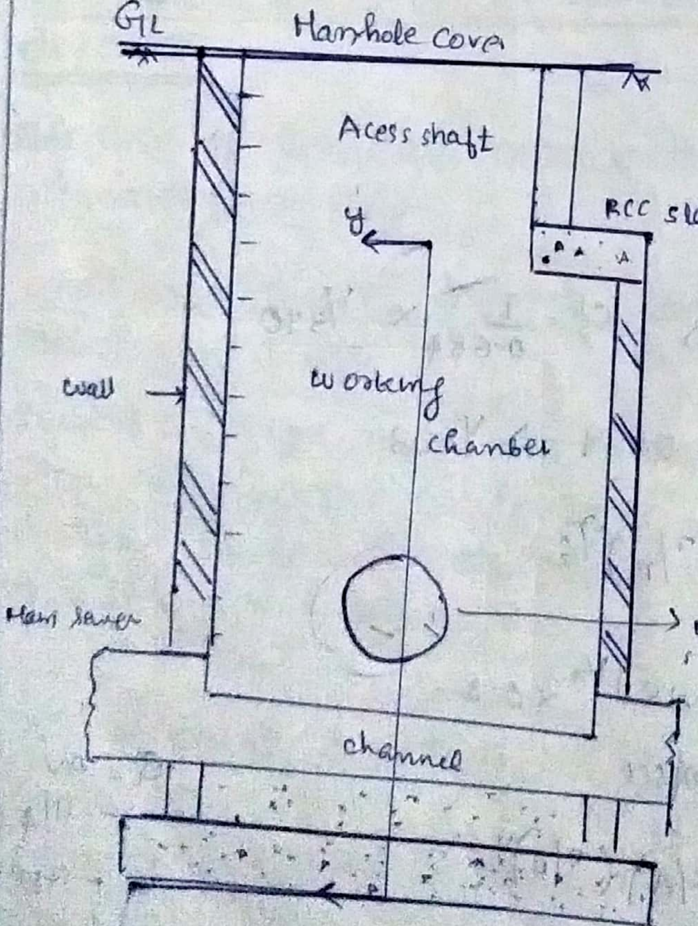
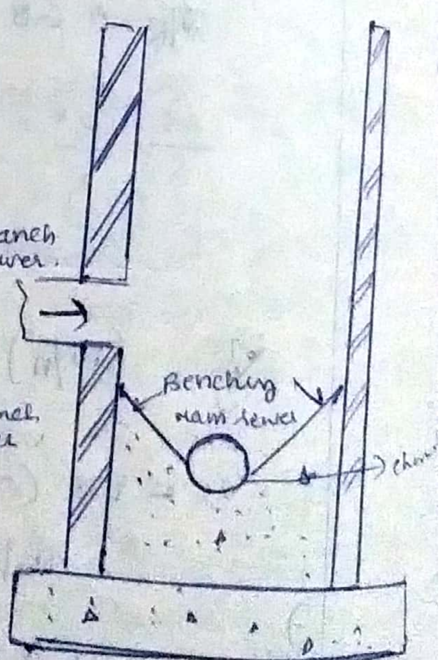
Module-02

Sewer Appurtenances

1. Man hole → shallow, Normal, Deep
2. Drop manholes
3. Lamp holes
4. Catch
5. Clean out
6. Flushing tanks
7. Grease and oil trap
8. Inlets
9. Inverted syphon
10. Storm regulator → leaping weir, overflow weir, siphon spillway



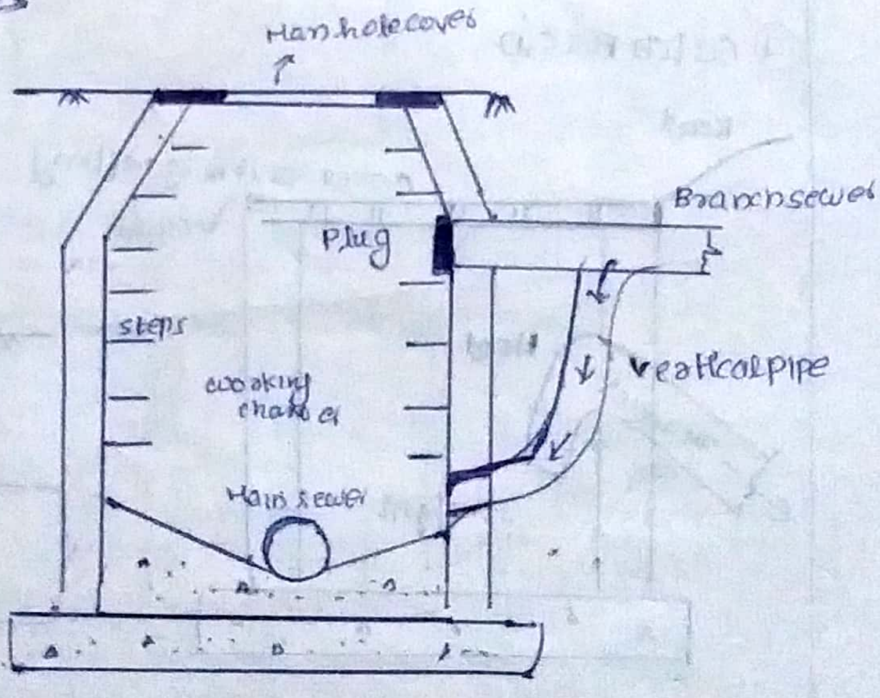


1. **Man hole**
- Shallow 0.75 to 0.9m
- Normal <1.5m
- Deep >1.5m

parts
- Access shaft
- working chamber
- Bottom/Invert
- side walk
- steps/ladder
- Top cover & Frame

