Sheet 11

Suspended Growth System

(Activated Sludge Process)

Theory (mechanism of action):

The action takes place in activated sludge according to the following stages:

1) Flocculation: (0.5-1 hour)

تجميع البكتريا و المواد العضوية على سطح الحمأة المعادة

By accumulating organics & bacteria on surface of the returned sludge.

2) Oxidation: (6 → 16 hours)

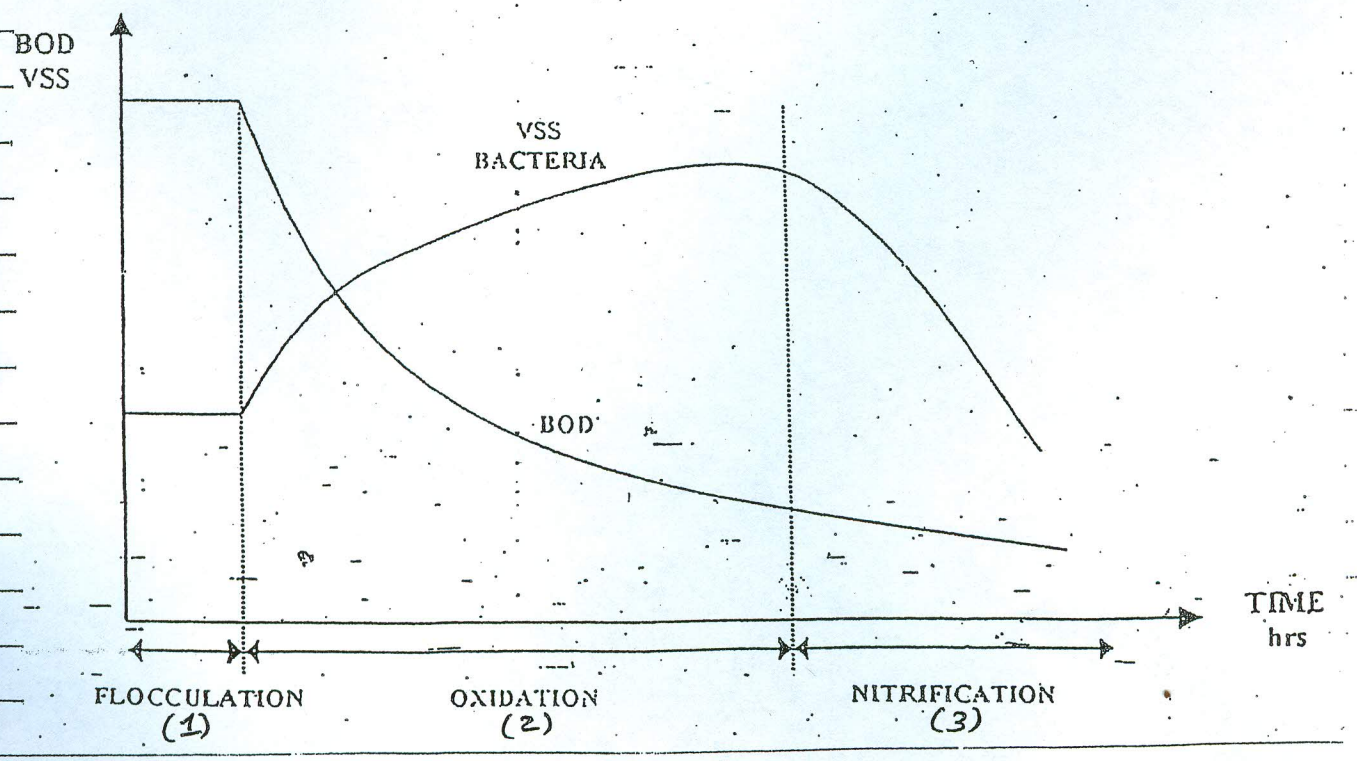
تحلل و أكسدة المواد العضوية عن طريق البكتريا الهوائية

