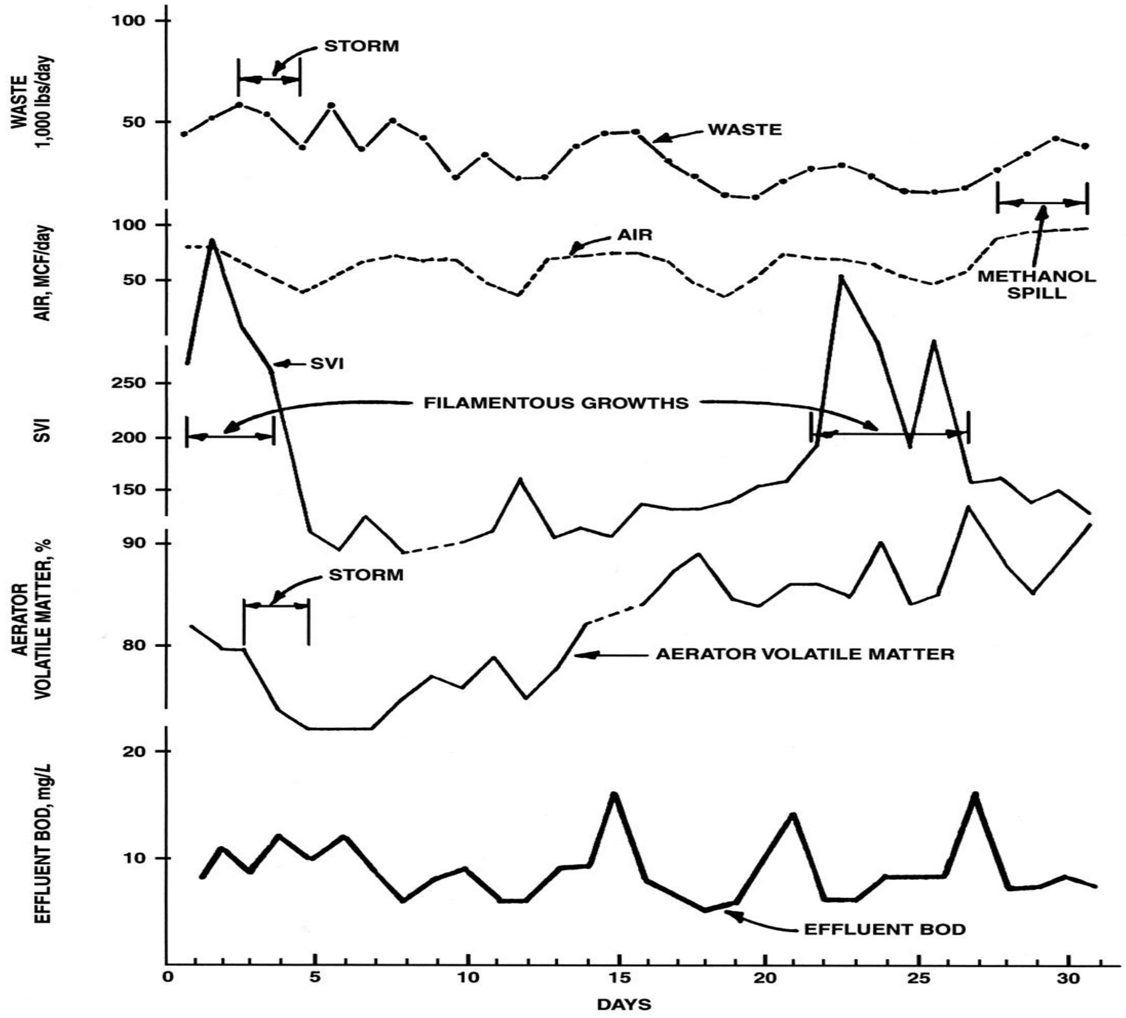
Example 2 of Process Parameter Plot



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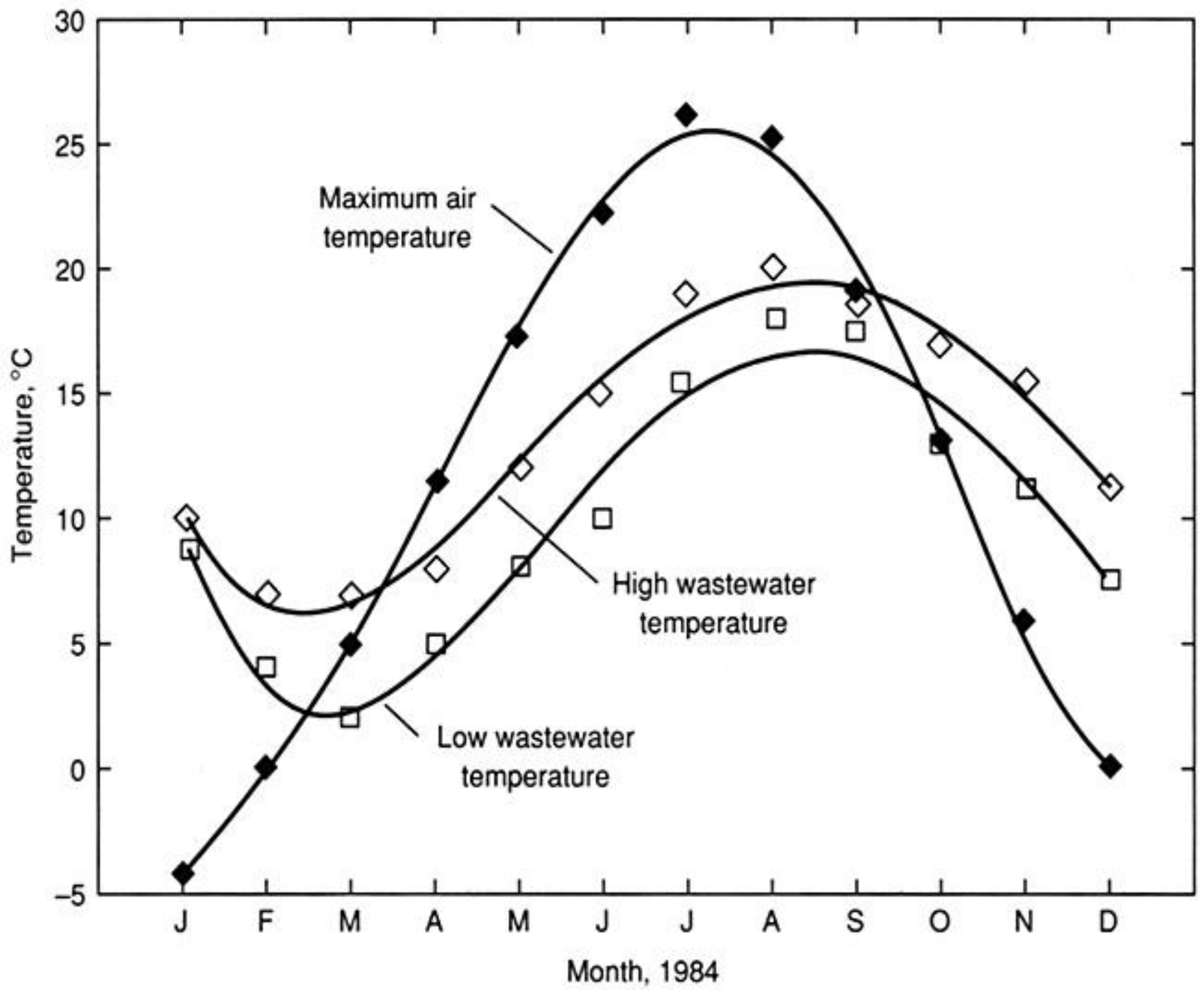
Daily Process Control Tasks

- Record Keeping
  - There are several process parameters that should be monitored daily and recorded. They include:
    - TSS and VSS
    - BOD, COD or TOC
    - DO
    - settleable solids/SVI
    - temperature
    - pH
    - clarity
    - chlorine demand
    - coliform group bacteria

Typical Influent Wastewater Temperatures



Daily Process Control Tasks

- Record Keeping
  - In addition to process control parameters, the following meter readings must be recorded to assist with monitoring plant performance.
    - Daily influent flow
    - Return sludge pumping rate
    - Waste sludge pumping rate
    - Air flow to diffused air system or hours operated at specific motor speeds for mechanical aeration.