Man hole is a masonry or RCC chamber constructed on the allignment of a sewer for providing access to the sewer for the purpose of inspection testing cleaning etc. These are provided @ every bent, junction change of grade - ent or change of diameter

2. **Drop Manholes**



A drop manhole is constructed to provide a connection b/w a high level branch sewer to low level main sewer when a branch sewer enters a man hole while more than 0.5 - 0.6 m above the main sewer
The sewage is not allowed to fall directly in to man-hole

to avoid possibilities of secuage being throwin on persons ~~evently~~ entering the working chamber of m hole

3. **Lamb hole:** provided to

4 Inlet

Inlet is a device used to admit stormwater and convey it into storm sewer or combined sewer

- vertical inlet | curb
- Horizontal | Gutter inlet
- combination inlet

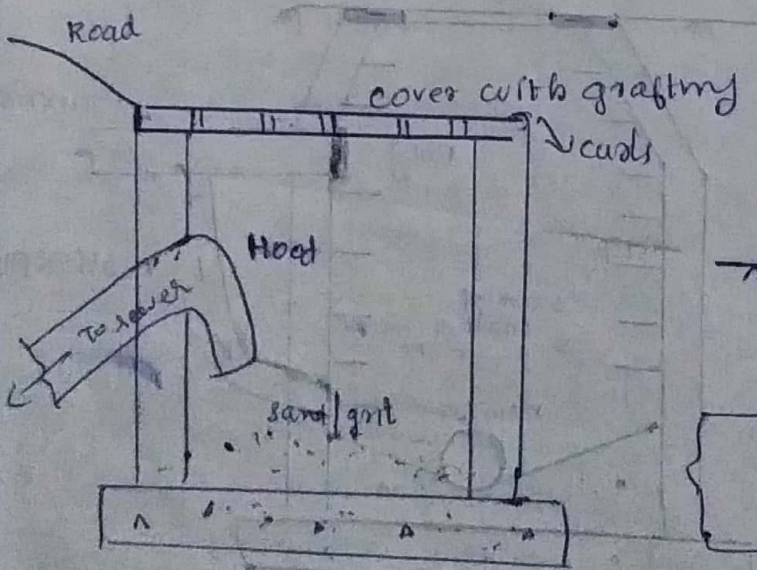
5 **Catch Basins**

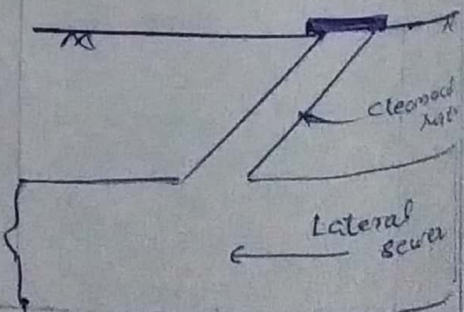
This is spcl type of inlet in which a basin is provided which allows sand, grit, debris

6. Clean-out (cleans)

These are inclined pipes used for clearing out the lateral sewer

7 Catch Basin





Hood → prevent foul gas

They are street inlet with additional settling basin sand, grit, debris get settled thus prevent their entry to sewer.

