22/7/..

Sewage charactezistics

* sewage (waste) based on where it is corning from

Industrial

domestic

commercial

* Generally

→ organic ⇒ which is decomposed : nitrogen etc

→ Inorganic ⇒ Grit .

→ Living organisms ⇒ bacteria, fungi etc., bacteria converts complex organic compounds to simple inorganic compounds

* physical charactezistics

① colour : Grey, when sewage get decomposed then it appears dark black

② odour : H_2S → musty odour

③ Temperature of sewage :- 20°c, if it combines the industrial waste then temperature increases

If it raises 60° then te bacteria ~~kills~~ dead. So decomposition is not possible

④ Turbidity :- passing of light into water

⑤ Totalsolids :-

suspended ⟨ settleble solids / non settleble solids (10^3 to 10^0)

collidal → (Dia of the particle : 10^{-1} to 10^{-3})

Dissolved → (Dia of te particles : 10^{-3} to 10^{-5})

→ suspended

These are measured by Imhoff cone

least of dimension is (50ml)

1 litre capacity of cone

The soil is kept in cone for 2 hours so the soil is settled at bottom of the cone.

Total & volatile solids

↓ ↓

$\frac{w_2 - w_1}{v} \times 100$ $\frac{w_2 - w_3}{v} \times 100$

* Chemical characteristics:-

Fresh sewage is in the form of alkanity (base)

→ pH : potentiometer, pH paper

→ chlorides : silver nitrate is used

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→ nitrate : 5 types

1) Organic nitrogen → jedhal method
2) Ammonia → water + nitrogen
3) Nitrates } → cholorometric method
4) Nitrites } These are formed due to partial decomposition
5) Alubumiod nitrogen

→ Dissolved oxygen : for living aerobic → 4 to 8 ppm

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Biological oxygen demand (BOD):-

oxygen demand required decomposition of organic matter

BOD → 20°c, 5 days ; $BOD_5^{20°c}$ 5 → days
20°c → temperature

2 methods

→ Direct method } now a day 28°c, 3 days is used
→ Dilution method }

→ organic matter (carbon nitrogen)

→ carbonaceous matter : first stage of BOD

→ nitrogeous matter : second stage of BOD

* First stage of BOD:-

organic matter is directly proportional to micro organisms)

(OM $\propto$ micro organisms)

$$\frac{dL}{dt} \propto t$$

$$\frac{dt}{dt} = -KL$$

$$\frac{dL}{L} = -K dt$$

Apply integration on both sides

$$\int_0^{t_q} \frac{dL}{L} = -\int K dt$$

$$\log_e L \Big]_0^{t_q} = -Kt$$

$$\log_e(t_q - L_0) = -Kt \qquad \log($$

$$\log_e\left(\frac{L_t}{L_0}\right) = -Kt$$

$$\frac{L_t}{L_0} = e^{-Kt}$$

$$L_t = L_0 e^{-Kt}$$

L_0 → ultimate BOD

K → deoxidation constant

$$y_t = L_0 - L_t$$

$$y_t^{20^\circ} = L_0(1 - e^{-Kt})$$

If $y_5^{20^\circ}$, K_{20°

$$K_T = K_{20^\circ}(1.047)^{(T-20^\circ)} ~~(T-20^\circ)~~$$

If $y_5^{30^\circ}$, K_{x°

* find the rate constant at a temperature of 30° If the value at 20° is 0.12/day

$K_{20°} = 0.12/\text{day}$

$K_T = K_{20°} (1.047)^{T-20°}$

reoxidation
1.106

$K_{30°} = K_{20°} (1.047)^{30-20°}$

$= 0.12 (1.047)^{10°}$

$= 0.189$

* For $BOD_5^{20°}$ of a sewage is 220 mg/lit. Determine $BOD_5^{30°}$ assume $K_{20} = 0.12/\text{day}$