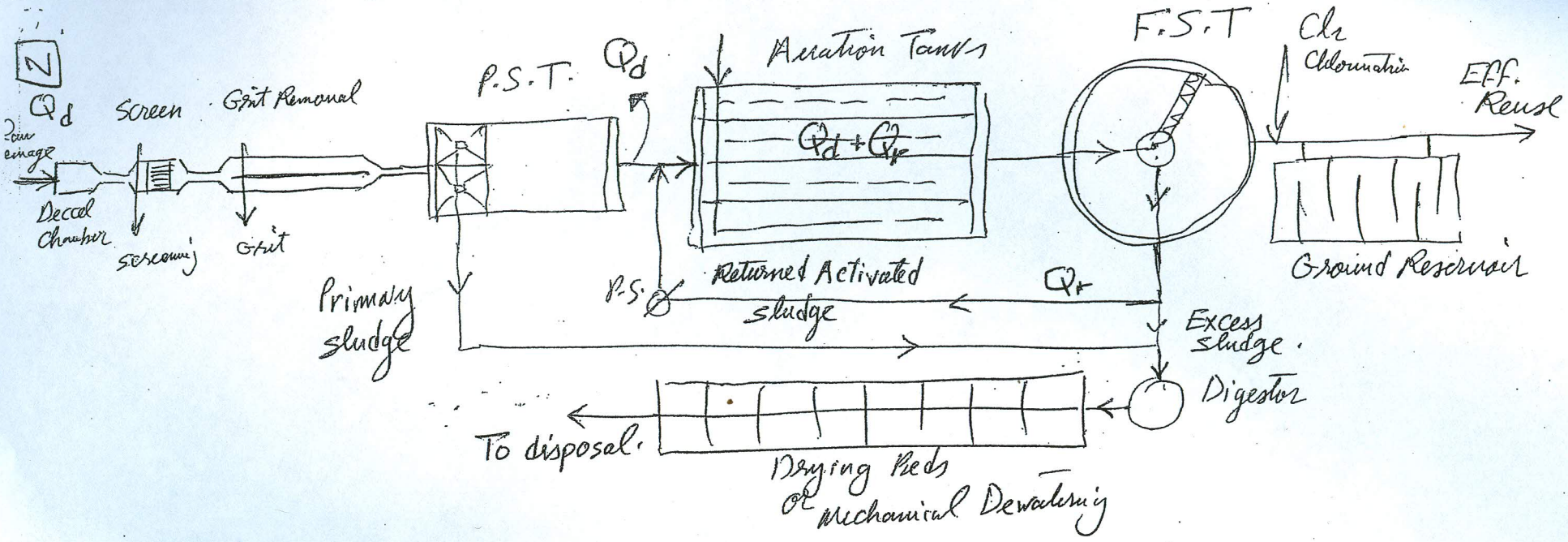
Biological oxidation of organics takes place by bacteria (aerobic action)

$$\text{Organic matter} + O_2 \xrightarrow[\text{Bacteria}]{\text{Aerobic}} \text{stable matter} + CO_2 + H_2O + \text{new bacteria}$$

3) Nitrification: (> 12 → 24 hrs)

نقص المواد العضوية يؤدي الي موت و تحلل بعض البكتريا و زيادة نسبة النيتروجين





Activated Sludge Wastewater Treatment Plant.

Aeration Methods

	Diffused air	Surface aeration
Air distribution	Uniform	Less
Mixing	Less	Better
Cost	High	Less
Operation maintenance	High	Less

Advantages of activated sludge:

- Small land area
- High BOD removal
- Control of the treatment process

Disadvantages:

- High capital and running cost
- Need for trained labors
- Sludge is more difficult to handle & treat

Factors affecting performance of activated sludge process:

1) Retention time ↑
2) F/M ratio ↓
3) Oxygen ↑
4) Sludge age ↑
5) Waste characterize ↑ (pH = 6-9).
6) Allowable organic load
7) Type of used system

Design criteria of Aeration Tanks.