Hood → prevent the escape of foul gases

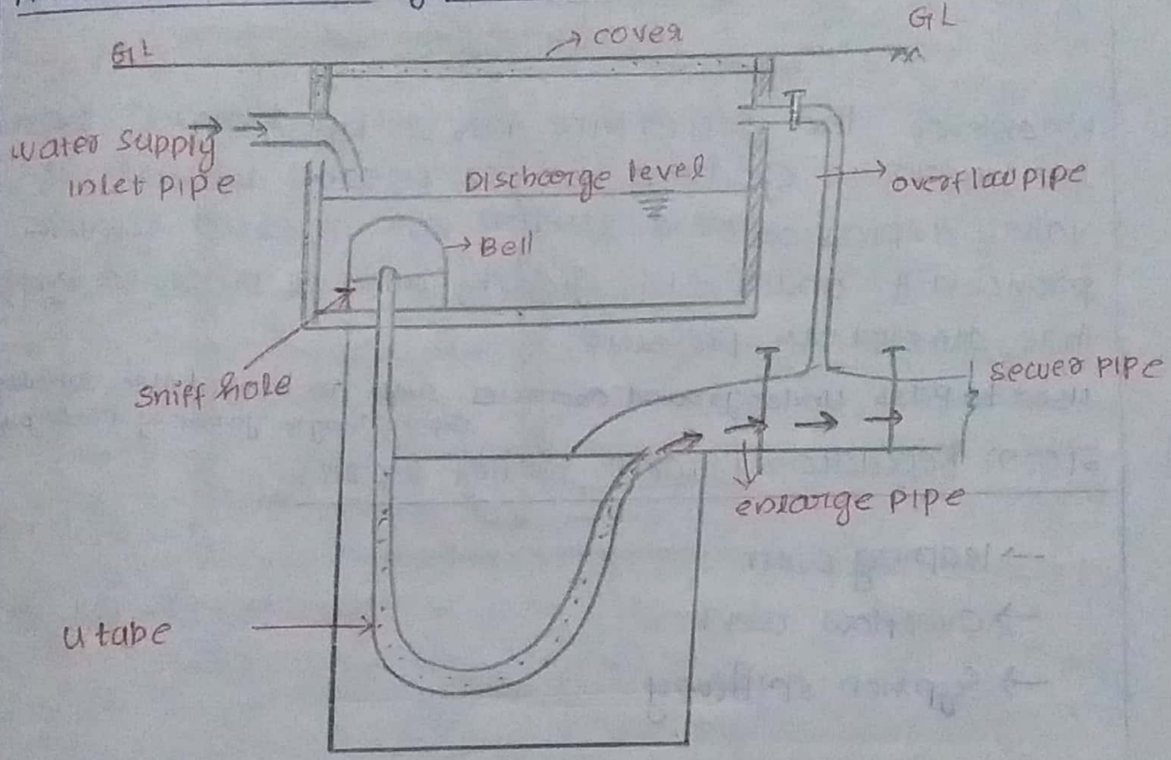
⑧ Flushing Tank

These are used when there are chances of sew blockage such as in the case of flat gradient not producing self cleansing velocity. The flushing tank are of 2 types

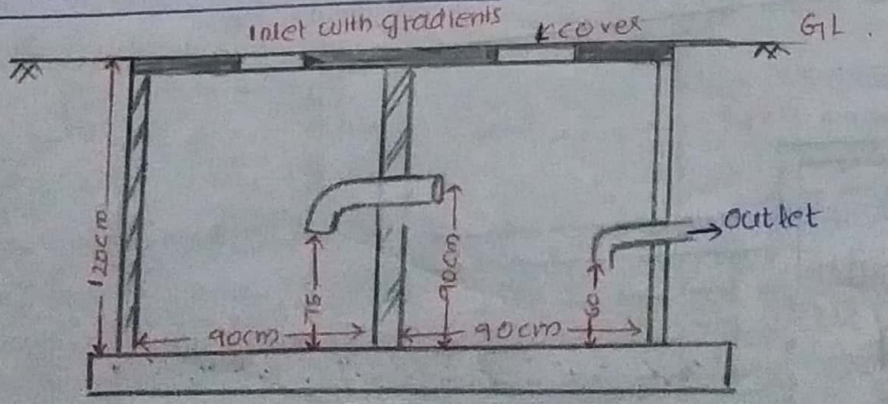
(i) Automatic flushing tank

(ii) Hand operating flushing tank

Automatic flushing tank

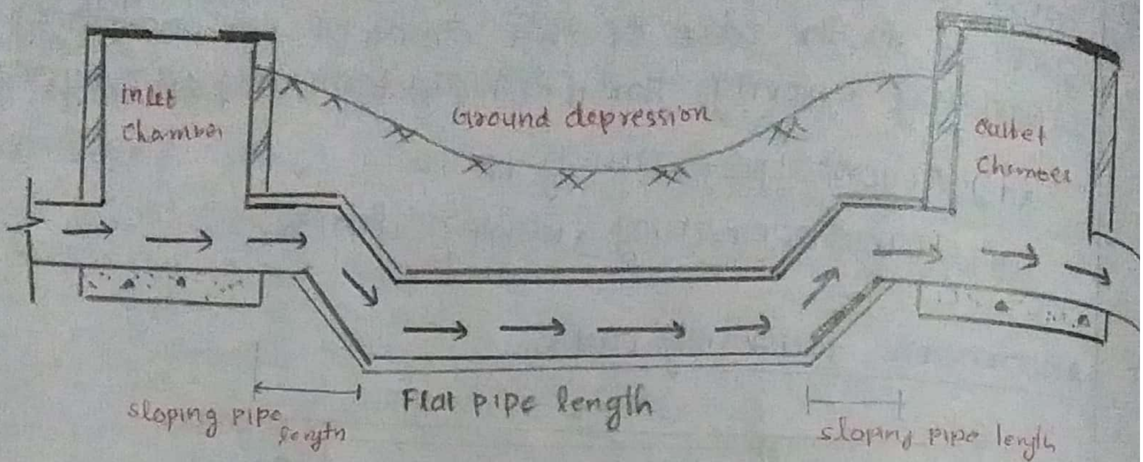


⑨ Grease and oil traps



It is used to remove grease & oil from sewage before it enters into sewerline & these are located @ plates such as automobile repair workshops, garrages, kitchens of hotels, oil and grease industries etc. If it is not provided the grease and oil will stick onto the sewer pipe matereal & reduce sewer capacity

(10) Inverted Syphons



Whenever the sewer pipe has to be dropped below the hydraulic gradient line for passing beneath a valley depression or a stream an inverted syphon is provided it under full gravity with a pressure greater than atmospheric pressure