Daily Process Control Tasks

- Daily Process Control Tasks
  - In addition to record keeping the following tasks should be performed:
    - Observation of plant flow, color, odor, scum, turbulence, clarity, etc...for any irregularities.
    - Examine mechanical equipment and motors for excessive vibrations, noises and temperature.
    - Review the log book
    - Review the lab data

Key Points and Exercise

- Turn to page 1-35 to summarize the unit key points.
- Turn to page 1-36 for the exercise

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Unit 2–Typical Operational Problems

Learning Objectives

- List six common process operational problems.
- List and explain possible plant changes that may result in process operational problems.
- Define sludge bulking, explain what causes it and identify possible solutions.
- Define septic sludge, explain what causes it and explain possible solutions.

Learning Objectives

- List five classifications of toxic substances and explain their effects on biological treatment systems.
- List and explain institutional, design and process controls that can be used to control toxic substances.
- Define rising sludge, explain what causes it and identify possible solutions.

Unit 2–Typical Operational Problems

Learning Objectives

- Explain what causes foaming/frothing and possible solutions.
- Explain the significance of the Process Troubleshooting Guide.
- List and explain seven common equipment operational problems.
- Describe the maintenance required for the various aeration equipment.

Typical Operational Problems

- Plant Changes
  - High Digester Supernatant Solids
  - Plant Influent Flow and Waste Characteristic Changes (BOD/COD, TSS)
  - Temperature Changes
  - Sampling Program Changes

Typical Operational Problems

- Sludge Bulking
  - describes a condition in which activated sludge has poor settling characteristics and poor compatibility.
  - Causes
    - The presence of filamentous organisms is the predominant cause of sludge bulking.
    - The presence of excess water, or bound water, in the bacteria cells reduces the sludge density.
    - Low pH, low DO and low nutrient concentrations have been linked to sludge bulking, but high F/M ratios (and low MCRTs) are the primary cause for repeated bulking.

Typical Operational Problems

- Sludge Bulking
  - Solutions
    - Increase the MCRT
    - Increase the DO
    - Increase hydraulic detention time in the aeration basin
    - Chlorinate the return sludge
    - Add flocculant
    - Control sulfide ions entering the aeration tanks

Typical Operational Problems

- Septic Sludge
  - is any sludge that has become anaerobic and is characterized by a foul odor.
  - Causes
    - Sludge becomes septic when it is allowed to sit stagnant long enough to deplete residual DO.
    - Sludge may turn septic if allowed to accumulate in pockets or “dead spots” too long.
    - Inadequate mixing in aeration tank
    - Inadequate return sludge rates in secondary clarifiers

Typical Operational Problems

- Septic Sludge
  - Solutions
    - Completely mix the contents of the aeration tank.
    - Maintain a flow velocity of at least 1.5 ft/sec to prevent sludge deposition.
    - Increase the return sludge rate to reduce the detention time.
    - Make sure the clarifier collection mechanism is on so that solids are removed from the draw-off hopper.
    - Make sure the sludge draw-off lines are not plugged.
    - Make sure the return sludge pumps and valves are operating properly.

Typical Operational Problems

- Rising Sludge
  - is the term used to describe sludge that slowly rises to the surface of secondary clarifiers. Rising sludge is differentiated from sludge bulking by the presence of gas bubbles on the surface of the clarifier.
  - Causes
    - Rising sludge is caused by the process of denitrification in the secondary clarifiers.

Typical Operational Problems

- Rising Sludge
  - Solutions
    - Increase the return sludge rate to decrease the detention time of the sludge in the clarifier.
    - Decrease the flow rate of activated sludge to the problematic clarifier if the return sludge rate can not be increased.
    - Increase the speed of the sludge collecting mechanism in the clarifier.
    - Decrease the MCRT by increasing the wasting rate.

Typical Operational Problems

- Foaming/Frothing
  - is the condition describing a buildup of foam or froth on the surface of the aeration tank.
  - Causes
    - a low MLSS
    - nutrient deficiencies, solids recycled from dewatering processes, the presence of surfactants (detergents) in the plant's influent, over aeration and polymer overdosing.
    - filamentous bacteria *Nocardia*. *Nocardia* foam is thick, dark brown foam that can be caused by a low F/M ratio, high MLSS (high MCRT) due to insufficient wasting and re-aerating activated sludge.

Typical Operational Problems

- Foaming/Frothing
  - Solutions are dependent on cause
    - Increase the MLSS concentration
    - Reduce the air supply during periods of low flow
    - Return digester supernatant slowly to the aeration tank during periods of low flow
    - Reduce the MCRT
    - Add a biological foam control agent
    - Chlorinate the return sludge
    - Spray chlorine solution or sprinkle calcium hypochlorite directly on surface of foam
    - Reduce the pH

Typical Operational Problems

- Toxic Substances
  - The EPA has developed a list of approximately 150 toxic substances, or "priority pollutants".
  - Categorical discharge standards are used to regulate the discharge of priority pollutants to publicly owned treatment works (POTWs) by commercial and industrial sources.
  - WWTPs discharging to surface waters are required to monitor their effluents for and comply with certain priority pollutant discharge limitations.
  - The toxicity of wastewater treatment plant effluents is typically measured using the whole effluent toxicity (WET) test.

Typical Operational Problems

- Toxic Substances
  - Priority pollutants fall into the following classifications:
    - heavy metals
    - inorganic compounds
    - organic compounds
    - halogenated compounds
    - pesticides, herbicides and insecticides

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Typical Operational Problems

- Toxic Substances
  - Effects on Biological Treatment Systems
    - In general, toxic organic compounds may be removed, transformed, generated or passed through the system unchanged. Typically present at concentrations that are non-toxic.
    - Inorganic compounds, such as copper, lead, silver, chromium, arsenic, and boron cations (positively charged ions) can be toxic to microorganisms.
    - Potassium, ammonium and elevated concentrations of sodium can be toxic to bacteria in sludge digesters.

Typical Operational Problems

- Toxic Substances
  - Controls:
    - Institutional Controls
      - Prohibited Discharge Standards
      - Categorical Standards
    - Design Controls
    - Process Controls

Checkpoint

- Turn to page 2-12 for the exercise

Processing Troubleshooting

- Process Troubleshooting Guidance
  - One of the most important principles in process troubleshooting is to make only one process change at a time and to give the system adequate time to respond to the change before making another change.
  - You will typically need to allow one week for the plant to stabilize after making a process change.

