Design of Sewage Treatment Plants

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Acknowledgements

References:

- http://cpheeo.nic.in/Sewerage.aspx
- CPHEEO=Central Public Health and Environmental Engineering Organisation

Contents

- Wastewater quality parameters
- Wastewater treatment procedure
- Design of wastewater treatment
- Operation and maintenance

Sanitation

- Sanitary engineering starts at the point where water supply engineering ends.
- All the taps, fixtures and appurtenances that receive water for use, discharge into the waste-water systems.
- Sanitary engineering starts with the collecting system and ends after the streams or other bodies of receiving water have been returned to the condition of relative purity desired for them.

Sanitary works

- Collection works,
- Treatment works, and
- Disposal works

Philosophy of Wastewater treatment

- To remove various contaminants present in sewage so as to produce an effluent and sludge which can be disposed off in the environment without causing health hazards or nuisance.

Introduction

- The main contaminants in the domestic sewage that are to be removed are:
  - Biodegradable organics
  - Suspended solids
  - Pathogens and
  - Nutrients

Domestic Sewage

- The contaminants in the domestic sewage are present in the form of Suspended (settleable, Non-settelable); Colloidal and Dissolved solids.
- The objective of the treatment process involving various

  (i) operations/processes or (ii) combination of operations and processes ; by which the contaminants are stabilised and removed.

Operations in Sewage Treatment

- Physical Unit Operations
  - Change is brought about by means of or through the application of physical forces
- Chemical Unit Processes
  - Change is brought about by means of or through chemical activities
- Biological Unit Processes
  - Change is brought about by means of or through biological activities

Physical Unit Operations

Applications of Physical Unit Operations in Sewage Treatment

Operation	*Application*
1. Screening	Removal of coarse and settleable solids by surface straining
2. Comminution	Grinding of coarse solids to a more or less uniform size
3. Flow equalization	Equalization of flow and mass loadings of BOD and suspended solids
4. Mixing	Mixing of chemicals and gases with sewage ; and maintaining solids in suspension
5. Flocculation	Promotes the aggregation of small particles into larger particles to enhance their removal by gravity sedimentation
6. Sedimentation	Removal of settleable solids and thickening of sludges
7. Floatation	Removal of finely divided suspended solids and particles with densities close to that of water. Also thickens biological sludges
8. Filtration	Removal of fine residual suspended solids remaining after biological or chemical treatment
9. Microscreening	Same as filtration. Also removal of algae from stabilization-pond effluents

Chemical Unit Processes

Applications of Chemical Unit Processes in Sewage Treatment

Process	*Application*
1. Chemical precipitation	Removal of phosphorus and enhancement of suspended solids removal in primary sedimentation facilities used for physical-chemical treatment.
2. Gas transfer	Addition and removal of gases.
3. Adsorption	Removal of organics not removed by conventional chemical and biological treatment methods ; also used for dechlorination of sewage before final discharge of treated effluent.
4. Disinfection	Selective destruction of disease-causing organisms, usually with chlorine or ozone.
5. Dechlorination	Removal of chlorine residual that exists after chlorination.
6. Others	Various other chemicals can be used to achieve specific objectives in sewage treatment.

Biological Unit Processes

Major Biological Unit Processes used for Sewage Treatment

Type	*Common name*	*Use**
Aerobic processes:		
Suspended growth	Activated-sludge process	
	Conventional (plug flow)	
	Continuous-flow stirred-tank	
	Step aeration	
	Pure oxygen	
	Modified aeration	Carbonaceous BOD removal (nitrification)
	Contact stabilization	
	Extended aeration	
	Oxidation ditch	
	Suspended-growth nitrification	Nitrification
	Aerated lagoons	Carbonaceous BOD removal (nitrification)
	Aerobic digestion	
	Conventional air	Stabilization, carbonaceous BOD removal
	Pure oxygen	
	High-rate aerobic algal ponds	Carbonaceous BOD removal

Biological Unit Processes

Major Biological Unit Processes used for Sewage Treatment

Attached growth	Trickling filters	
	Low-rate	Carbonaceous BOD removal (nitrification)
	High-rate	Carbonaceous BOD removal
	Roughing filters	Carbonaceous BOD removal (nitrification)
	Rotating biological contacters	Nitrification
	Packed-bed reactors	Carbonaceous BOD removal (nitrification)
Combined processes	Trickling filter, activated sludge	
	Activated sludge, trickling filter	
Anoxic processes:		
Suspended growth	Suspended-growth denitrification	Denitrification
Attached growth	Fixed-film denitrification	

Biological Unit Processes

Major Biological Unit Processes used for Sewage Treatment

Anaerobic processes:		
Suspended growth	Anaerobic digestion	Stabilization, carbonaceous BOD removal
	Standard-rate, single-stage	
	High-rate, single-stage	
	Two-stage	
Attached growth	Anaerobic contact process	Carbonaceous BOD removal
	Anaerobic filter	Carbonaceous BOD removal, stabilization (denitrification)
	Anaerobic lagoons (ponds)	Carbonaceous BOD removal (stabilization)
Aerobic/anoxic or anaerobic processes:		
Suspended growth	Single-stage nitrification-denitrification	Carbonaceous BOD removal, nitrification, denitrification
	Nitrification-denitrification	Nitrification, denitrification
	Facultative lagoons (ponds)	Carbonaceous BOD removal
	Maturation or tertiary ponds	Carbonaceous BOD removal (nitrification)
Attached growth	Anaerobic-facultative lagoons	Carbonaceous BOD removal
Combined process	Anaerobic -facultative-aerobic lagoons	

