UNIT V DISPOSAL OF SEWAGE AND SLUDGE MANAGEMENT

Standards for Disposal - Methods – dilution – Self purification of surface water bodies – Oxygen sag curve – Land disposal – Sludge characterization – Thickening – Sludge digestion – Biogas recovery – Sludge Conditioning and Dewatering – disposal – Advances in Sludge Treatment and disposal.

Disposal of Treated Effluent

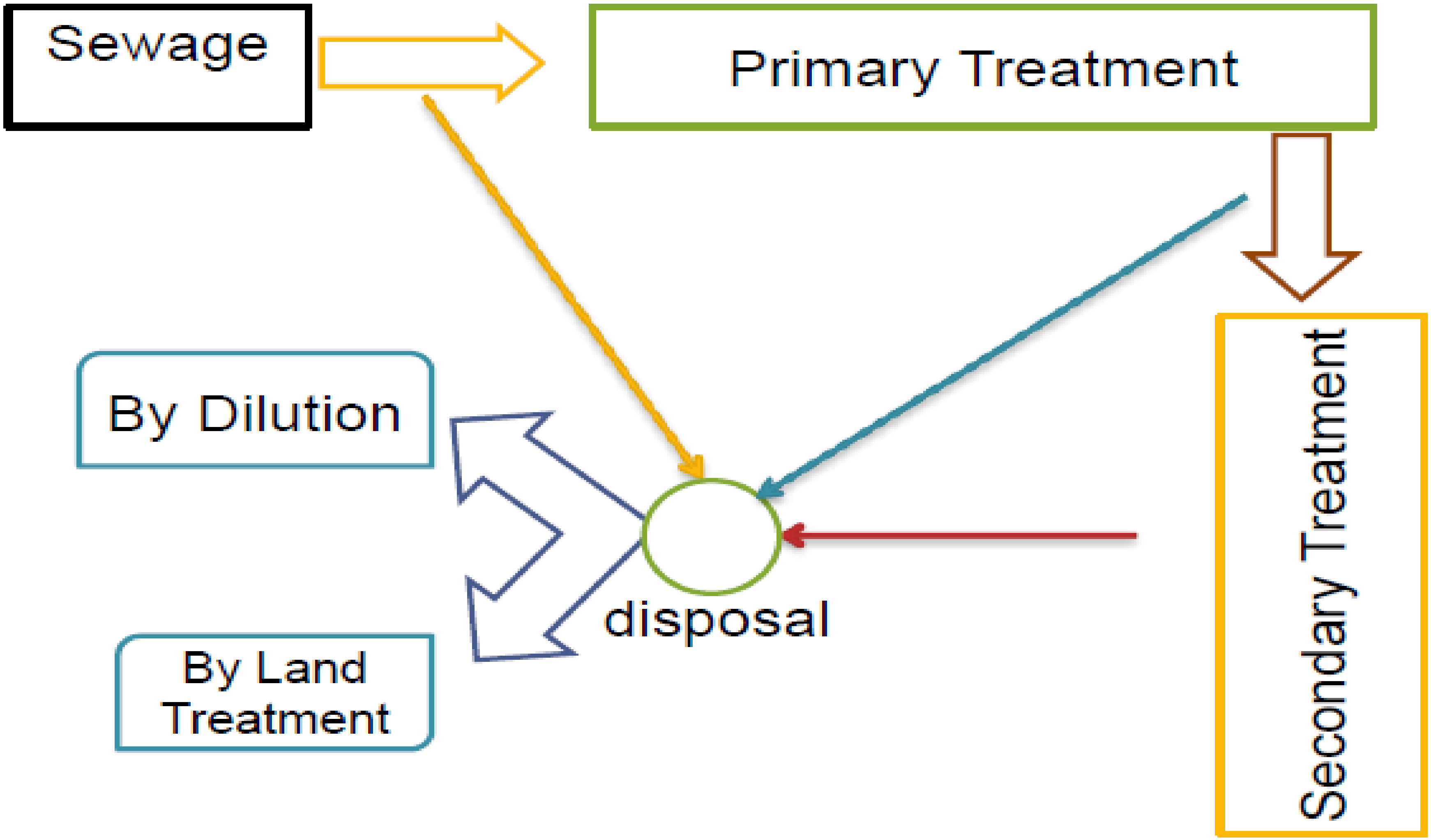
- The treated effluent from the STPs may be
  - discharged into surface waters, such as rivers, streams etc.,
  - or used on land for irrigation.
- The quality of effluent should meet effluent standards

Effluent Standards

- The tolerance limits for discharge of treated sewage into surface waters (CPCB)

Characteristics	Tolerance limits
pH	5.5 to 9.0
Suspended Solids, mg/L	30
BOD (3 days at 27°C), mg/L	20
Fecal coliforms, MPN/100mL	1000

Sewage Disposal Methods



Disposal by Dilution i.e,
(Disposal into water bodies)

Disposal By Dilution

- Disposal by dilution is a process in which the treated waste water from ETPs is discharged into a large static body of water or in a moving water body such as rivers or streams.
- The discharged wastewater is purified in due course of time, by the self purification of natural water.
- The effluent discharge and degree of treatment of wastewater depends upon the self purification capacity of the stream and its intended water use.

Conditions favouring dilution without treatment

- Where wastewater is quite fresh.
- SS has been removed from wastewater.
- The volume of receiving body is more than the wastewater discharge.
- Dilution water having high DO, to satisfied the BOD of wastewater.
- Where Swift forward currents are available.
- Wastewater does not contain toxic substances.
- Water is not used for drinking immediately after point of discharge.

Standards of dilution

Dilution factor	Standards of purification required
Above 500	No treatment required. Raw sewage can be directly discharged into river
Between 300 to 500	Primary treatment such as PST is required so that SS concentration is less than 150 mg/lit
Between 150 to 300	Treatment such as screening, sedimentation and chemical precipitation are required so that SS concentration is less than 50 mg/lit
Less than 150	Thorough treatment is required, SS should be less than 50 mg/lit and BOD_5 should be less than 20 mg/lit

Self purification of Rivers

- When sewage is discharged into the river or stream, the BOD of mix of river water increases initially and DO level starts falling.
- As river water travels further BOD gradually reduces and DO increases and reaches its saturation level.
- Thus river gets purified on its own.
- This phenomena is known as self purification of stream.

Dissolved Oxygen

- Oxygen present in water as dissolved oxygen (DO)
- Indicator of the freshness of the water body.
- The concentration of DO is proportional to the water temperature.
- Higher the water temperature, lower will be the DO concentration.
- Lower the temperature higher will be the DO concentration.
- Fish and other aquatic life require higher DO for their respiration

Saturation DO at Different Temperature

Temp °C	*Saturation mg/L*	*Temp °C*	*Saturation mg/L*	*Temp °C*	*Saturation mg/L*
0	14.62	15	10.15	30	7.63
2	13.84	16	9.95	32	7.40
4	13.13	18	9.54	34	7.20
5	12.48	20	9.17	35	7.10
6	12.80	22	8.83	36	7.00
8	11.87	24	8.53	38	6.80
10	11.33	25	8.38	40	6.60
12	10.83	26	8.22		
14	10.37	28	7.92		

Self Purification of river

- Various actions (forces) influencing (involving in) the self purification are:
  - Dilution
  - Dispersion
  - Sedimentation,
  - Oxidation,
  - Reduction,
  - Water temperature, and
  - Sunlight

Dilution

- When the sewage is discharged into the receiving water, dilution takes place due to bulk volume of flow in the river which reduces the concentration of organic matter.
- When the dilution factor is quite high, large quantities of DO are always available which will increase the oxidation of organic matter reduce the pollutional effects.
- Aerobic conditions will always exist because of dilution.
- Minimum dilution required is at least 10

Dispersion due to currents

- River water currents, which readily disperses sewage in the river, preventing locally high concentration of pollutants.
- High velocity enhances the transport of pollutants down river and improves aeration which reduces the concentration of pollutants.
- High velocity improves reaeration which reduces the time of recovery, though length of river affected by the wastewater is increased.

Sedimentation

- If stream velocity is lesser than the settling (scour) velocity of particles then sedimentation will take place, which has the following effects:
  - SS contribute to BOD will be removed by settling and hence downstream water quality will be improved.
  - Due to settled solids anaerobic decomposition may take place at the bed level.

Oxidation

- The organic matter present in the sewage is oxidized by aerobic bacteria utilizing DO of the river waters.
- This process continues till complete oxidation of organic matter takes place.
- The flowing river is capable of absorbing more oxygen through reaeration and increases the DO concentration in the river.

Reduction

- Reduction occurs in the stream due to hydrolysis of organic matter biologically or chemically.
- Anaerobic bacteria decompose the organic matter into liquids and gases, thus paving the way for stabilization by oxidation.

Water Temperature

- At low water temperature activity of bacteria is low., and hence decomposition is slow., though DO is more because of increased solubility of oxygen in water.

- At higher water temperature purification will take lesser time though amount of DO is less in the water.

Sunlight

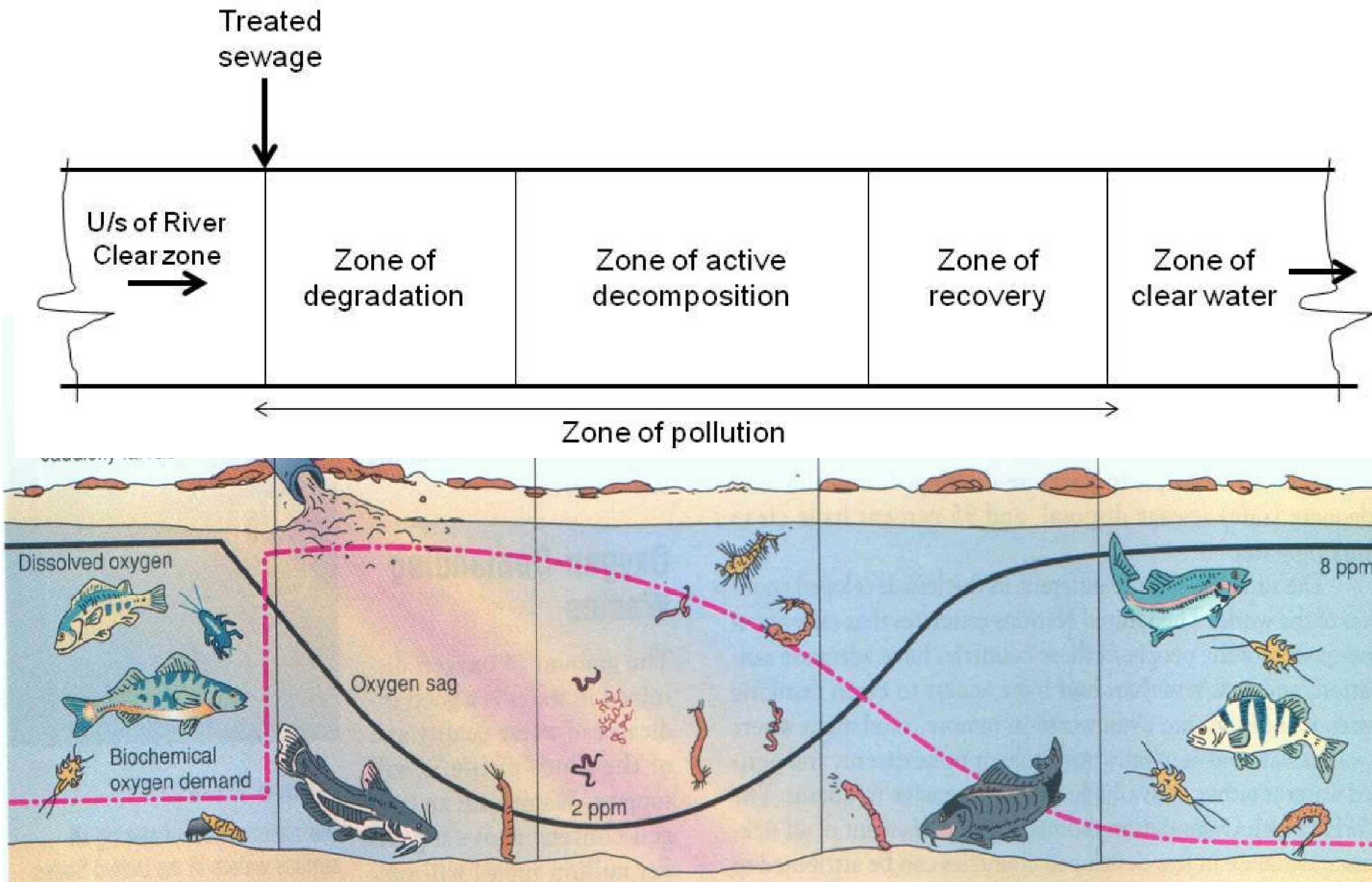
- Sunlight helps certain micro-organisms to absorb CO_2 and give out oxygen, thus resulting in self purification.
- UV radiation of sunlight acts as disinfectant and stimulates growth of algae which produces oxygen during photosynthesis.
- Hence wherever there is algal growth water contains more DO during daytime.