- Allowable Organic Load (L) = 450 → 600 Kg BOD / 1000 m^3 / day.
- Retention Time (T) = 6 → 8 hrs.
- Depth (d) = 3 – 6 m
- Length (L) ≯ 50 m.
- Width (B) = 1.5 → 2 depth
- Number of units (n) ≥ 2.
- MLSS : Mixed Liquor Suspended Solids.
  = 1500 → 3000 mg/L. (gm/m^3).

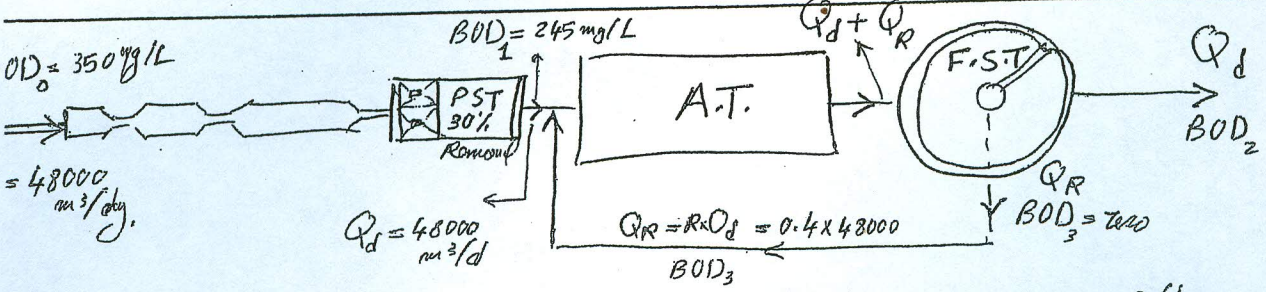
- $\frac{F}{M}$ = Food to Microorganisms Ratio
  = 0.2 → 0.5 d^{-1}
  = $\frac{T.O.L\ (gm\ BOD/d)}{MLSS\ (gm/m^3) \times Volume\ (m^3)} = \frac{L\ (gm/m^3/d)}{MLSS\ (gm/m^3)}$.

$$\frac{F}{M} = \frac{\frac{Applied\ BOD\ (mg/L) \times FLOW\ (m^3/d)}{1000}}{\frac{MLSS\ (mg/L) \times Aeration\ Tank\ Volume\ (m^3)}{1000}}$$

- Returned Sludge Ratio = 0.2 → 0.5 Q_{des}.
- Amount of Required Air = 70 → 80 m^3_{air} / Kg $BOD_{removed}$ / day.
- Overall Efficiency = 90 → 95 %.

Example: (1) Design the aeration Tanks required for a conventional activated sludge sewage treatment plant given the following data:

- Designed Flow (Q_d) = 48000 m^3/day.
- BOD of Raw Sewage = 350 mg/L.
- Returned Sludge = 0.4 of sewage flow.
- MLSS = 2000 mg/L.
- Allowable Organic Load (L) = 550 gm BOD/m^3/day.
- BOD removal in PST = 30 %.
- Air Required = 80 m^3/Kg BOD/day.



- Q_{design} = 48000 m^3/day = $\frac{48000}{24}$ = 2000 m^3/hr.
- BOD after PST = 0.7 X 350 = 245 mg/L.
- T.O.L = $Q_d \times BOD_1 + Q_R \times BOD_3$ (BOD$_3$ = zero)

$$= 48000 \frac{m^3}{d} \times 245 \frac{g}{m^3} + Q_R \times \text{zero} = 117.6 \times 10^5 \text{ gm/d.} = 117.6 \times 10^2 \text{ Kg/d.}$$

- Volume = $\frac{T.O.L}{L} = \frac{117.6 \times 10^5 \text{ g/d}}{550 \text{ g/m}^3\text{/d}} = 21381.8 \text{ m}^3$

Check:

$$T \text{ (Time)} = \frac{\text{Volume.}}{Q_d + Q_R}$$

$$= \frac{21381.8 \text{ m}^3}{(2000 + 0.4 \times 2000) \text{ m}^3\text{/hr}} = 7.64 \text{ hr.}$$

$\rightarrow$ (6 $\rightarrow$ 8 hr) $\therefore$ O.K.

