Activated Sludge

Overview


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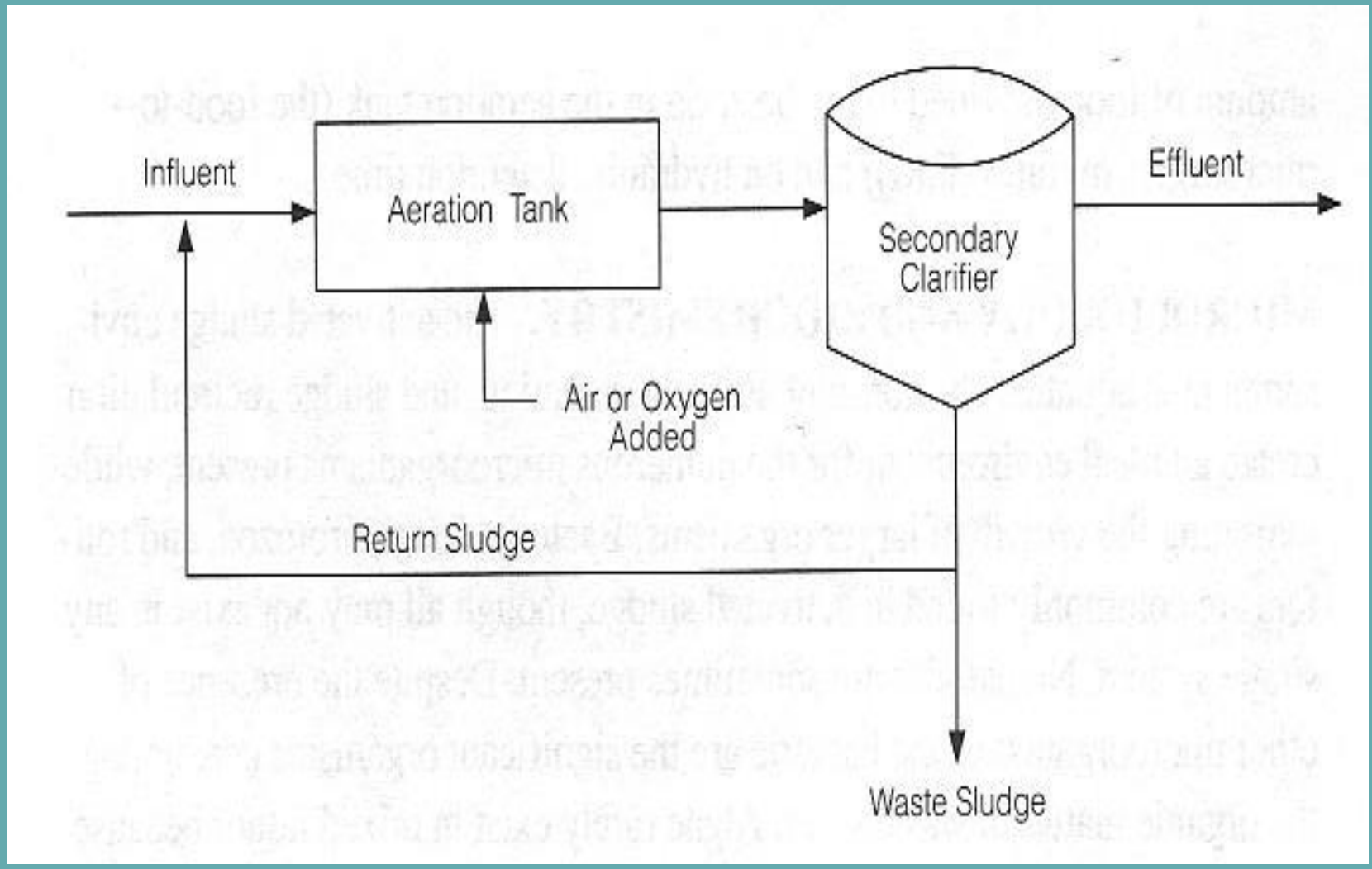
HOFFMAN


Influent
Aeration Tank
Secondary
Clarifier
Effluent
Air or Oxygen
Added
Return Sludge
Waste Sludge

Purpose And Process Description

- Stabilize organics and remove solids
- Aerobic, suspended growth, biological system
  - Mixed Liquor
  - Aeration Systems

The Activated Sludge Process

- The Activated Sludge Process (ASP) has the advantage of producing a high quality effluent for a reasonable operating and maintenance cost.
- The ASP uses microorganisms to feed on organic contaminants in wastewater to produce that high quality effluent.

ASP

- The basic principle behind all activated sludge processes is that as microbes grow, they form particles that clump together. After leaving the secondary treatment process these particles (floc) are allowed to settle to the bottom of the tank (Secondary Clarifier), leaving a relatively clear liquid free of organic material and suspended solids.

ASP

- Described simply, screened wastewater is mixed with varying amounts of recycled liquid containing a high proportion of organisms taken from a secondary clarifying tank, and it becomes a product called mixed liquor. This mixture is stirred and injected with large quantities of air to provide oxygen and keep solids in suspension.

ASP

- After a period of time, mixed liquor flows to a clarifier where it is allowed to settle. A portion of the bacteria is removed as it settles, and the partially cleaned water flows on for further treatment.
- The resulting settled solids, the activated sludge, are returned to the first tank to begin the process again.

ASP History

- Initially developed in England in the early 1900s, the ASP did not become widespread in the U.S. until the 1940s.
- Today a number of variations of the basic process have been developed.
- The three most common variations are:
  - Extended aeration
  - Sequencing batch reactors
  - Oxidation ditches

Glossary

- Activated Sludge – sludge particles produced in wastewater by the growth of organisms in aeration tanks. The term "activated" comes from the fact that the particles teem with bacteria, fungi, and protozoa. Activated sludge is different from primary sludge in that the sludge particles contain many living organisms that can feed on the incoming wastewater.

Glossary

- Activated sludge process - a biological wastewater treatment process which speeds up waste decomposition. Activated sludge is added to wastewater, and the mixture is aerated and agitated. After a certain amount of time, the activated sludge is allowed to settle out by sedimentation and is disposed of (wasted) or reused (returned to the aeration tank)

Glossary

- Aerobic – a condition where oxygen is present
- BOD – biological oxygen demand. Measure of organic material in wastewater. (strength of wastewater)
- Bulking – sludge that forms clouds in the secondary clarifiers when the sludge does not settle properly, usually caused by filamentous bacteria.