Reactors for Sewage Treatment

- Batch
- Plug flow
- CSTR (Continuous flow stirred tank)
- Arbitrary flow
- Fluidised bed
- Membrane bio reactor

Classification of Sewage Treatment

- Preliminary
  - To remove floating materials such as dead animals, wood pieces, tree branches, papers, heavy settleable inorganic solids, fats, oil, grease etc.
- Primary
  - To remove large suspended organic solids
- Secondary
  - Removal of residual organic matter and suspended material.
- Tertiary
  - To remove the contaminants that are not removed in conventional treatment

Preliminary Treatment of Sewage

- Screens
- Grit chambers
- Comminutors
- Skimming tanks
- Floatation units
- Flow measuring units

Preliminary Treatment of Sewage

Preliminary Treatment Units, their Functions and Expected Efficiencies

Purification Effected	*Process or unit employed*	*BOD5 removal (% of original)*	*Removal of suspended solids (% of original)*	*Removal of Total coliforms (% of original)*	*Disposal of Residuals*
1. Removal of floating materials such as dead animals, wood pieces, tree branches, rags, papers and other large sized floating materials	Coarse and fine screens of different designs	5-10	2-10	10-20	Screenings disposed of by burials or burnings
2. Removal of heavy *settleable inorganic solids*	Grit chambers or Detritus tanks.	10-20	20-40	10-20	Grits disposed of by burials or burnings or raising low lying area
3. Removal of *fats and greases*	Floatation units and skimming tanks	20-30	20-40	10-20	Skimmings being unstable volatile materials, are disposed of by first stabilizing them in digestion tanks by anaerobic process.

Primary Treatment of Sewage

TABLE 10.5. Primary Treatment Units, their Functions and Expected Efficiencies

Purification Effected	*Process or unit employed*	*BOD_5 removal (% of original)*	*Removal of suspended solids (% of original)*	*Removal of Total coliforms (% of original)*	*Disposal of Residuals*
Removal of large *suspended organic solids*	(i) Plain sedimentation tanks	30-35	60-65	25-75	Sludge, after stabilization in digestion tanks, is used as a manure or soil builder.
	OR				
	(ii) Septic tanks	20-30	40-60	25-75	These units combine sedimentation and sludge digestion. Sludge used as manure while effluents is either treated for secondary treatment or disposed of by land treatment.
	OR				
	(iii) Imhoff Tanks				

Secondary Treatment of Sewage

TABLE 10.6. Secondary Treatment Units, their Functions and Expected Efficiencies

Purification Effected	*Process or unit employed*	*BOD_5 removal (% of original)*	*Removal of suspended solids (% of original)*	*Removal of Total coliforms (% of original)*	*Disposal of Residuals*
Removal of fine suspended and dissolved organic matter	(i) Chemical flocculation and sedimentation OR	50-85	70-90	40-80	Sludge containing organic matter has to be stabilized in digestion tanks before use as manure or soil builder
	(ii) Intermittent sand filters followed and preceded by plain sedimentation OR	90-95	85-95	95-98	Same as above
	(iii) High rate trickling filters followed and preceded by plain sedimentation	60-95	65-92	80-85	Same as above

Secondary Treatment of Sewage

TABLE 10.6. Secondary Treatment Units, their Functions and Expected Efficiencies

Purification Effected	*Process or unit employed*	*BOD_5 removal (% of original)*	*Removal of suspended solids (% of original)*	*Removal of Total coliforms (% of original)*	*Disposal of Residuals*
	(iv) Low rate trickling filters followed and preceded by plain sedimentation	90-95	70-92	90-95	Same as above
	OR				
	(v) Activated sludge treatment process and secondary settling tanks	75-95	85-90	90-98	Same as above
	OR				
	(vi) Oxidation ponds	85-90	85-90	90-98	Effluents are generally disposed of by using them for irrigation

Tertiary Treatment of Sewage

- Various processes that are used in the tertiary treatment of sewage are
  - Chemical clarification
  - Recarbonation
  - Filtration
  - Activated carbon adsorption
  - Disinfection
  - Nitrogen removal
  - Phosphorous removal
  - Demineralisation

Summary

Unit Operations, Unit Processes and Treatment Systems used to Remove Major Contaminants found in Sewage

Contaminant	*Unit operation, unit process, or treatment system*
Suspended solids	Sedimentation Screening and comminution Filtration (various types) Floatation Chemical-polymer addition Coagulation/sedimentation Land treatment systems
Biodegradable organics	Activated-sludge processes Fixed-film: trickling filters Fixed-film : rotating biological contactors Lagoon (various types) Intermittent sand filtration Land treatment systems Physical-chemical systems
Pathogens	Chlorination Hypochlorination Ozonation Land treatment systems

Summary

Nutrients:	
Nitrogen	Suspended-growth nitrification and denitrification (various types) Fixed-film nitrification and denitrification (various types) Ammonia stripping Ion exchange Breakpoint chlorination Land treatment systems
Phosphorus	Metal-salt addition Lime coagulation/sedimentation Biological-chemical phosphorus removal Land treatment systems
Refractory organics	Carbon adsorption Tertiary ozonation Land treatment systems
Heavy metals	Chemical precipitation Ion exchange Land treatment systems
Dissolved inorganic solids	Ion exchange Reverse osmosis Electrodialysis

Process Flow Sheet (Conventional)