Assume d = 5 m.

$\therefore$ Total Area = $\frac{\text{Volume}}{\text{depth}} = \frac{21381.8 \text{ m}^3}{5 \text{ m}} = 4276.36 \text{ m}^2$

$4276.36 = \pi \times L \times B$

Take L = 50 m, B = (1.5 $\rightarrow$ 2d) = 10 m.

$\therefore$ Number of A.T. $(n) = \frac{4 < T0.5D}{50 \times 10} \leq 8.6$

Take $n = 9$

$\therefore B_{modified} = 9.5\,m$.

Actual $\Longrightarrow$ $n = 9$ & $L = 50\,m$ & $B = 9.5$ & $d = 5\,m$.

Check:

$$\frac{F}{M} = \frac{T.O.L}{MLSS \times Volume} = \frac{L}{MLSS} = \frac{550\ g/m^3/d}{2000\ g/m^3}$$

$$= 0.275\ d^{-1}$$

$\longrightarrow (0.2 \longrightarrow 0.5) \therefore O.K.$

Air Required:

$$Q_{Air\ Req.} = 80\ m^3/Kg\,BOD/d \times TOL\ Kg\,BOD/d$$

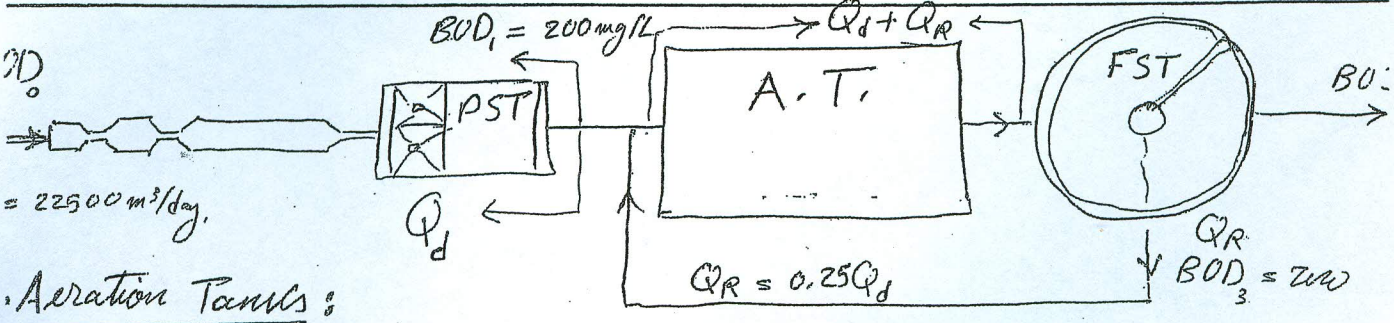
$$= 80\ m^3/Kg\,BOD/d \times 117.6 \times 10^3\ Kg/d = 9408 \times 10^3\ m^3_{\text{هواء}}/day$$

$$= 653\ m^3_{\text{هواء}}/min$$

Example (2):

Design a conventional activated sludge process facilities to treat 22500 m^3/day of settled wastewater, containing 200 mg/L BOD after primary treatment. Assume the following conditions are applicable:-

- $\frac{F}{M}$ ratio = 0.2
- MLSS = 3000 mg/L.
- Returned sludge = 0.25 of design sewage flow.
- Air Required = 100 m^3_{air} / Kg $BOD_{removed}$ / day.
- Retention Time for F.S.T = 3 hrs.
- SLR for F.S.T $\neq$ 30 $m^3/m^2/day$.



= 22500 m^3/day.

