Wastewater Treatment (Secondary Treatment)

General plant Flow diagram

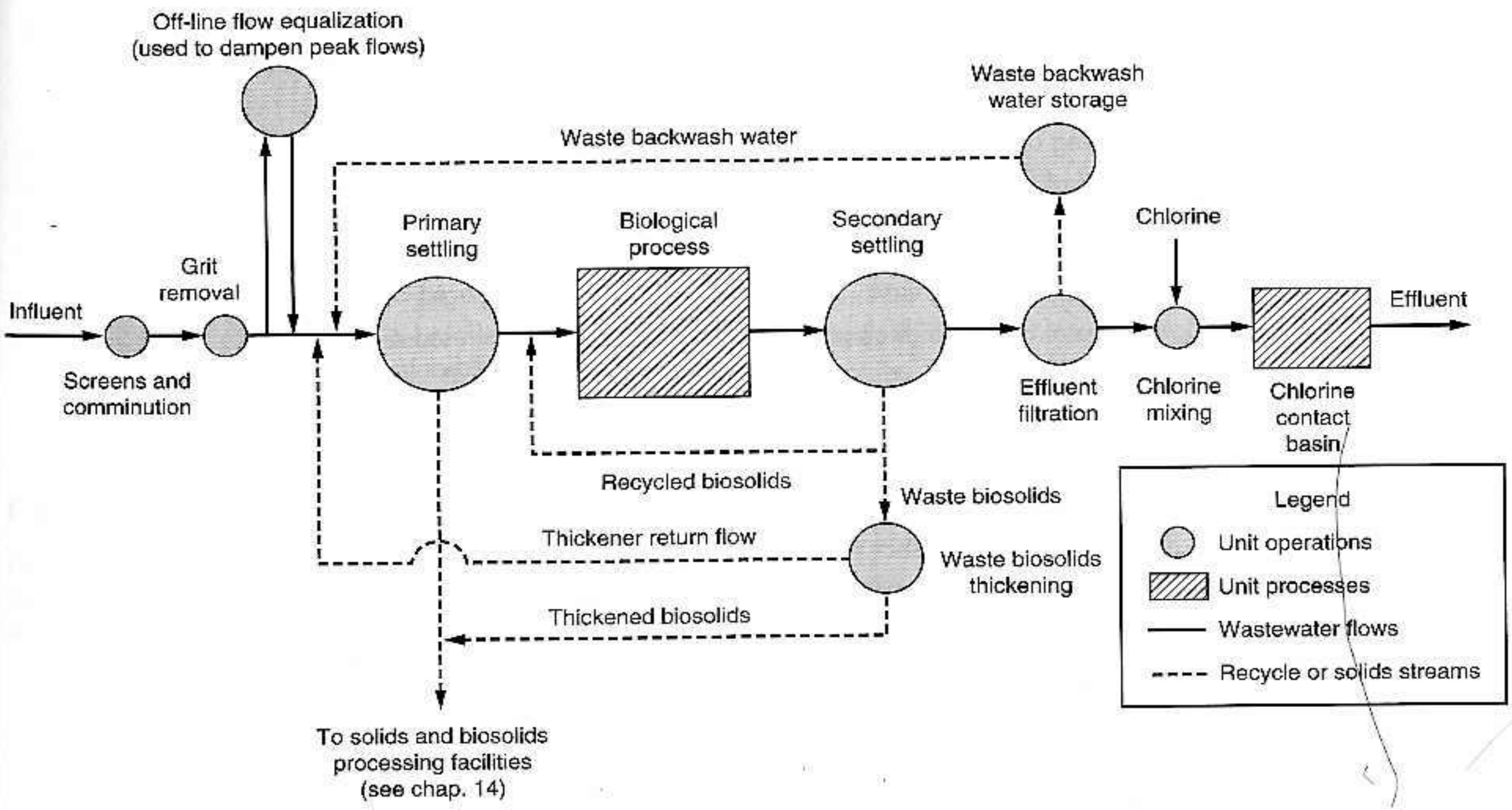


Figure 5–1

Location of physical unit operations in a wastewater-treatment plant flow diagram.

M&E (4th ed)