Given data

$BOD_5^{20°c} = 220 \text{ mg/lit}$

$K_{20} = 0.12/\text{day}$

$BOD_5^{30°c}$

$BOD = y_5^{20°} = L_0 (1 - e^{-Kt})$

$\Rightarrow 220 = L_0 (1 - e^{-0.12 \times 5})$

$L_0 = 487.6$

$BOD = y_5^{30°} =$ ~~487.6 (1-~~

$K_{30} = K_{20} (1.047)^{30°c - 20°c}$

$= 0.12 (1.047)^{10°}$

$= 0.189/\text{day}$

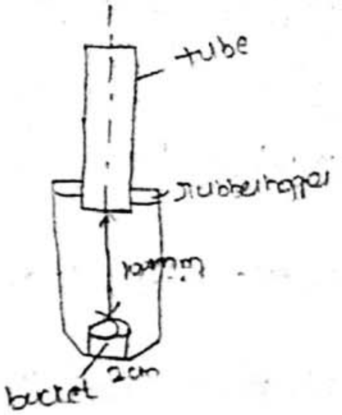
$$BOD = y_5^{30^\circ} = L_0(1-e^{-Kt})$$

$$= 487.6(1-e^{-(0.189)(5)})$$

$$= 487.6(1-0.388)$$

$$= 298 \text{ mg/lt}$$

<u>sampling tube</u>



24 hrs – 24 samples

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* COD:- → chemicals

3 hours

some amount of

Decomposition of fats, lignin, organic & (inorganic substance

potassion dichromate ($K_2Cr_2O_7$) + H_2O.

It consumes more oxygen than BOD

It is easy process

* ~~TOD~~ :- THOD :-

[find ~~the~~ rate constant at a temperature of 30°, If its ~~value~~ at 28 is ~~0.42/day~~].

* During BOD test conducted on a 5% dilution of waste, the following observation were taken.

i) DO (Dissolved oxygen) of aerated water used for dilution = 3.6 Mg/Lr

ii) DO of original sample = 0.8 Mg/Lr

iii) DO of diluted sample after 5 day incubation is 0.7 Mg/Lr

compute i) Five day BOD ii) ultimate BOD

Assume Deoxidation constant test temperature has 0.12 (base 10)

Dilution = 5% of waste

5% → dilute
95 → aerated water

Aerated water (DO) = 3.6 Mg/Lr

original waste water (DO) = 0.8 Mg/l

Final DO after decomposition = 0.7 Mg/l

$$\text{DO for test specimen} = \left(0.8 \times \frac{5}{100}\right) + 0.95 \times 3.6$$

$$= 3.46$$

$$\text{oxygen consumed} = 3.46 - 0.7$$

$$= 2.76 \text{ Mg/l}$$

$$\text{BOD}_{\text{for 5 days}} = \text{oxygen consumed} \times \text{dilution factor}$$

$$= 2.76 \times \frac{100}{5}$$

$$= 55.2 \text{ Mg/l}$$

Cd

8/8/17.

Treatment method :-

* unit processor → only sedimentation
↓
physically

* unit operation → By adding chemicals,
↓
Biologically

* Methods → ① priliminary :- screens, grit chamber, skimming tank
large bodies ↓ sand, soil ↓ oil, greese ↓

Comminutors, floatation
grinding

Screes :- coarse : > 50mm
medium : 50 to 20mm
fine : < 20mm

Bar Racks : inclinedly placed (angle - 45°)

② primary treatment :-

→ sedimentation with coagulation
→ septic tank
→ Immoffanks → sludge removal

③ secondary treatment :-

→ Attached growth process
→ suspended growth process
→ combined growth process

→ Attached growth process :- utilize a solid medium (such as rocks, slag, are specially designed ceramic or plastic) materials upon which bacteria solids are accumulated in order to maintain a high population

Example : trickling filters, intermediate sand filters, Aerobic lagoons, ~~suspended growth~~

→ Suspended growth process :- Maintain adequate biological mass in suspension within the liquid in the reactor, by employing either natural or mechanical mixing

Example : Activated sludge process, sludge digestion system, Aerated lagoons

→ Combined growth process :-

Both attached and suspended growth process

Example : Activated sluge - trickling filter
- facultative lagoons (aerobic, Anae Aerobic)