- Aeration Tanks:

$$\frac{F}{M} = \frac{\text{Applied BOD (mg/L)} \times \text{Flow } (m^3/d) / 1000}{\text{MLSS (mg/L)} \times \text{Aeration Tanks Volume } (m^3) / 1000}$$

$$0.2 = \frac{200 \times 22500 / 1000}{3000 \times V\ (m^3) / 1000}$$

$\therefore$ Volume (V) = 7500 m^3.

- Assume depth d = 5 m. $\therefore$ Total Area = 1500 m^2
  Width B = 7.5 m. $n \times L \times B$ = 1500 m^2
  choose L = 50 m. $\therefore n \Longrightarrow 4$

Check: T (Detention Time) = $\frac{\text{Volume}}{Q_d + Q_R} = \frac{7500\ m^3}{1.25 \times 22500\ m^3/hr} \times 24$ hr.

= 6.4 hr.

Check :

$$\text{Allowable Organic Load (L)} = \frac{\text{T.O.L}}{\text{Volume}}$$

$$= \frac{22500\ m^3/d \times 200\ gm/m^3}{7500\ m^3}$$

$$= 600\ g\ BOD/m^3/d. \quad \therefore O.K.$$

Air Required :

$$\text{Air Quantity} = 100\ m^3/Kg\ BOD/d \times \text{T.O.L Kg BOD/d.}$$

$$= 100 \times (22500\ m^3/d \times 0.2\ Kg/m^3)$$

$$= 450000\ m^3_{air}/day.$$

$$= 312.5\ m^3_{air}/min.$$

Final Sedimentation Tanks :

$$Q_{d_{FST}} = Q_d + Q_R = 1.25 \times 22500\ m^3/d$$

$$= 28125\ m^3/d.$$

$$= 1171.9\ m^3/hr.$$

$$\text{Volume} = Q \times \text{Time}$$

$$= 1171.9\ m^3/hr \times 3\ hr$$

$$= 3515.7\ m^3.$$

Assume depth = 3 m

$\therefore$ Total Area = 1172 m^2.

$\therefore$ Assume n = 4 units

$\therefore$ a = 293 m^2.

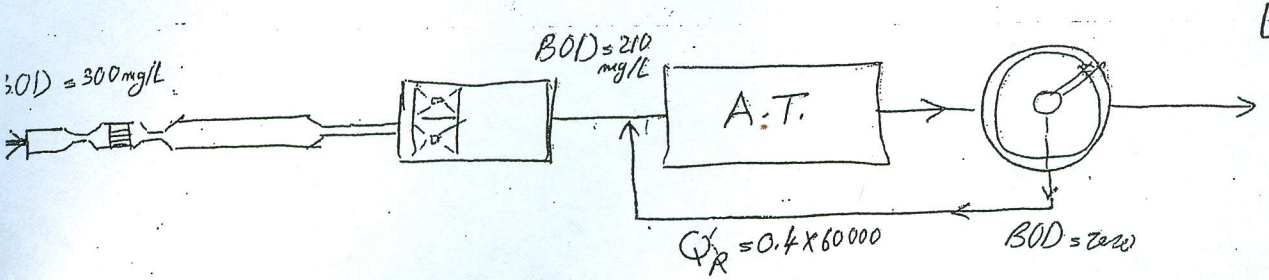
$\therefore$ choose 4 @ 19.5 m.

Check SLR :

$$S.L.R = \frac{Q\ m^3/day}{\text{Total Area}\ (m^2)}$$

$$= \frac{1.25 \times 22500\ m^3/day}{1172\ m^2} = 24\ m^3/m^2/dy.$$

$< 30\ m^3/m^2/dy$



$Q_{des.}$ = 60000 m^3/day = $\frac{60000}{24}$ = 2500 m^3/hr.

BOD after PST = 0.7 × 300 = 210 mg/L.

T.O.L = 60000 × 210 + Q_R × zero = 126×10^5 gm/d.
= 126×10^2 kg/d.

Volume = $\frac{T.O.L}{L}$ = $\frac{126 \times 10^5 \text{ gm/d}}{450 \text{ gm/m}^3\text{/d}}$ = 28000 m^3.