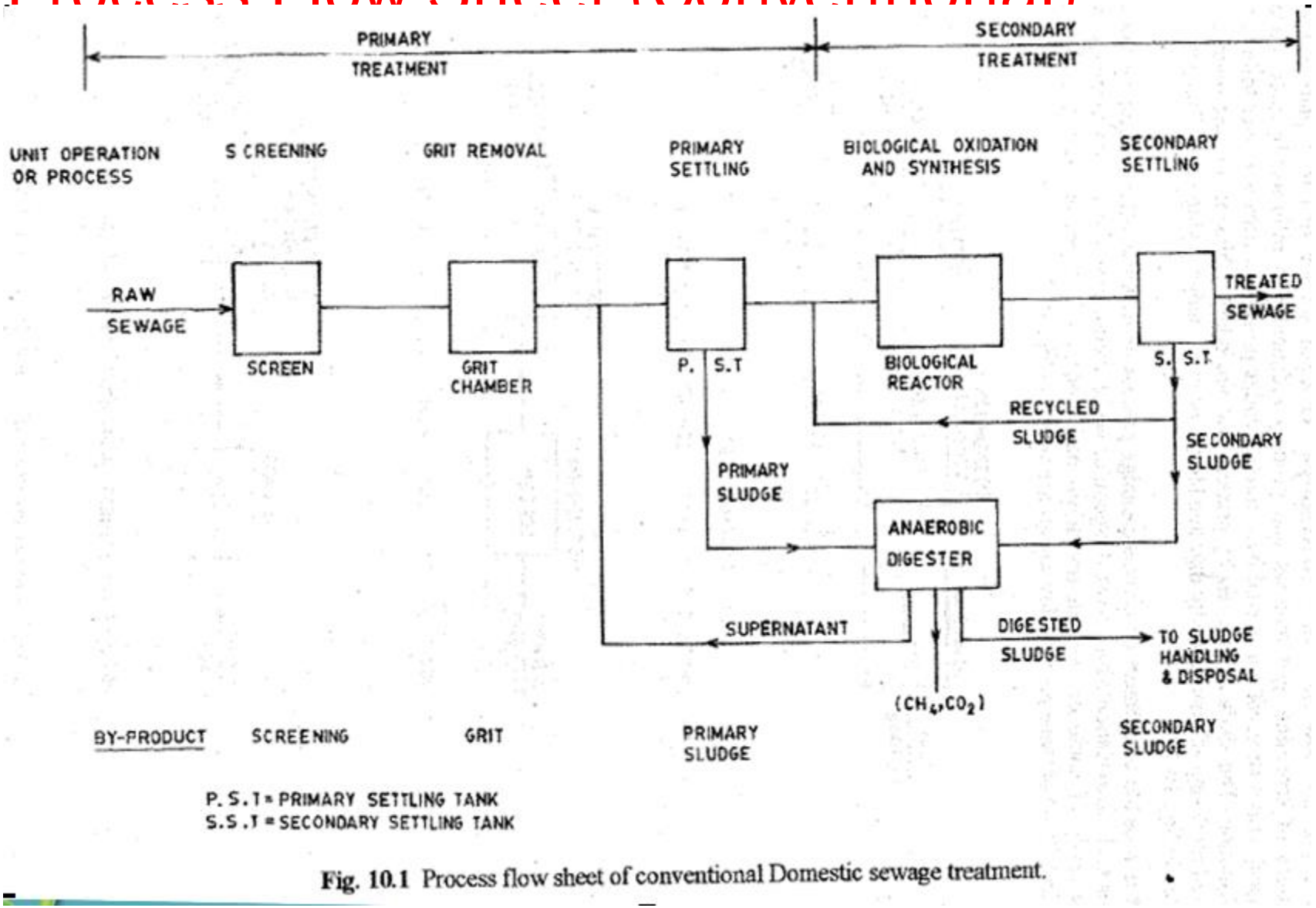
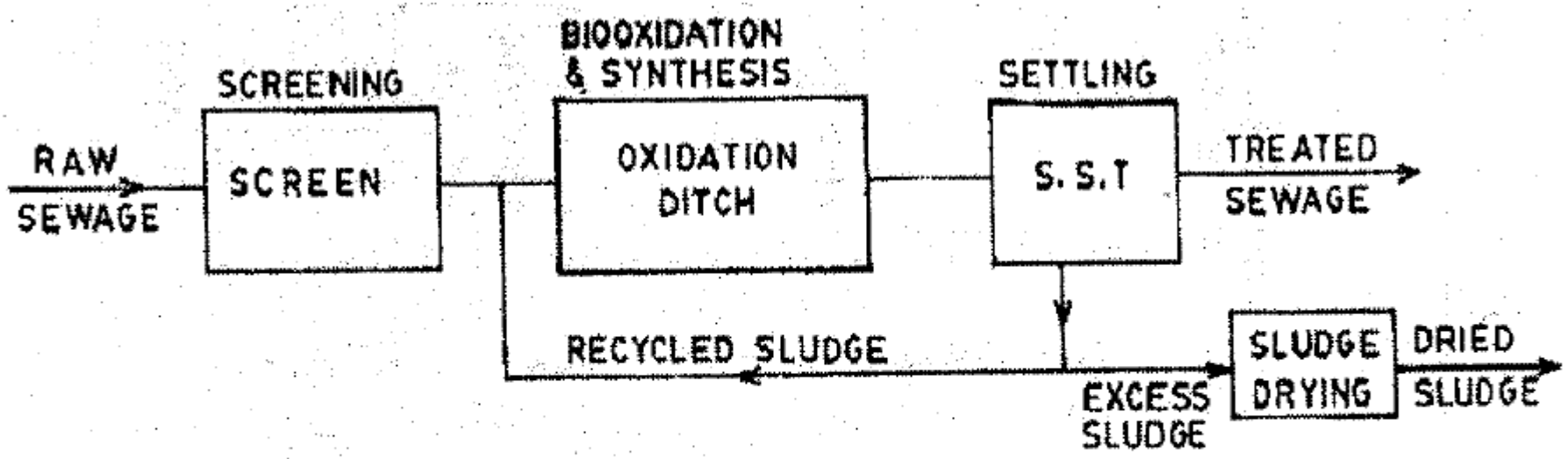


Fig. 10.1 Process flow sheet of conventional Domestic sewage treatment.