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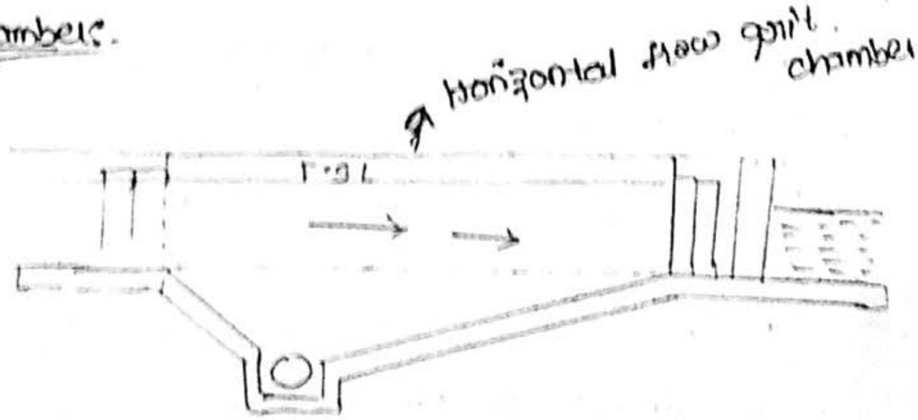
* Grit chambers.



Grit is the heavy mineral material found in raw sewage and it may contain sand, gravel, silt, broken glass, small fragments of metal and other small inorganic solids that have subseeding velocities (or) specific gravity greater than those of organic solids in putresible solids in waste water

Generally grit chamber is of two types

(1) Horizontal flow grit chamber

(2) Aerated grit chamber

Design para considerations:-

The flow velocity should neither be low as to cause settling of lighter organic matter, nor should it should be so high has not to cause the settlement of entire silt, ~~grit~~ grit present in the sewage

settling velocity

$$V_s = \frac{g}{18}\left(\frac{\rho_s - \rho}{\mu}\right) d^2 \quad \text{or} \quad \frac{g}{18}\left(\frac{S_s - 1}{\nu}\right) d^2$$

$d < 0.1\,mm$

V_s = settling velocity (cm/sec)

d = size of particle (cm)

μ = viscosity

ρ = density of liquid

g = acceleration due to gravity (cm/sec^2)

ρ_s = mass density of particles (gm/cm^3)

ρ

$V_s = \sqrt{3.33g\left(\frac{\rho_s-\rho}{\rho}\right)d}$ (d > 1mm)

and

$V_s = 60.6\,(S_s - 1)\,d\left(\frac{3T+70}{100}\right)$ (0.1mm < d < 1.00mm)

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pq' 2018

* Design a grit chamber for a maximum waste water flow of 8000 m³/day to remove particles upto of 0.2mm dia having specific gravity of 2.65. The settling velocity of these particles is found to range from 0.018 to 0.022 m/sec maintain a constant flow through velocity of 0.3 m/sec through the provision of a proportional flow weir

Sol: Let us provide a rectangular section for grit chamber

Now $V_h = 0.3\text{ m/sec}$

$Q = AV_h$

$A = \frac{Q}{V_h} = \frac{8000}{24\times60\times60\times0.3}$

$= 0.3086\text{ m}^2$

Assume depth = 1m

then $B = \frac{0.3086}{1} = 0.3086$ $\left(\begin{array}{l}B\times h\\ = 0.3086\end{array}\right)$

∴ provide $B = 0.35\text{m}$

settling velocity $V_s = 0.018$ to 0.022 m/sec

$V_s = 0.02$ m/sec

Detention time $= \frac{\text{depth}}{V_s}$

$= \frac{1}{0.02}$

$= 50$ sec

Also length $= V_h \times$ detention time

$= 0.3 \times 50$

$= 15$ m

86)

* Sedimentation tank :-

Out of the factors which hinder the sedimentation or settling of the particle under gravity, the velocity of flow of water is one which can be easily controlled. In the continuous flowtype the waste water continuously keeps on moving in the tank, though with a small velocity during which time the suspended particles settle at the bottom before they reach the outlet

Rectangular sedimentation tank :-

There are two types of continuous flow tanks

i) Horizontal flow tank
ii) vertical flow tank

i) Horizontal flow sedimentation tank :-

In the design of a horizontal flow tank, the aim is to achieve as nearly as possible the ideal conditions of equal velocity at all points lying on each vertical in the settling zone. the design of horizontal flow tanks is based on the following assumptions

(i) within the settling or sedimentation zone. The particles settle exactly in the same manner as they do in a quiescent tank of equal depth

② The flow is horizontal and stedy and the velocity is uniform in all parts of the settling zone for a time equal to the detention period

③ The concentration of suspended particles of each size is the same at all points of the vertical cross-section at the inlet end

④ A particle is removed when it reaches the bottom of the settling zone

Vertical flow settling tanks:-

vertical flow settling tanks are usually in the form of small diameter circular tanks with deep conical happers.