Check: T (Time) = $\frac{\text{Volume}}{Q_d + Q_R}$

= $\frac{28000 \text{ m}^3}{(2500 + 0.4 \times 2500) \text{ m}^3\text{/hr}}$ = 8 hr.

∴ O.K

Assume depth = 5 m.

Total Area = $\frac{\text{Volume}}{\text{depth}}$ = $\frac{28000 \text{ m}^3}{5 \text{ m}}$ = 5600 m^2.

∴ 5600 m^2 = n × L × B

Take L = 50 m & B = (1.5 → 2d) = 10 m

NO. of A.T. (n) = $\frac{5600}{50 \times 10}$ = 11.2.

Take n = 12.

∴ $B_{modified}$ = 9.3.

∴ Actual ⟹ n = 12 & L = 50 m & B = 9.3 m & d = 5 m.

Check: $\frac{F}{M}$ = $\frac{T.O.L}{MLSS \times Volume}$ = $\frac{L}{MLSS}$ = $\frac{450 \text{ g/m}^3\text{/d}}{2000 \text{ g/m}^3}$

= 0.225 d^{-1} ≈ O.K

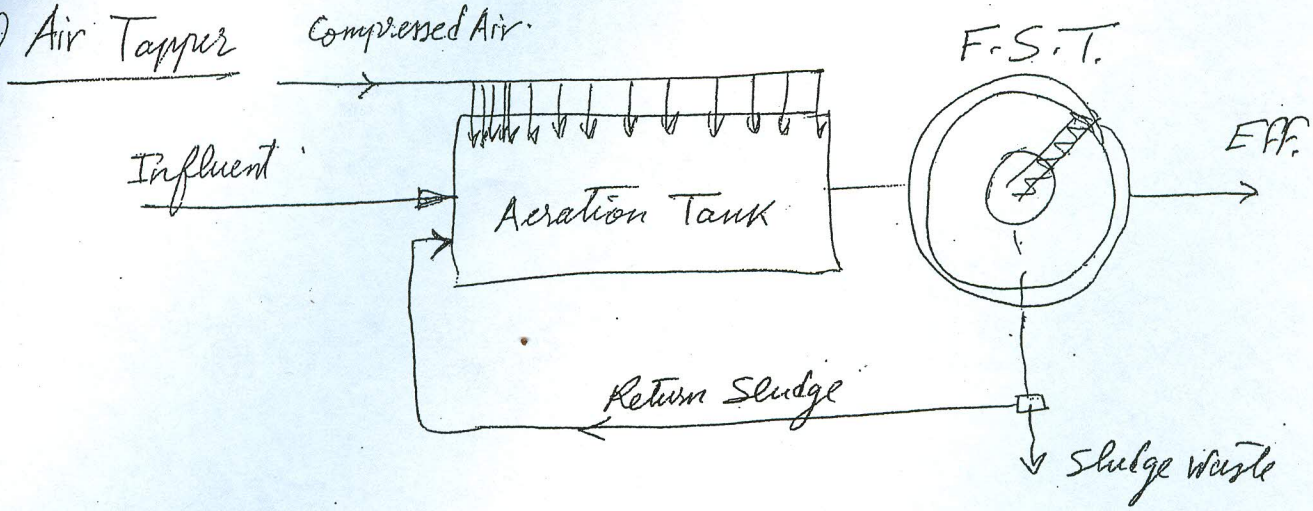
Air Req.: Q_{Air} = 80 m^3/Kg BOD/d × 126×10^2 Kg/d = 10080×10^2 m^3/day