P > atm P

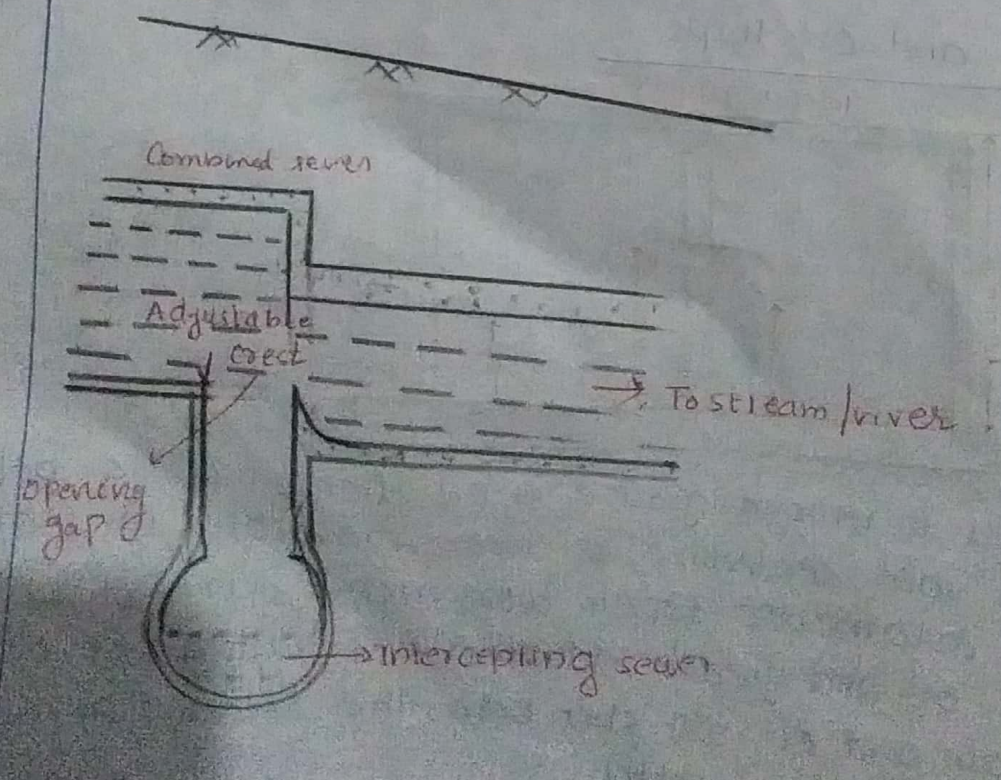
used to pass underground obstacles such as buried pipe, subway

sloping length joined by flat pipe

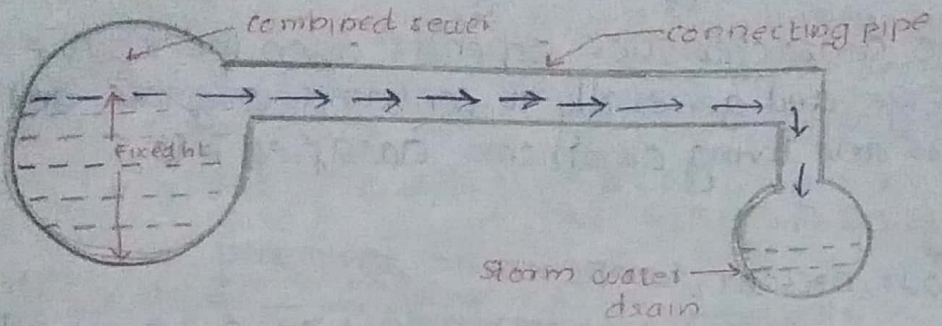
(11) Storm Regulators / Storm Relief works

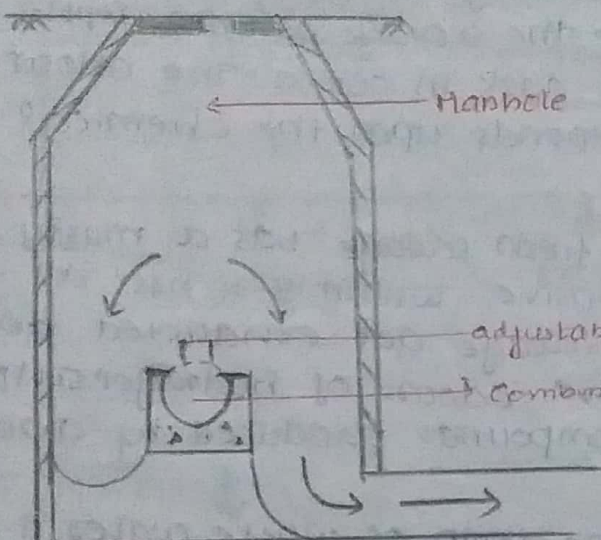
→ leaping weir
→ Overflow weir
→ Syphon spillway