The diameter of the tank may vary from 7 to 9 m while the total height may vary from 7.5 to 9m

They are constructed below the ground and partly above the ground.

waste water, after passing through screens, enters the tank from near the bottom, rises upwards through the sludge blanket, gets clarified and then escapes through an effluent trough located along the top periphery

The tank is so designed that the upward velocity of flow is less than the settling velocity of smallest particle to be removed

* Design a primary settling tank of rectangular shape for a town having a population of 50,000, with a water supply of 180 litres per capita per day.

Sol Assuming that 80% of water supplied to the city is converted into sewage,

total sewage flow = $0.8 \times 50,000 \times 180$

$= 7200 \times 10^3$ litres/day

let us assume a detention period of 2 hours

$\therefore$ capacity required $= \frac{7200}{24} \times 2 = 600m^3$

Again, let us assume an overflow rate of $30\ m^3/d/m^2$ for average flow

Surface area = $7200/30 = 240m^2$

$\therefore$ effective depth = $600/240 = 2.5m$

Again $B \times L = 240m^2$

taking $L = 4B$

$B(4B) = 240$

$B = 7.46m$

$\therefore L = 4B = 30m$

Provide 4m for inlet and outlet arrangements

Total length $= 30 + 4 = 34m$

Also, provide 1m depth for sludge accumulation and 0.5m as free board. Hence total depth = 2.5 + 1 + 0.5 = 4m

Hence the dimensions of the tank will be 34m × 7.5m × 4m

* Design a circular primary settling tank for the data of Population 50,000, with a water supply of 180 litres per capita per day

Sol Assume that 80% of water supplied to the city is converted into sewage,

Total sewage flow = 0.8 × 50000 × 180

$= 7200 \times 10^3$ litres/day.

let us assume a detention period of 2 hours

$\therefore$ capacity required $= \frac{7200}{24} \times 2$

$= 600 m^3$

let us provide an overflow rate of $30 m^3/d/m^2$

$\therefore$ surface area required $= \frac{7200}{30}$

$= 240 m^2$

Hence dia of tank $= \sqrt{\frac{240 \times 4}{\pi}} = 17.5 m$

$\therefore$ Effective depth of tank $= \frac{\text{capacity}}{\text{surface area}} = \frac{600}{240} = 2.5 m$

provide 1m extra depth of sludge accumulation and 0.5m depth as free board

SECONDARY TREATMENT

Activated sludge plant involves:

1. Wastewater aeration in the presence of a microbial suspension,
2. Solid-liquid separation following aeration,
3. Discharge of clarified effluent,
4. Wasting of excess biomass, and
5. Return of remaining biomass to the aeration tank.

In activated sludge process wastewater containing organic matter is aerated in an aeration basin in which micro-organisms metabolize the suspended and soluble organic matter. Part of organic matter is synthesized into new cells and part is oxidized to CO2 and water to derive energy. In activated sludge systems the new cells formed in the reaction are removed from the liquid stream in the form of a flocculent sludge in settling tanks. A part of this settled biomass, described as activated sludge is returned to the aeration tank and the remaining forms waste or excess sludge.

Activated Sludge Process Variables

The main variables of activated sludge process are the mixing regime, loading rate, and the flow scheme.

Mixing Regime

Generally two types of mixing regimes are of major interest in activated sludge process: ***plug flow*** and ***complete mixing***. In the first one, the regime is characterized by orderly flow of mixed liquor through the aeration tank with no element of mixed liquor overtaking or mixing with any other element. There may be lateral mixing of mixed liquor but there must be no mixing along the path of flow.

In complete mixing, the contents of aeration tank are well stirred and uniform throughout. Thus, at steady state, the effluent from the aeration tank has the same composition as the aeration tank contents.

The type of mixing regime is very important as it affects (1) oxygen transfer requirements in the aeration tank, (2) susceptibility of biomass to shock loads, (3) local environmental conditions in the aeration tank, and (4) the kinetics governing the treatment process.