Processing Troubleshooting Guide

11.67 Process Troubleshooting Guide (adapted from *PERFORMANCE EVALUATION AND TROUBLESHOOTING AT MUNICIPAL WASTEWATER TREATMENT FACILITIES*, Office of Water Program Operations, US EPA, Washington, DC)

INDICATOR/OBSERVATION	PROBABLE CAUSE	CHECK OR MONITOR	SOLUTION
1. Sludge floating to surface of secondary clarifiers.	1a. Filamentous organisms predominating in mixed liquor ("bulking sludge").	1a. SVI—if less than 100, 1(a) is not likely cause; microscopic examination can be used to determine presence of filamentous organisms.	1a. (1) Increase DO in aeration tank if less than 1.5 mg/*L* at effluent end of aerator. (2) Increase MCRT to greater than 6 days. (3) Increase sludge return rate and reduce or stop wasting. (4) Supplement deficiency of nutrients so that BOD to nutrient ratio is no more than 100 mg/*L* BOD to 5 mg/*L* total nitrogen, 1 mg/*L* phosphorus, and 0.5 mg/*L* iron. (5) Add 5-10 mg/*L* of chlorine to return sludge until SVI <150 (should be controlled within 2-3 days). Microscopically examine sludge to avoid destruction of beneficial organisms during chlorine application. (6) Increase pH to 7. (7) Add 50-200 mg/*L* of hydrogen peroxide to aeration tank until SVI <150.
	1b. Denitrification occurring in secondary clarifiers; nitrogen gas bubbles attaching to sludge particles; sludge rising in clumps.	1b. Nitrate concentration in clarifier influent; if no measurable NO_3^-, then 1(b) is not the cause.	1b. (1) Increase sludge return rate (will increase clarifier hydraulic load and reduce detention time). (2) Increase DO in aeration tank. (3) Reduce MCRT. (4) Reduce flow to offending unit if sludge return rate cannot be effectively increased.
2. Pin floc in secondary clarifier overflow—SVI is good but effluent is turbid.	2a. Excessive turbulence in aeration tanks.	2a. DO in aeration tank.	2a. Reduce aeration agitation (reduce blower CFM output or depth of submergence and RPM of mechanical aerator).
	2b. Overoxidized sludge.	2b. Sludge appearance.	2b. Increase sludge wasting to decrease MCRT.
	2c. Anaerobic conditions in aeration tank.	2c. DO in aeration tank.	2c. Increase DO in aeration tank to at least 1.0 to 1.5 mg/*L* in aerator effluent.
	2d. Toxic shock load.	2d. Microscopically examine sludge for inactive protozoa.	2d. (1) Re-seed sludge with sludge from another plant if possible; enforce industrial waste ordinances. (2) Stop wasting. (3) Return rate as high as possible to reestablish culture.

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Checkpoint

- Turn to page 2-16 for the exercise

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Equipment Problems and Maintenance

ABNORMAL SURFACE AERATOR OPERATION

Item	Abnormal Condition	Possible Cause	Operator Response
Motor	High or uneven amperage	Moisture	Have electrician MEG[a] check motor. Have motor rewound.
		Winding breakdown	
		Degree of impeller submergence results in amperage draw in excess of motor amperage design	Adjust aerator.
		Excessive motor bearing or gear reducer friction	Inspect and lubricate bearings and gears. Overhaul if needed.
Gear Reducer	Bearing or gear noise	Lack of proper lubrication	Repair or replace oil pump. Change oil.
			Remove obstruction in oil line.
Shaft Coupling	Unusual noise and vibration	Cracked coupling	Replace coupling. Align impeller shaft.
		Loose coupling bolts/nuts as a result of vibration	Torque bolts.[b] Use "locking" nuts. Align impeller shaft.
Impeller	Unusual noise and vibration	Loose blades	Torque blade bolts.[b] Use lock-washers. Align impeller.
		Cracked blades	Replace. Torque bolts.[b] Align.

[a] Use instrument (megger) to check insulation resistance of motor.
[b] Tighten bolts to manufacturer's torque rating. Ratings are given in foot-pounds or kilogram-meters.

Equipment Problems and Maintenance

- Surface Aerator Maintenance
  - Follow the manufacturer's O & M manuals.
  - General guidelines:
    - Motors
    - Gear reducers
    - Coupling and impeller

Equipment Problems and Maintenance

- Air Filters
  - Operational problems and maintenance
    - The cleanliness of air filters is typically measured by the pressure difference between the inlet and outlet with a manometer.
    - The pressure difference will increase as the filters are loaded with particulate.
    - Excessive pressure drops across the air filters will result in reduced blower performance.
    - Air filters should be removed, cleaned and reinstalled according to the manufacturer's operation and maintenance manual.

Equipment Problems and Maintenance

- Blowers
  - Operational problems may include:
    - unusual noises or vibration
    - air flow problems
    - motor problems
    - oil temperature problems

Equipment Problems and Maintenance

- Blower Maintenance
  - Generally, all new oil-lubricated equipment requires a “break in” period of about 400 hours before changing the oil.
  - Change the oil after every 1,400 hours of operation.
  - Check the drained oil after “break in” period for metal particulates.
  - Lubricate the grease-lubricated bearings after every 500 hours of operation.
  - See the aerator section for blower motor maintenance.
  - Check all valves

Equipment Problems and Maintenance

ABNORMAL AIR DISTRIBUTION SYSTEM OPERATION

Item	Abnormal Condition	Possible Cause	Operator Response
Meter(s)	High, low, or no indication	Loose movement	Tighten or replace.
		Out of calibration	Calibrate.
		Dirt in mechanism	Clean.
		Pointer dragging on scale plate	Adjust pointer.
		Bypass valve open or leaking	Close or repair.
		Meter piping leaks	Tighten or replace.
		Meter piping plugged	Clean piping.
Seals, gaskets, and flex connections	Leaking	Loose bolts or fittings	Tighten.
		Blown out	Replace.
	Worn	Usual deterioration	Replace.
Pipe	Corrosion	Condensate	Drain traps daily, install additional traps, flush pipe, paint pipe, and/or remove standing water from around pipe.
	Sludge inside pipe	Vacuum action by blower operating in reverse	Flush pipe, install check valve on blower, and/or repair check valve.
	Dirt	No or inefficient air filtration	Install filters. Clean filters more frequently.
Valves	Difficult to operate or frozen	Hardened grease	Remove old grease and apply seizing[a] inhibitor. Operate valves monthly.
		Corrosion	Drain condensate traps daily. Apply seizing inhibitor.

[a] Seizing. Seizing occurs when an engine overheats and a component expands to the point where the engine will not run. Also called freezing.

Equipment Problems and Maintenance

- Air Distribution System Maintenance
  - Inspect the following at least every six months:
    - Loose pipe support clamps.
    - Shifting of pipes out of original alignment.
    - Loose nuts and bolts on flanges and fittings.
    - Seized valves (exercise valves with the blower off at least once a month to prevent seizing).
    - Corrosion damage.
    - Prevent metal surfaces from corroding by maintaining paint coatings.