Leaping weir

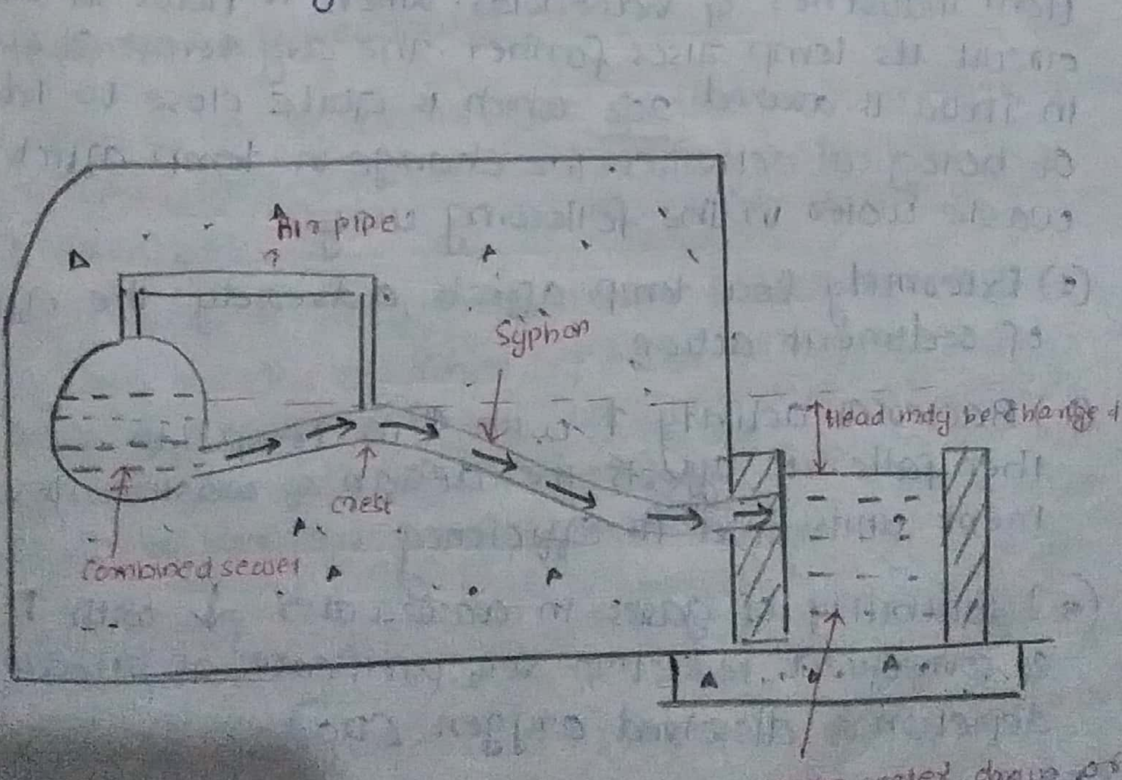


Overflow weir





Syphon spillway



Characteristics of sewage

sewage characteristics depends upon the source of its discharge and generally it contains organic and inorganic matters and living organisms. classified into 3

COT T 1. Physical characteristics :

colour, odour, temperature, turbidity

G, Y, light Brown → fresh
Black / Dark Brown → septic or stale

Colour: Fresh domestic sewage has a grey colour some what resembling a weak solution of soap with the passage of time the sewage become septic and is more or less black or dark in colour. The colour of industrial waste water depends upon the chemical process used in industries

Odour: Normal fresh sewage has a musty odour which is normaly not offensive. within 3-4 hrs all the oxygen Present in the sewage get exhausted and it starts emitting offensive odours of hydrogen sulphide gas and other sulphur compounds produced by anerobic micro organism

Temperature: The temp of waste water is higher that that of the water supply due to addition of warm water from industries & households. When it flows in closed circuit its temp rises farther. The avg. temp of waste water in India is around 20°C which is quite close to ideal temp of biological activities. The change in temp affects the waste water in the following ways:

(1) Extremely low temp affects adversely the efficiency of sediment action

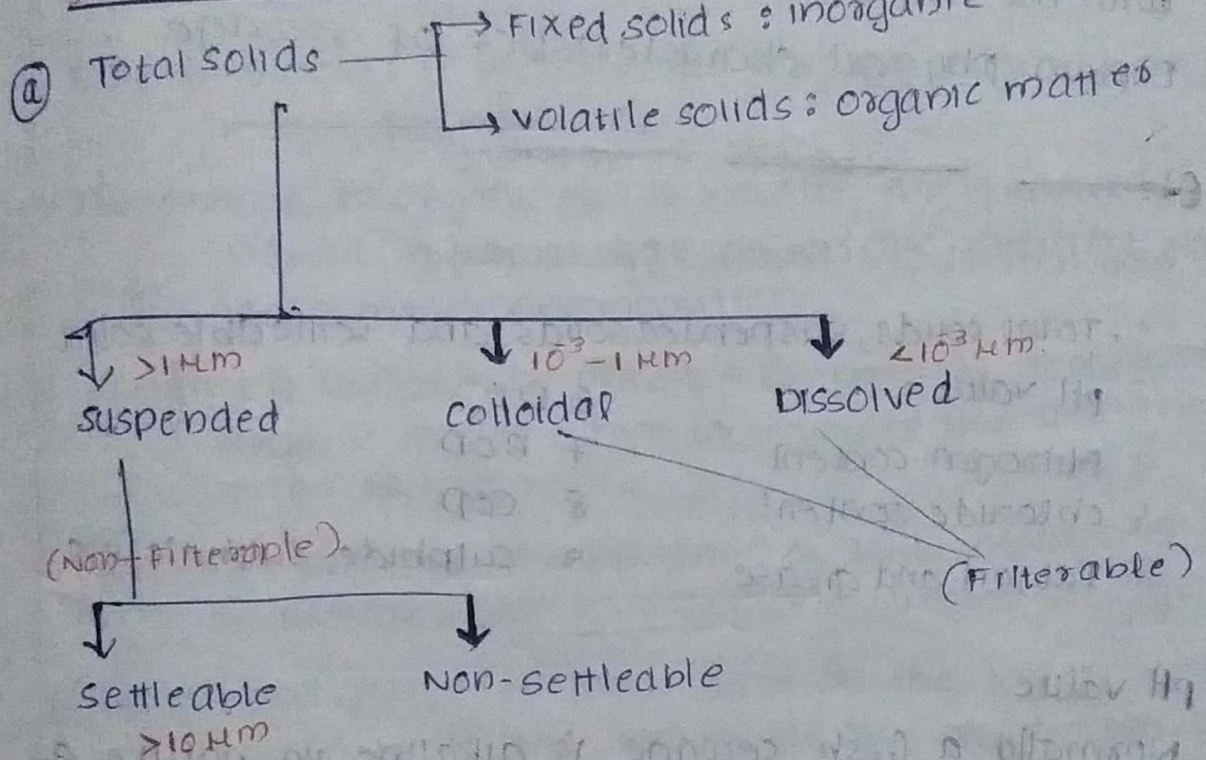
(2) Bacterial activity ↑ with ↑ in temp upto 60°C and then falls. it affects the design of waste water treatment units and its efficiency