Glossary

- F:M – food to microbe ratio
- Floc – clumps of bacteria
- Flocculation – agitation of wastewater to induce the small, suspended particles to bunch together into heavier particles (floc) and settle out.
- Loading – a quantity of material added to the process at one time
- MLSS – mixed liquor suspended solids

Glossary

- MLVSS – volatile mixed-liquor suspended solids
- Mixed liquor – activated sludge mixed with raw wastewater
- Package plant – pre-manufactured treatment facility small communities or individual properties use to treat wastewater
- SRT – solids retention time

Glossary

- Sludge – the solids that settle out during the process
- Supernatant – the liquid that is removed from settled sludge.
- TSS – total suspended solids
- Wasting – removing excess microorganisms from the system
- CBOD – Carbonaceous Biochemical Oxygen Demand

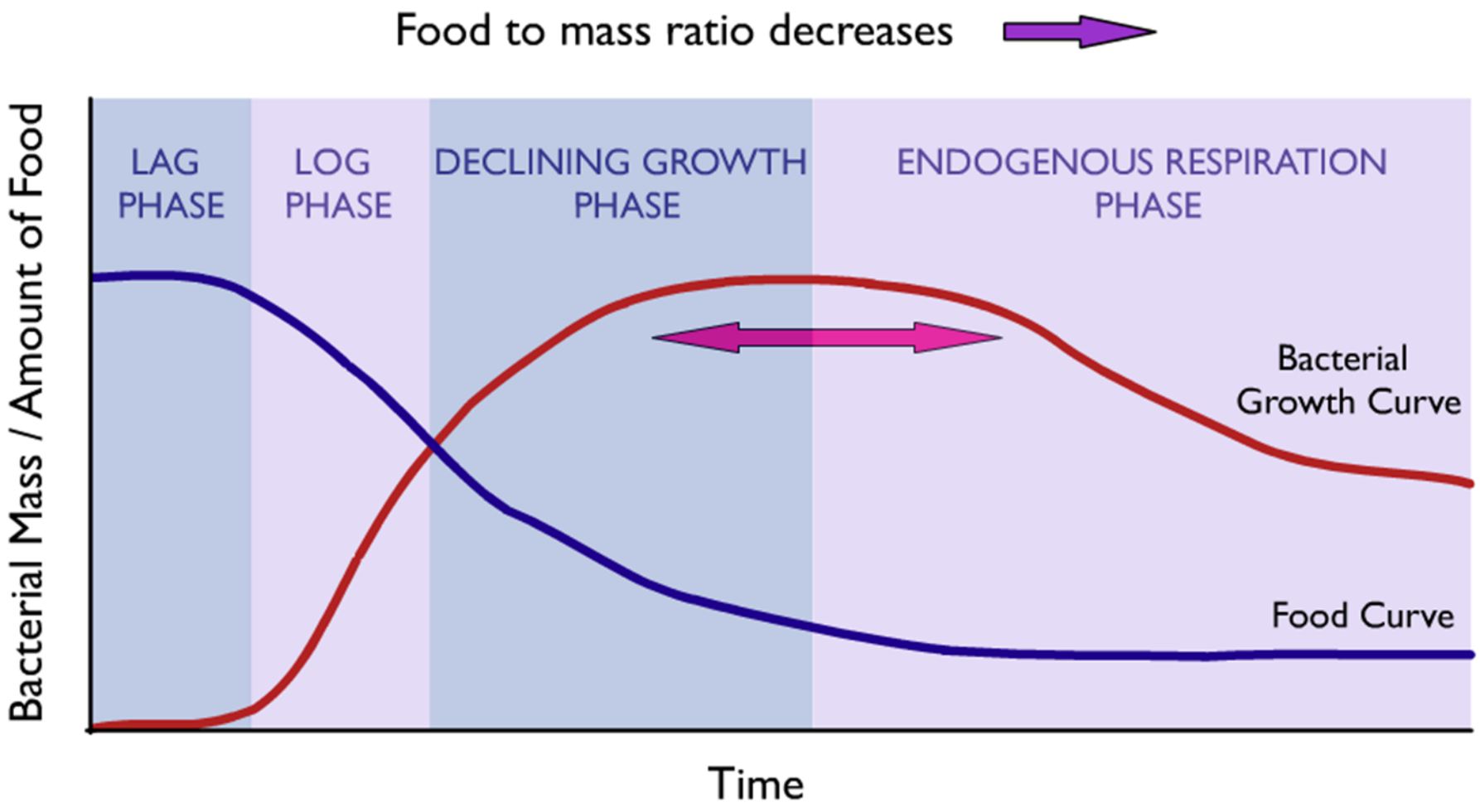
Wastewater Oxygen Demand

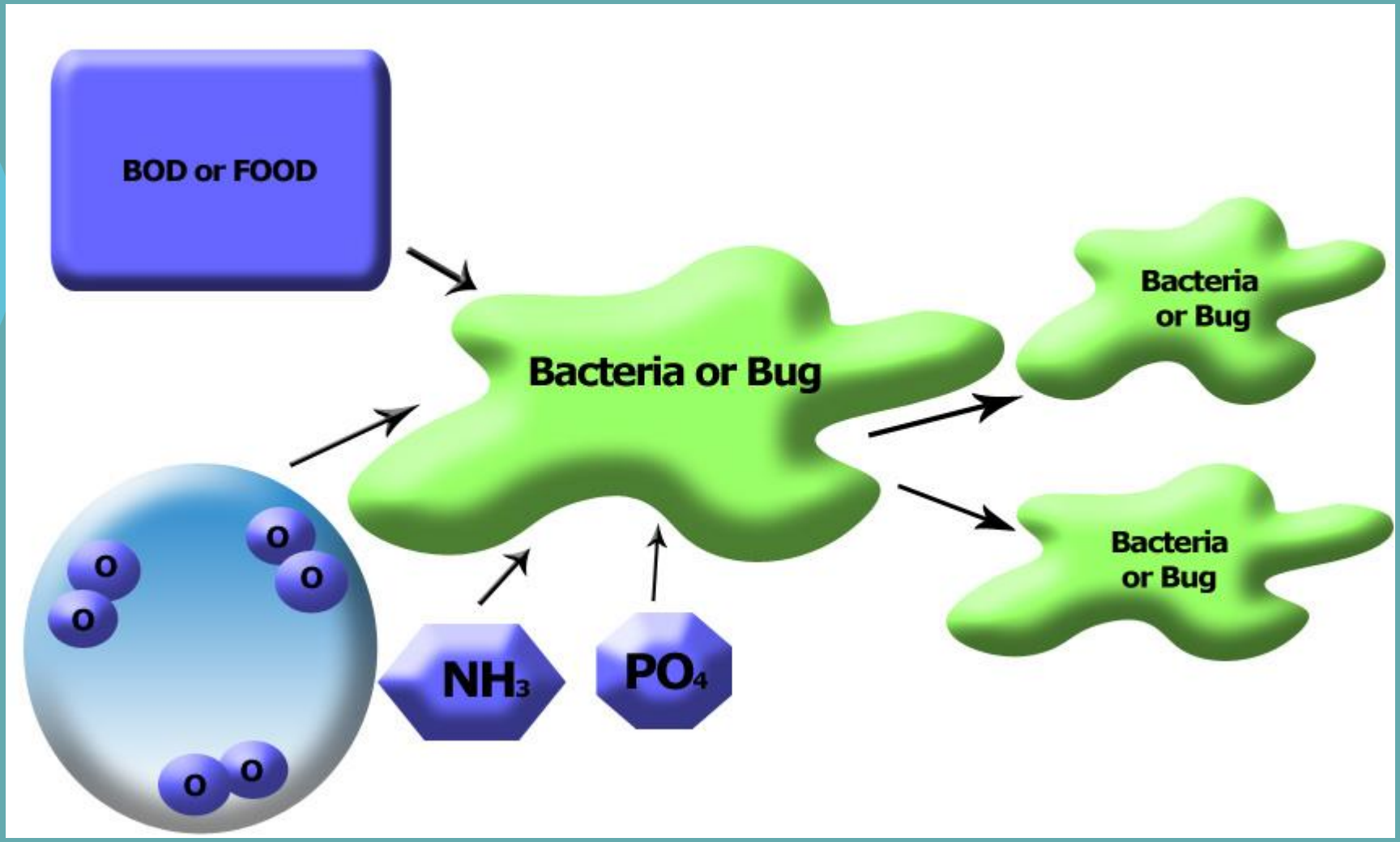
- Carbonaceous
  - Oxidation of carbon
  - CBOD
    - Nitrification inhibitors
- Nitrogenous
  - Conversion of ammonia to nitrites then nitrates