Loading Rate

A loading parameter that has been developed over the years is the ***hydraulic retention time*** (HRT), θ, d

$\theta = V Q$

V= volume of aeration tank, m3, and Q= sewage inflow, m3/d

Another empirical loading parameter is ***volumetric organic loading*** which is defined as the BOD applied per unit volume of aeration tank, per day. A rational loading parameter which has found wider acceptance and is preferred is ***specific substrate utilization rate***, q, per day.

$q= Q (SO - Se) V X$

A similar loading parameter is ***mean cell residence time*** or ***sludge retention time*** (SRT), θc, d

$\theta c = V X QwXr + (Q-QwXe)$

where SO and Se are influent and effluent organic matter concentration respectively, measured as BOD5 (g/m3), X, Xe and Xr are MLSS concentration in aeration tank, effluent and return sludge respectively, and Qw= waste activated sludge rate.

Under steady state operation the mass of waste activated sludge is given by

$QwXr = YQ (SO - Se) - kd XV$

where Y= maximum yield coefficient (microbial mass synthesized / mass of substrate utilized) and kd = endogenous decay rate (d-1) .

From the above equation it is seen that $1/\theta c = Yq - kd$

If the value of Se is small as compared SO, q may also be expressed as ***Food to Microorganism ratio***, F/M

$F/M = Q(SO- Se) / XV = QSO / XV$

The θc value adopted for design controls the effluent quality, and settleability and drainability of biomass, oxygen requirement and quantity of waste activated sludge.

Flow Scheme

The flow scheme involves:

- the pattern of sewage addition
- the pattern of sludge return to the aeration tank and
- the pattern of aeration.

Sewage addition may be at a single point at the inlet end or it may be at several points along the aeration tank. The sludge return may be directly from the settling tank to the aeration tank or through a sludge reaeration tank. Aeration may be at a uniform rate or it may be varied from the head of the aeration tank to its end.

Aeration Tank

The **volume of aeration tank** is calculated for the selected value of □c by assuming a suitable value of MLSS concentration, X.

$VX = YQ\theta c(SO - S)$

1+□kdθc

Alternately, the tank capacity may be designed from

F/M = QSO / XV

Hence, the **first step** in designing is to choose a suitable value of θ***c (or F/M***) which depends on the expected winter temperature of mixed liquor, the type of reactor, expected settling characteristics of the sludge and the nitrification required. The choice generally lies between 5 days in warmer climates to 10 days in temperate ones where nitrification is desired along with good BOD removal, and complete mixing systems are employed.

The **second step** is to select two interrelated parameters ***HRT, t and MLSS concentration***. It is seen that economy in reactor volume can be achieved by assuming a large value of X. However, it is seldom taken to be more than 5000 g/m3. For typical domestic sewage, the MLSS value of 2000-3000 mg/l if conventional plug flow type aeration system is provided, or 3000-5000 mg/l for completely mixed types. Considerations which govern the upper limit are: initial and running cost of sludge recirculation system to maintain a high value of MLSS, limitations of oxygen transfer equipment to supply oxygen at required rate in small reactor volume, increased solids loading on secondary clarifier which may necessitate a larger surface area, design criteria for the tank and minimum HRT for the aeration tank.

Design of Completely Mixed Activated Sludge System

Design a completely mixed activated sludge system to serve 60000 people that will give a final effluent that is nitrified and has 5-day BOD not exceeding 25 mg/l. The following design data is available.

Sewage flow = 150 l/person-day = 9000 m3/day BOD5 = 54 g/person-day = 360 mg/l ; BODu = 1.47 BOD5Total kjeldahl nitrogen (TKN) = 8 g/person-day = 53 mg/l Phosphorus = 2 g/person-day = 13.3 mg/l Winter temperature in aeration tank = 18°C Yield coefficient Y = 0.6 ; Decay constant Kd = 0.07 per day ; Specific substrate utilization rate = 0.038 mg/l)-1 (h)-1 at 18°C Assume 30% raw BOD5 is removed in primary sedimentation, and BOD5 going to aeration is, therefore, 252 mg/l (0.7 x 360 mg/l).

Design:

(a) ***Selection of*** θ***c, t and MLSS concentration*****:**

(b) Considering the operating temperature and the desire to have nitrification and good sludge settling characteristics, adopt θc = 5d. As there is no special fear of toxic inflows, the HRT, t may be kept between 3-4 h, and MLSS = 4000 mg/l.