(3) solubility of gases in wastewater ↓ with ↑ in temp & consequent reductn in self purificatn of streams due to depletion of dissolved oxygen (DO)

(4) Abnormally high temp can enhance the growth of undesirable water plants and waste water ~~Analyst~~ fungus

Turbidity : It is a measure of light emitting properties of water and is used to indicate the quality of waste discharge w.r.t colloidal matters. For more concentrated sewage, turbidity is higher can be measured by turbidimeter (turbid rod also used) (NTU-unit).

2 Chemical Characteral.



1-10 µm ⟶ By coagulation.

The total solids is defined as all the matters that remains as residue upon evaporation to 103-105°c.
It is classified into 2, Fixed & volatile solid

volatile solids is calculated in the following way
The dry residue obtained by evaporating the waste water @ 105°c & subjected to heating & ignition at 550°c in a muffle furnance about (15-20 min). The loss of wt due to this operation is the volatile solids.

Assignment

Q, Define sullage, storm water, sewage and night soil

2. Explain time of concentratn

Q. Determine the size of O^r sewer for a discharge of 700 lps running half full. Assume $f = 0.0001$, $n = 0.01$

4. Discuss the merits and demerits of separate & combined system of sewage

5. Discuss the purpose served by an inverted syphon with the help of a neat sketch

6. Explain physical characteristics of sewage

~~Chemical characteristic of sewage~~

Chemical characteristic of sewage

1. Total solids, suspended solids and settleable solid
2. pH value
3. Nitrogen content
4. chloride content
5. Fat, oil and grease
6. DO
7. BOD
8. COD
9. sulphide, sulphate, H_2S

org- Free- nitrite nitrate

(b) pH value

Normally a fresh sewage is alkaline in nature as the time passes pH ↓es due to ~~unive~~ anaerobic or nitrification process

$$pH = -\log[H]^+$$

(c) chloride contents

Domestic sewage ⟶ 120 mg/l
Normal water/drinking water ⟶ 250 ppm

If the chloride content is high. It indicates the presence of industrial waste and also the infiltration of sea water. If the chloride content is high it indicates high strength of sewage.

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ⓓ Nitrogen content

- → Free Ammonia / Ammonia N_2
- → Albuminoid N_2 / Organic N_2
- → Nitrite
- → Nitrate

Free Ammonia : It indicate the very Ist stage of organic matter decomposition

org - Ist Albuminoid or organic N_2 : It indicate the quantity of N_2 present in the sewage before the starting of organic matter decomposition

Free - Ist
Nitrite → partly
Nitrate → fully

Nitrite : It indicate the presence of partialy decomposed organic matter which indicates the treatment given is incomplete

Nitrate : Indicate the presence of fully oxidised organic
It indicates well oxidised and treated sewage

ⓔ Fat, oil and grease : It forms seem on the top of sedimentation tank and also in the case of filtration. It may clog the voids of filtering media

ⓕ Sulphides, sulphates and H_2S gas : During aerobic decomposition sulphur compounds oxidised to sulphates and sulphides and during anaerobic decomposition sulphur compounds get reduced to sulphides with liberation H_2S, CO_2 and Methane gases

Aerobic - Sulphur → sulphate & sulphide
Anaerobic - Sulp → sulphide (H_2S, CO_2, CH_4)

ⓖ Dissolved oxygen (DO)

4 ppm (min) ⟹ For sustainability of aquatic life

ⓗ COD ⟹ Chemical oxygen Demand

* Measure of total organic matter includes bio degradable and non-biodegradable

ⓘ BOD ⟹ Biochemical oxygen demand

Measure of biologically degradable organic matter

$BOD_5 = DO_{consumed} \times$ Dilution Factor

$DO_{consumed} = DO_{initial} - DO_{Final}$

Dilution Factor = $\frac{\text{Total diluted sample volume}}{\text{Vol. of undiluted sewage sample}} = \frac{V_{diluted}}{V_{undiluted}}$

BOD_5 = 68% BOD_{total} ⟹ 5 days incubation

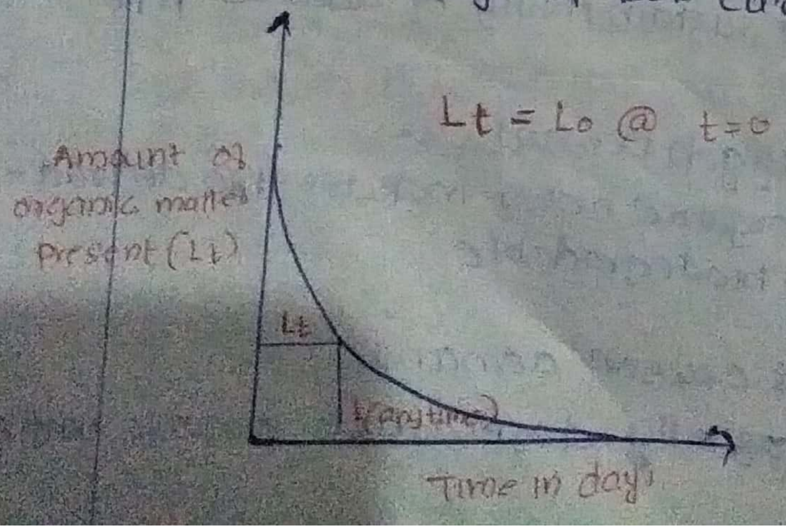
BOD_{10} = 90% BOD_{total} ⟹ 10 days incubation