ZONES OF POLLUTION IN THE RIVER

Zone of Pollution

- The section of river from the point of sewage discharge to the point where the river becomes clear is referred as zone of pollution.
- The following well-defined zones are established within the zone of pollution:
  - Zone of Degradation,
  - Zone of Active Decomposition and
  - Zone of Recovery.
  - Zone of clear water

Zone of Pollution

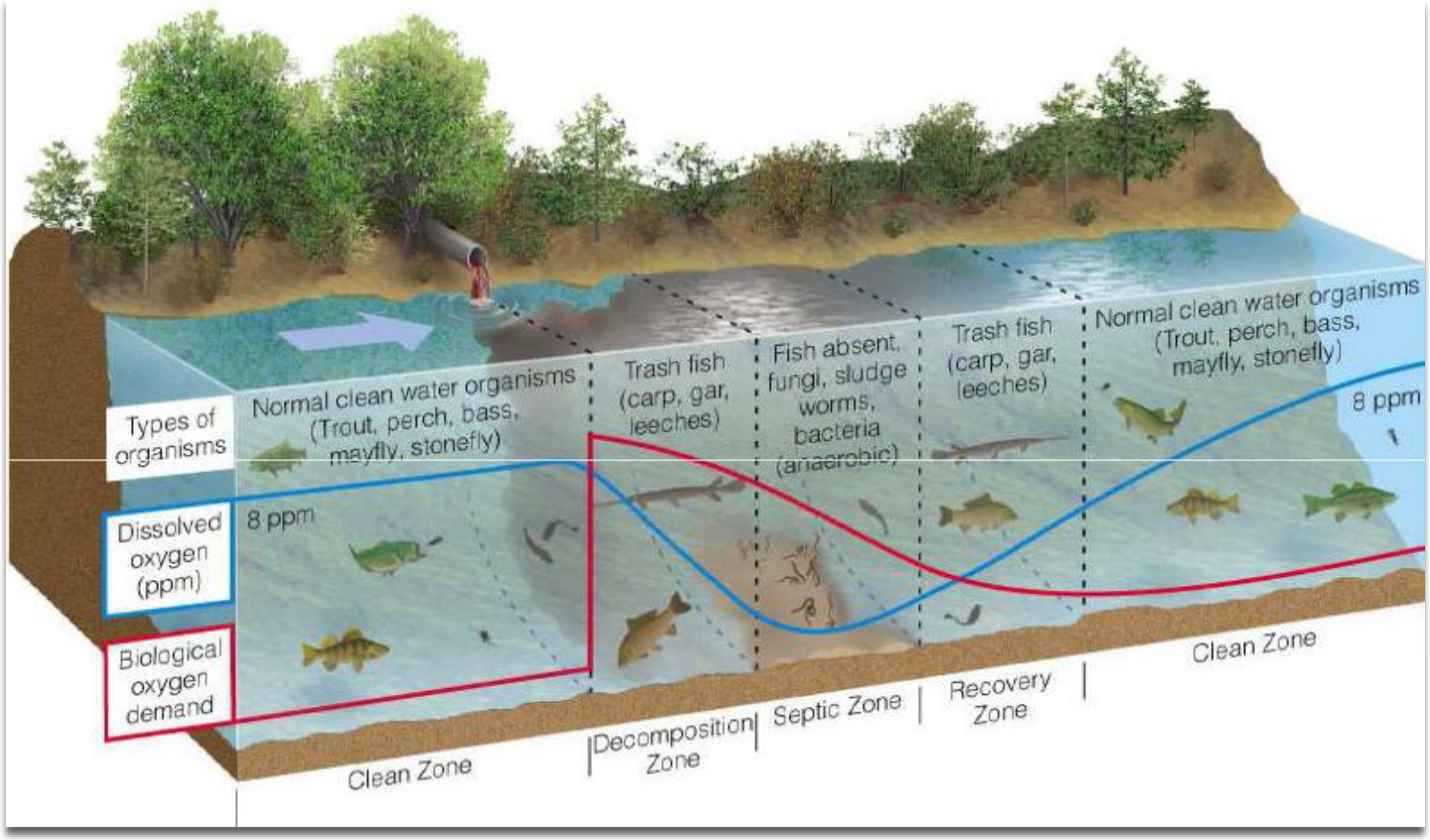


Features

Features of different zones of pollution

Features	Zone of Degradation	Zone of Active decomposition	Zone of recovery	Zone of clear water
Water colour	Brown	Dark Brown	In-significant	Clear
DO	Rapid fall	Minimum DO	Increase in DO	Approaching saturation level
Surface condition	Turbid and debris floating	Scum formation on the surface	Clear water with floating matter	Clear water
Fish and other aquatic life	Declining	Die or migrate	Reappear	Normal
Other features	Entry of sun light prevented	Entry of some light	UV disinfection of coliforms	Clear liquid

Zone of Pollution



1. Zone of degradation

- Situated just below outfall sewer.
- Water is dark and turbid with sludge at the bottom.
- DO reduces up to 40% of saturation level.
- CO_2 content increases.
- Reaeration is slower than deoxygenation.
- Conditions are unfavorable for aquatic life.
- Anaerobic decomposition takes place in this zone.

2. Zone of active decomposition

- Water in this zone becomes grayish and darker than previous zone.
- DO concentration falls to zero.
- CH_4, H_2S, CO_2 and N_2 are present because of anaerobic decomposition.
- Fish life is absent but bacteria are present.
- At the end of this zone DO rises to 40% of saturation.
- Aquatic life starts to reappear.

3. Zone of recovery

- Process of recovery starts.
- Stabilization of organic matter takes place in this zone.
- BOD falls and DO content increases above 40% value.
- NO_4, SO_4 and CO_3 are formed.
- Near the end of this zone entire aquatic life reappears.

4. Clear water zone

- Water becomes clearer and attractive in appearance.
- DO rises to saturation level.
- Oxygen balance is attained.
- Recovery is complete.
- Some pathogenic microorganisms may be present.

Oxygen Sag Curve

- When pollutional load is discharged into the stream, DO goes on reducing. This process is known as deoxygenation.

- It depends upon organic matter present and temperature.

- The variation or depletion of DO is represented graphically by deoxygenation curve.

Oxygen Sag Curve

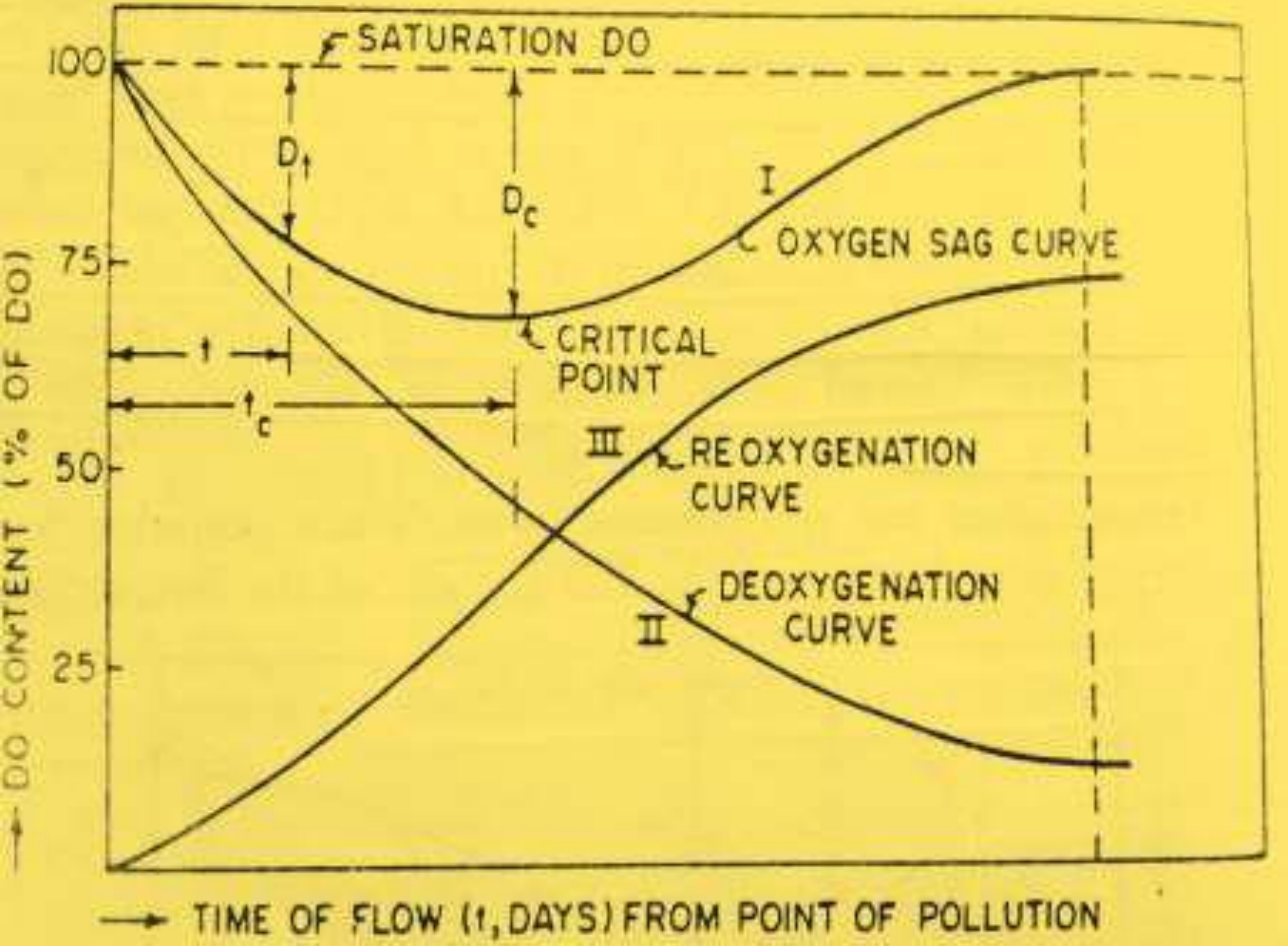
- At the same time oxygen gets added into the stream through various processes such as photosynthesis, rains etc.
- The curve representing oxygen gaining process is known as Reoxygenation or reaeration curve.
- In a running polluted stream deoxygenation and reaeration processes go hand in hand.

Oxygen Sag Curve

- The amount of DO deficit can be obtained by graphically adding both the curves. The resultant curve is known as 'Oxygen sag curve'.
- The difference between the saturation concentration of DO at river water temperature and the actual concentration of DO at any point is known as the DO deficit (D_t)
- DO deficit is given by

$$\text{DO deficit} = \text{saturation DO} - \text{Actual DO}$$

$$= DO_{sat} - DO_{act}$$



SATURATION DO
100
75
50
25
Dt
Dc
I
OXYGEN SAG CURVE
CRITICAL POINT
t
tc
III
REOXYGENATION CURVE
DEOXYGENATION CURVE
II
DO CONTENT (% OF DO)
TIME OF FLOW (t, DAYS) FROM POINT OF POLLUTION