Process Control

- Relationship of food to microbial concentration
- Retention time of microbial cells
- Dissolved oxygen

BACTERIAL GROWTH




BOD or FOOD
Bacteria or Bug
Bacteria or Bug
Bacteria or Bug
O
O
O
O
O
O
NH_3
PO_4

Process Control

- Constant MLSS
- F:M Ratio
- Sludge Age
- Mean Cell Residence Time (MCRT)
- Settleability (Settleometer)

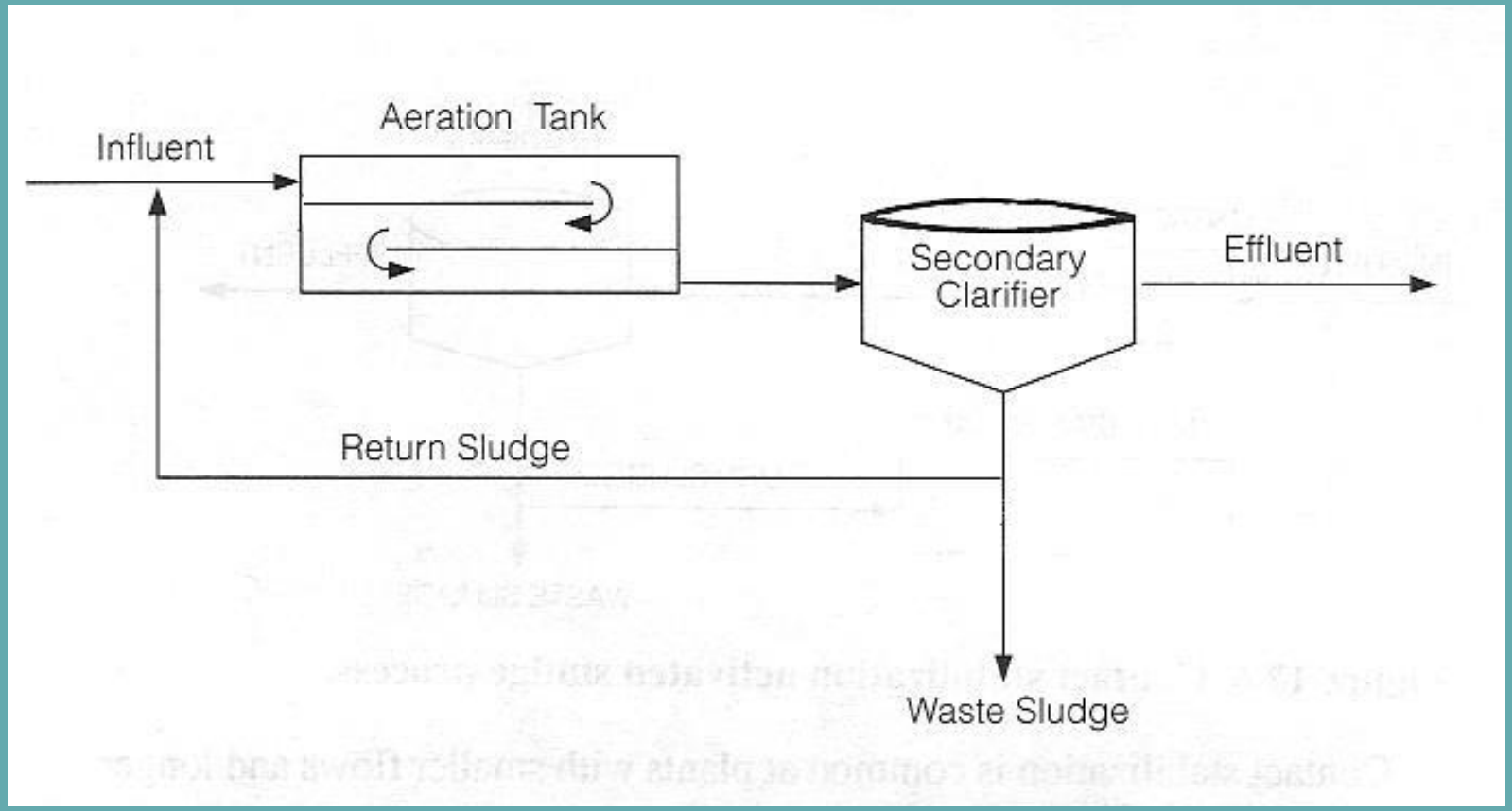
Return Activated Sludge

- Returns “activated” microorganisms to aeration basin
- 20 – 100% of wastewater flow
- Point of return – modification specific

Waste Activated Sludge

- Removes excess microbial population to side-stream
- 1 – 20 %
- Daily change should not be more than 10 – 15%

Conventional (Plug Flow)



Conventional (Plug Flow)