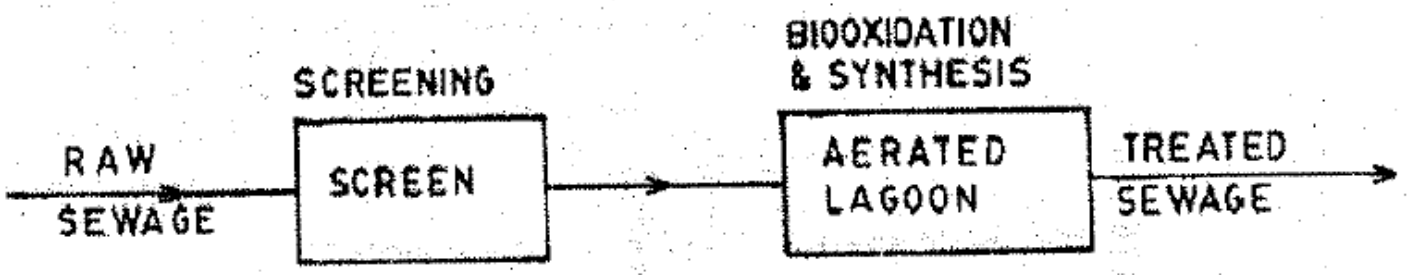
Process Flow Sheet (low cost)



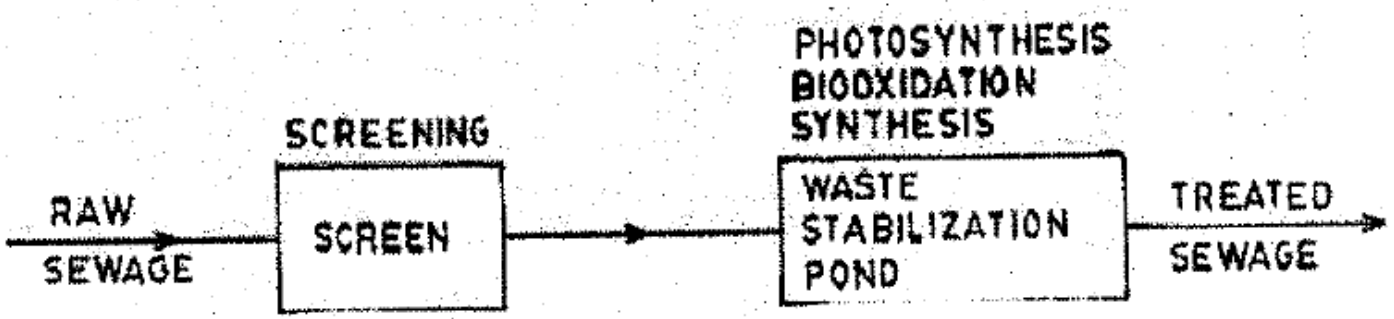
S. S. T= SECONDARY SETTLING TANK

(a) PROCESS FLOW SHEET INCORPORATING OXIDATION DITCH.

Process Flow Sheet (low cost)



(b) PROCESS FLOW SHEET EMPLOYING AERATED LAGOON.



(c) PROCESS FLOW SHEET USING WASTE STABILIZATION POND.

Process Flow Sheet (Anaerobic)