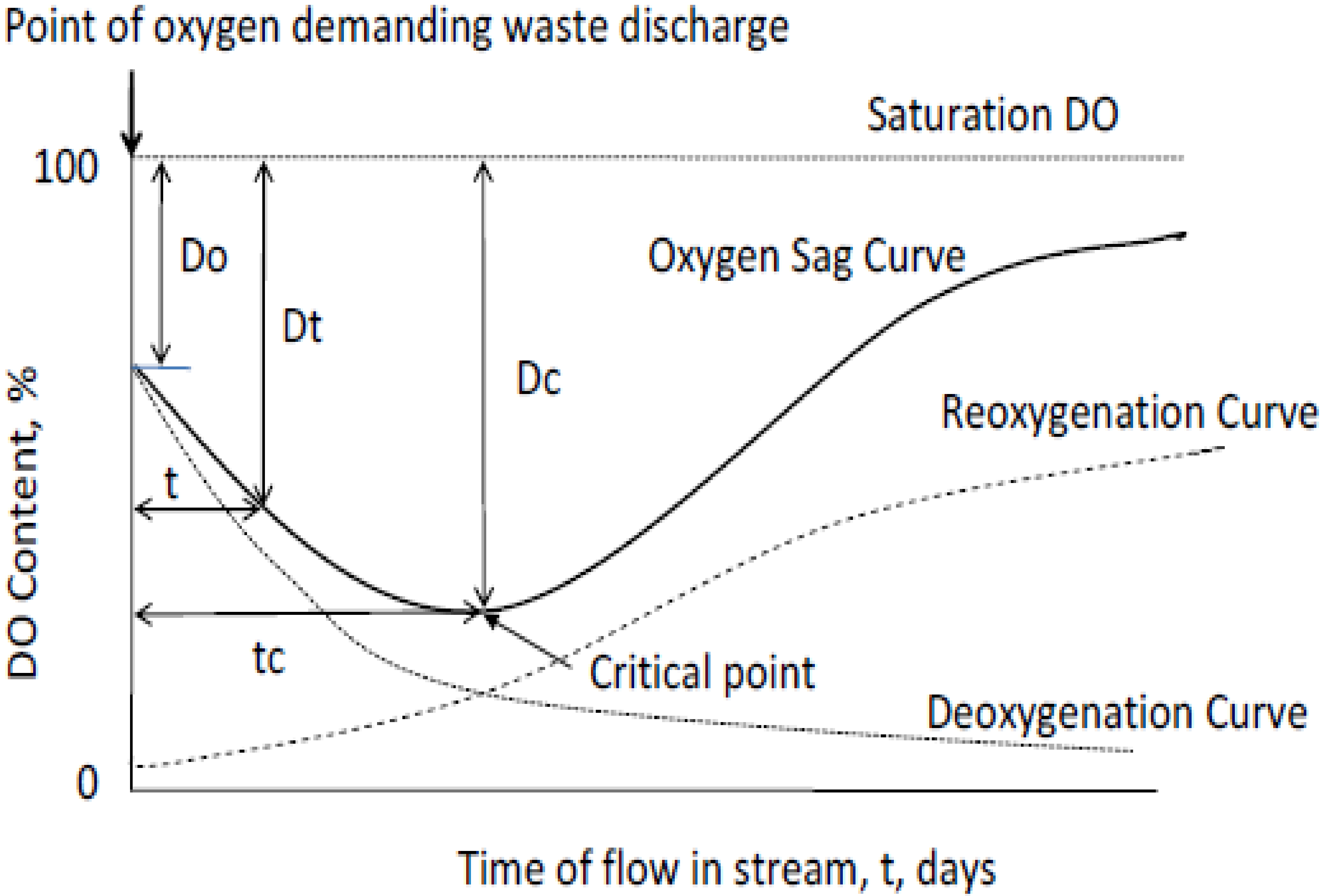


Figure 12.1 Deoxygenation, reoxygenation and oxygen sag curve

Oxygen Sag Curve

- Oxygen sag curve illustrates how the oxygen concentration changes with time and distance downstream of a discharge point.
- The Streeter-Phelps equation, developed in the year 1920s from pollution studies in the Ohio River in the US, is used for determining the DO deficit as a function of deoxygenation and reaeration.

Streeter-Phelps Equation

$$D_t = \frac{K_1 L_o}{K_2 - K_1}\left(10^{-K_1 t} - 10^{-K_2 t}\right) + D_o \times 10^{-K_2 t}$$

where

D_t =DO deficit at time t, at down stream location, mg/L

D_o=initial DO deficit at time t = 0, mg/L

K_1 = deoxygenation rate constant, d^{-1}

K_2 = reaeration rate constant, d^{-1}

L_o= ultimate BOD at time t = 0, mg/L

t = time of travel in the river from point of discharge, d

The critical time of travel, t_c

- The location of the critical point, where the DO concentration is the least, and D_t is the maximum, is of the location of greatest interest, because the conditions there are worst.
- Design for mitigation of water quality is based on this location.
- The location of the critical point or the critical time of travel, t_c can be determined by using the following equation.
- The value of critical deficit can be found by substituting $t = tc$ in the Streeter Phelps Equation

$$t_c = \frac{1}{K_2 - K_1} \log\left[\frac{K_2}{K_1}\left\{1 - \frac{D_o\left(K_2 - K_1\right)}{K_1 L_o}\right\}\right]$$

Limitations

- Self purification is possible only when:
  - treated sewage with BOD less than 20 mg/L should be discharged into perennial rivers.
  - Rivers should have a minimum dilution of 10.
  - The minimum flow is assessed based on flow for 7 consecutive days that may occur once in 10 years.
  - In Tamil Nadu no such river is existing

Example

A city discharges treated sewage effluent at 240 cumecs into a river flowing at 1500 cumecs with a mean velocity of 0.1 m/s.

The 5-day BOD of sewage and river water at 20°C are 20 mg/L and 3.5mg/L respectively.

The upstream DO is 7.8 mg/L. at a temperature of 20°C.

The constants of K_1 and K_2 (to base 10) are 0.15/day and 0.40/day respectively.

Calculate the critical time (t_c) where the minimum DO will occur, the distance (X_c), where this will occur and the minimum DO concentration.

Solution

$$DO_{mix} = \frac{7.80 \times 1500 + 0 \times 240}{1500 + 240} = 6.72\, mg / L$$

$$BOD_{mix} = \frac{3.5 \times 1500 + 20 \times 240}{1500 + 240} = 5.77\, mg / L$$

D_o = DO_{sat} at 20°C – DO_{mix}

= 9.17 – 6.72 = 2.45 mg/L

Calculate ultimate BOD (L_o)

$$L_o = \frac{BOD}{\left(1-10^{-K_1 t}\right)}$$

$$L_o = \frac{5.77}{\left(1-10^{0.15\times5}\right)} = 7.02 mg/L$$

Calculate time before minimum DO

$$t_c = \frac{1}{K_2 - K_1}\log\left[\frac{K_2}{K_1}\left\{1-\frac{D_o\left(K_2 - K_1\right)}{K_1 L_o}\right\}\right]$$

$$t_c = \frac{1}{0.40-0.15}\log\left[\frac{0.40}{0.15}\left\{1-\frac{2.45\left(0.40-0.15\right)}{0.15\times7.02}\right\}\right] = 0.76\,days$$

t_c = 0.76 days

velocity of flow = 0.1 m/s

Distance d/s for minimum DO concentration to occur (X_c)

X_c = 0.1 x 0.76 x 24 x 60 x 60

= 6566 m or 6.57 km

Maximum DO deficit = D_c

$$D_t = \frac{K_1 L_o}{K_2 - K_1}\left\{10^{-K_1 t} - 10^{-K_2 t}\right\} + D_o 10^{-K_2 t}$$

$$D_c = \frac{0.15 \times 7.02}{0.40 - 0.15}\left\{10^{-0.15\times 0.76} - 10^{-0.40\times 0.76}\right\} + 2.45 \times 10^{-0.40\times 0.76}$$

D_c = 2.36 mg/L

$D_{min} = C_{sat} - D_c$

D_{min} = 9.17 – 2.36 = 6.81 mg/L

Disposal by land treatment

- It is wastewater spread on the surface of land.

Mechanism:

- Some part of the wastewater evaporates; other part percolates in the ground leaving behind suspended solids which are partly acted upon by the bacteria and partly oxidised by exposure to atmospheric actions of air, heat & light.

Suitability of land Treatment

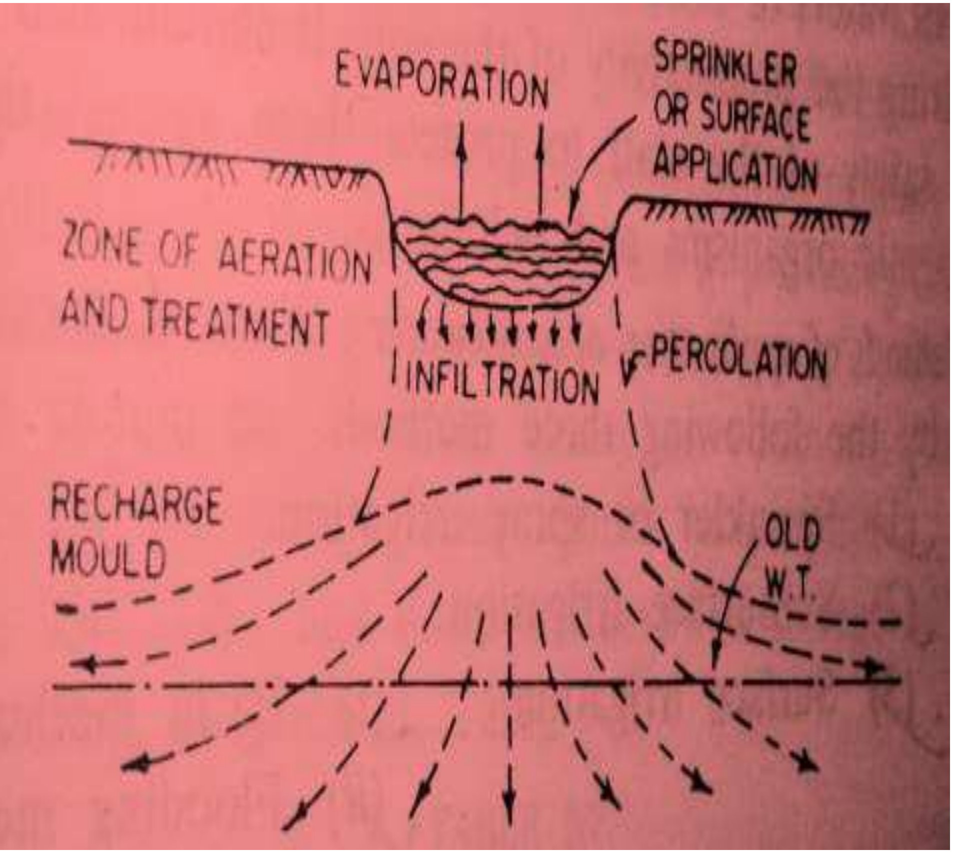
- **Alternative to river**
  - Not located in the vicinity
  - Very small flow
- **Land**
  - Percolating land eg. Sandy , Loamy, or alluvial soil
- **Climate**
  - Arid climate
  - Low water table
  - Demand for irrigation water

Methods of Land Treatment

- *According to the percolating capacity of soil*

Method Used	Percolation Rate
Rapid infiltration	6-25 mm/min
Irrigation	2-6 mm/min
Overland flow	<2 mm/min

Rapid Infiltration



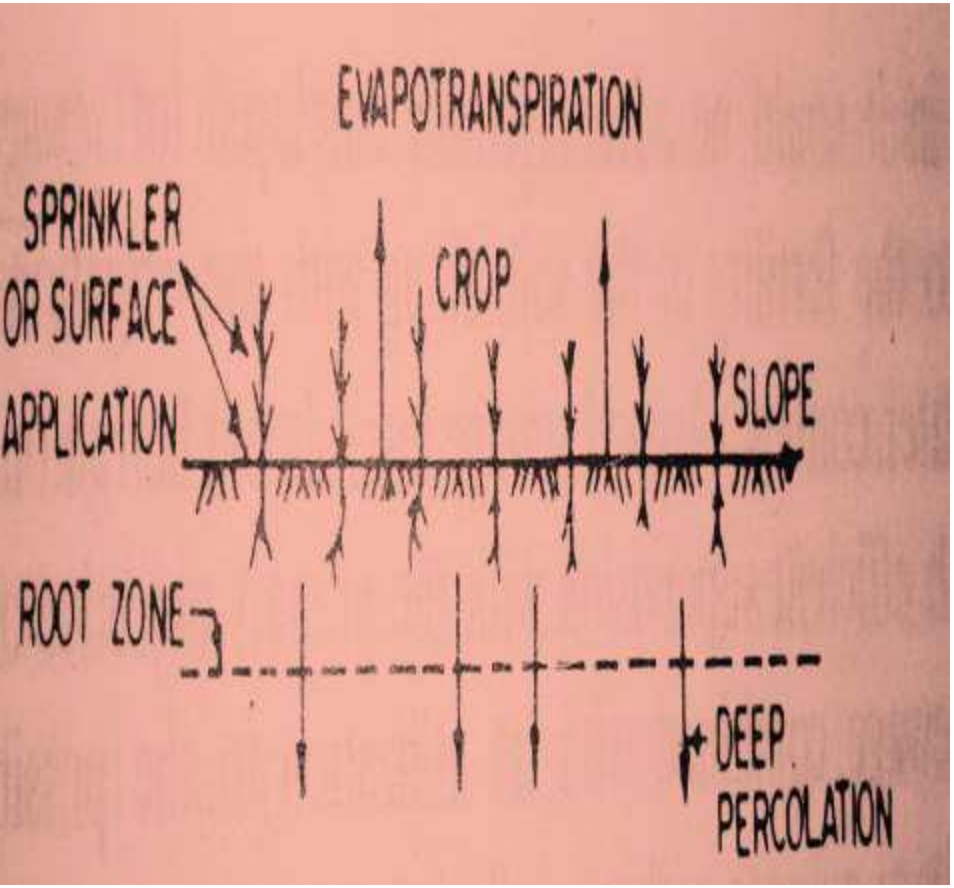
Rapid Infiltration

- Great basin or pond is prepared where sewage is applied and allowed to percolate down.