Detention Time	4 – 8 hours
MLSS	1,000 – 3,000 mg/L
F:M	0.2 – 0.5
Sludge Age	3.5 – 7 days
MCRT	4 – 15 days
D.O.	1 – 3 mg/L

* 1 pound BOD removal ≈ 0.5 pounds of solids produced

Extended Aeration

Detention Time	> 18 hours
MLSS	2,000 – 5,000 mg/L
F:M	0.05 – 0.1
Sludge Age	>10 days
MCRT	>20 days

* Produces fewer solids per pound of BOD removed

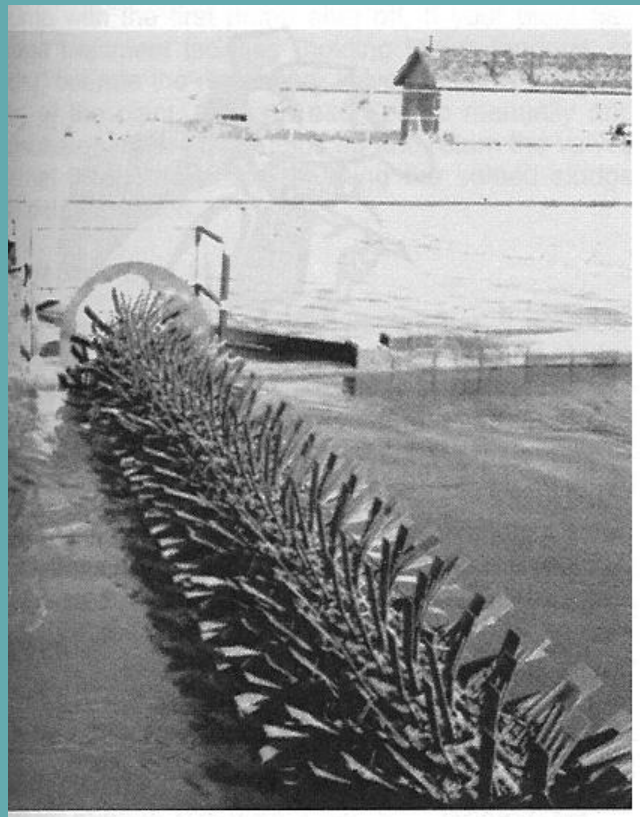
Oxidation Ditch

Detention Time	3 – 24 hours
MLSS	3,000 – 6,000 mg/L
F:M	0.03 – 0.1
Sludge Age	20 – 35 days
D.O. Levels*	0.5 – 3.0 mg/L
Velocity	1.0 – 1.5 fps (1.0 minimum)
Liquid levels**	3 – 7 feet