Equipment Problems and Maintenance

ABNORMAL AIR HEADER OPERATION

Item	Abnormal Condition	Possible Cause	Operator Response
Valve	Valve leaks at stem	Loose stem packing nut	Tighten nut.
		Defective packing	Secure distribution system and replace packing.
	Valve will not seat closed	Corrosion	Secure distribution system and clean or replace valve.
		Butterfly rubber seat defective	Secure distribution system and replace rubber seat.
		Butterfly or gate has come off valve system	Secure distribution system and replace.
Swing header pivot joints	Air leaks from joint	Defective "O" ring	Close header valve, pull header from tank with crane, and replace "O" ring.
		Loose joint	Tighten.
		Insufficient grease in joint	Apply 3 to 5 shots of grease.
		Cracked joint	Replace.
Fixed header couplings or unions	Air leaks from couplings, unions, or end caps	PVC has defective glue bond	Remove, clean with PVC solvent, bond, and allow bond to cure.
		Pipe has leak through thread	Remove, apply teflon tape, tighten.
Horizontal header	Uneven water motion (roll) in tank	Header not perfectly level, thus allowing more air to one side	Level header with surveyor's level (tank empty) or use Mason's level.
		"O" rings or gaskets defective or connections loose	Replace "O" rings or gaskets. Tighten connections.
Header pipe	Interior corrosion	Moisture	Use PVC or galvanized pipe.
	Exterior corrosion	Moisture	Use PVC, galvanized pipe, or paint pipe with an epoxy coating.
		Electrolysis	Use a sacrificial (magnesium) anode or coat surface.

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Equipment Problems and Maintenance

- Air Headers/Diffusers Maintenance
  - Monthly:
    - Exercise all regulating/isolation valves to prevent seizing.
    - Apply grease to the upper pivot swing joint O-ring cavity (swing header).
    - Check for loose fittings, nuts and bolts.
    - Increase air flow to the diffusers to 2-3 times the normal flow to blow out biological growths.
    - Loose nuts and bolts on flanges and fittings.

Equipment Problems and Maintenance

- Air Headers/Diffusers Maintenance
  - Yearly:
    - Raise the headers, clean and check for loose fittings, nuts and bolts.
    - Apply grease to the pivot joint O-ring cavity (swing header).
    - Check for corrosion and paint, as necessary, with epoxy coating.
    - Raise the header and inspect diffusers for damage. Clean and replace diffusers as needed.

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Equipment Problems and Maintenance

- Motors and Gear Reducers
  - Operational problems and maintenance
    - See the surface aerator section for information on motor and gear reducer operational problems on page 2-18 of your workbook.

Key Points and Exercise

- Turn to page 2-28 to summarize the unit key points.
- Turn to page 2-29 for the exercise

Learning Objectives

- Explain why microbiology is important in the activated sludge process.
- List and identify four typical microorganisms found in activated sludge.
- List the equipment required during sample collection.

Learning Objectives

- Identify four sampling locations for various treatment plant processes.
- Explain two methods of sample preparation.
- Identify the components of a microscope typically used at Wastewater Treatment Plants.

Learning Objectives

- Explain three common observations that are recorded.
- List and explain three means of interpreting results of microscopic observations.
- Explain how to decide when to make a process change.

Learning Objectives

- List possible process changes that can be made and explain what the purpose of each process change is.
- Explain how frequently processes should be monitored during good operations, poor operations and following a process change.

Microbiology of the Activated Sludge Process

- Activated Sludge
  - The activated sludge process is a living process that requires knowledge of the microorganisms involved.
  - You should know which microorganisms are desirable and undesirable and how these microorganisms respond to the environment in the aeration tanks.

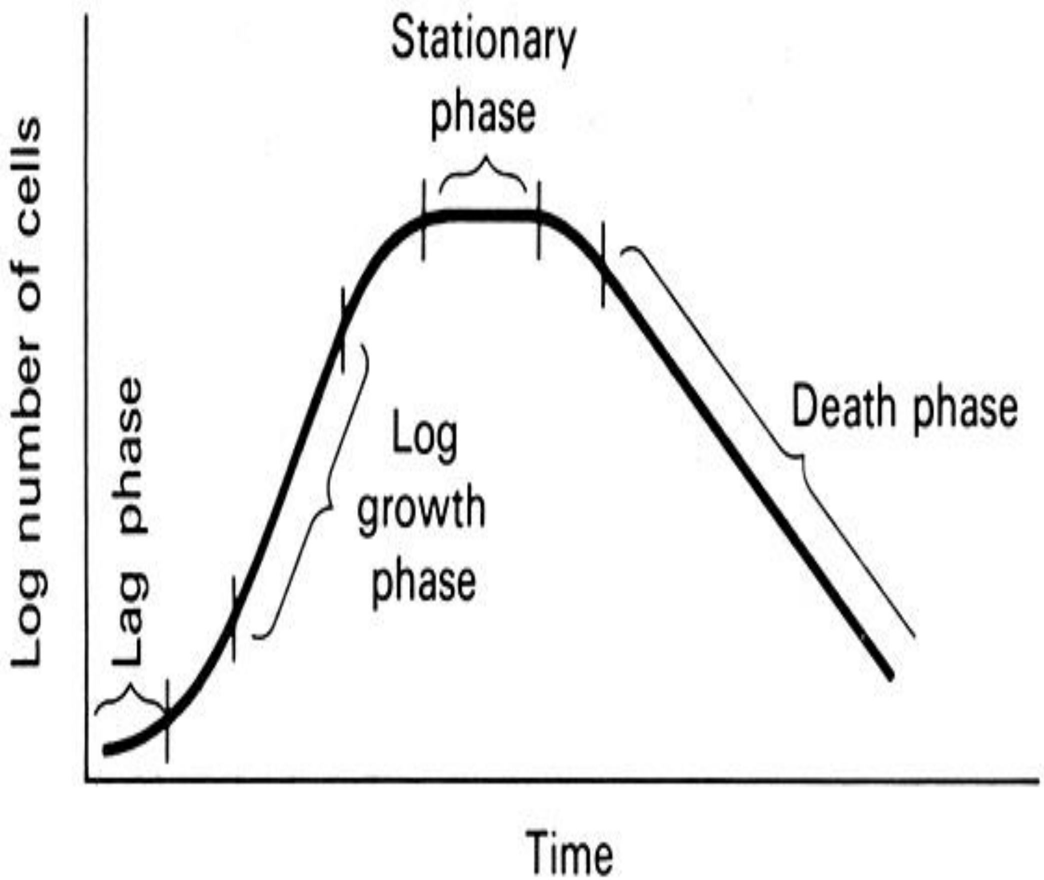
Microbiology of the Activated Sludge Process

- Microbiology as a Tool
  - Microscopy may be used to control the process.
  - The numbers and types of microorganisms in a sample can be helpful in determining what is happening and deciding which process change to make.
  - It can be used to forecast potential plant upsets.
  - Incorporating microscopic observations into your routine process control strategy will enable you to “see” the beginning stages of deteriorating conditions before any significant impact to the final effluent quality.