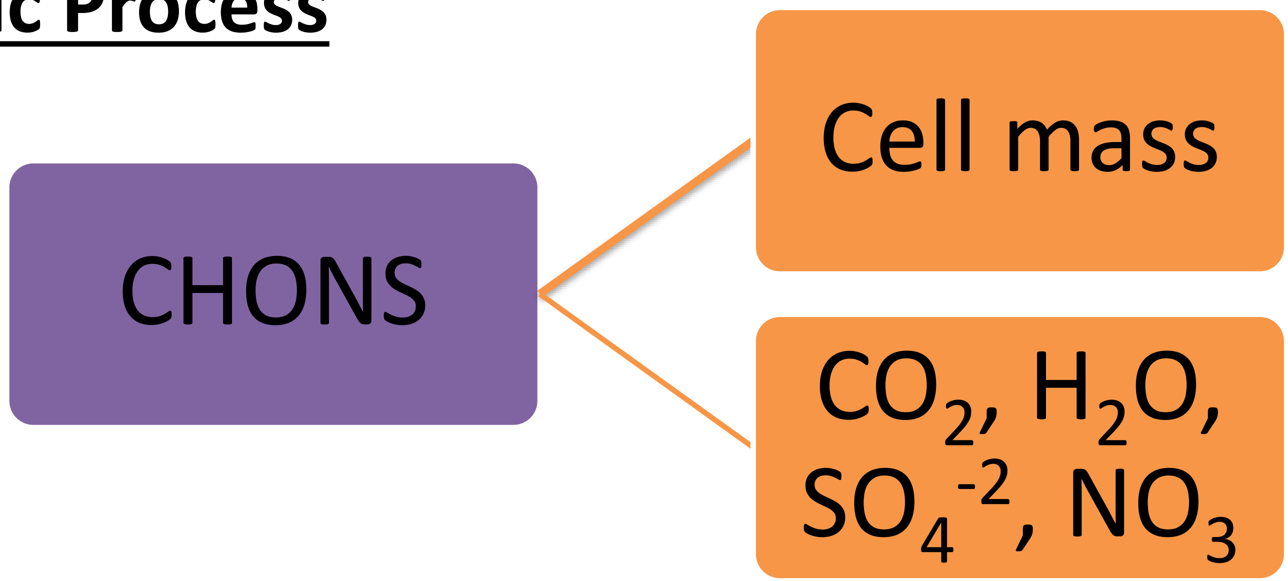
SECONDARY TREATMENT

Purpose :

- The main purpose of secondary treatment is to remove BOD which does not benefit as much as SS from primary settling.
- It is a process which is capable of biodegrading the organic matter into non-polluting end products ,e.g. Water,CO_2 and biomass.

SECONDARY TREATMENT

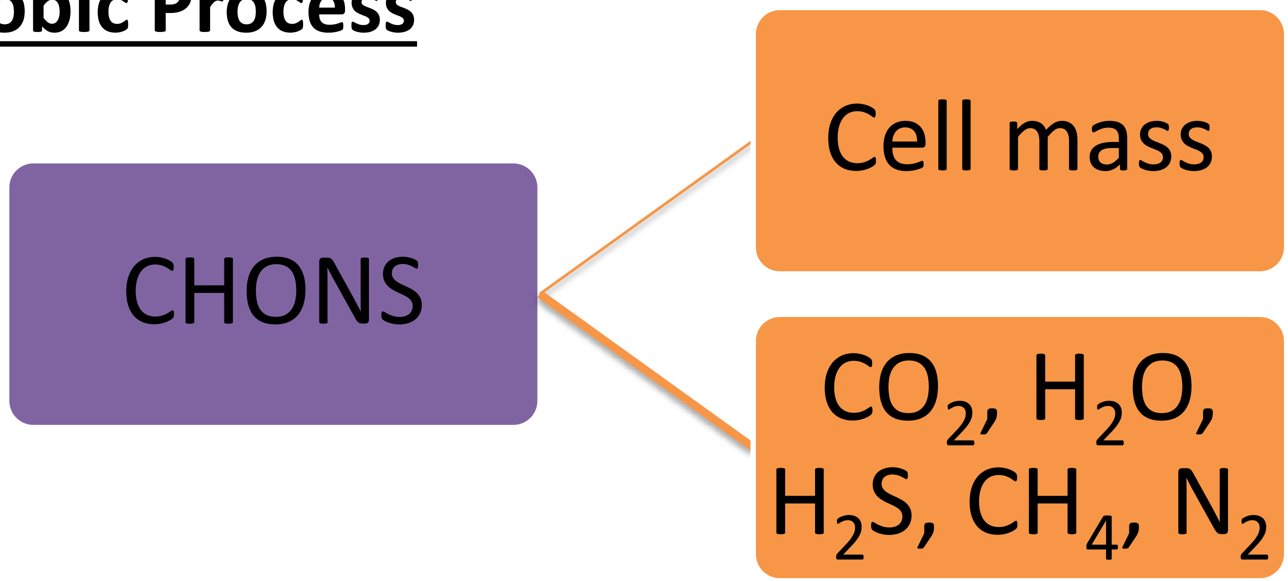
Aerobic Process



So, **more sludge** is produced in aerobic process. Bacteria that work in the presence of oxygen are Aerobic Bacteria. The bulk of available energy finds its way into Cell Mass yielding a stable effluent which will not undergo further decomposition

SECONDARY TREATMENT

Anaerobic Process



So, **less sludge** is produced in anaerobic process. Bacteria that work in the absence of oxygen are Anaerobic Bacteria. The end products of an anaerobic process are odorous (due to the formation of H2S

SECONDARY TREATMENT

Suspended growth

Suspended growth systems are defined as those aerobic processes in which the treatment is done by keeping bacteria in suspension and maintaining high microorganism concentration through the recycle of biological solids.