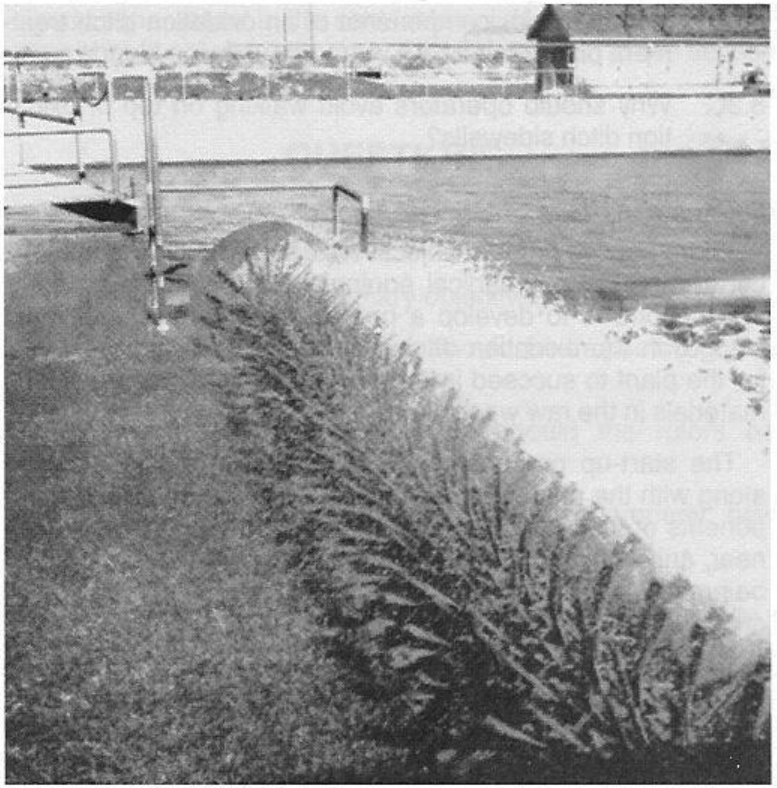
*15 feet upstream of rotor

**Level control weir

Oxidation Ditch

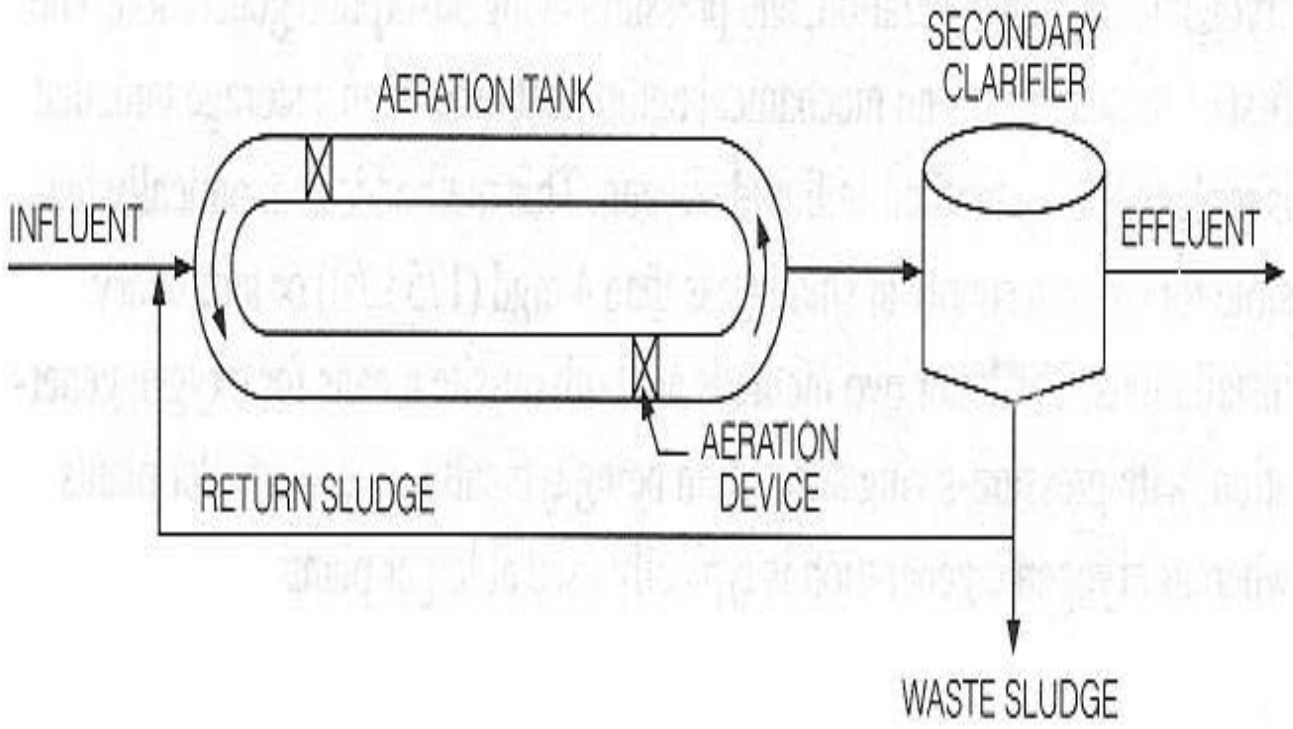


Brush rotor

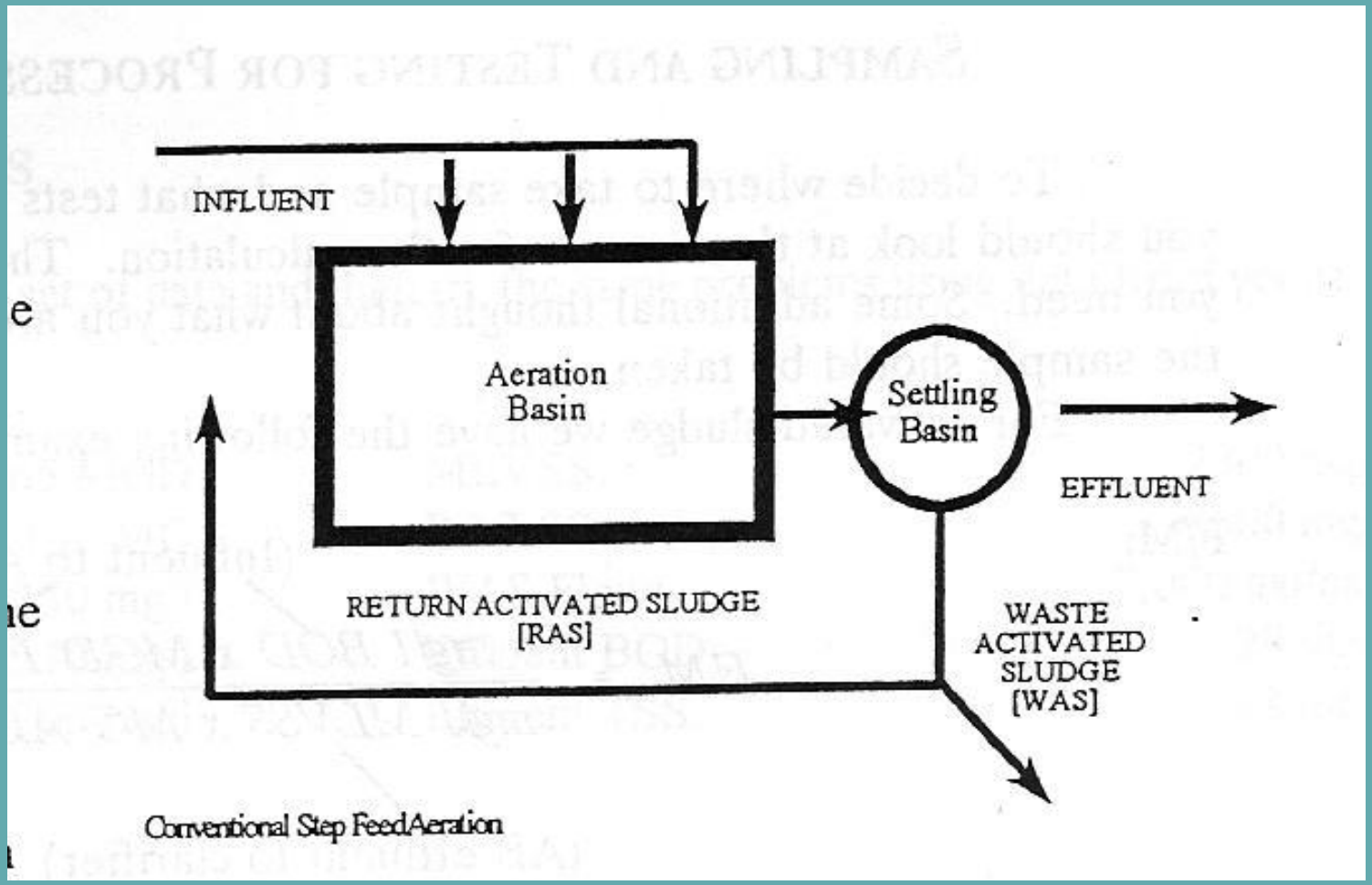


Brush rotor

Oxidation Ditch



Step Feed



Conventional Step FeedAeration

Step Feed

- Process control – same as conventional
- Even distribution of waste loads
- Reduction of oxygen sags in aeration basin
- Better handling of shock loads
- Lower solids loading on secondary clarifier
  - Useful in short term control of bulking sludge

Sequence Batch Reactors (SBR)