Microbiology of the Activated Sludge Process

- Bacteria
  - Bacteria are single-celled organisms and are the most predominant organisms in activated sludge.
  - They are categorized by their shape to include:
    - Coccus – round or spherical shape
    - Bacillus – cylindrical or rod shape
    - Spirillum – spiral shape

Typical Growth Cycle for Bacteria



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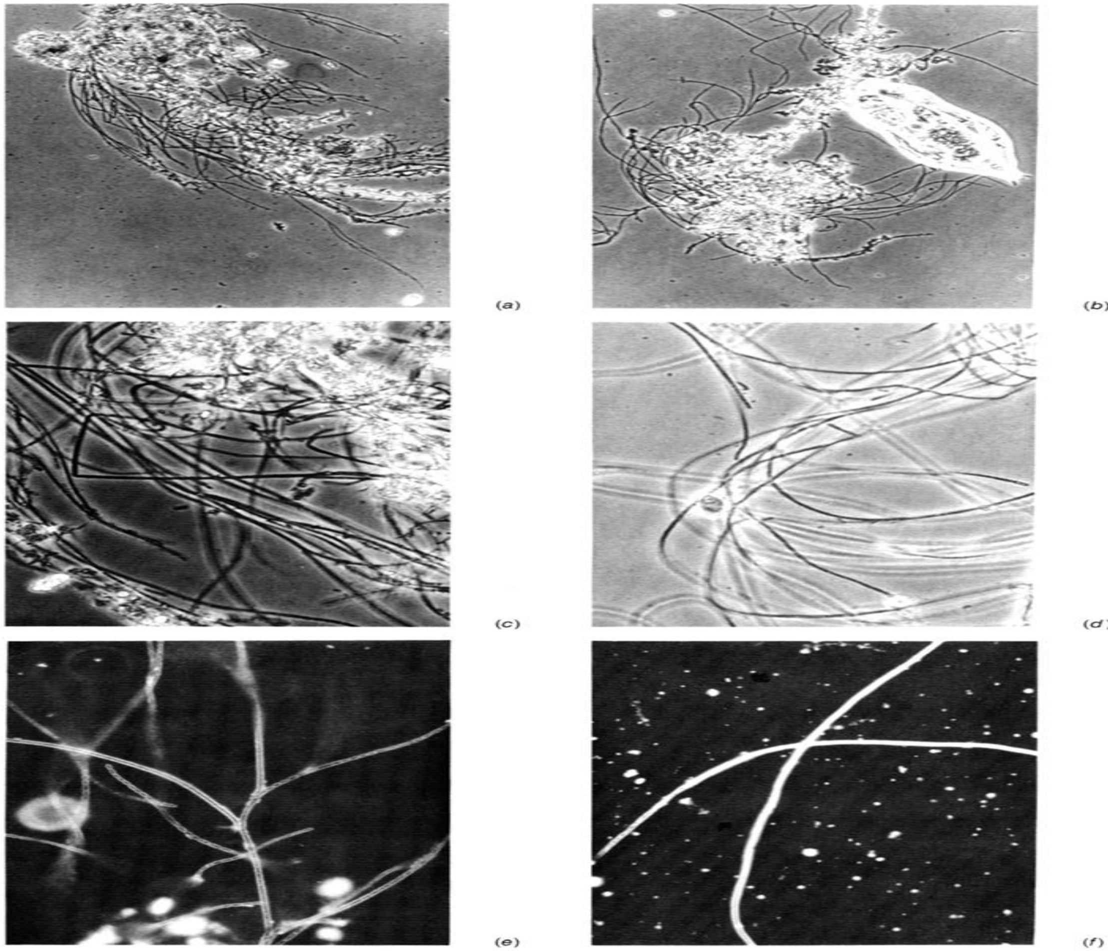
MICROORGANISMS IN ACTIVATED SLUDGE

- Bacteria growth occurs in four stages:
  - The lag phase - cells become acclimated to the waste and begin to divide.
  - The log-growth phase - cells divide at their generation rate because there is plenty of food available.
  - The stationary phase - the growth rate decreases due to the depletion of the food supply.
  - The death phase (also called the “endogenous” phase) - cells begin to feed on themselves in the absence of another food supply.

Microorganisms in Activated Sludge

- Filaments
  - Filaments are formed by filamentous bacteria, which attach themselves to each other, forming multi-cellular chains.
  - Filaments can be classified as "long" and "short."
    - Long filaments are the "backbone" that holds bacterial flocs together, giving them good settling characteristics.
    - Sludge bulking results when filaments begin to predominate and grow out of control.
    - The most common short filament is called *Nocardia*. Nocardia form short, web-like branches and can cause foaming and/or frothing in the aeration tanks and excessive brown floating scum in secondary clarifiers.

Filamentous Bacteria in Sludge Bulking



Typical filamentous organisms found in bulking sludge: (*a* and *b*) phase contrast, 100X, (*c*) phase contrast, 400X, (*d* and *e*) filaments of *Sphaerotilus*, phase contrast and dark field, 400X, and (*f*) filaments of *Thiothrix*, dark field, 400X.

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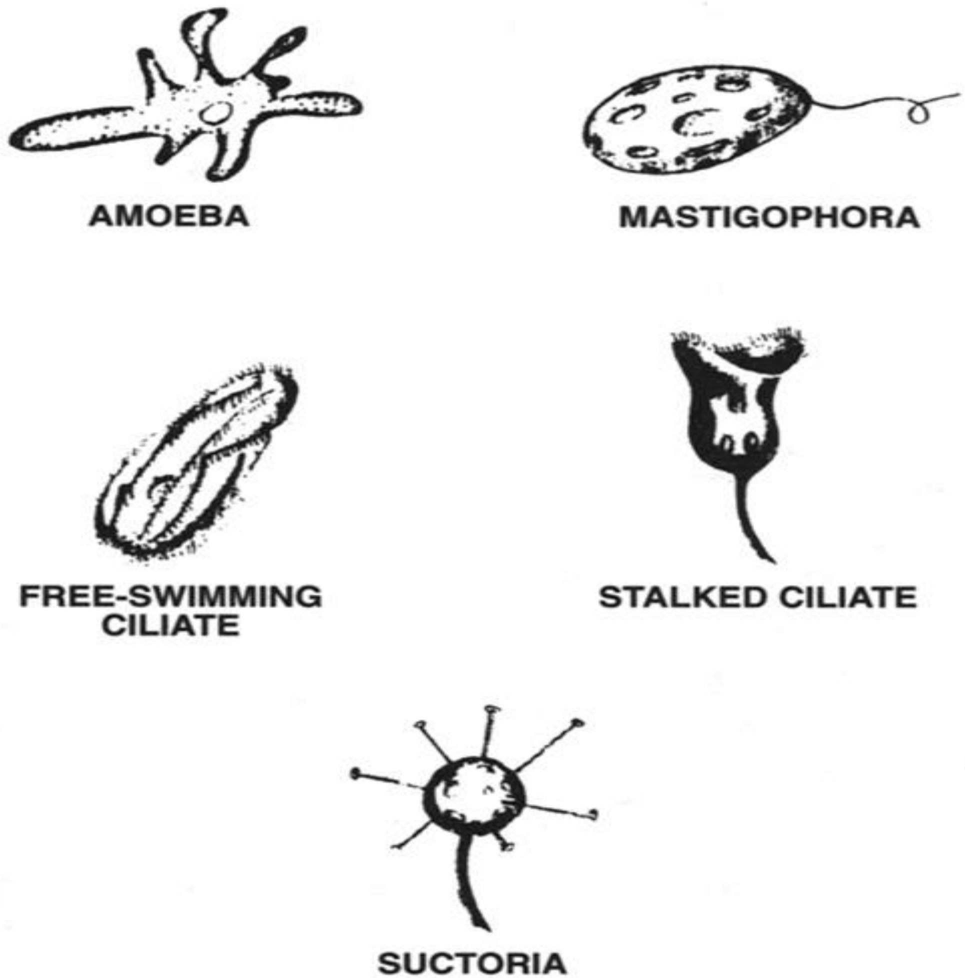
Microorganisms in Activated Sludge

- Protozoa
  - Protozoa are single celled organisms ranging in size from 10 microns to over 300 microns.
  - They are easily visible under the microscope at 100X magnification.
  - The presence or absence of protozoa is an indicator of the amount of bacteria in the sludge and the degree of treatment.
  - There are five types of protozoa - amoeba, mastigophora, free-swimming ciliate, stalked ciliate, and suctoria.