-Two or more basins are used to maintain adequate infiltration capacity

-Rate of infiltration is high(6 to 25 mm/min)

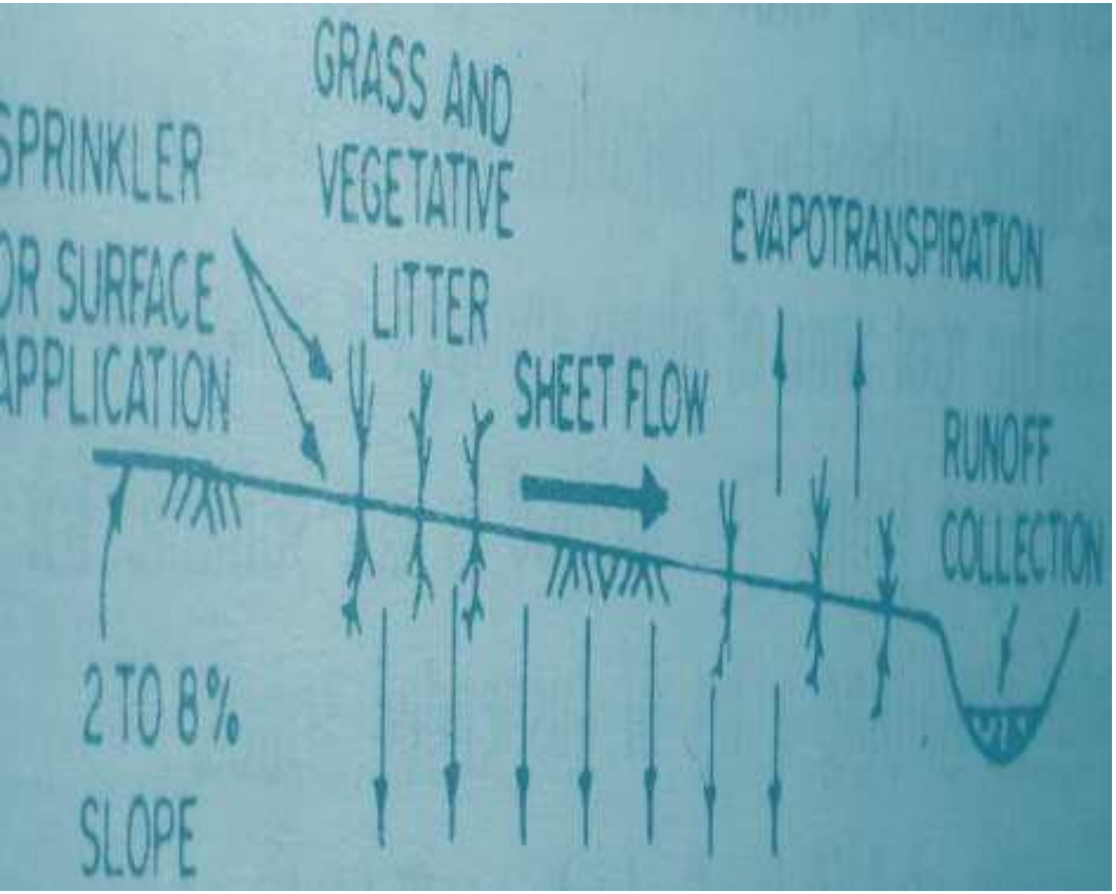
Irrigation or Sewage Farming



Irrigation or Sewage Farming

In sewage farming, to support plant growth, controlled discharge of sewage is applied to the land

Overland Runoff



Overland Runoff

The controlled discharge of sewage is applied on ground having a slope 2 to 8% where it follows down from vegetative areas and appears as runoff which is collected than disposed off.

Broad Irrigation & Sewage Farming

(Effluent Irrigation)

Broad Irrigation	Sewage Farming
Successful disposal of Sewage	Successful growing of the Crops
Raw or settled sewage is applied	Raw sewage isn’t used
Suitable for relatively more pervious soil.	

Result: Crop is raised & Sewage is disposed by land application

Sewage Sickness & its Prevention

- The phenomenon of inability to take any further load of sewage by the land.
- The pores of soil gets clogged, preventing oxidation and causing noxious smells.

Its Prevention

- Pretreatment of Sewage
- Provision of extra land
- Under Drainage of soil
- Proper choice of land
- Rotation of crops
- Shallow depth application

Sludge Management

Sludge Management

- The term sludge refers to the solids that are settled and separated during wastewater treatment.
- It is necessary to treat properly or dispose the sludge generated during the various stages of wastewater treatment like primary sedimentation, secondary sedimentation and sludge generated from advanced (tertiary) treatment, if any.

Sludge Management

- The quantity of sludge generated depends upon the degree of treatment or quality of treated effluent required

  i.e., higher the degree of wastewater treatment, the larger the quantity of sludge to be treated and handled

Sludge Management

- Because of strict rules and regulations involving the handling and disposal of sludge, it has become necessary to reduce the volume of sludge in order to reduce the operating costs (approximately 50% of the plant cost) of treatment plants.
- Hence a properly designed and efficiently operated sludge processing and disposal system is essential to the overall success of the wastewater treatment plant.

Sludge characterization

- The sludge generated during the wastewater treatment can be classified into three categories:

1. ***Primary Sludge***
2. ***Secondary Sludge***
3. ***Tertiary Sludge***

Characteristics of Primary Sludge

- Sludge settled in primary settling tanks comes under this category which contains

  - 3% to 7% solids out of which approximately 60% to 80% are organic.
- Primary sludge solids are usually gray in color, slimy, fairly coarse, and with highly obnoxious odors.
- This type of sludge can be digested readily by aerobic or anaerobic bacteria under favorable operating conditions.

Characteristics of Secondary Sludge

- This type of sludge from secondary settling tanks has commonly a brownish, flocculent appearance and an earthy odor.
- It consists mainly of microorganism containing 75% to 90% organic fraction and remaining inert materials.
- The organic matter may be assumed to have a specific gravity of 1.01 to 1.05, depending on its source, whereas the inorganic particles have high a specific gravity of about 2.5.

Characteristics of Tertiary Sludge

- The nature of sludge from the tertiary (advanced) treatment process depends on the unit process followed like membrane processes or chemical methods, etc.
- Chemical sludge from phosphorus removal is difficult to handle and treat.
- Tertiary sludge from biological nitrification and denitrification is similar to waste activated sludge.

Objectives of Sludge Treatment

Sludge is stabilized to

(i) Reduce the organic content

(ii) Reduce pathogens

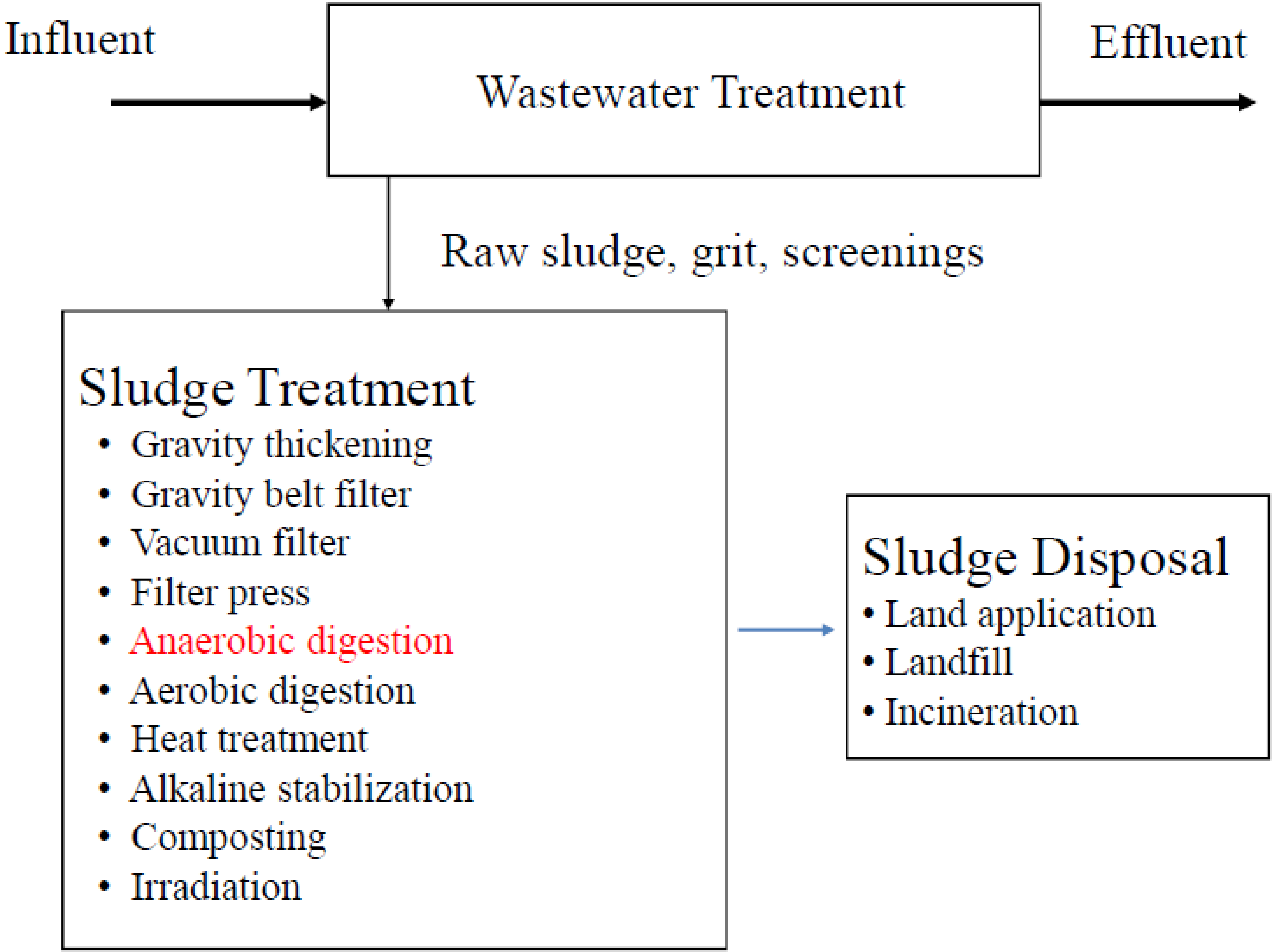
(iii) Eliminate odours

(iv) Reduce, or eliminate the potential for decomposition

(v) Improve dewatering characteristics of the sludge to reduce volume for disposal.

(vi) Safe and aesthetically acceptable disposal of sludge.

(vii) By product of methane is used as fuel & and helps in controlling temperature and also generates power.


Influent
Wastewater Treatment
Effluent
Raw sludge, grit, screenings
Sludge Treatment
• Gravity thickening
• Gravity belt filter
• Vacuum filter
• Filter press
• Anaerobic digestion
• Aerobic digestion
• Heat treatment
• Alkaline stabilization
• Composting
• Irradiation
Sludge Disposal
• Land application
• Landfill
• Incineration

Sludge Treatment

- The reduction in volume of the sludge can be achieved by
  - thickening,
  - dewatering and
  - drying; and
- Stabilization of organic matter can be obtained by employing
  - digestion (aerobic or anaerobic),
  - incineration,
  - composting,
  - heat treatment,
  - chlorine oxidation or lime stabilization

Flow sheet for biological sludge treatment

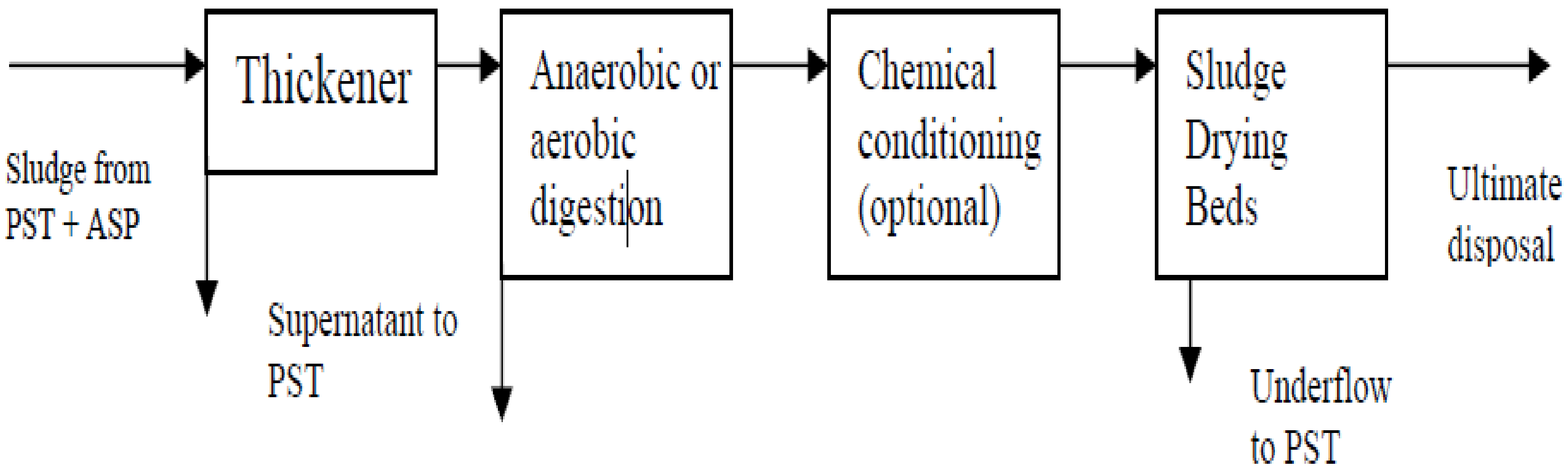


Figure 22.1 Flow sheet for biological sludge treatment

Sludge Thickening

- Sludge thickening or dewatering is adopted for reducing the volume of sludge and increasing the solid contents. This will help in following:

(i) increasing the loading on the digester, requiring lesser digester volume,

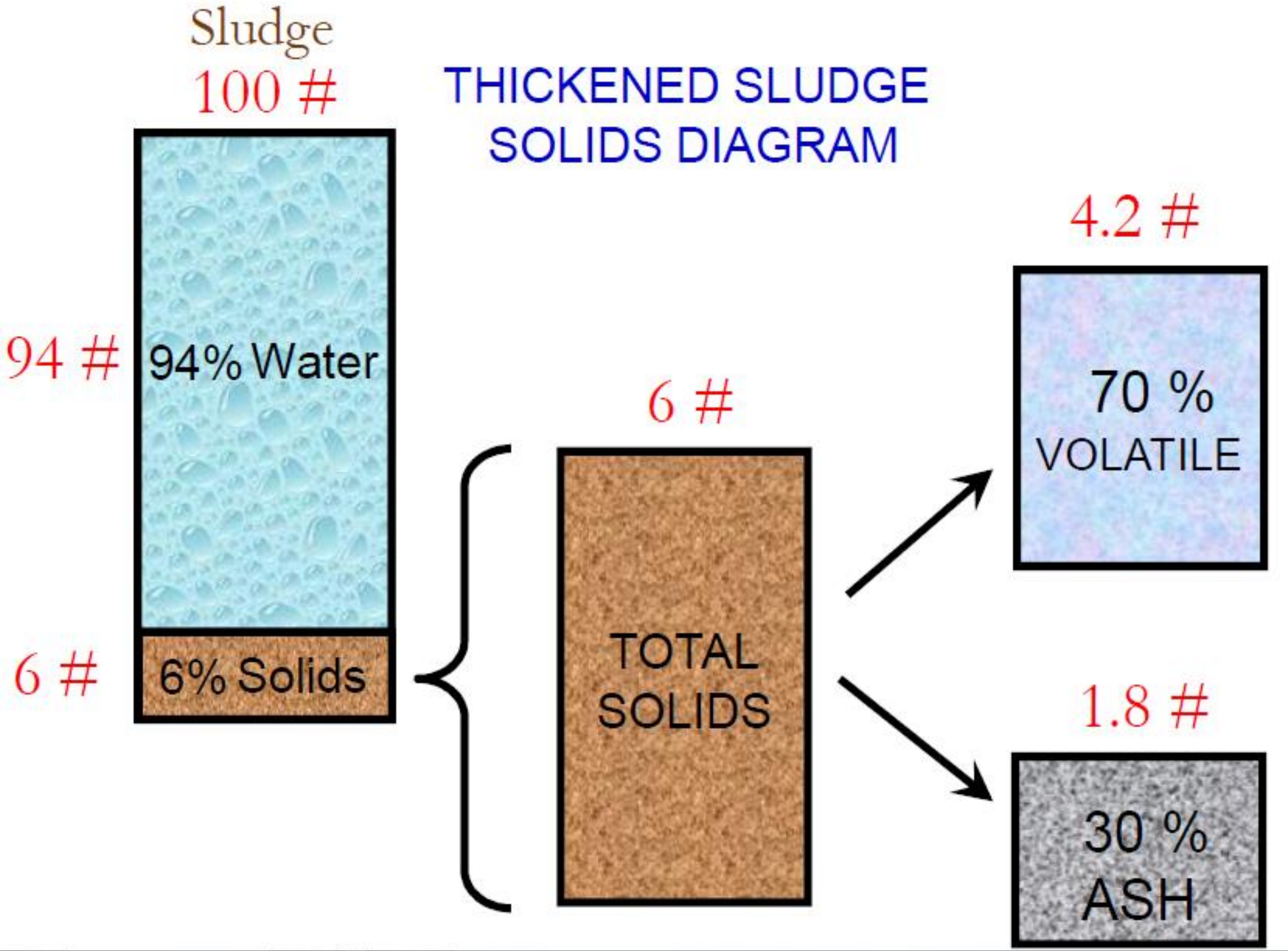
(ii) increase feed solids concentration to vacuum filters,

(iii) economize transport and handling cost of sludge within the plant and final disposal,

(iv) minimize land required and handling cost for final disposal of the digested sludge on land, and

(v) save fuel if incineration is practiced.

THICKENED SLUDGE SOLIDS DIAGRAM



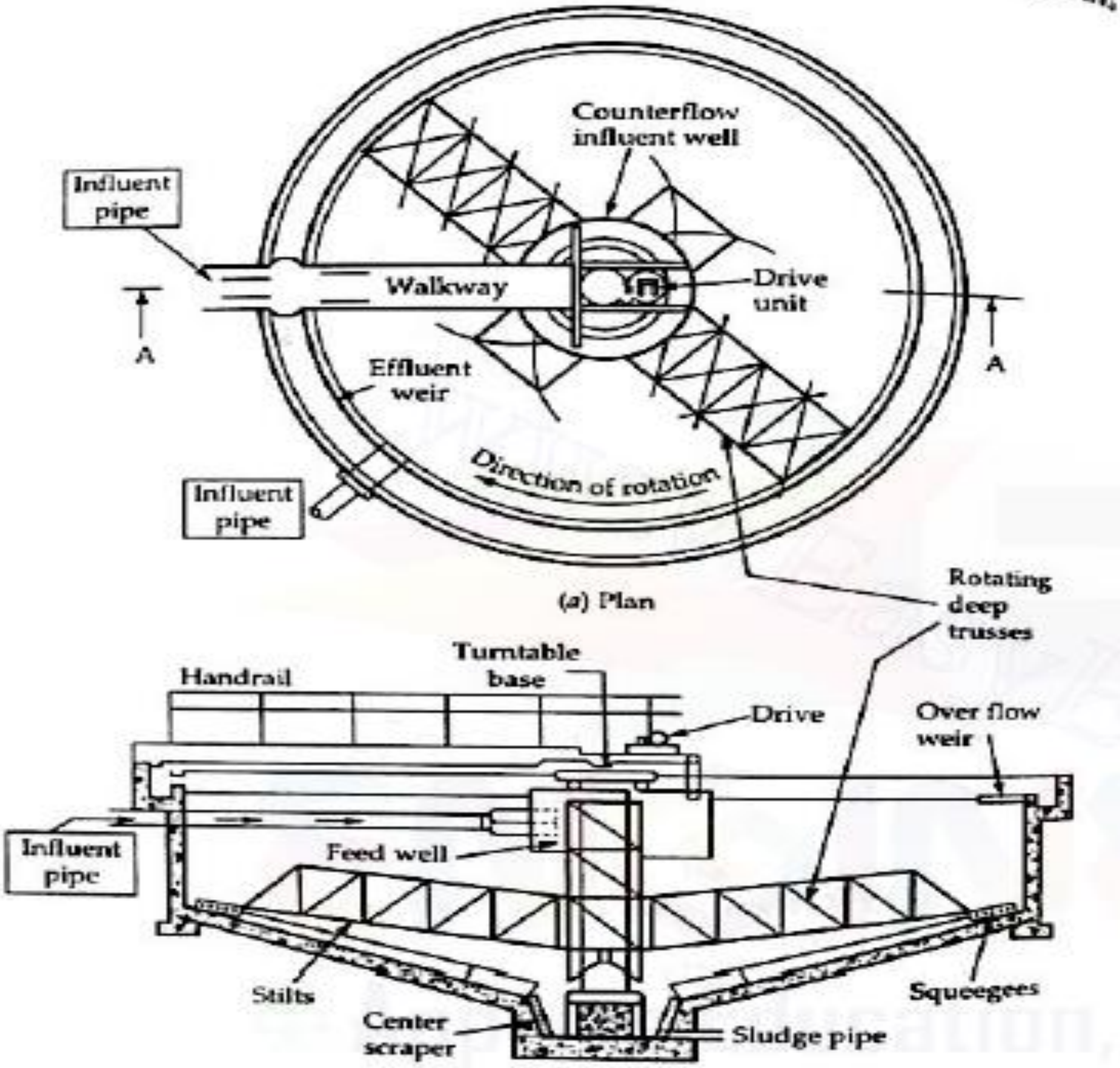
Sludge Thickening

- In sludge thickeners, greater amount of water is removed from the sludge.
- The thickening of the sludge can be achieved by 3 types of thickening units

1. Gravity thickener,
2. Floatation thickener
3. Centrifugal thickener

Gravity thickener

- It consists of a small circular opening tank, like sedimentation tank except that it is deeper to accommodate a greater volume of sludge and has a heavier raking mechanism.
- Slowly rotating rake mechanism, like deep truss are provided to stir the sludge gently, opening up channels for water to escape, thereby promoting densification of sludge.



(*a*) Plan

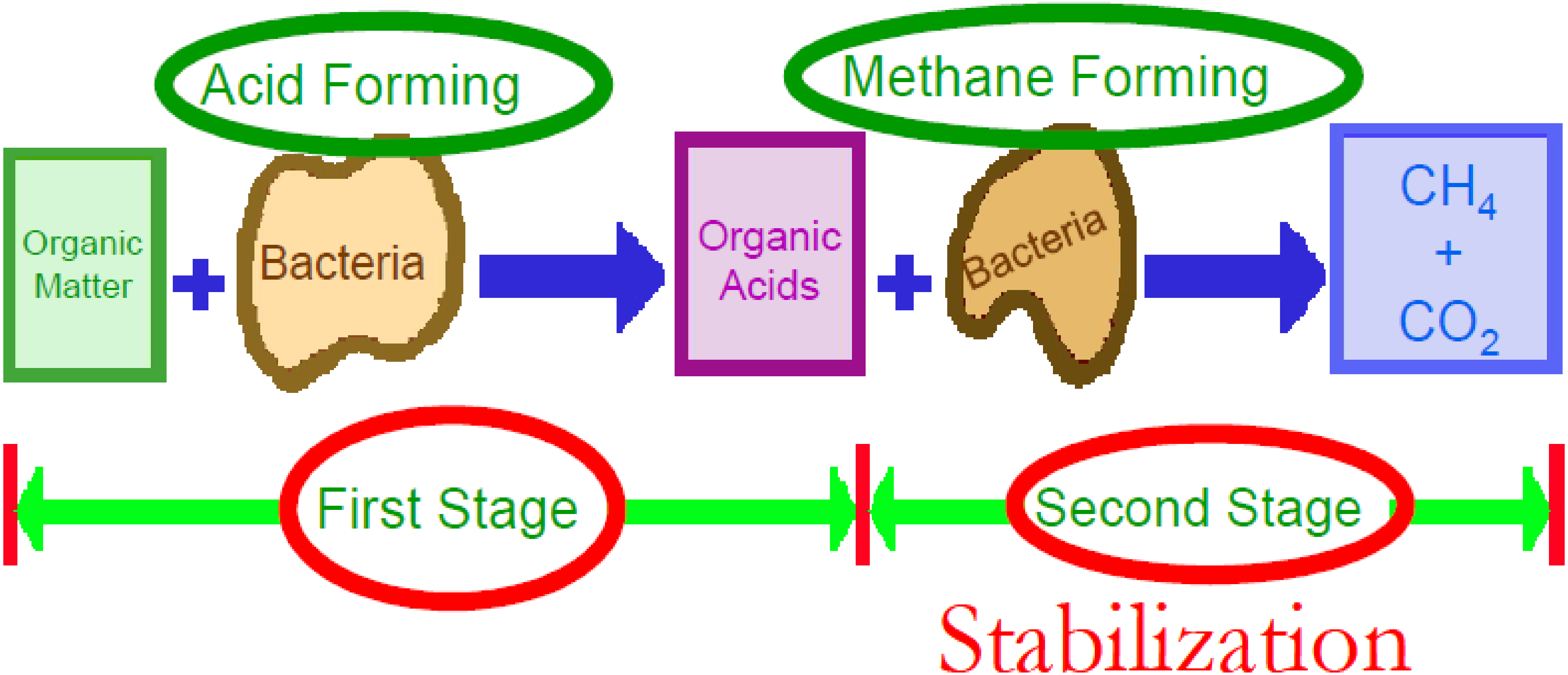
(*b*) Section AA

Anaerobic Sludge Digestion

- In anaerobic digestion process the organic material, in mixture of primary settled sludge and biological sludge from secondary clarifier, is converted to CH_4 and CO_2 under anaerobic conditions.
- This is carried out in an air tight reactor in absence of oxygen.
- Most microbes used in this digestion are anaerobes or facultative type.