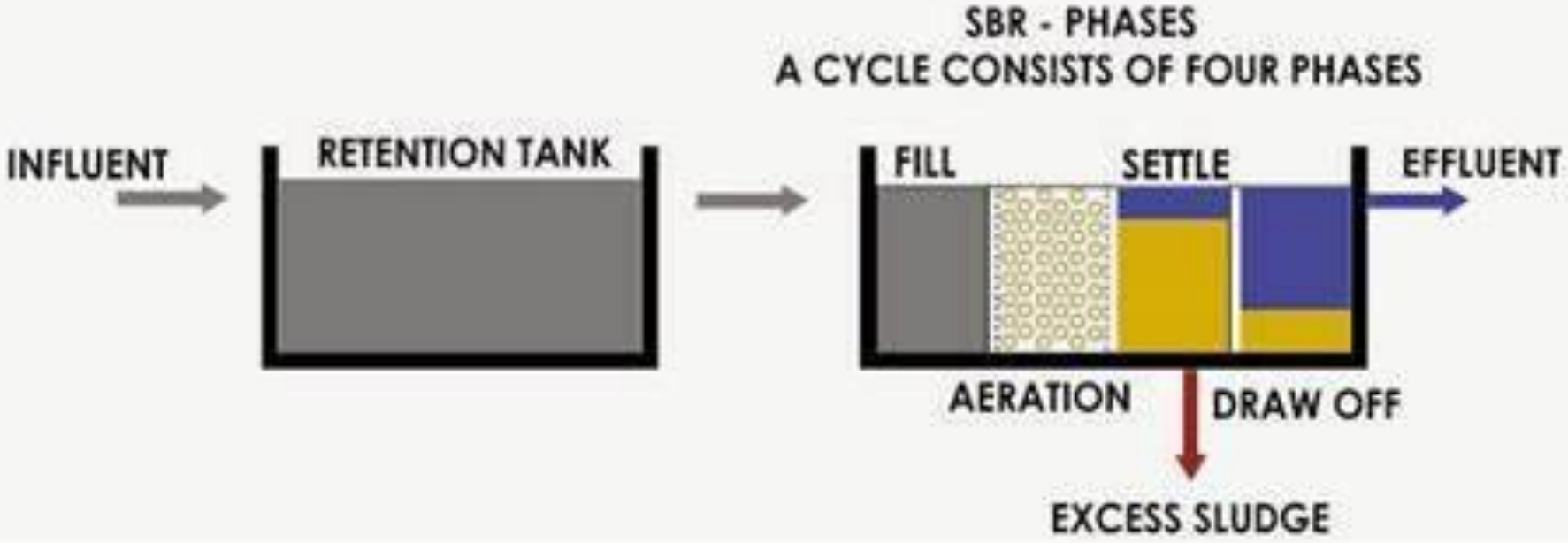
- Batch Process
- Steps
  - Fill
  - React
  - Settle
  - Draw
  - Idle

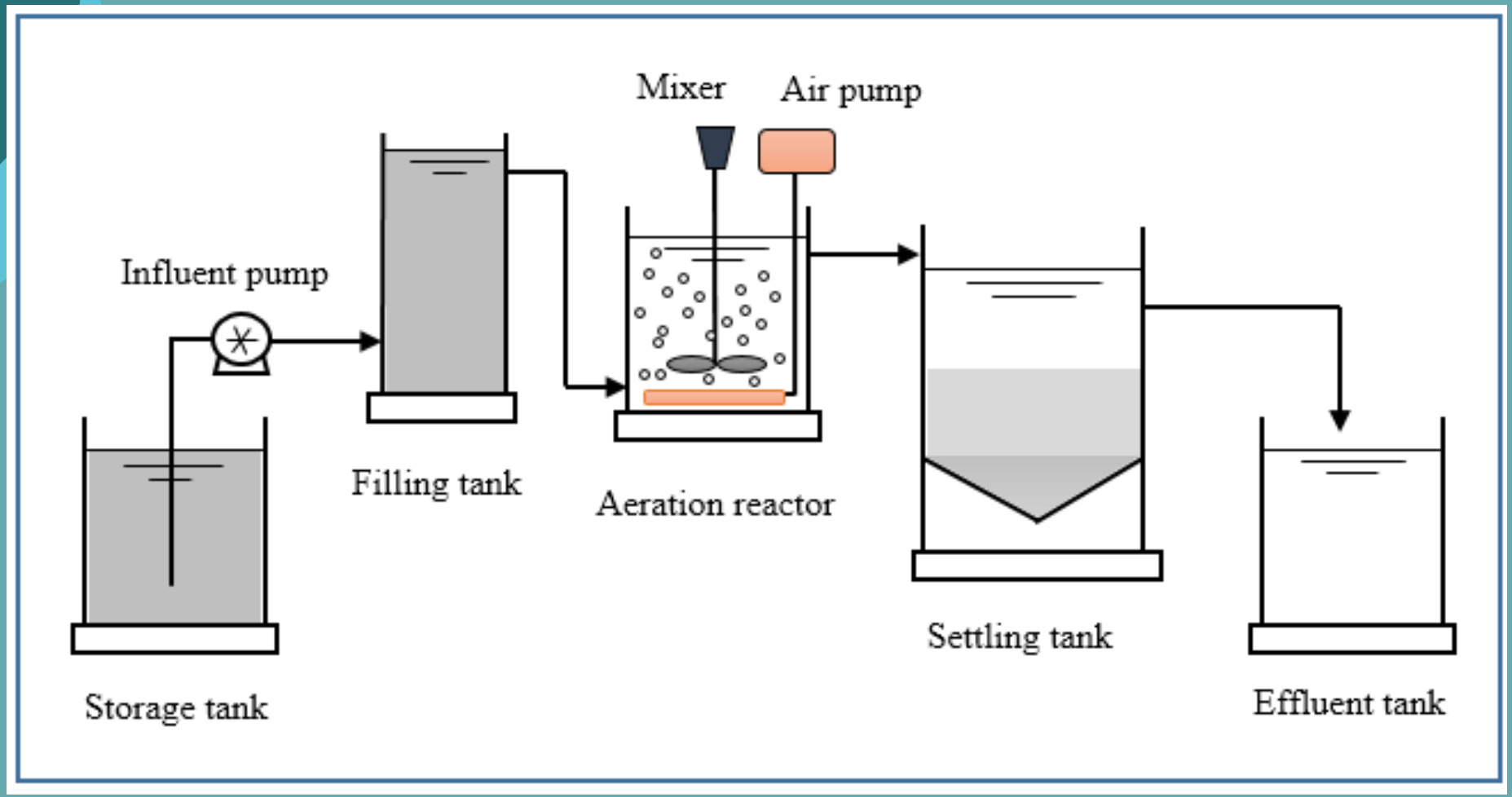
SBR

- F:M 0.02-0.05
- MLSS 2000-6000
- Operating Depth 10-20 feet
- Freeboard 1.5 feet
- Cycles/Day 2-6
- Sludge Age 25-45 days
- D.O. 1 – 3 mg/L
- BOD Removal 85 – 98%
- HRT 3.5 – 7 hours

(extended 18-36 hours)