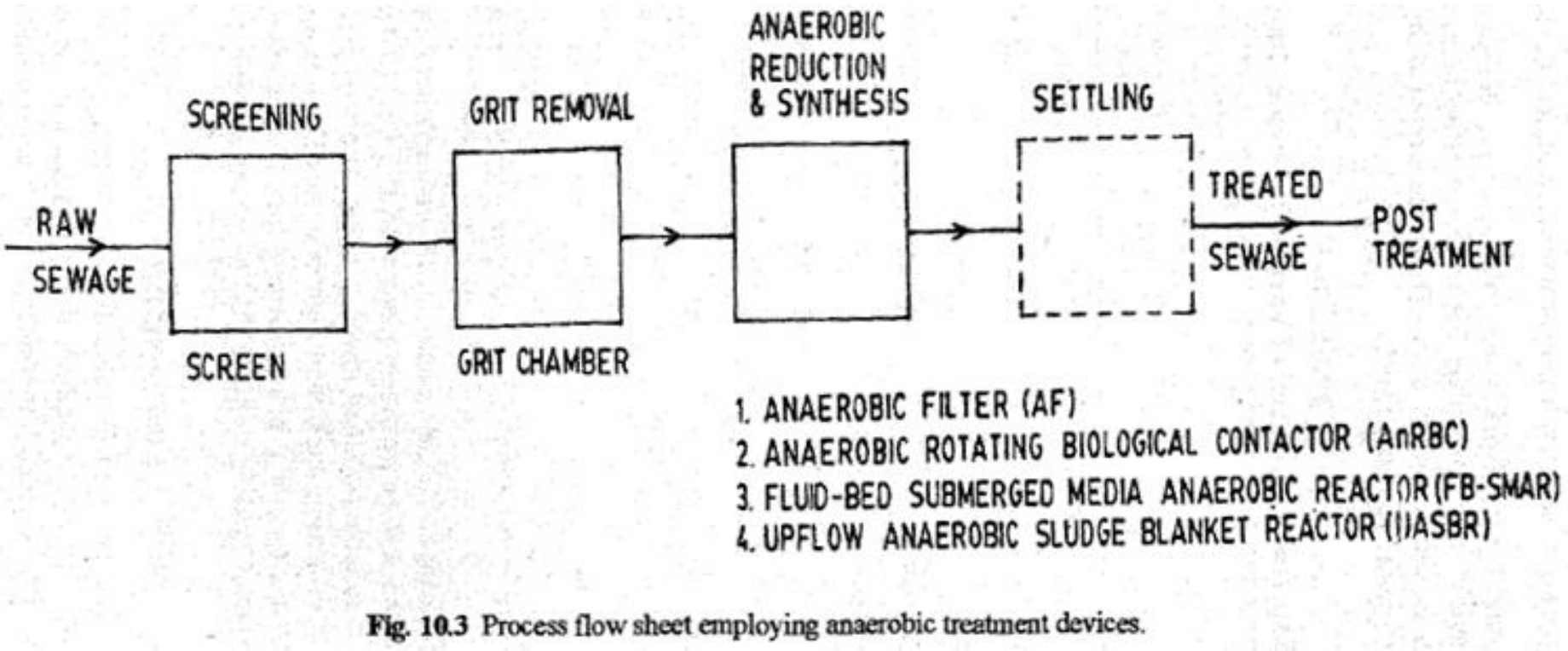


Fig. 10.3 Process flow sheet employing anaerobic treatment devices.

Expected Efficiencies of Various Treatment Units

Process	*Percentage reduction*		
	BOD_5	*Suspended solids*	*Total coliform*
1. Primary Treatment (sedimentation)	30-45	45-60	40-60
2. Chemical Treatment	45-65	60-80	60-90
3. Secondary Treatment			
(*i*) Standard trickling filters	70-90	75-85	80-90
(*ii*) High rate trickling filters			
(*a*) Single stage	75-80	75-85	80-90
(*b*) Two stage	90-95	90-95	90-95
(*iii*) Activated sludge plants	85-95	85-90	90-96
(*iv*) Stabilization Ponds			
(*a*) Single cell	90-95	80-90	90-95
(*b*) Two cells	95-97	90-95	95-98

Design and Construction of S.T.Ps

Contribution of human wastes in grams per capita per day

	Parameters				Range
1	Biochemical oxygen demand, BOD				45-54
2	Chemical oxygen demand, COD				1.6-1.9 times BOD
3	Total organic carbon, TOC				0.6-1.0 times BOD
4	Total solids, TS				170-220
5	Suspended solids, SS				70-145
6	Grit (inorganic,0.2 mm and above)				5-15
7	Grease				10-30
8	Alkalinity as calcium carbonate ($CaCO_3$)				20-30
9	Chlorides				4-8
10	Total nitrogen N				6-12
11	Organic nitrogen				~0.4 total N
12	Free ammonia				~0.6 total N
13	Nitrate				~0.0-0.5 total N
14	Total phosphorus				~0.6-4.5
15	Organic phosphorus				~0.3 total P
16	Inorganic(ortho- and poly-phosphates)				~0.7 total P
17	Potassium(as potassium oxide K_2O)				2.0-6.0
Microorganisms in 100 ml of sewage					
18	Total bacteria	10^9-10^{10}	22	Protozoan cysts	Up to 10^3
19	Coliforms	10^9-10^{10}	23	Helminthic eggs	Up to 10^3
20	Faecal streptococci	10^5-10^6	24	Virus (plaque forming units)	10^2-10^4
21	Salmonella Typhosa	10^1-10^4			

Typical composition of Sewage (Concentration of various parameters)

Item	Per capita contribution (g / c /d)	water supply (L / c / d)	Sewage Generation 80 % of (3)	Concen-tration (mg/L)
(1)	(2)	(3)	(4)	(5)
BOD	27.0	135	108	250.0
COD	45.9	135	108	425.0
TSS	40.5	135	108	375.0
VSS	28.4	135	108	262.5
Total Nitrogen	5.4	135	108	50.0
Organic Nitrogen	1.4	135	108	12.5
Ammonia Nitrogen	3.5	135	108	32.5
Nitrate Nitrogen	0.5	135	108	5.0
Total Phosphorus	0.8	135	108	7.1
Ortho Phosphorous	0.5	135	108	5.0

Illustration BOD = 27 *1000 (mg) / 135 X 0.8 (litres) = 250 mg/L

General standards for Discharge of Environmental Pollutants

No	Characteristics	Standards			
		Inland Surface Water	Public Sewers, (A)	Land for Irrigation	Marine Coastal Areas
1	Colour and odour	(B)		(B)	(B)
2	SS	100	600	200	(C), (D)
3	Particle size of SS	(E)	-	-	(F), (G)
4	pH value	5.5 to 9.0			
5	Temperature	(H)	-	-	(H)
6	Oil and grease	10	20	10	10
7	Total residual chlorine	1.0	-	-	1.0
8	Ammoniacal nitrogen (as N)	50	50	-	50
9	Total Kjeldahl Nitrogen, (TKN) (as N)	100	-	-	100
10	Free ammonia (as NH_3)	5.0	-	-	5.0
11	Biochemical Oxygen Demand	30	350	100	100
12	Chemical Oxygen Demand	250	-	-	250