Anaerobic Digestion Process

"TWO-STAGE" Process



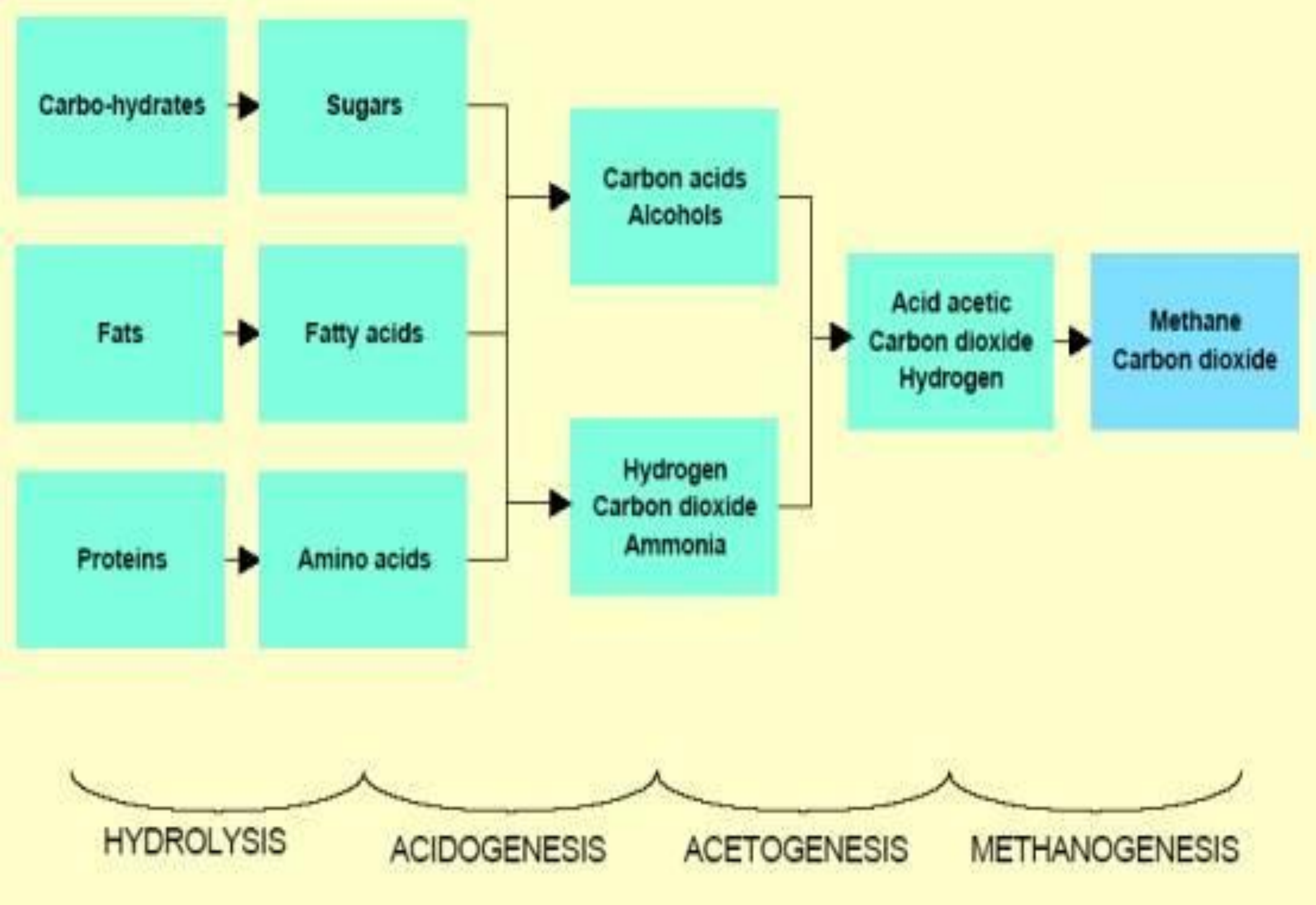
Anaerobic Sludge Digestion

- During oxidation of organic matter anaerobically following reaction occurs
- Organic matter $\xrightarrow{\text{(Anaerobic bacteria)}}$ CO_2 + CH_4+

New cell + energy for cells + Other products

(H_2S, H_2, N_2 etc.)

The process of anaerobic sludge digestion



The process of anaerobic sludge digestion

- The breakdown of three major organic matters is shown below:
- Carbohydrates $\longrightarrow$ Simple sugars $\longrightarrow$ Alcohols, aldehydes $\longrightarrow$ Organic acids
- Proteins $\longrightarrow$ Amino acids $\longrightarrow$ Organic acids + NH_3
- Fats and oils $\longrightarrow$ Organic acids
- Organic acids $\longrightarrow$ CO_2 (55-75%) + CH_4 (35-45%) + H_2S, H_2, N_2 etc. in traces

Anaerobic sludge digestion

- The first group of microorganisms hydrolyzes the complex organic substances to soluble end products and is called as hydrolytic bacteria.
- The second group of microorganisms called acidogenic bacteria converts the product of first group of bacteria into simple end product primarily VFA and alcohols.
- The third group called methanogenic bacteria converts the produced acid by the second group into methane and carbon dioxide.

Anaerobic sludge digestion

- Alkalinity present in the reactor should be sufficient for proper functioning of the digester to maintain the pH between 6.5 to 8.0.
- Temperature has got tremendous effect in the functioning of a digester.
- It has been established that two types of bacteria, mesophilic (20 to 40^{o}C) and thermophilic (45 to 65^{o}C) are responsible for biodegradation.
- Therefore, the digester can be operated either at mesophilic or thermophilic temperature range.

Anaerobic Digestion Operating Parameters

- **Temperature**
  - Optimum 98^{o}F (35^{o}C)
  - General Operating Range 35 to 65^{o}C
- **pH**
  - Optimum 7.0 to 7.1
  - General Limits 6.7 to 7.4
- **Sludge Loading**
  - Recommended loadings for anaerobic digesters that are mixed and heated are 3.2-7.2 kg VS/m^3/day.
  - However loading rates of (0.5-0.6 kg VS/m^3/day) are typical.

Anaerobic Digestion Operating Parameters

- **Gas Composition**
  - Carbon Dioxide 65 to 69 percent
  - Methane 31 to 35 percent
  - Hydrogen Sulfide Trace
- **Volatile Acids Concentration (as Acetic Acid)**
  - Normal Operation 200 to 800 mg/L
  - Maximum Approximately 2,000 mg/L
- **Alkalinity Concentrations as $CaCO_3$**
  - Normal Operation 2,000 to 3,500 mg/L

Products of Digestion

1. Gases
   - Methane (CH_4)
   - Carbon Dioxide (CO_2)
2. Scum
   - Lighter Solids
3. Supernatant
   - Liquid Removed
4. Digested Sludge
   - “Stabilized”

Anaerobic Digestion Systems

- Single-Stage Digester with a Floating Cover (Standard Rate)
  - Contents Unmixed and Unheated
  - Td = 30 to 60 days
- Single-Stage High Rate Digestion System
  - Contents Mixed and Heated
  - Td = 15 days or less
- Two-Stage Anaerobic Digestion System
  - Second Stage Can Function as a Solids Separation Phase
  - Additional Digestion Can also occur in this Second Stage

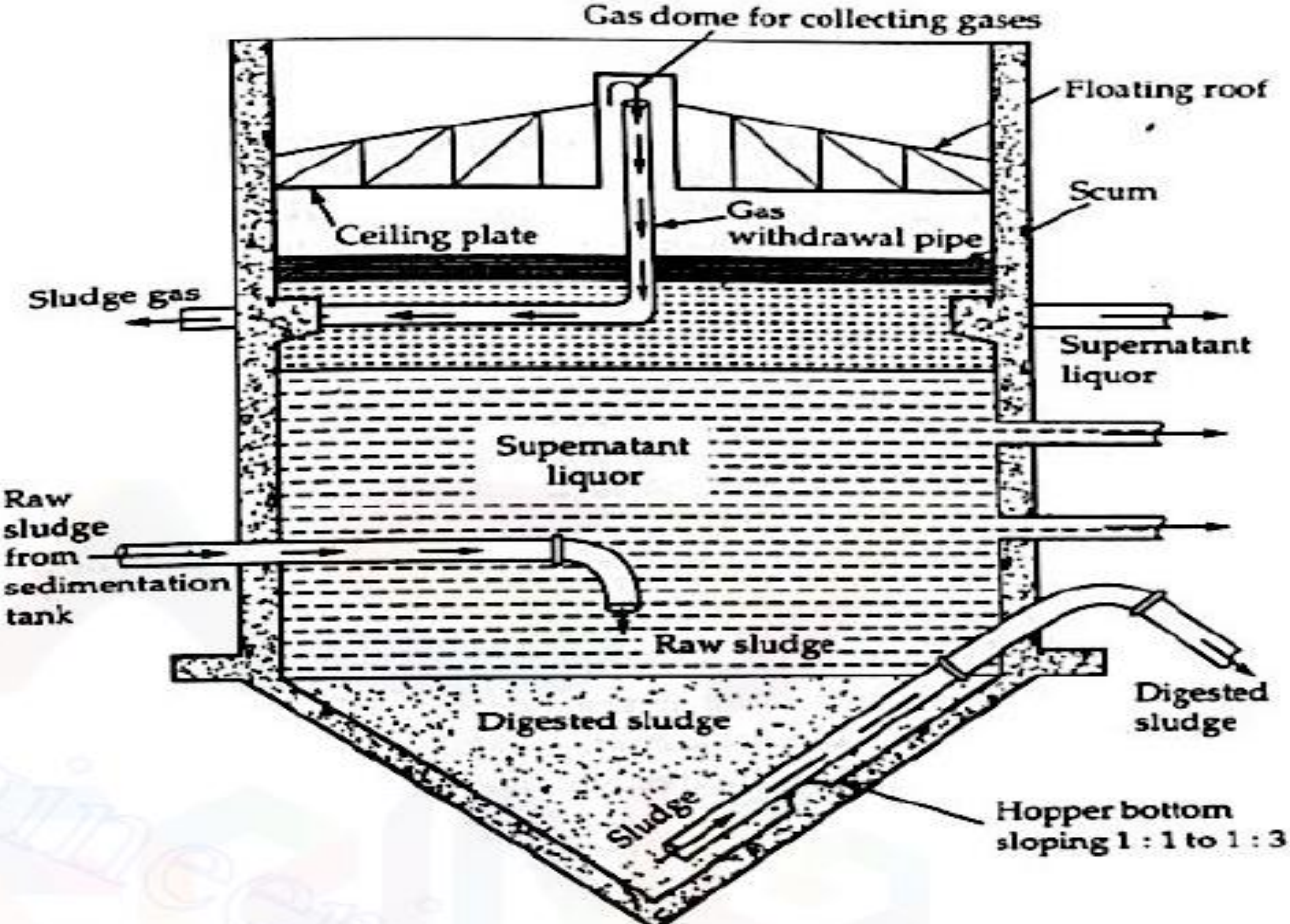
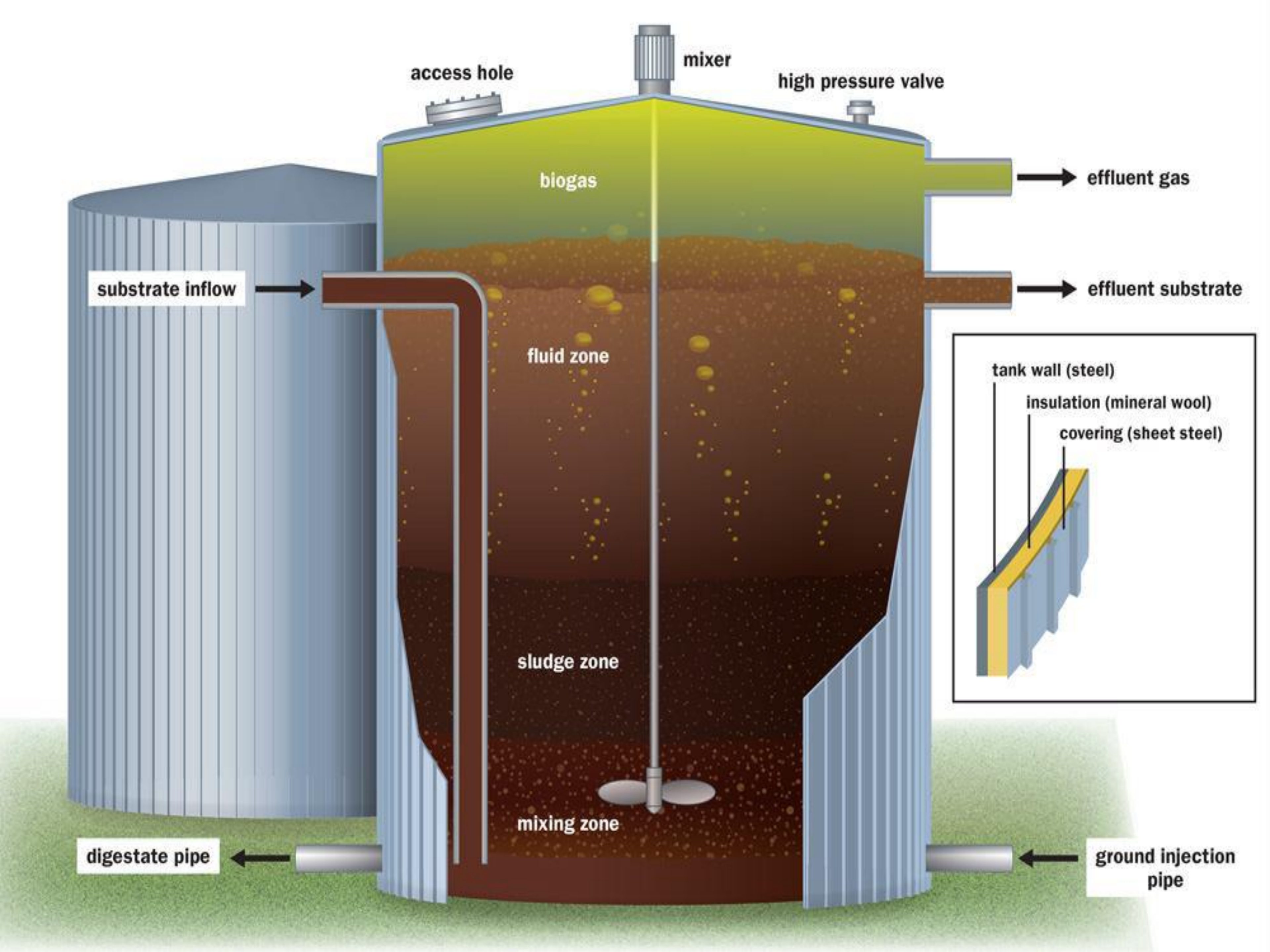
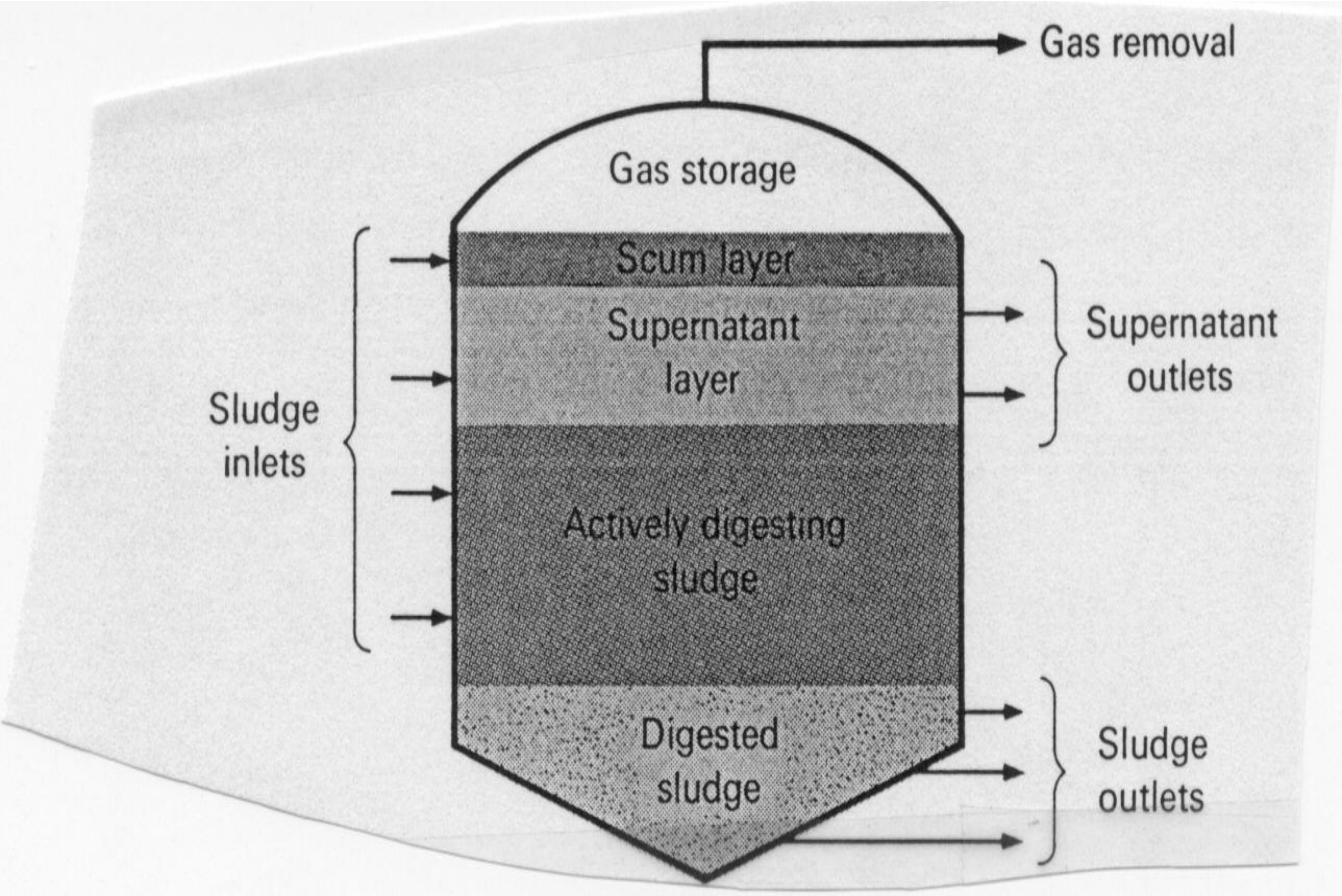