- Activated sludge processes
- Aerated lagoons

Attached growth

Attached growth or fixed film reactors allow a microbial layer to grow on the surface of the media while exposed to the atmosphere and wastewater is sprayed on the surface. The microbial layer converts the organic waste to biomass and by products.

- Trickling filters etc.

ACTIVATED SLUDGE PROCESS

Activated sludge

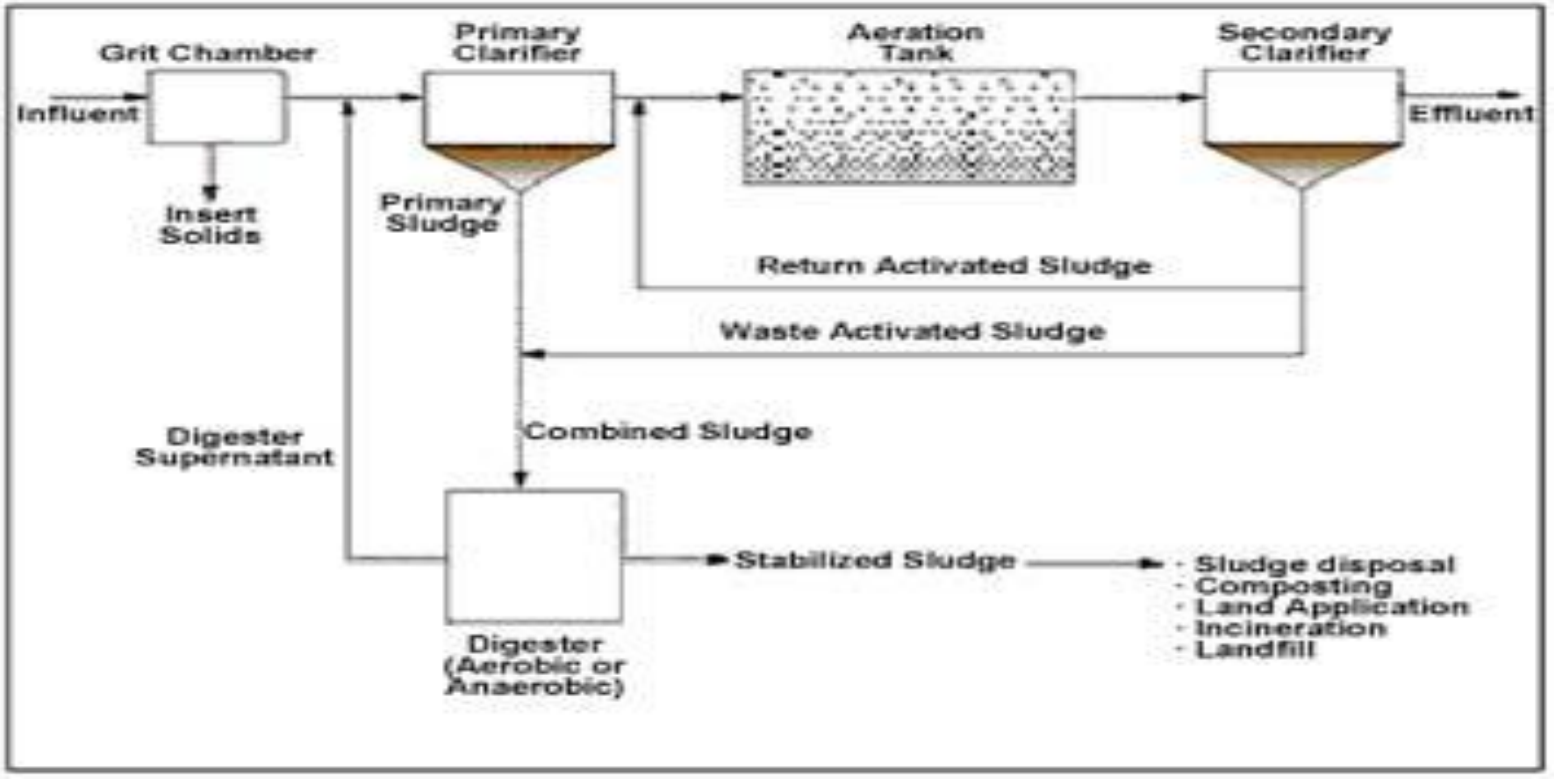
Activated sludge is a heterogeneous microbial culture/floc, composed of bacteria and other microorganisms, which is produced in a raw or settled sewage by the growth of these organisms. These flocs are centers of high biological activity and hence called activated sludge.

Mixed Liquor:

It is the mixture of sewage and activated sludge in the aeration tank.