General standards for Discharge of Environmental Pollutants

13	Arsenic (as As)	0.2			
14	Mercury (as Hg)	0.01	0.01	-	0.01
15	Lead (as Pb)	0.1	1.0	-	2.0
16	Cadmium (as Cd)	2.0	1.0	-	2.0
17	Hexavalent Chromium (as Cr 6+)	0.1	2.0	-	1.0
18	Total Chromium (as Cr)	2.0	2.0	-	2.0
19	Copper (as Cu)	3.0	3.0	-	3.0
20	Zinc (as Zn)	5.0	15.0	-	15.0
21	Selenium (as Se)	0.05	0.05	-	0.05
22	Nickel (as Ni)	3.0	3.0	-	5.0
23	Cyanide (as CN)	0.2	2.0	0.2	0.2
24	Fluoride (as F)	2.0	15.0	-	15.0
25	Dissolved phosphates (as P)	5.0	-	-	-
26	Sulphide (as S)	2.0	-	-	5.0
27	Phenolic compounds (as C_6H_5OH)	1.0	5.0	-	5.0
28	Radioactive materials				
	Alpha emitters, micro curie/L	10^{-7}	10^{-7}	10^{-8}	10^{-7}
	Beta emitters, micro curie/L	10^{-6}	10^{-6}	10^{-7}	10^{-6}
29	Bio-assay test	(I)			
30	Manganese (as Mn),	2.0	2.0	-	2.0
31	Iron (as Fe),	3.0	3.0	-	3.0
32	Vanadium (as V),	0.2	0.2	-	0.2
33	Nitrate Nitrogen (as N),	10.0	-	-	20.0
34.	Faecal Coliform, MPN/100 ml for discharge	onto land		into water	
		(J)	(K)	(J)	(K)
		1,000	10,000	1,000	10,000

Preliminary Treatment of Sewage

Screening

- Screening is essential for removal of floating materials which are mainly sachets, plastic sheet bits, leaves, fibres, rags, etc.
- If these are not removed, they will get into the pumps and entangle in the impellers.
- They can also be drawn into suction pipes and choke them and it is difficult to locate their position in the pipeline.
- They can cause objectionable shoreline conditions where disposal into sea is practiced.
- Screens are used ahead of pumping stations, meters and as a first step in all STPs.
- A screen is a device with openings generally of uniform size.

Preliminary Treatment of Sewage

- Screening
- Types of Screens
  - Coarse Screens (with openings >25 mm)
  - Medium Screens (with openings of ≈ 12 mm)
  - Fine Screens (with openings of ≈ 5 mm)

Preliminary Treatment of Sewage

- Screening

Preliminary Treatment of Sewage

- Screening

Preliminary Treatment of Sewage

- Screening
- Design Considerations
  - Velocity of flow
    - 0.6-1.2 m/s
  - Loss of head
    - Normally 0.15 m, should not exceed 0.3 m
  - Materials
    - Coarse screens
      - Steel bars
    - Fine screens
      - Steel bars, Bronze plates or wire mesh
  - Angle of inclination
    - 45-60 with horizontal for manually cleaned and 60-90 for mechanically cleaned
  - Free board
    - 0.3 m
  - Max width
    - 1.5 m

Preliminary Treatment of Sewage

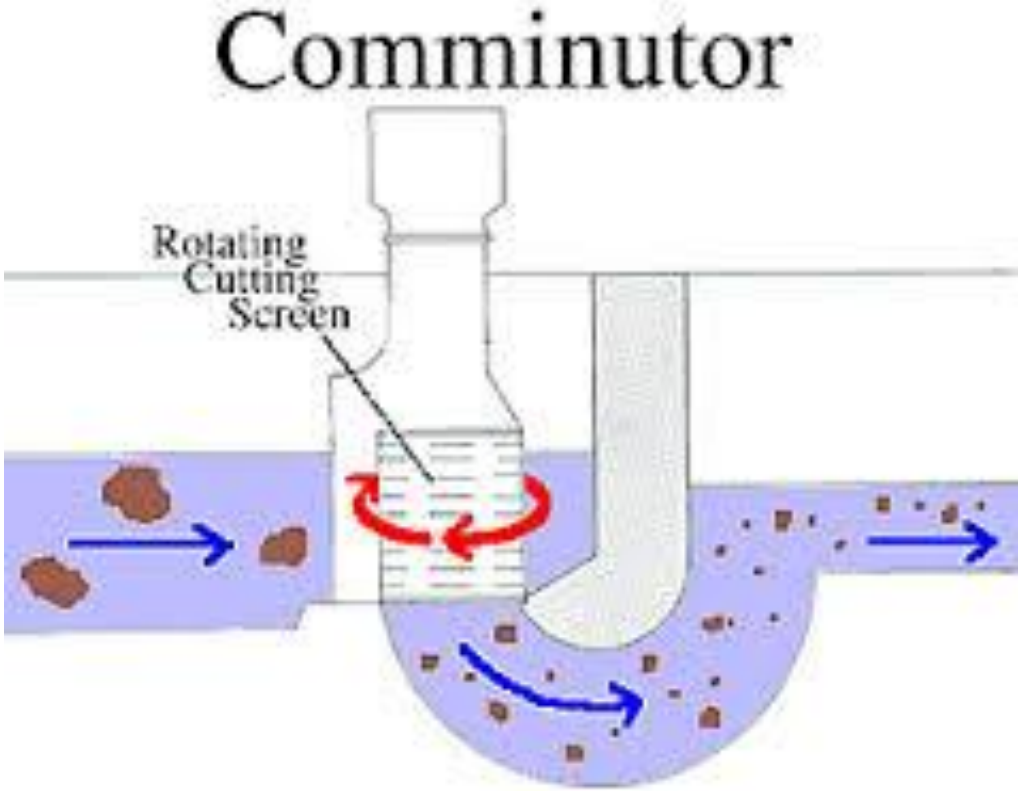
- Screening
- Design Procedure for Screens
  - Calculate the projected area of screens using the peak sewage flow
  - Calculate the number of bars
  - Calculate the width and length of screen channel
  - Calculate the height of screen
  - Calculate the velocity of flow in screen channel
  - Calculate the head loss through the screens
  - Calculate the hydraulic loading for peak flow