(c) **(b)** ***Effluent BOD5:***

(d) Substrate concentration, S = 1 (1/θc + kd)= 1 (1/5□+ 0.07)

(e) qY (0.038)(0.6)

(f) S = 12 mg/l.

(g) Assume suspended solids (SS) in effluent = 20 mg/l and VSS/SS =0.8.

(h) If degradable fraction of volatile suspended solids (VSS) =0.7 (check later), BOD5 of VSS in effluent = 0.7(0.8x20) = 11mg/l.

(i) Thus, total effluent BOD5 = 12 + 11 = 23 mg/l (acceptable).

(j) ***(c)** Aeration Tank:*

(k) VX = YQθc(SO - S) where X = 0.8(4000) = 3200 mg/l

(l) 1+ kdθc or 3200 V = (0.6)(5)(9000)(252-12)

(m) [1 + (0.07)(5)]

(n) V = 1500 m3

(o) Detention time, t = 1500 x 24 = 4h 9000

(p) F/M = (252-12)(9000) = 0.45 kg BOD5 per kg MLSS per day (3200) (1500)

(q) Let the aeration tank be in the form of four square shaped compartments operated in two parallel rows, each with two cells measuring 11m x 11m x 3.1m

(r) **(d)** ***Return Sludge Pumping:***

(s) If suspended solids concentration of return flow is 1% = 10,000 mg/l

(t) R = MLSS = 0.67

(u) (10000)-MLSS

(v) Qr = 0.67 x 9000 = 6000 m3/d

(w) **(e)** ***Surplus Sludge Production:***

(x) Net VSS produced QwXr = VX = (3200)(1500)(103/106) = 960 kg/d

(y) θc (5)

(z) or SS produced =960/0.8 = 1200 kg/d

If SS are removed as underflow with solids concentration 1% and assuming specific gravity of sludge as 1.0,

Liquid sludge to be removed = 1200 x 100/1 = 120,000 kg/d= 120 m3/d

(f) ***Oxygen Requirement***

For carbonaceous demand,

oxygen required = (BODu removed) - (BODu of solids leaving)

= 1.47 (2160 kg/d) - 1.42 (960 kg/d)

= 72.5 kg/h

For nitrification, oxygen required = 4.33 (TKN oxidized, kg/d)

Incoming TKN at 8.0 g/ person-day = 480 kg/day. Assume 30% is removed in primary sedimentation and the balance 336 kg/day is oxidized to nitrates. Thus, oxygen required = 4.33 x 336 = 1455 kg/day = 60.6 kg/h

Total oxygen required = 72.5 + 60.6 = 133 kg/h = 1.0 kg/kg of BODu removed.

Oxygen uptake rate per unit tank volume = 133/1500 = 90.6 mg/h/l tank volume

(g) *Power Requirement:*

Assume oxygenation capacity of aerators at field conditions is only 70% of the capacity at standard conditions and mechanical aerators are capable of giving 2 kg oxygen per kWh at standard conditions.

$$\text{Power required} = \frac{136}{0.7 \text{ x } 2} = 97 \text{ kW (130 hp)}$$

= (97 x 24 x 365) / 60,000 = 14.2 kWh/year/person

Trickling Filters

- Trickling filter is an ***attached growth process*** i.e. process in which microorganisms responsible for treatment are attached to an inert packing material. Packing material used in attached growth processes include rock, gravel, slag, sand, redwood, and a wide range of plastic and other synthetic materials.

Process Description

- The wastewater in trickling filter is distributed over the top area of a vessel containing non-submerged packing material.

- Air circulation in the void space, by either natural draft or blowers, provides oxygen for the microorganisms growing as an attached biofilm.

- During operation, the organic material present in the wastewater is metabolised by the biomass attached to the medium. The biological slime grows in thickness as the organic matter abstracted from the flowing wastewater is synthesized into new cellular material.

- The thickness of the aerobic layer is limited by the depth of penetration of oxygen into the microbial layer.

- The micro-organisms near the medium face enter the endogenous phase as the substrate is metabolised before it can reach the micro-organisms near the medium face as a result of increased thickness of the slime layer and loose their ability to cling to the media surface. The liquid then washes the slime off the medium and a new slime layer starts to grow. This phenomenon of losing the slime layer is called ***sloughing***.