ACTIVATED SLUDGE PROCESS

Process Description:



ACTIVATED SLUDGE PROCESS

Process Description:

- In this process, a mixture of ***Sewage*** and ***Activated Sludge*** is agitated and aerated in an aeration tank.
- Bacteria present in the activated sludge aerobically metabolize the organic matter present in the influent.
- The organic matter is oxidized to CO2, H2O, NH3 etc and a portion of it is converted into new bacterial cells.

ACTIVATED SLUDGE PROCESS

Process Description:

- The activated sludge is subsequently separated from MIXED LIQUOR by gravity in the secondary sedimentation tank (final clarifier).
- A portion of this sludge is returned to aeration tank, as needed, and rest is wasted.

SLUDGE SETTLEABILITY

- **Efficiency of ASP** depend upon the **settleability of sludge** in final clarifier (SST). The biological floc that settle by gravity leaves a clear supernatant for disposal or further (tertiary) treatment.

- However if filamentous microorganisms grow in the aeration tank, they do not settle by gravity and contribute to BOD and SS in the effluent

SLUDGE SETTLEABILITY

<u>Measurement of Sludge Setteleability:</u>

- Settling characteristics of sludge is measured in terms of sludge volume index.

<u>Sludge Volume Index (SVI):</u>

- It is the volume in mL occupied by one gram of settled suspended solids.

$$SVI = \frac{V_s \times 1000}{MLSS}$$

Where;

- Vs = Settled sludge volume (ml/L) (measured by im hoff cone. or a cylinder)
- MLSS = Mixed Liquor Suspended Solids, (mg/L) (A measure of microorganisms in aeration tank)
- ***SVI from 50 to 150 indicated good settling characteristics.***

ACTIVATED SLUDGE PROCESS

Sludge Bulking:

- Excessive carryover of flocs, resulting in the inefficient operation of final clarifier is referred to as BULKING SLUDGE.

Conditions Promoting Growth of Filamentous Microorganisms:

- Insufficient aeration
- Lack of nutrients (N,P)
- Presence of toxic substances
- Low pH
- Over loading i.e. high F:M ratio

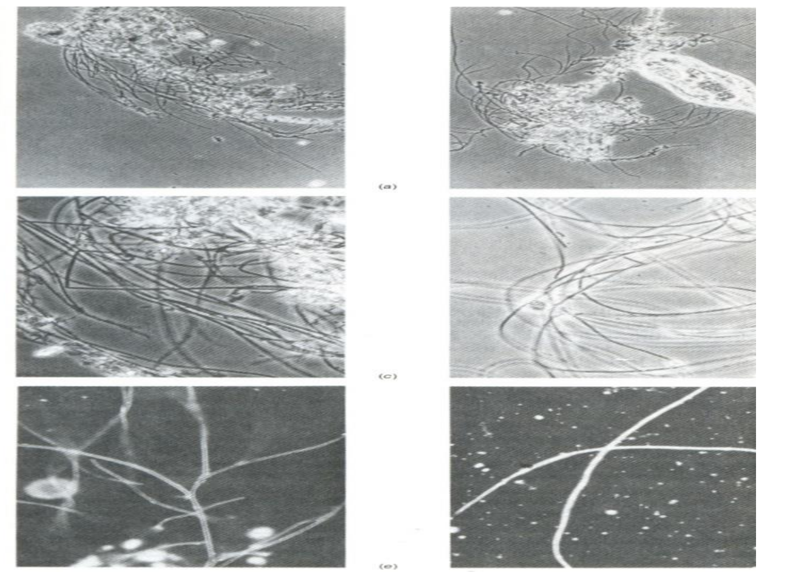


FIGURE 8-18
Typical filamentous organisms found in bulking sludge: (*a* and *b*) phase contra
contrast, 400X, (*d* and *e*) filaments of *Sphaerotilus*, phase contrast and dark fiel

Sludge Bulking:

F:M Ratio

- Food to microorganism ratio is the most useful design and operational parameter of ASP.
- This ratio controls the rate of oxidation and the mass of organisms by maintain microbial growth .
- It is expressed interms of kg of BOD applied per day per kg of MLSS
- If Q is the sewage flow in m^3/day and it has a BOD expressed in mg/L, then:

$$Food = \frac{Q \times BOD}{1000} \quad \frac{kg\ BOD}{day}$$

F:M Ratio

- If V is the volume of aeration tank in m^3 and it has an MLSS concentration expressed in mg/L, then :