Preliminary Treatment of Sewage

- Comminuting Devices

- a mechanically cleaned screen which incorporates a cutting mechanism that shreds the retained material and enabling it to pass along with the sewage
- recommended for smaller sized STPs of up to 1 MLD.

Preliminary Treatment of Sewage



Preliminary Treatment of Sewage

- Grit Removal

- Grit removal is necessary to protect the moving mechanical equipment and pump elements from abrasion and accompanying abnormal wear and tear.
- Removal of grit also reduces the frequency of cleaning of digesters and settling tanks.

Preliminary Treatment of Sewage

- Grit Removal
- Design considerations
  - Settling velocity
  - Surface overflow rate
  - Detention period
    - 45 to 90 sec
  - Bottom scour velocity
  - Velocity control device
    - Proportional flow weir
    - Parshall flume
  - Number of units
  - Loss of Head

Preliminary Treatment of Sewage

- Grit Removal

- Design Procedure for GRIT chamber
  - Compute the settling velocity
  - Compute the surface overflow rate
  - Determine the dimensions of the chamber
  - Design the velocity control facility

Preliminary Treatment of Sewage

- Velocity control devices

Proportional flow weir

Preliminary Treatment of Sewage

- Velocity control devices

Parshall Flume

Preliminary Treatment of Sewage

Flow Equalization

- when the peak factor exceeds 3 by a wide margin, it is advisable to equalize the sewage flow before feeding to the STP units.

Primary Treatment of Sewage

- SETTLING
- The primary clarifier is located after screens and grit chambers and reduces the organic load on secondary treatment units.

Primary Treatment of Sewage

- SETTLING
- Design considerations
  - Velocity of flow
  - Surface overflow rate
  - Detention period
    - 2-2.5 hours
  - Tank dimensions
    - Rectangular or circular
  - Inlet and outlet
  - Weir loading