SEQUENCING BATCH REACTOR

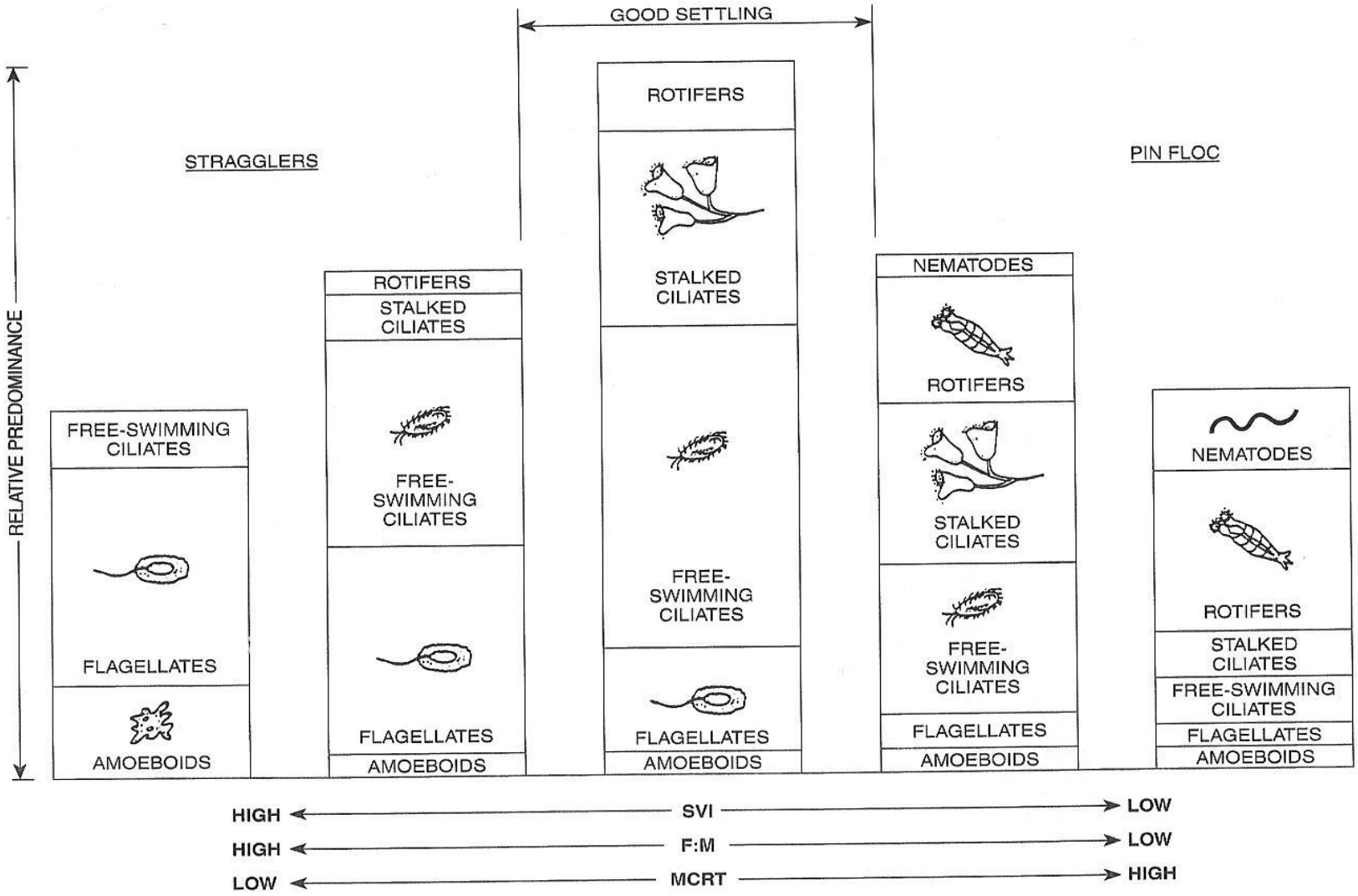



Mixer
Air pump
Influent pump
Filling tank
Aeration reactor
Settling tank
Storage tank
Effluent tank

Microbiology

- Heterotrophic Bacteria
  - Organics
    - Carbon and energy source
  - Aerobic respiration
  - microorganisms + O_2 + organics→ new cell material + energy + H_2O + CO_2 + by-products
- Autotrophic Bacteria
  - CO_2 and HCO_3^- – carbon source
  - Inorganics – energy source (minimal energy)

Predominance of Microorganisms



Young or Underoxidized Sludge

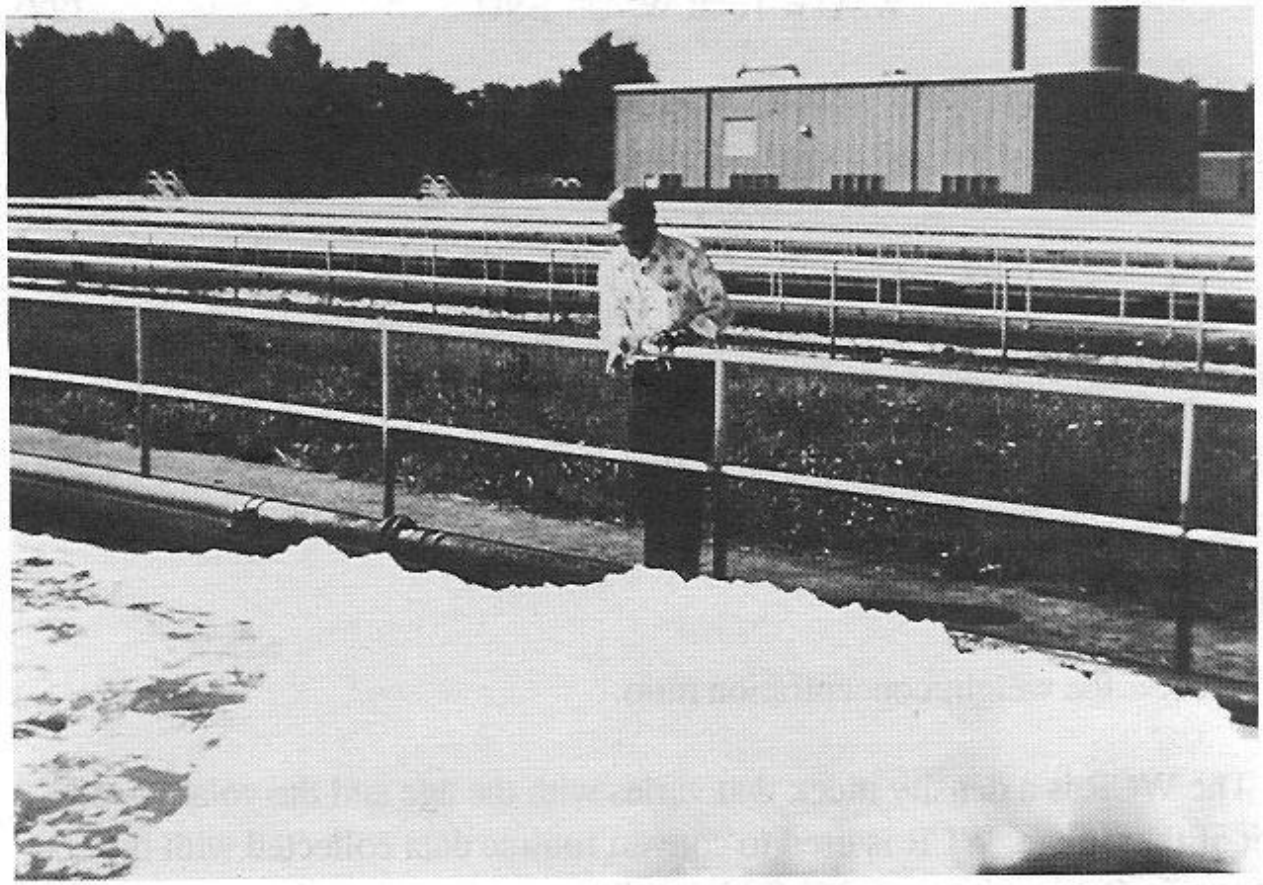


Figure 17.19 Stiff, white billowing foam: young, underoxidized sludge with voluminous, white billowing foam, caused here by excessive wasting.