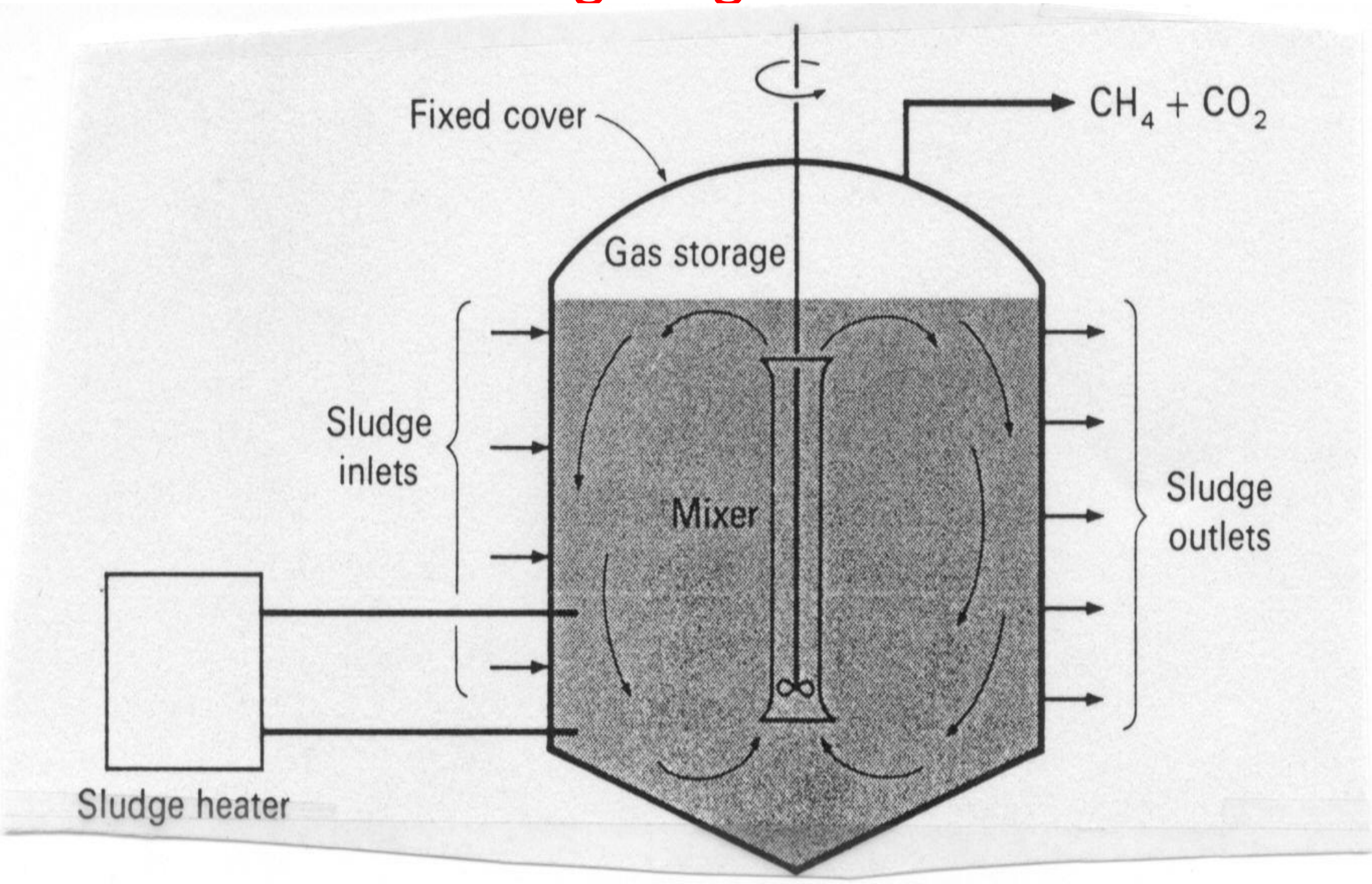
Fig. 9.28. Cross-section of a typical sludge digestion tank.


access hole
mixer
high pressure valve
biogas
effluent gas
substrate inflow
effluent substrate
fluid zone
tank wall (steel)
insulation (mineral wool)
covering (sheet steel)
sludge zone
mixing zone
digestate pipe
ground injection pipe

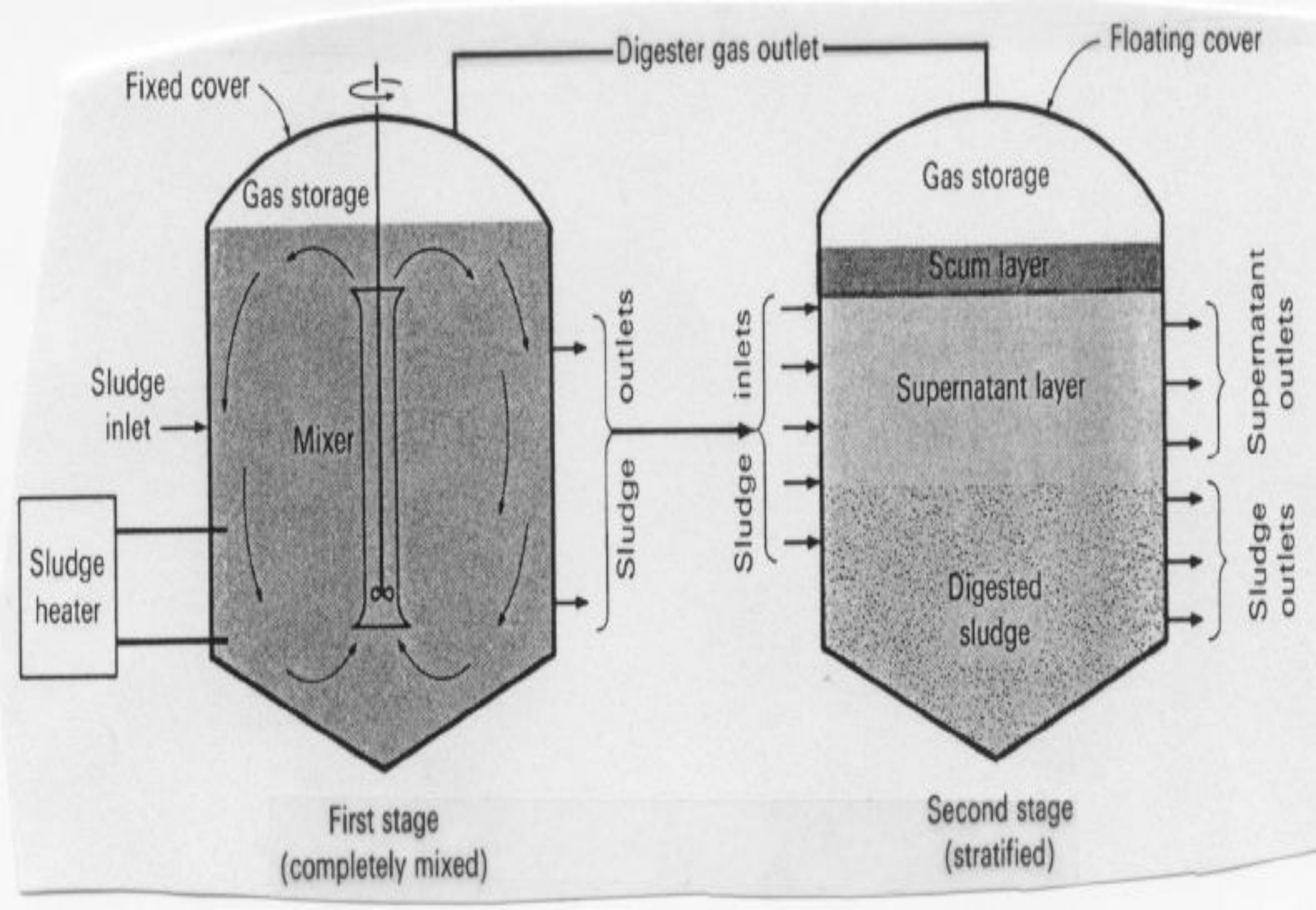
Conventional Standard Rate Anaerobic Digester