The sloughed off film and treated wastewater are collected by an underdrainage which also allows circulation of air through filter. The collected liquid is passed to a settling tank used for solid- liquid separation

Process Design

Generally trickling filter design is based on empirical relationships to find the required filter volume for a designed degree of wastewater treatment. Types of equations:

1. NRC equations (National Research Council of USA)
2. Rankins equation
3. Eckenfilder equation
4. Galler and Gotaas equation

NRC and Rankin's equations are commonly used. NRC equations give satisfactory values when there is no re-circulation, the seasonal variations in temperature are not large and fluctuations with high organic loading. Rankin's equation is used for high rate filters.

NRC equations**:** These equations are applicable to both low rate and high rate filters. The efficiency of single stage or first stage of two stage filters, E2 is given by

E2= 100 1+0.44(*F1.BOD*/V1.Rf1)1/2

For the second stage filter, the efficiency E3 is given by

E3= 100 [(1+0.44)/(1- E2)](*F2.BOD*/V2.Rf2)1/2

where E2= % efficiency in BOD removal of single stage or first stage of two-stage filter, E3=% efficiency of second stage filter, *F1.BOD*= BOD loading of settled raw sewage in single stage of the two-stage filter in kg/d, *F2.BOD*= *F1.BOD*(1- E2)= BOD loading on second-stage filter in kg/d, V1= volume of first stage filter, m3; V2= volume of second stage filter, m3; Rf1= Recirculation factor for first stage, R1= Recirculation ratio for first stage filter, Rf2= Recirculation factor for second stage, R2= Recirculation ratio for second stage filter

Rankins equation: This equation also known as Tentative Method of Ten States USA has been successfully used over wide range of temperature. It requires following conditions to be observed for single stage filters:

1. Raw settled domestic sewage BOD applied to filters should not exceed 1.2 kg BOD*5*/day/ m3 filter volume.
2. Hydraulic load (including recirculation) should not exceed 30 m3/m2 filter surface-day.

Recirculation ratio (R/Q) should be such that BOD entering filter (including recirculation) is not more than three times the BOD expected in effluent. This implies that as long as the above conditions are satisfied efficiency is only a function of recirculation and is given by:

E = (R/Q) + 1 (R/Q) + 1.5

Methods of disposal :

Open burning of Solid Wastes

Not an ideal method in the present day context

Dumping into Sea

- Possible only in coastal cities
- Refuse shall be taken in barges sufficiently far away from the coast (15-30 km) and dumped there
- Very costly
- Not environment friendly

Sanitary Landfilling of Solid Wastes

- Simple, cheap, and effective
- A deep trench (3 to 5 m) is excavated
- Refuse is laid in layers
- Layers are compacted with some mechanical equipment and covered with earth, leveled, and compacted
- With time, the fill would settle
- Microorganisms act on the organic matter and degrade them
- Decomposition is similar to that in composting
- Facultative bacteria hydrolyze complex organic matter into simpler water soluble organics
- These diffuse through the soil where fungi and other bacteria convert them to carbon dioxide and water under aerobic conditions
- Aerobic methanogenic bacteria utilize the methane generated and the rest diffuses into the atmosphere
- Too much refuse shall not be buried – fire hazard
- Moisture content – not less than 60% for good biodegradation
- Refuse depth more than 3m – danger of combustion due to compression of bottom layers – hence should be avoided
- Refuse depth is generally limited to 2m
- Temperature in the initial stages of decomposition – as high as 70 degree C – then drops
- Reclaimed areas may be used for other uses

Engineered Landfills of Solid Wastes

- Bottom of the trench is lined with impervious material to prevent the leachate from contaminating groundwater
- A well designed and laid out leachate collection mechanism is to be provided
- Leachate so collected is treated and then disposed off.