$$Microorganisms = \frac{V \times MLSS}{1000}\ kg\ MLSS$$

- Therefore,

$$F:M = \frac{Q \times BOD}{V \times MLSS}\ per\ day$$

$$F:M = \frac{BOD}{t \times MLSS}\ per\ day$$

F:M Ratio

$$F:M = \frac{BOD}{t \times MLSS} \; per\ day$$

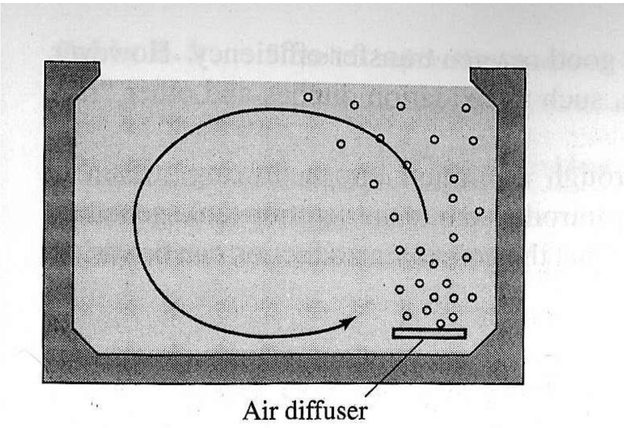
- Where, t is the aeration time in days.

- An F:M ratio between 0.25 to 0.5 per day is usually employed and promises good settling characteristic of sludge.

AERATION SYSTEMS

Diffused aerators

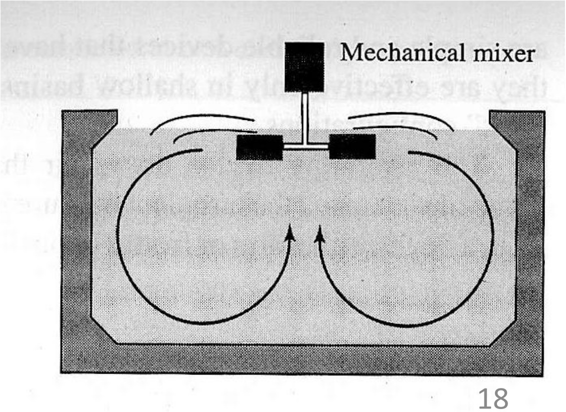
- Diffusers are generally placed in rows at 0.6 to 1 m apart at the bottom of aeration tank.
- Operation of diffusers is noise less
- Less aerosols are formed
- The size of diffuser 150 mm in diameter
- Bubble size 20 mm to 2.5 mm .



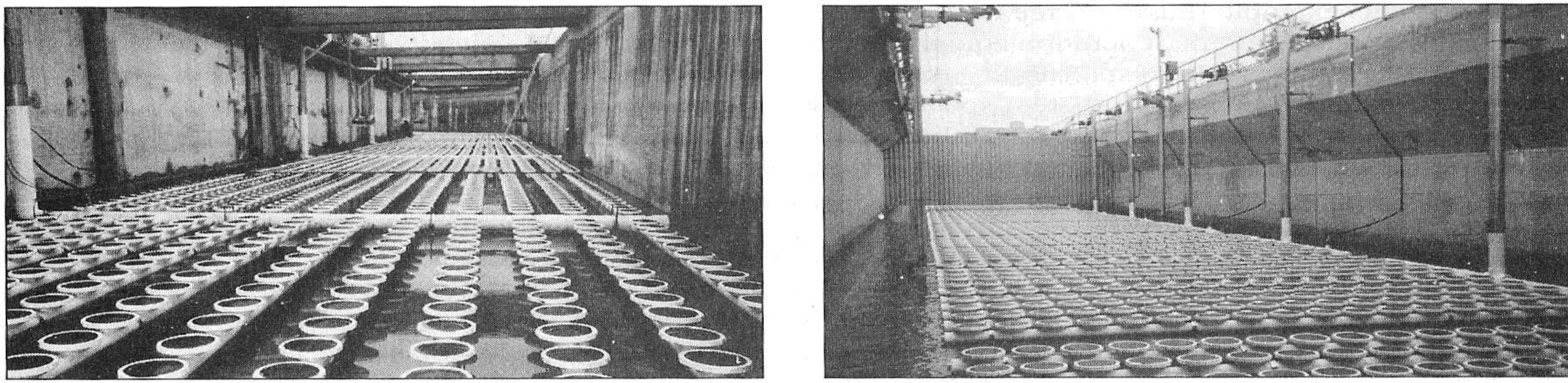
a. Diffused aeration

Surface aerators

- Mechanical surface aerators are employed in the aeration tank.
- They spin partially in and partially out of the mixed liquor.
- The mixed liquor is violently throw across the surface of the tank for adsorption of oxygen from the air. Surface aerators require less maintenance and provide visual evidence of break down.



b. Mechanical aeration



a. b

Photo 6.3 Example of porous diffusers placed throughout the tank's bottom to give good mixing. SOURCE: With permission from Sanitaire.

www.worldwidelife.org/cci/aquaculture_photos.cfm (Oct. 23, 2007)

DESIGN CRITERIA

Parameter	Value	Units
F:M ratio	0.25-0.5	Per day
MLSS	1500-3000	mg/L
Air supply	5-15	m^3 of air/m^3 of sewage
Return sludge	25-100	%
Aeration time	4-8	Hours
Dissolved oxygen level	2(minimum)	mg/L
No. of aeration tank	2	
Aeration tank dimensions: Rectangular L:W Depth	 less than 5:1 3-5	 m