Protozoa


AMOEBA
MASTIGOPHORA
FREE-SWIMMING CILIATE
STALKED CILIATE
SUCTORIA

Microorganisms in Activated Sludge

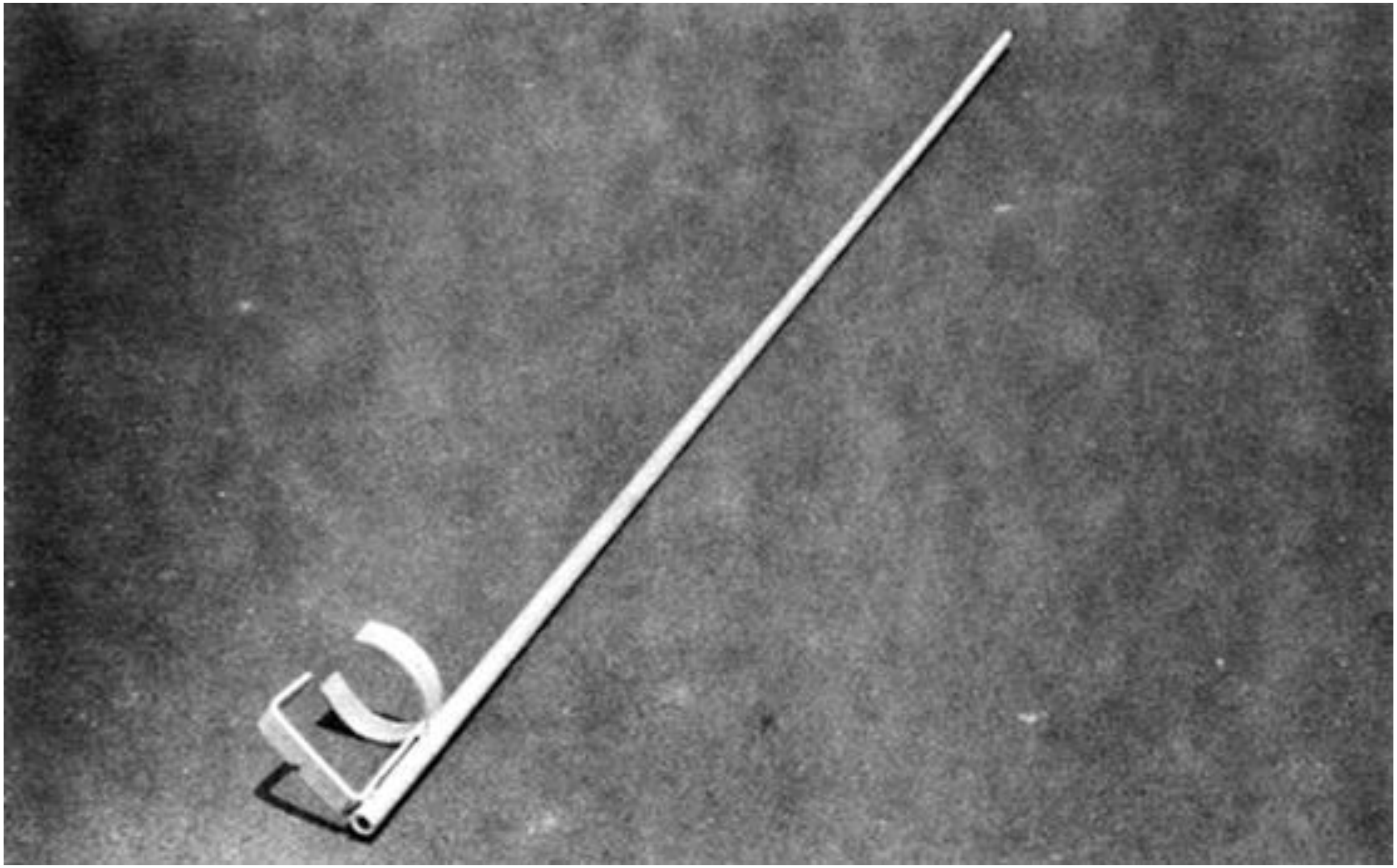
- Rotifers
  - are multicellular animals with rotating cilia on the head and a forked tail.
  - are an indication of an old activated sludge with a high MCRT and are usually associated with a turbid effluent.

- Worms
  - are strict aerobes and can metabolize solid organic matter not easily metabolized by other microorganisms.
  - are usually found in sludge from extended aeration plants.

Sample Collection and Preparation

- Sample Collection
  - You will need a dipper pole with a bottle holder or other appropriate collection equipment.
  - Use a 100 to 300 mL plastic bottle.
  - Collect your sample from the same spot in the aeration tank at the same time each day.
  - Conduct the microscopic observation within 15 minutes.