Incineration of Solid Waste

- A method suited for combustible refuse
- Refuse is burnt
- Suited in crowded cities where sites for land filling are not available
- High construction and operation costs
- Sometimes used to reduce the volume of solid wastes for land filling
- Primary chamber – designed to facilitate rapid desiccation of moist refuse and complete combustion of refuse and volatile gases
- A ledge or drying hearth is provided for this purpose
- Secondary chamber – between the primary chamber and the stack – temperatures above 700 degree C
- All unburnt and semi burnt material are completely burnt here

Waste to Energy Combustors

- Incinerators – Refuse was burned without recovering energy – exhaust gas is very hot – exceeds the acceptable inlet temperature for electrostatic precipitators used for particulate emission control
- Modern combustors – combine solid waste combustion with energy recovery

Combustors for Solid Waste

- Storage pit – for storing and sorting incoming refuse
- Crane – for charging the combustion box
- Combustion chamber consisting of bottom grates on which combustion occurs
- Grates on which refuse moves
- Heat recovery system of pipes in which water is turned to steam
- Ash handling systems
- Air pollution control systems

- Grates – Provide turbulence so that the MSW can be thoroughly burned, moves the refuse down, provides under fire air to the refuse through openings in it (to assist in combustion as well as to cool the grates)
- Operating temperature of combustors ~ 980 to 1090 degree C

Composting

- Similar to sanitary landfilling
- Yields a stable end product – good soil conditioner and may be used as a base for fertilizers
- Popular in developing countries
- Decomposable organic matter is separated and composted

Methods

1. Open window composting
2. Mechanical composting

Open window composting

- Refuse is placed in piles, about 1.5m high and 2.5m wide at about 60% moisture content
- Heat build up in the refuse piles due to biological activity – temperature rises to about 70 degree C
- Pile is turned up for cooling and aeration to avoid anaerobic conditions
- Moisture content is adjusted to about 60%
- Piled again – temperature rises to about 70 degree C
- The above operations are repeated
- After a few days (~ 7 to 10 weeks) temperature drops to atmospheric temperature – indication of stabilization of compost

Mechanical composting

- Process of stabilization is expedited by mechanical devices of turning the compost
- Compost is stabilized in about 1 to 2 weeks
- To enrich compost – night soil, cow dung etc. are added to the refuse
- Usually done in compost pits
- Arrangements for draining of excess moisture are provided at the base of the pit

- At the bottom of the pit, a layer of ash, ground limestone, or loamy soil is placed – to neutralize acidity in the compost material and providing an alkaline medium for microorganisms
- The pit is filled by alternate layers of refuse (laid in layers of depth 30 – 40 cm) and night soil or cow dung (laid over it in a thin layer)
- Material is turned every 5 days or so
- After ~ 30 days – it is ready for use

Methods used in India

Indore method – aerobic – brick pits 3 x 3 x 1 m – up to 8-12 weeks materials are turned regularly in the pits and then kept on ground for about 4-6 weeks – 6 to 8 turnings in total

Bangalore method – anaerobic – earthen trenches 10 x 1.5 x 1.5 m – left for decomposition – takes 4 to 5 months

Vermicomposting

- Ideal for biodegradable wastes from kitchens, hotels etc.
- At household level, a vessel or tray more than 45 cm deep, and 1 x 0.60m may be sufficient
- A hole shall be provided at one end in the bottom for draining the leachate out into a tray or vessel
- Lay a 1” thick layer of baby metal or gravel at the bottom of the tray
- Above that lay an old gunny bag or a piece of thick cloth, a layer of coconut husk upside down over it and above that a 2” thick layer of dry leaves and dry cow dung (powdered)
- Lay the biodegradable waste over it
- Introduce good quality earthworms into it (~ 10 g for 0.6 x 0.45 x 0.45 m box)
- If the waste is dry, sprinkle water over it daily
- Rainwater should not fall into the tray or vessel or box
- Keep it closed
- If the box is kept under bright sun earthworms will go down and compost can be taken from the top
- Compost can be dried and stored
- Continue putting waste into the box
- Add little cow dung at intervals
- Do not use vermiwash directly. Dilute in the ratio 1:10 before use

Disposal by Ploughing into fields

- Not very commonly used
- Not environment friendly in general

Disposal by hog feeding

- Not common in India
- Refuse is ground well in grinders and then fed into sewers
- Disposal of garbage into sewers – BOD and TSS increases by 20-30%
- Disposal of residual refuse – still a problem

Salvaging

- Materials like paper, metal, glass, rags, certain types of plastic etc. can be salvaged, recycled, and reused

Fermentation or Biological Digestion

- Biodegradable Waste – convert to compost
- Recycle whatever is possible
- Hazardous wastes – dispose it by suitable methods
- Landfill or incinerate the rest