BOD of water during 5 day @ 20°C is generally taken as standard demand. If oxygen supply is for more than 5 day the oxygen is consumed radiply for 6-7 days then slows down until 20 days. Then it again accelerate for some time and again slows down. The BOD for Ist 20 days is taken as the carbonaceous demand.

The carbonaceous demand is also know as the Ist stage demand, or initial demand. After 20 days the demand is known as nitrogenous demand or 2nd stage demand

The rate @ which BOD is satisfied @ any time depends on temp and also on the amount and the nature of organic matter present in sewage @ that time

Ist stage of BOD Curve



$$\frac{dL_t}{dt} = -kL_t \longrightarrow (1)$$

where, L_t = Amount of I st stage BOD remaining in sample at any time, t (mg/L)

k = rate constant (per day)

t = time (in days)

Integrating (1)

$$\int_{L_0}^{L_t} \frac{dL_t}{L_t} = \int -k\,dt$$

$$\log_e L_t = -kt + C \quad (@\, t=0,\ L_t = L_0)$$

$$\therefore \log_e L_0 = C$$

$$\Rightarrow \log_e L_t = -kt + \log_e L_0$$

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

$$2.3 \log_{10}\left(\frac{L_t}{L_0}\right) = -kt$$

$$\log_{10}\left(\frac{L_t}{L_0}\right) - \frac{-kt}{2.3} = -0.43kt = -k_D t$$

where k_D = De $\Rightarrow$ oxygenation constant

$$\log_{10}\left(\frac{L_t}{L_0}\right) = -k_D t$$

$$\left(\frac{L_t}{L_0}\right) = L_0 10^{-k_D t}$$

$Y_t = L_0 - L_t$ (Quantity of organic matter oxidized during t days)

$$= L_0 - L_0 10^{-k_D t}$$

$$\boxed{Y_t = L_0(1 - 10^{-k_D t})}$$ (I st stage BOD reaction)

Ultimate BOD:

when $t=\infty$, $Y_\infty = L_0(1-10^{-\infty}) = L_0(1-\frac{1}{10^\infty})$

$Y_\infty = L_0$

$L_0 \longrightarrow$ Fixed value doesn't depend on temp

$K_D \longrightarrow$ value determines speed of reactn

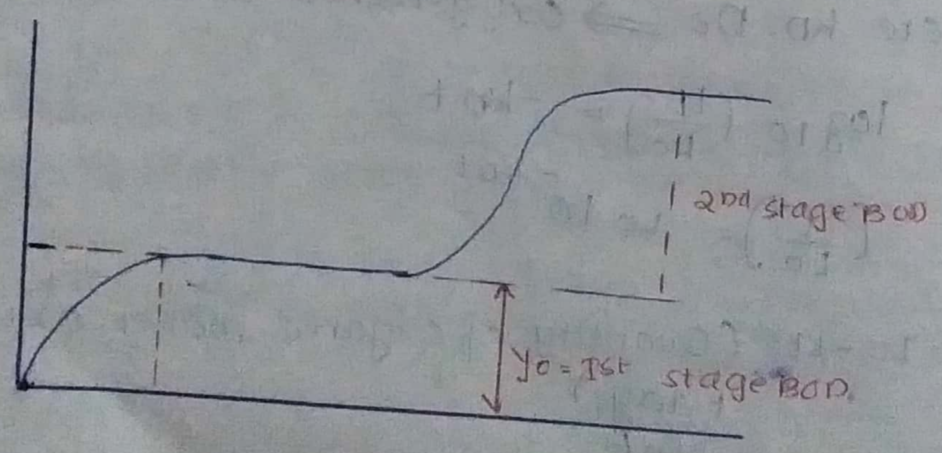
(deoxygenation constant)

$K_D(T^\circ) = K_D(20^\circ)(1.047)^{T-20}$

Generaly $K_D = 0.05$ to 0.2 (per day)

water type	K_D (per day)
Tap water	<0.05
Surface water	$0.05-1$
Muncipal waste water	$0.1-0.15$
Treated sewage water	$0.05-0.1$

Combined BOD curve



Q1. A 25ml of raw sewage has been diluted to 250ml and DO concentratn of dil sample @ the beginning of BOD test was 8 mg/l and 5mg/l after 5 days incubation @ 20°C. Find BOD of raw sewage

Ans BOD = DO × DF

$DO = DO_{initial} - DO_{final}$

$8 - 5 = 3$

Dilution Factor $DF = \frac{250}{2.5} = 100$

$BOD = DO_{cons} \times DF$

$= DO_i - DO_f \times \frac{V_{diluted}}{V_{undil}}$

$= (8-5) \times \frac{250}{2.5}$

$BOD = (8-5) \times 100$

$= 300 mg/l$

given
$DO_{initial} = 8$
$DO_{final} = 5$
$V_{diluted} = 250$
$V_{undilu} = 2.5$

Q2. For the waste water sample the 5 day BOD @ 20°C is 200 mg/l and is 67% of the ultimate. what will be the 4 day BOD @ 30°C ?