Dipper Pole and Bottle Holder



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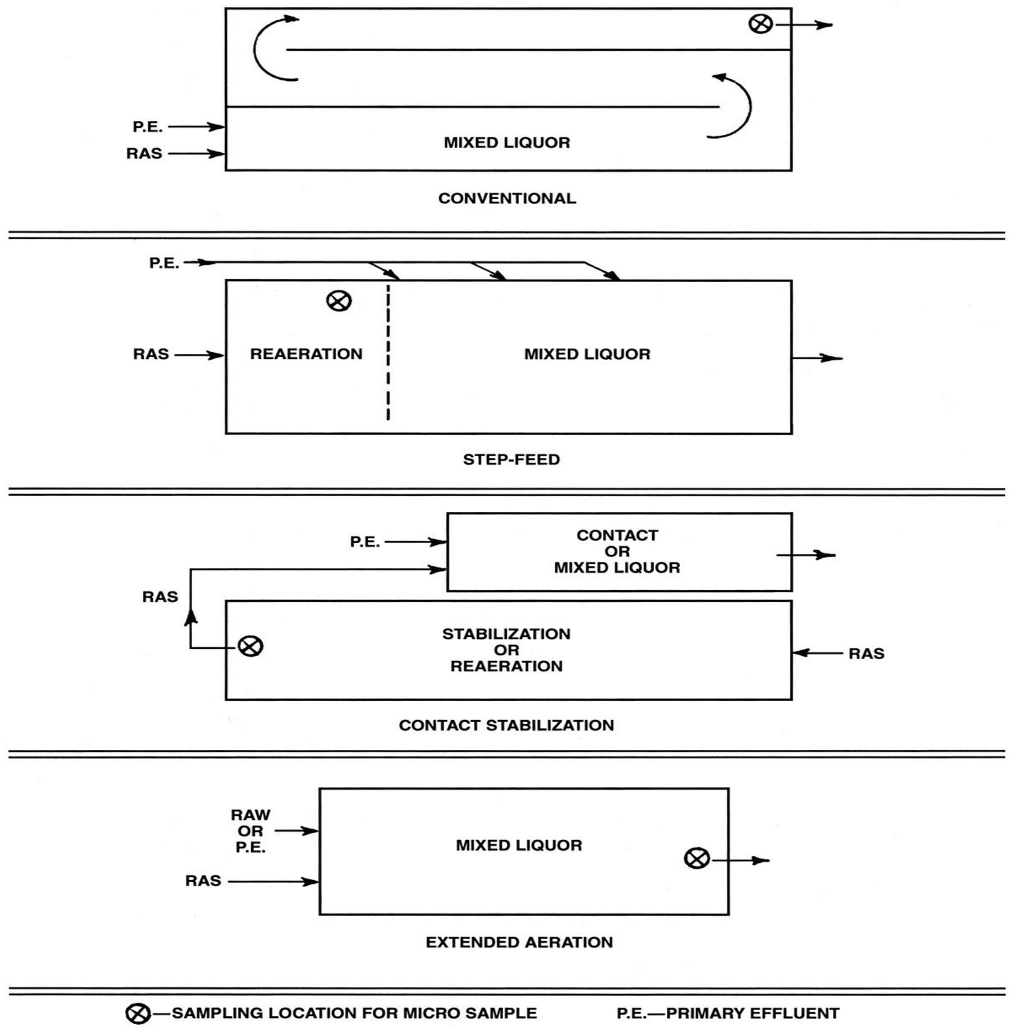
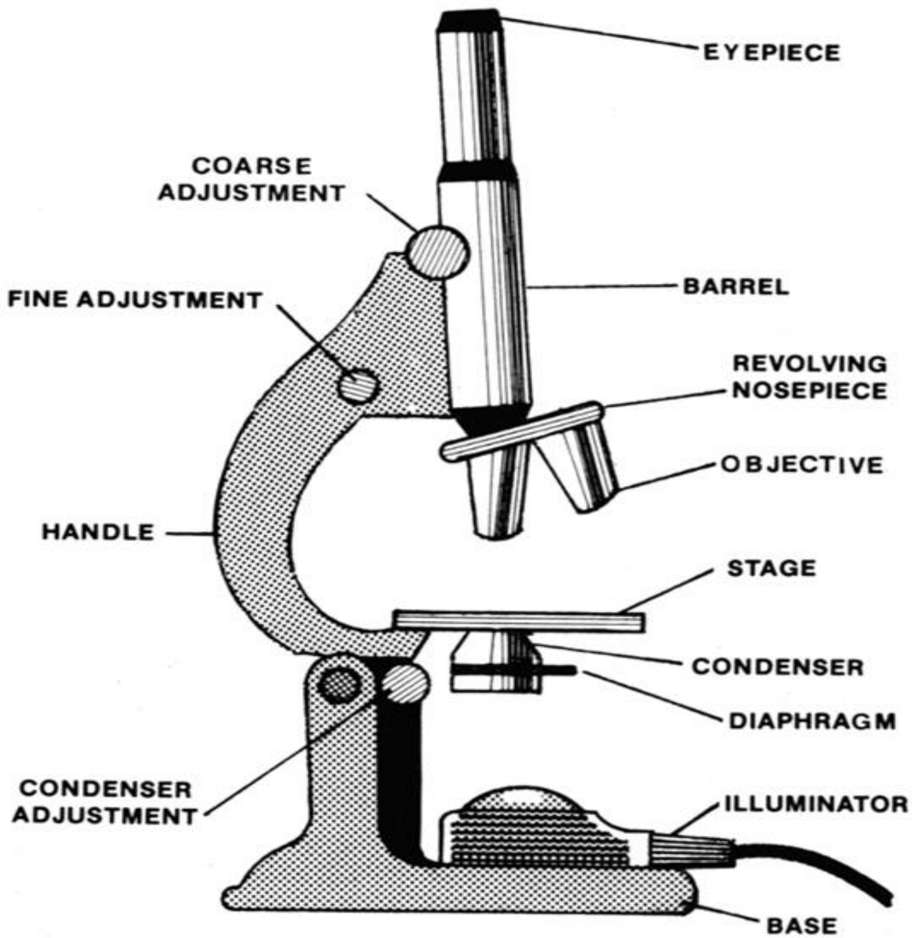
Sampling Locations



Sample Collection and Preparation

- Sample Preparation
  - There are two methods of sample preparation:
    - a wet mount slide is used to observe live organisms.
    - a stained dry slide is used to observe filamentous bacteria.

Compound Microscope



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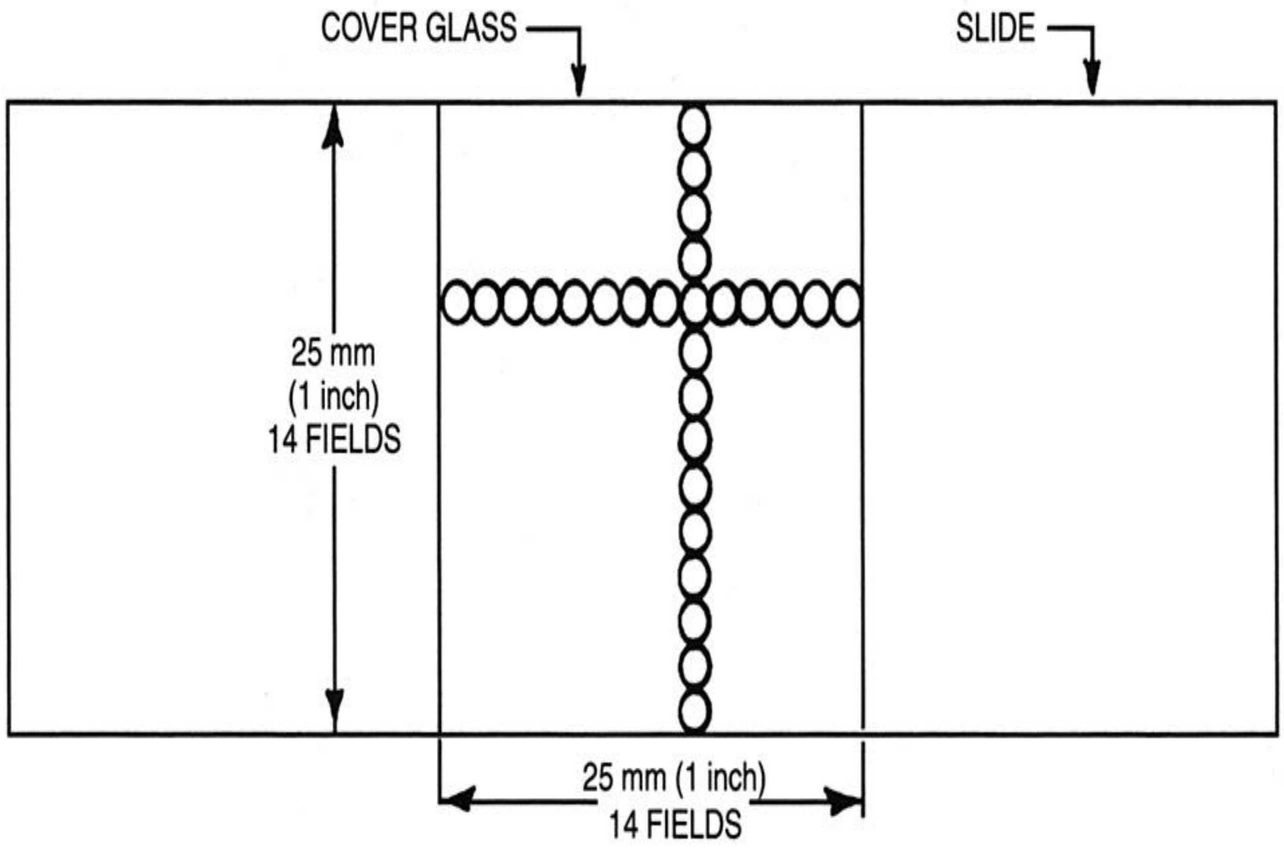
Microorganism Counts on a Slide