= 700 m^3/min

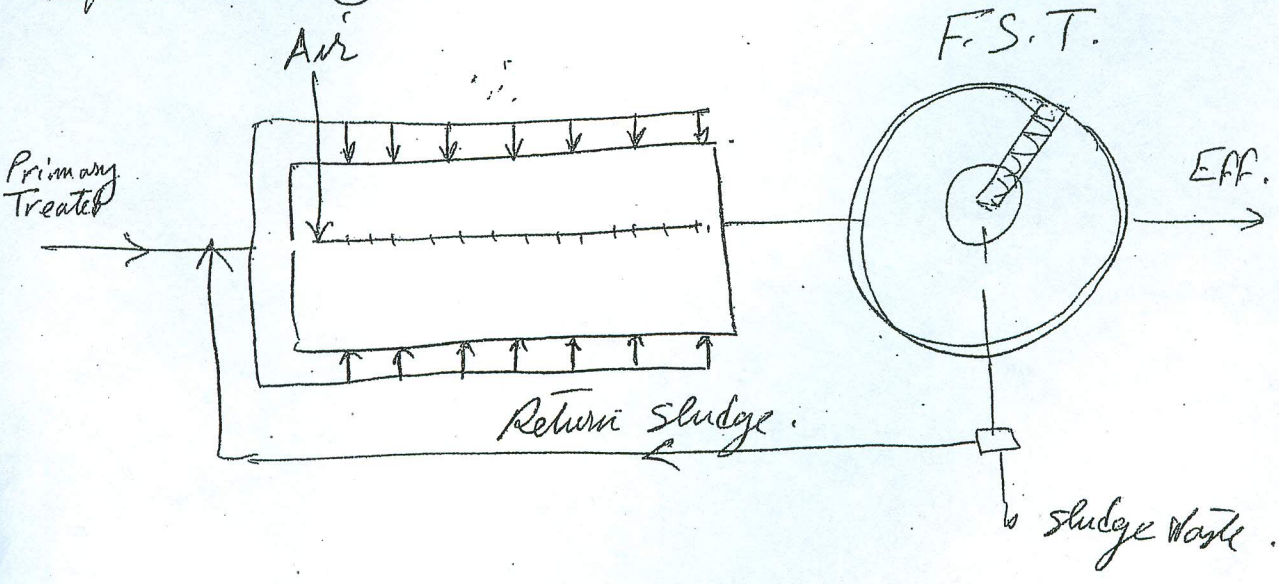
Modifications of Activated Sludge Process

(1) Step Aeration

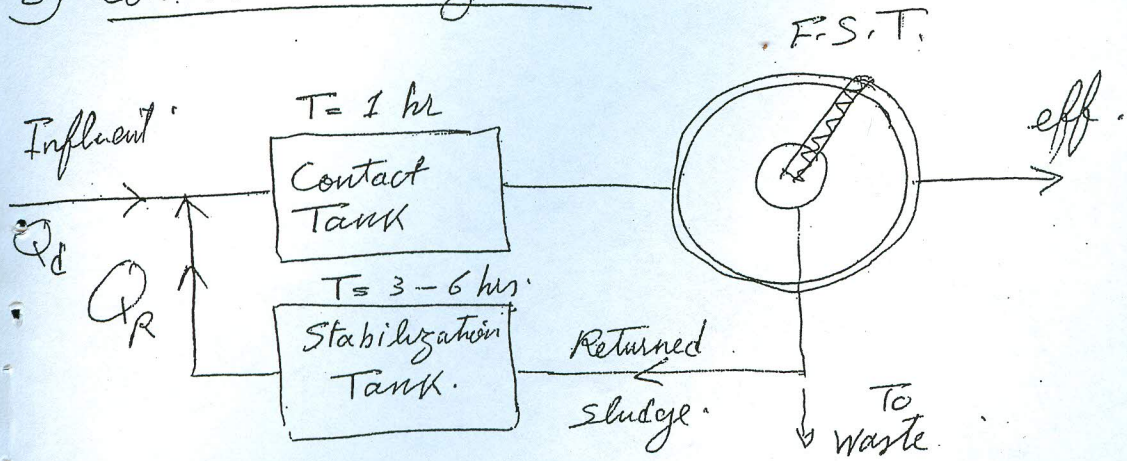
(a) Air Tapper



(b) Influent Stepping



② Contact Stabilization



③ Extended Aeration