$Y_t = L_0(1 - 10^{-K_D t})$

$Y_t = Y_5 = 200 mg/l$, $t = 5$

$Y_5 = 0.67 L_0$

$\Rightarrow 200 = 0.67 L_0$

$L_0 = \frac{200}{0.67} = 298.507$

$200 = 298.507(1 - 10^{-K_D 5})$

$= \frac{200}{298.507} - 1 = -10^{-K_D 5}$

$= 10^{-K_D 5} = 0.33$

$-K_D 5 = -0.48$

* if $T = 20°$ to $30°$
$\theta = 1.056$

$K_{D(20)} = 0.0963$ per day

$K_{D(30°)} = K_{D(20°)} \theta^{T-20}$

$= 0.0963 (1.056)^{30-20}$

$= 0.166$ per day

∴ 4 day BOD @ 30°C

$Y_4 = 298.507(1 - 10^{(-0.166 \times 4)})$

$= 233.799 mg/l$

Q3. During BOD test conducted on a 5% solution of waste of following observations were taken

* DO aerated water used for dilution = 3.6 mg/l
* $DO_{orginal\ sample}$ = 0.8 mg/l
* $DO_{diluted\ sample\ after\ 5\ day\ incubation}$ = 0.7 mg/l

compute (i) 5 day BOD (ii) Ultimate BOD

Assume deoxygenation constant @ the test temp as 0.12

Ans

100 — 5% sewage water
100 — 95% aerated "

Diluted Sample contain 5% sewage water and 95% aerated water

∴ DO of test specimen (DO initial) = ($DO_{waste\ water}$ × content) + $DO_{aerated}$ × Con

= 0.8 × 0.05 × 3.6 × 0.95

= 3.46 mg/l

DO of incubater water after 5 days = 0.7 mg/l (DoFinal)

∴ DO consumed = $DO_{initial} - DO_{Final}$ = 3.46 − 0.7 = 2.76 mg/l

(i) BOD_5 = DO consumed × DF = 2.76 × 100/5 = 55.2 mg/l

(ii) Ultimate BOD = $L_0(1 - 10^{-K_D t})$

$Y_5 = L_0(1 - 10^{-K_D t})$

$55.2 = L_0(1 - 10^{-0.12 \times 5}) \Rightarrow L_0 = 73.717$ mg/l

Q4. The BOD of a sewage incubated for 1 day @ 30°c has been found to be 100 mg/l. what will be the 5 day 30°c to 20°c. Assume K @ 20°c as 0.12.

BOD $Y_1 = 100$ mg/l @ 30°c

$K(30°) = K_D(20°)\, \theta^{T-20}$

$= 0.12 \times (1.056)^{30-20} = 0.207$ per day

$Y_1 = L_0(1 - 10^{-K_D t})$

$Y_1(30°) = L_0(1 - 10^{-(0.207 \times 1)}) = 100$

$L_0 = 263.761$ mg/l

$Y_5(20°) = 263.761(1 - 10^{-0.12 \times 5})$

$= 197.507$ mg/l

Population Equivalent

Industrial waste waters are generally compared with per-capita normal domestic waste waters so as to rationaly charged the industries for the pollution caused by them.

$$\text{Population Equivalent} = \frac{\text{Std. 5 day BOD of industrial sewage}}{\text{Std 5 day BOD of domestic sewage per person per day}}$$

(Std 5 day BOD of domestic sewage per person per day → 0.08 kg/person/day)

Q. The avg sewage flow from a city 80 MLD. If the avg 5 day BOD is 285 mg/l compute the total daily 5 day oxygen demand in kg and the population equalent of sewage. Assume per capita BOD of sewage per day = 75 g

Ans.

$$\frac{\text{kg/day}}{\frac{\text{kg}}{\text{person/day}}} = \text{person}$$

Quantity of sewage flowing per day = 80×10^6 l

Avg. 5 day BOD = 285 mg/l

Total 5 day BOD = $285 \times 80 \times 10^6$ mg/day

$= 2.28 \times 10^{10}$ mg/day

$= 22800$ kg/day

$$\text{Population Equivalent} = \frac{\text{Std 5 day BOD of indu. sewage}}{\text{Std 5 day BOD of domestic sewage per person/day}}$$

$$= \frac{22800 \text{ kg/day}}{\frac{75}{1000} \text{ kg/person/day}}$$

$= \underline{3,04,000}$

Note: population equivalent indicate the strength of industrial waste water for estimating the treatment required @ muncipal sewage treatment plant and also helps in assessing the charges for the treatment from the industries

Relative Stability

Relative Stability = $\frac{\text{Oxygen available in effluent}}{\text{Oxygen required to satisfy first stage BOD demand}}$

$S = 100(1 - 0.794^{t_{20}})$

$S = 100(1 - 0.63^{t_{37}})$

Q. If period of incubation is 10 days (t_{20}) @ 20°C in the relative conductivity test on sewage calculate the % of relative stability

Since 20°C use 1st equat^n

$S = 100(1 - 0.794^{t_{20}})$

$= 100(1 - 0.794^{10})$

$= 90.07\ \%$