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Worksheet for Microorganism Counting

DATE ____________________

TIME ____________________

WORKSHEET FOR MICROORGANISM COUNTING

ENTER SUM OF ALL 28 FIELDS FOR TOTAL OF EACH TYPE OF BUG

						CILIATES									
								STALKED							
FIELD		AMOEBA		LARGE FLAGELLATES		FREE SWIMMING		SINGLES		COLONIES		ROTIFIERS		LONG FILAMENTS	
1	15														
2	16														
3	17														
4	18														
5	19														
6	20														
7	21														
8	22														
9	23														
10	24														
11	25														
12	26														
13	27														
14	28														
TOTAL															

HIGH	←	SVI	→	LOW
HIGH	←	F:M	→	LOW
LOW	←	MCRT	→	HIGH

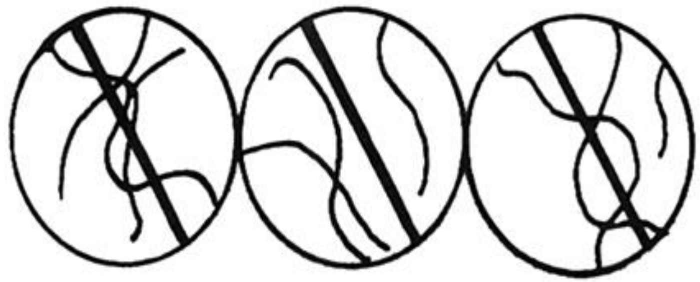
TINY FLAGELLATES ____________________ NOCARDIA ____________________

WORMS ____________________ FLOC CONDITION ____________________

Technique for Counting Filaments

#1 #2 #3

FIELDS:

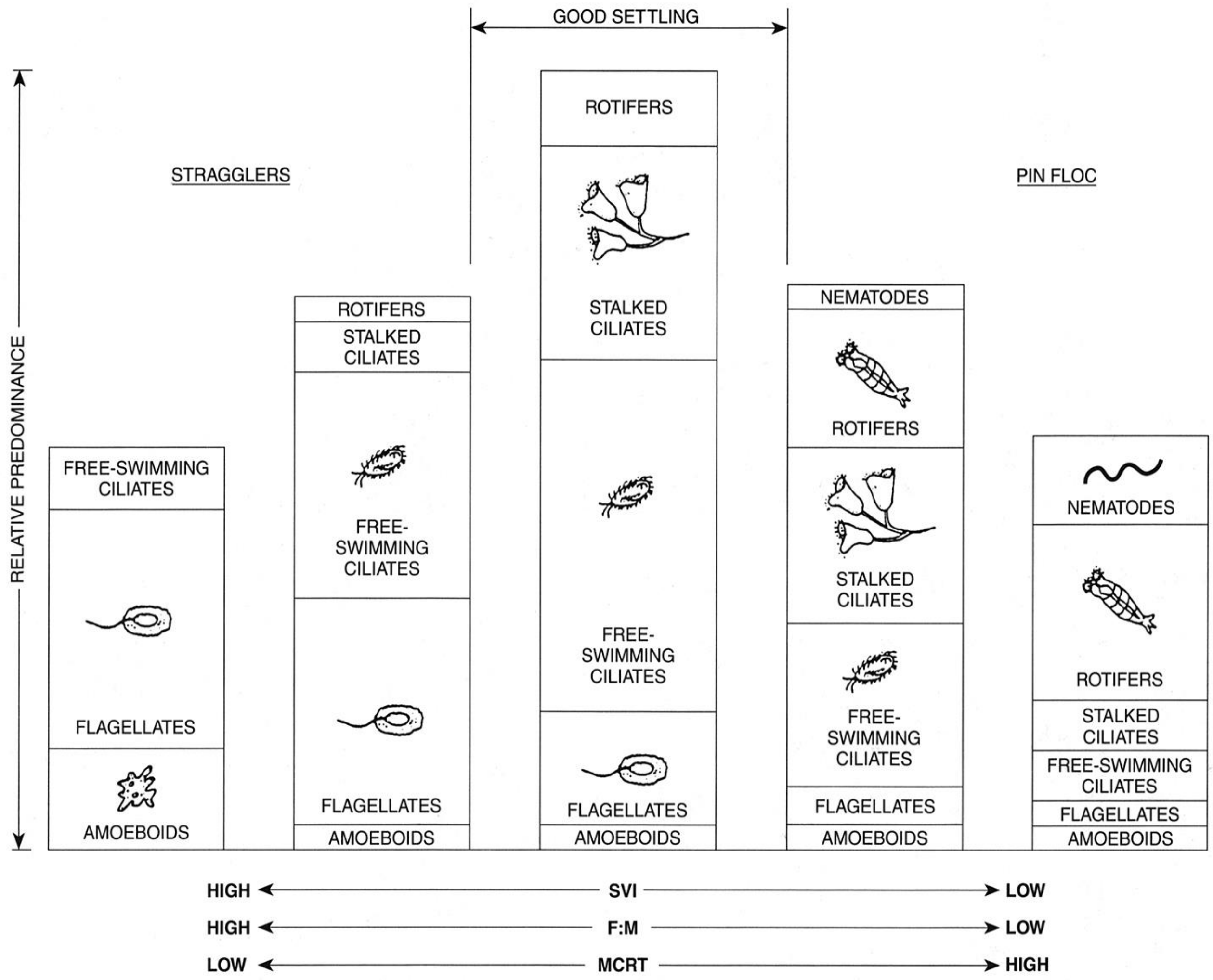


COUNT: 5 + 0 + 4 = (ADD ALL 28 FIELDS FOR TOTAL COUNT)

TECHNIQUE FOR COUNTING FILAMENTS*

**NOTE:* Techniques shown are modifications of original work by R. D. Beebe, City of San Jose, California, and D. Jenkins, University of California, Berkeley (1981). Paper presented at California Water Pollution Control Association meeting.

Indicators of Stable and Unstable Treatment Processes



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Sample Collection and Preparation

- Response to Results
  - Microscopy vs. Process Data
  - Changes in Microorganism Populations
  - Deciding When to Make a Process Change
  - Which Process Changes to Make
  - How Much Change to Make

Sample Collection and Preparation

- Monitoring Processes
  - The frequency of monitoring should be based on plant performance.
    - Good operation
      - two to three times per week or to suit your comfort level
    - Poor operation
      - Return to daily or twice-daily microscopic observations
    - Following a process change
      - Return to daily or twice-daily microscopic observations after a process change until it's been determined the correct change was made.

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Key Points and Exercise

- Turn to page 3-20 to summarize the unit key points.
- Turn to page 3-21 for the exercise

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