High Rate, Continuous-Flow, Stirred Tank Single Stage Digester



Two-Stage Anaerobic Digester



Tank Design

- Cylindrical: 20~125 ft in diameter, > 25 ft deep, conical bottom with a min. slope of 1 vertical to 4 horizontal; a “waffle” shape bottom to minimize grit accumulation and to reduce the need for digester cleaning
- Rectangular: rarely used due to poor mixing and dead zones
- Egg-shape: eliminate cleaning, better mixing, better control of the scum layer, and smaller land area requirements; steel or reinforced concrete; due to better mixing devices, the use may not be justified.
- Provide ways of cleaning out grit and scum
- Door at ground level

Biogas Recovery

- Guidelines for amount of biogas produced per amount of organic material digested
- Sewage sludge: 0.75 – 1.12 Nm^3 per kg of volatile solids destroyed **(typical value: 0.95 Nm^3/kg)**
- Organic solid waste:
  - 0.38 – 0.42 Nm^3 per kg of volatile solids added (at a retention time of 14 days) for single-stage processes
  - Up to 0.6 Nm^3 per kg of VS added for two-stage processes

Biogas composition

- The methane fraction produced in the biogas varies with the input material; as a rule of thumb:
- carbohydrates: approx. 50 vol.-% methane
- fats: approx. 70 vol.-% methane
- proteins: approx. 84 vol.-% methane

Compound	Vol %
Methane	50-75
Carbon dioxide	25-50
Nitrogen	< 7
Oxygen	< 2
Hydrogen sulfide	< 1
Ammonia	< 1

Sludge Conditioning

- Sludge is conditioned to improve its dewatering characteristics.
- Two methods are commonly used for sludge conditioning (i) addition of chemicals and (ii) heat treatment.
- Chemical conditioning results in coagulation of the solids and release of the absorbed water.
- Conditioning is used in advance of vacuum filtration and centrifugation.
- Chemicals used include ferric chloride, lime, alum and organic polymers.
- The chemical dosage required is determined in the laboratory test.
- The sludge which is difficult to dewater requires higher dose.

Sludge Dewatering

- The digested sludge is applied on the sludge drying beds, the water content of the sludge can be reduced to around 70%.
- Sludge drying beds require large land area (nearly 40% of the total area required for sewage treatment plant), hence at the places where land is not available other alternatives such as, mechanical dewatering on vacuum filters, filter press or centrifuge followed by heat drying or incineration could be used after sludge conditioning.
- In India, most of the parts of the country there is favourable climate for open sludge drying, hence sludge drying beds are preferred as an economical way and easy to manage.

Sludge Drying Beds

- This is used where land available is adequate and the dried sludge is used for soil conditioning.
- The sludge is applied on the bed of sand, which is supported on gravel.
- Major portion of the liquid drains off in the first few hours after which drying occur due to evaporation.
- Sludge cake shrinks, producing cracks which further accelerate evaporation from the sludge surface.

Sludge Drying Beds

- In dry region generally the sludge will get dried within two weeks.
- The drying period will depend on sunshine, rainfall, wind velocity, and relative humidity, apart from sludge characteristics.
- Under adverse weather condition, it may take up to four weeks.
- The sludge drying beds should be located at least 100 m away from houses to avoid smelling problem.

Design Criteria for Sludge Drying Beds

Area of beds:

- The land requirement can be substantial with the value of 0.1 to 0.25 m^2/capita for anaerobically digested sludge.
- Generally the cycle time is up to 2 weeks for warmer climate and 3 to 6 weeks.

The specifications for preparation of sludge drying beds are as follows:

Underdrains:

- It is made from the open joined vitrified clay pipe or tiles of at least 10 cm diameter.
- Pipe should not be laid more than 6 m apart from each other.
- Arrangement should be made to return the drained water to primary sedimentation tank.

Design Criteria for Sludge Drying Beds

Gravel:

- Gravel covers the under-drainage system.
- Graded gravel is placed around the under drains in layers up to 30 cm, with minimum of 15 cm above under drains (Figure 22.7).
- At least top 3 cm layer of gravel is of 3 to 6 mm size.

Sand:

- Sand of effective size 0.5 to 0.75 mm and uniformity coefficient not greater than 4 is used.
- The depth of the sand may vary from 20 to 30 cm.

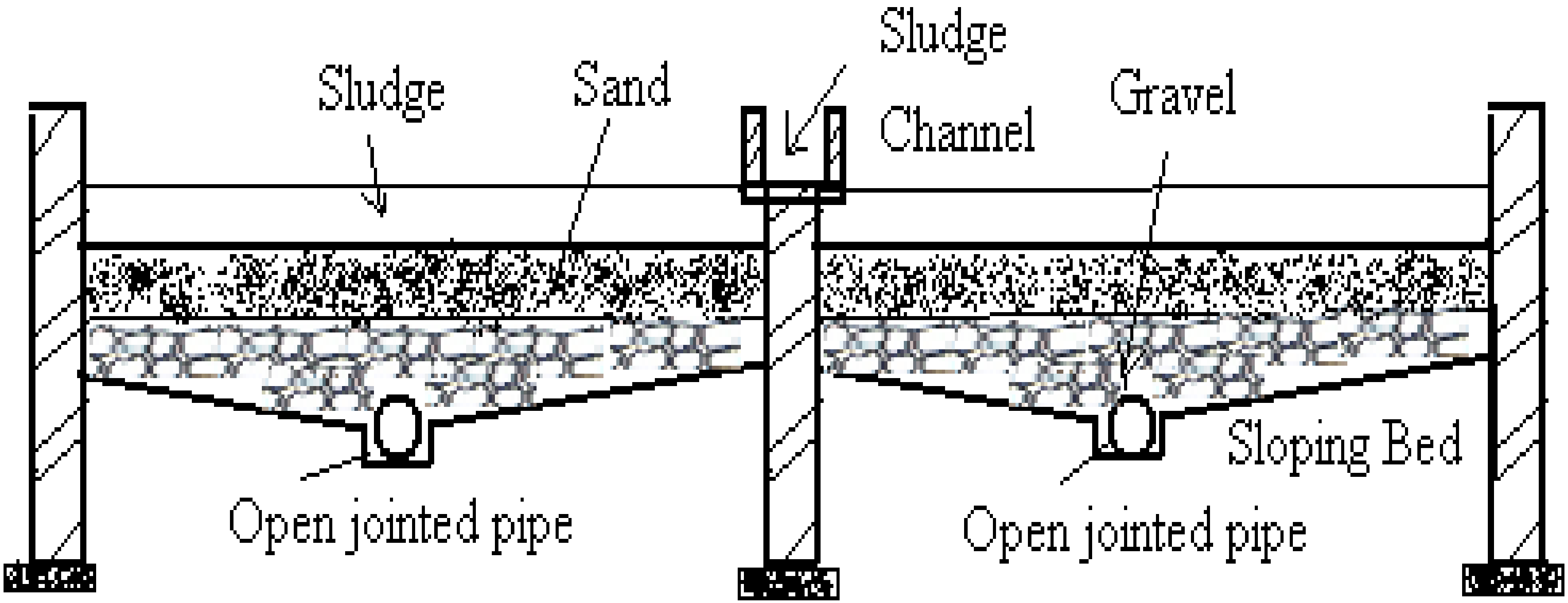


Figure 22.7 Sectional elevation of sludge drying beds

Design Criteria for Sludge Drying Beds

Dimensions:

- Sludge drying beds are commonly 6 to 8 m wide and 30 m long. With the bed slope of 0.5%.

Sludge Inlet:

- Pipe of minimum 20 cm diameter should be used for sludge inlet pipe.
- This pipe should discharge sludge at minimum height of 0.3 m above the sand bed.

Removal of Sludge:

- Dried sludge cake is removed by shovel or forks when the moisture content is less than 70%.
- After removal of the dried sludge the sand bed is prepared by leveling for next cycle of sludge application.

DISPOSAL OF DIGESTED SLUDGE

- Spreading on farm land
- Dumping (in abandoned quarries)
- Land filling (Sanitary)
- Sludge lagooning
- Composting
- Disposing in Inland water bodies or Sea.

Disposal on land-1

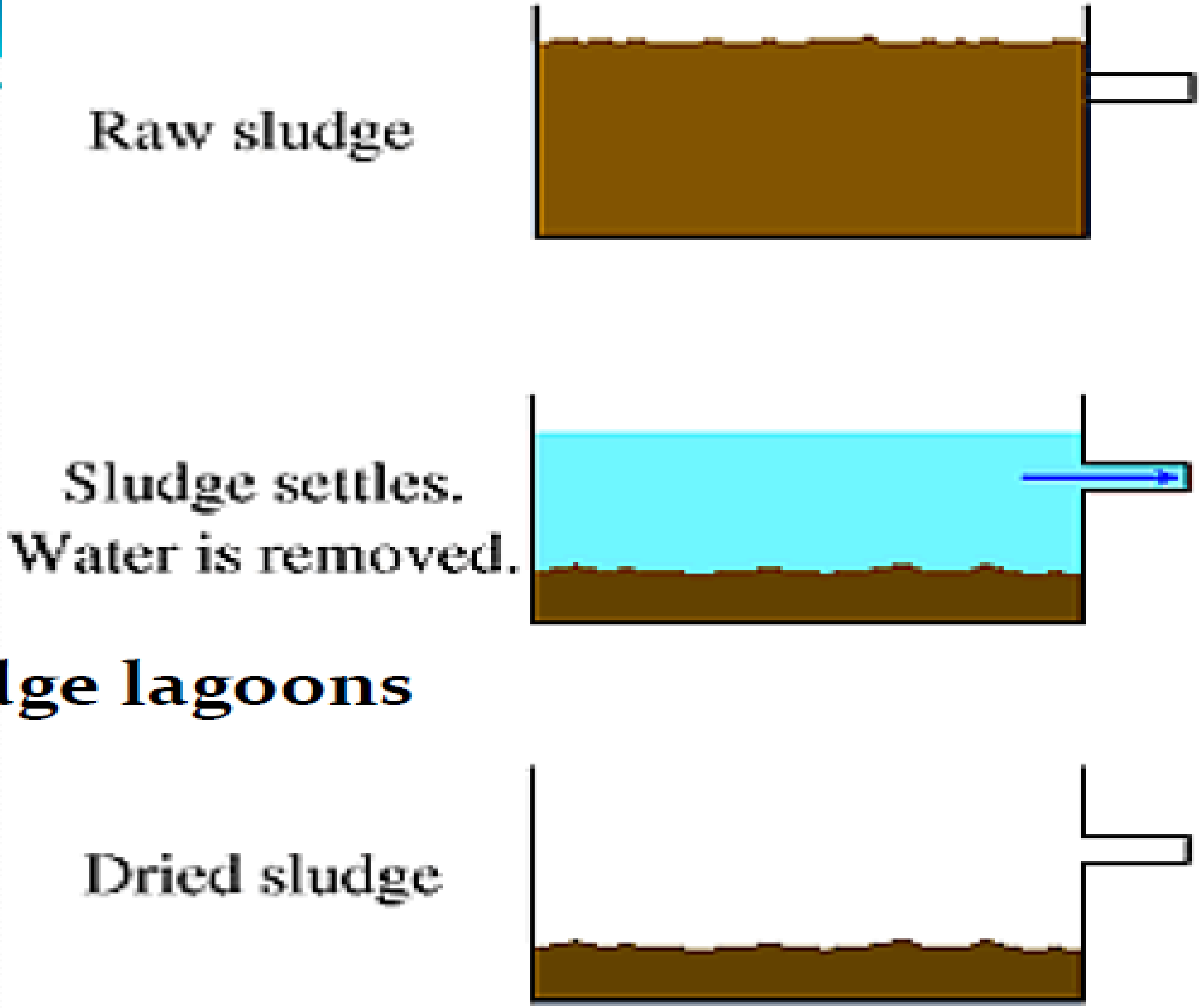

Disposal on
land-2

Disposal in farms

Disposal into the sea


Sludge
Lagooning

Sludge lagoons



Windrow Composting

Advances in Sludge Treatment and disposal

- Sludge Thickening
  - Floatation thickener
  - Centrifugal thickener
- Stabilization of organic matter can be obtained by employing
  - incineration,
  - composting,
  - heat treatment,
  - chlorine oxidation or lime stabilization

- Dewatering

  - Vacuum, pressure filters, or centrifuge methods for removing water from the solids.

Belt Filter Press

Centrifuge


NX 4850
Alfa Laval

Thank you!