Return Sludge

$$Qr/Q = Vs/(100-Vs)$$

Where,

Qr= flow of return sludge

Q=flow of sewage

Vs=Volume of settled sludge in ml

TYPES OF ACTIVATED SLUDGE PROCESS

1. Conventional (Plug Flow):

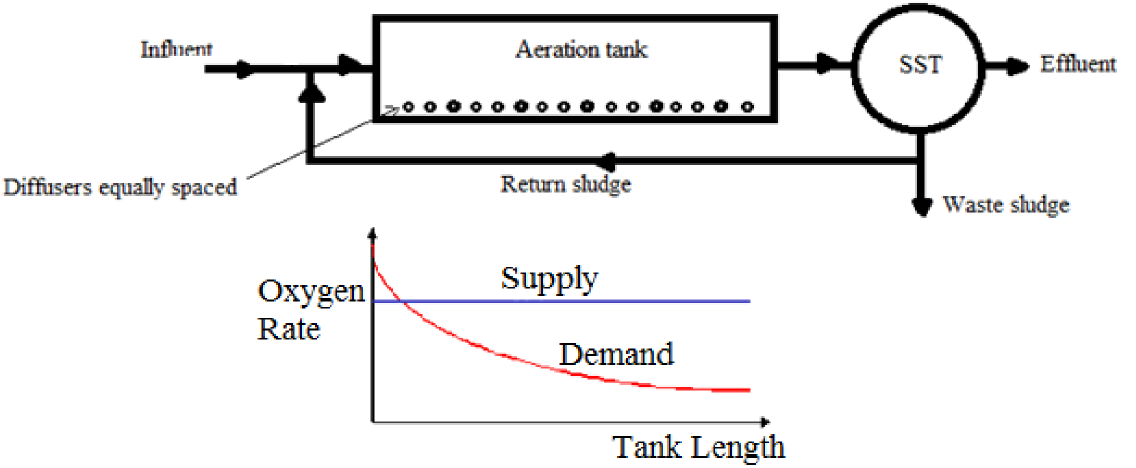


Fig: Conventional Activated Sludge Process

Disadvantages:

- F:Mratio varies as the wastewater travels in the tank.
- DO requirements become less along the length of aeration tank, but the supply is same along the length

TYPES OF ACTIVATED SLUDGE PROCESS

2. Tapered Aeration:

- The tapered aeration process attempts to match the oxygen supply to demand by introducing more air at the head end.
- This can be achieved by varying the diffuser spacing.

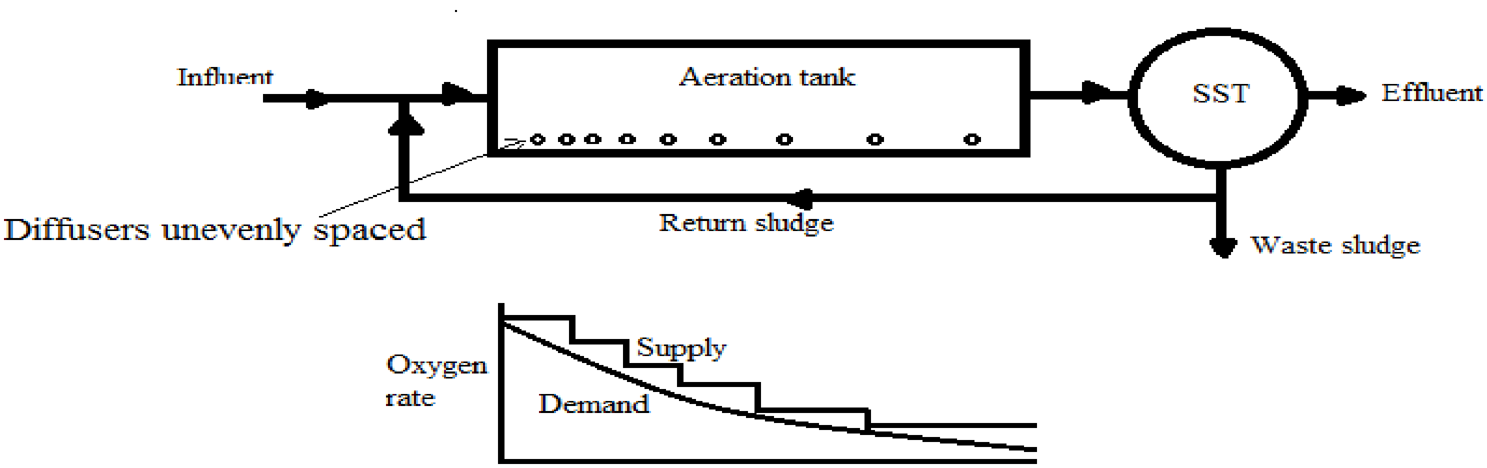


Fig: Tappered aeration activated sludge process

TYPES OF ACTIVATED SLUDGE PROCESS

3. Step Aeration Process:

- The step aeration process distributes the waste flows to a number of points along the basin, thus avoiding the locally high oxygen demand encountered in conventional or step aeration process.