Overoxidized Sludge

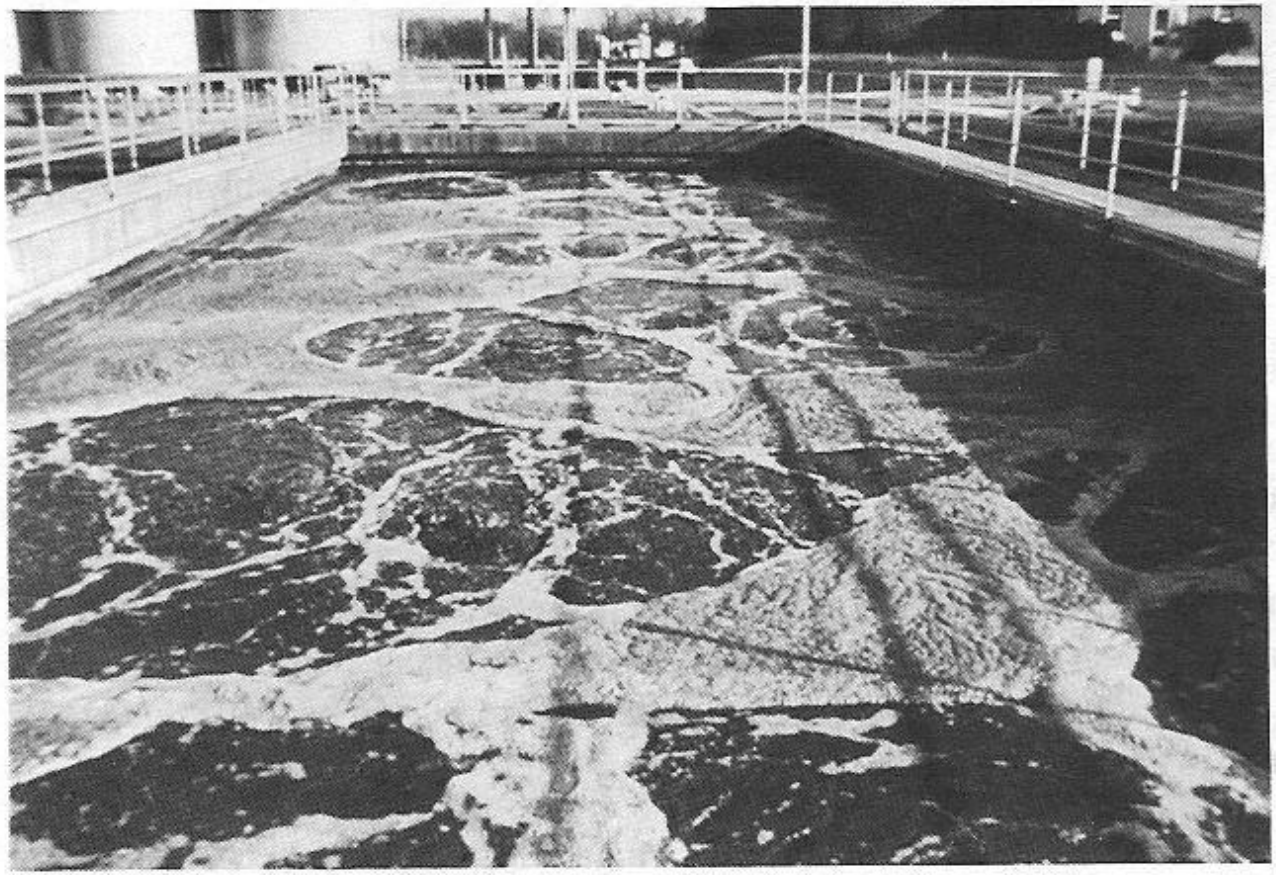


Figure 17.18 Dark brown, scummy foam: old, overoxidized sludge, caused here by insufficient wasting.

Nitrification

- Conversion of ammonia to nitrites to nitrates
- Microorganisms
  - Nitrosomonas
    - Ammonia to nitrite
  - Nitrobacter
    - Nitrite to nitrate

Nitrification Requirements

- D.O.
- pH
- Temperature
- MCRT
- MLVSS
- Alkalinity

- 1.5 – 4.0 mg/L
- 7.0 – 8.9 (not less than 7.0)
- 15º - 35 ºC (not less than 10 ºC)
- 14 – 18 days
- 1,500 – 2,000 mg/L
- 7.1 mg/L per mg/L N

(50 mg/L after nitrification)

Denitrification

- Conversion of nitrates to nitrites to nitric oxide, nitrous oxide, or nitrogen gas
- Heterotrophic bacteria (facultative)

Denitrification Requirements

Anoxic conditions	<0.1 mg/L
pH	7.0 – 9.0
Temperature	Not less than 10°C
Carbon to NO_3 Ratio	3:1

*3.6 mg/L recovery of alkalinity

Aeration Basin Color Characteristics

- Black
- Grey
- Brown
- Red Brown
- Pale Manila or Buff colored

- Septic
- Partial Septicity
- Normal – 1,800 – 4,000 mg/L
- Normal 3,000 mg/L; well aerated; 2 mg/L or >DO; good settling
- High DO; Low solids; poor settling; possible shock load and deflocculation

Help Chart

- Problems
- Causes
- Observed Effect(s)
- Possible Remedy

Safety

- Can you swim in activated sludge?
- Points of entry, bacteria
- Sounds, ears
- Reflection, eyes
- Weather, all different seasons
- Moving parts, equipment

Information

- Information on this presentation came from:
  - EPA
  - NMED
  - Pipeline nesc
  - Sacramento Study Guide
  - Internet, different sites
  - Oh, and my experience

Questions?

- Thank you for your time
- I hope that this presentation was helpful to you.

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