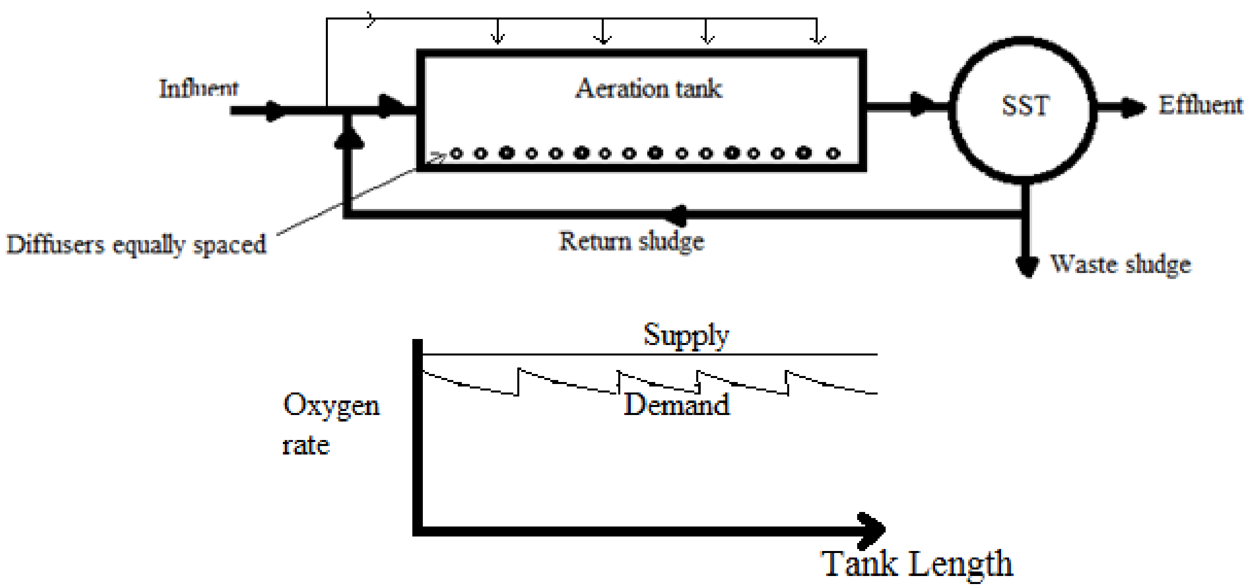


Fig: Step-aeration activated sludge Process

TYPES OF ACTIVATED SLUDGE PROCESS

4. Completely Mixed Process:

- The completely mixed process disperses the incoming waste and return sludge uniformly through the basin thus equalizing the demand and supply of oxygen.
- Completely mixed activated sludge process is effective in handling ***shock loads***.

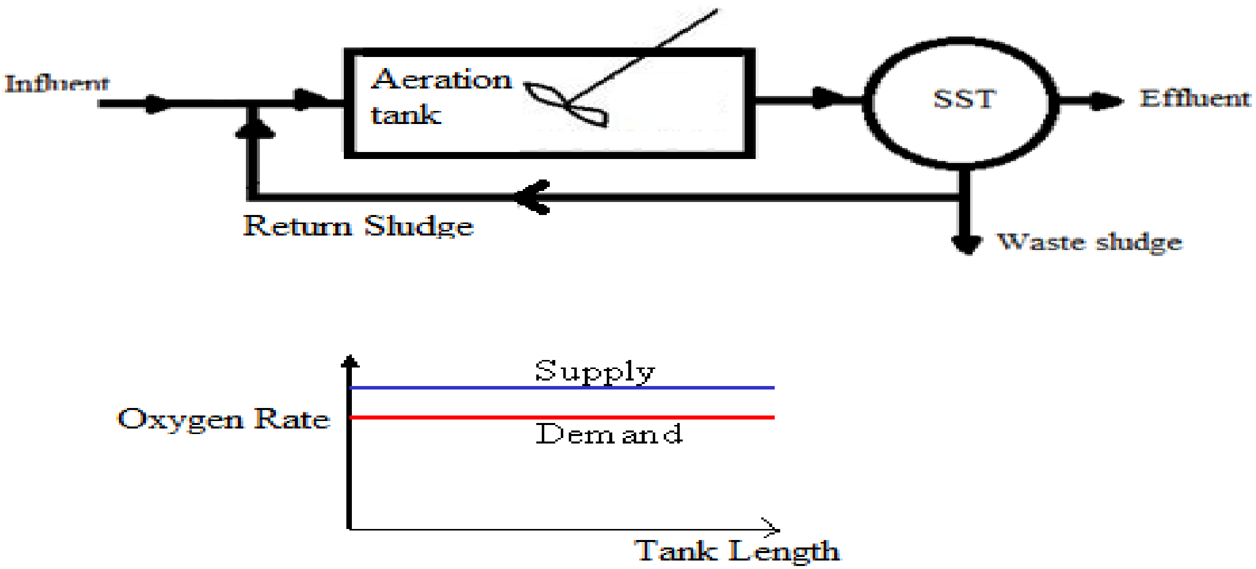
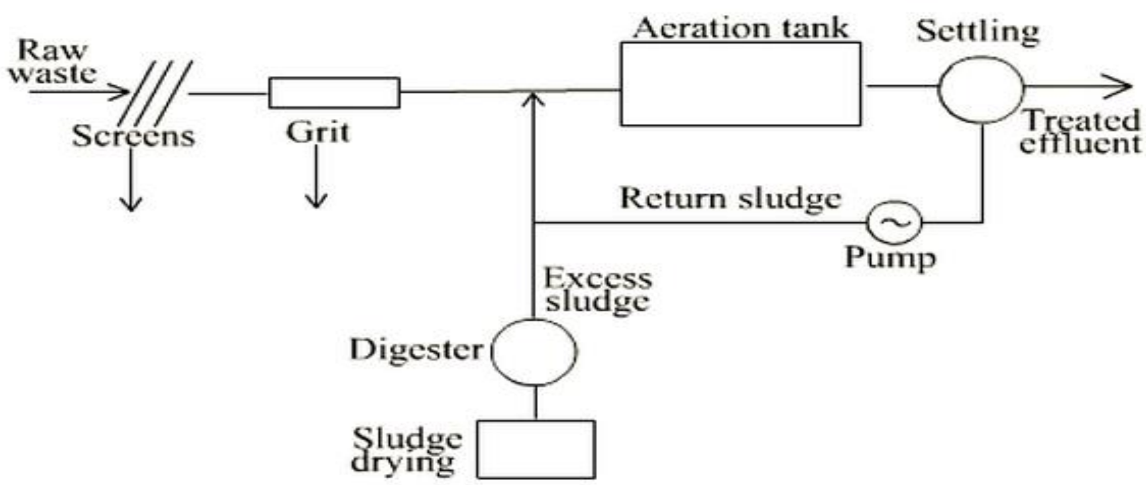


Fig: Completely mixed activated sludge process

TYPES OF ACTIVATED SLUDGE PROCESS

5. Extended Aeration Process:

- Extended aeration is a completely mixed process operated at long hydraulic detention time and high sludge age.
- Aeration is done for extended periods of time (24 to 36hrs) so that minimum substrate is left.
- Typically used for small flows.
- In many cases PST is omitted.
- Many extended aeration plants are prefabricated units(“package plants”).



TYPES OF ACTIVATED SLUDGE PROCESS

6. High Rate ASP:

- High rate process is employed when high BOD and SS removals are not required.
- High F:M ratio (> 0.5) is maintained so tank size is reduced.
- Due to high F:M ratio, biomass mostly remains in suspension in the effluent contributing to poor effluent quality.

ACTIVATED SLUDGE PROCESS

<u>OPERATIONAL CONTROLS OF ASP</u>

The basic components used in operational controls are;

- DO
- MLSS
- SVI
- F:M ratio
- Return sludge
- Microscopic examination of sludge

ACTIVATED SLUDGE PROCESS

Advantages of ASP:

- High BOD removal (upto > 95 %)
- Low land area required
- Odor free operation
- Treats industrial wastes well

Disadvantages:

- Extremely sensitive process
- Need skilled operation
- Sludge bulking problems
- High operating costs

Problems

1. Design the aeration tank for a sewage flow of 20,000m^3/day. The BOD of sewage is 200 mg/L. Adopt an F:M of 0.4 per day and MLSS concentration of 2000 mg/L.
2. An ASP with aeration tank volume of 900 m^3 is treating a sewage flow of 4000m^3/day with a BOD of 250 mg/L. It is desired to achieve an SVI of 80 ml/mg by adopting a recirculation ratio of 0.25.Calculate the FM ratio at which the aeration tank should be operated.
3. An ASP is to be design to treat a sewage flow of 6 m3/min with a BOD of 200 mg/L from the primary sedimentation tank. Using F:M ratio of 0.4 per day and MLSS concentration of 3000mg/L. Calculate the volume of aeration tank. How much sludge should be recirculated?
4. Domestic sewage flow of 8000m3/day with a BOD of 260 mg/L is to be treated by an ASP if a recirculation ratio of 0.25 and SVI of 100 is desired .Calculate the size of the aeration tank.

Problems

5. Calculate the size of aeration tank in an ASP plant treating $3m^3$/min of settled sewage with a BOD of 150 mg/L. The plant is loaded at an F:M ratio of 0.45 per day and MLSS concentration of 2500 mg/L is to be maintained. Calculate the value of SVI if the sludge recirculation ratio is 0.25.