Primary Treatment of Sewage

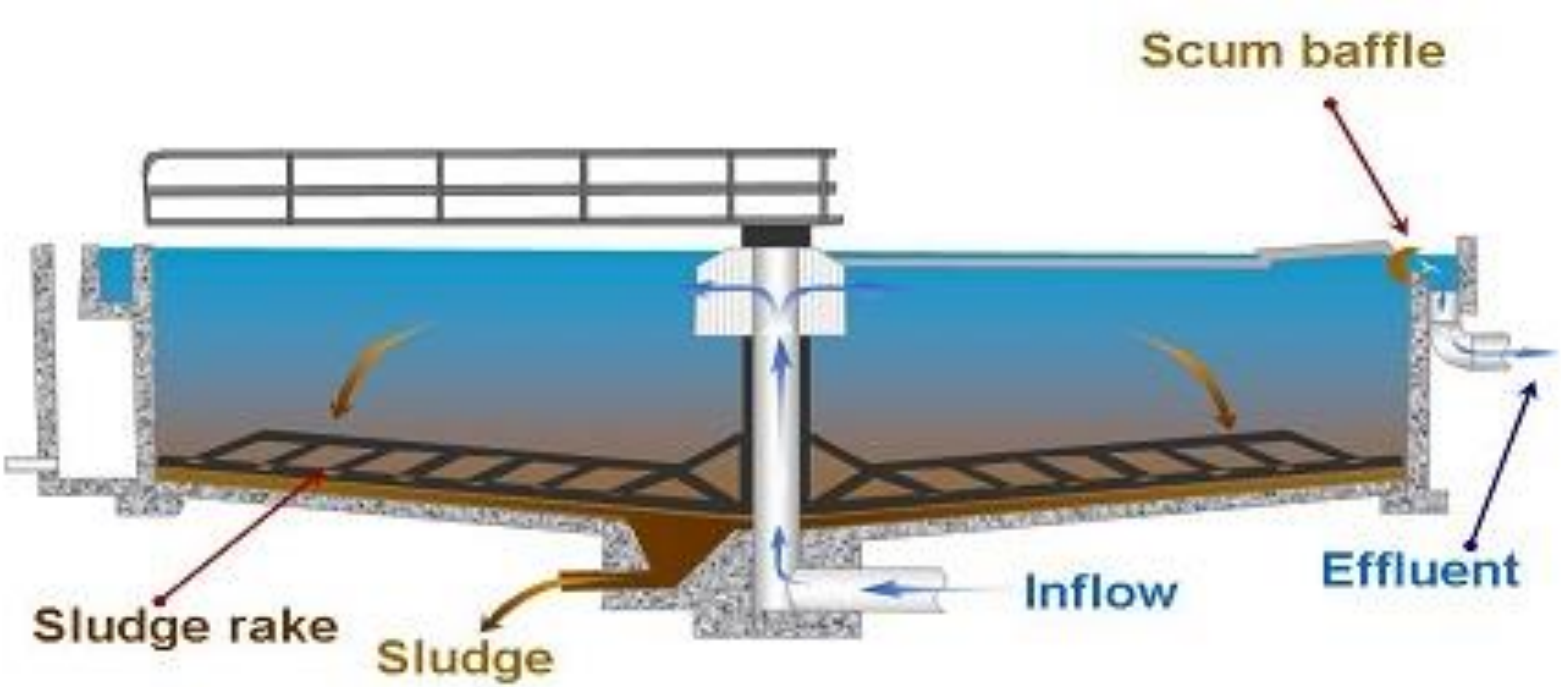
- SETTLING

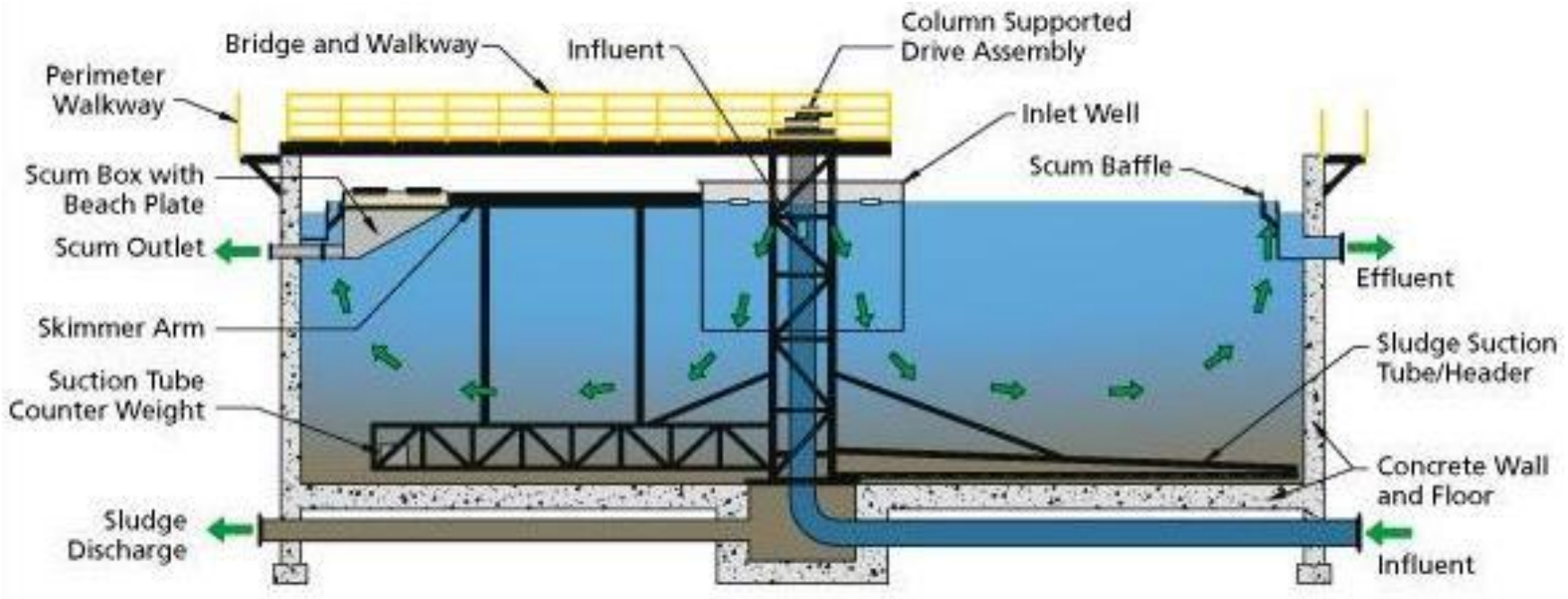
Table 5.8 Design Parameters for Clarifiers

Type of Settling	Overflow rate, cum/sqm/day		Solid loading, kg/day/sqm		Side Water Depth, m	Weir loading, cum/m/day
	Average	Peak	Average	Peak	Average	Average
Primary Clarifiers						
Primary Settling only	25 - 30	50 - 60	Not applicable		≥ 2.5 - 3.5	125
Followed by secondary treatment	35 - 50	80 - 120	Not applicable		≥ 2.5 - 3.5	125
With excess sludge return	25 - 35	50 - 60	Not applicable		≥ 3.5 - 4.5	125
Secondary Clarifiers						
Secondary settling for activated sludge	15 - 35	40 - 50	70 - 140	210	≥ 3.0 - 3.5	185
Secondary settling for extended aeration	8 - 15	25 - 35	25 - 120	170	≥ 3.0 - 4.0	185

Primary Treatment of Sewage

- SETTLING
- Design procedure
  - Compute the capacity of the tank by assuming the detention period.
  - Adopt the required depth of the tank
  - Calculate the surface area required
  - Perform cross check for the dimensions obtained


Scum baffle
Sludge rake
Sludge
Inflow
Effluent


Bridge and Walkway
Influent
Column Supported
Drive Assembly
Perimeter
Walkway
Inlet Well
Scum Box with
Beach Plate
Scum Baffle
Scum Outlet
Effluent
Skimmer Arm
Sludge Suction
Tube/Header
Suction Tube
Counter Weight
Concrete Wall
and Floor
Sludge
Discharge
Influent

Secondary Treatment of Sewage

- Activities in Aerobic Digestion

Oxidation

$$Organic matter + O_2 + bacteria \rightarrow CO_2 + H_2O + NH_3 + other \text{ end products} + \text{energy}$$

Synthesis

$$\text{Organic matter} + O_2 + bacteria + energy \rightarrow New \text{ microbial cell tisue}$$

Endogeneous respiration

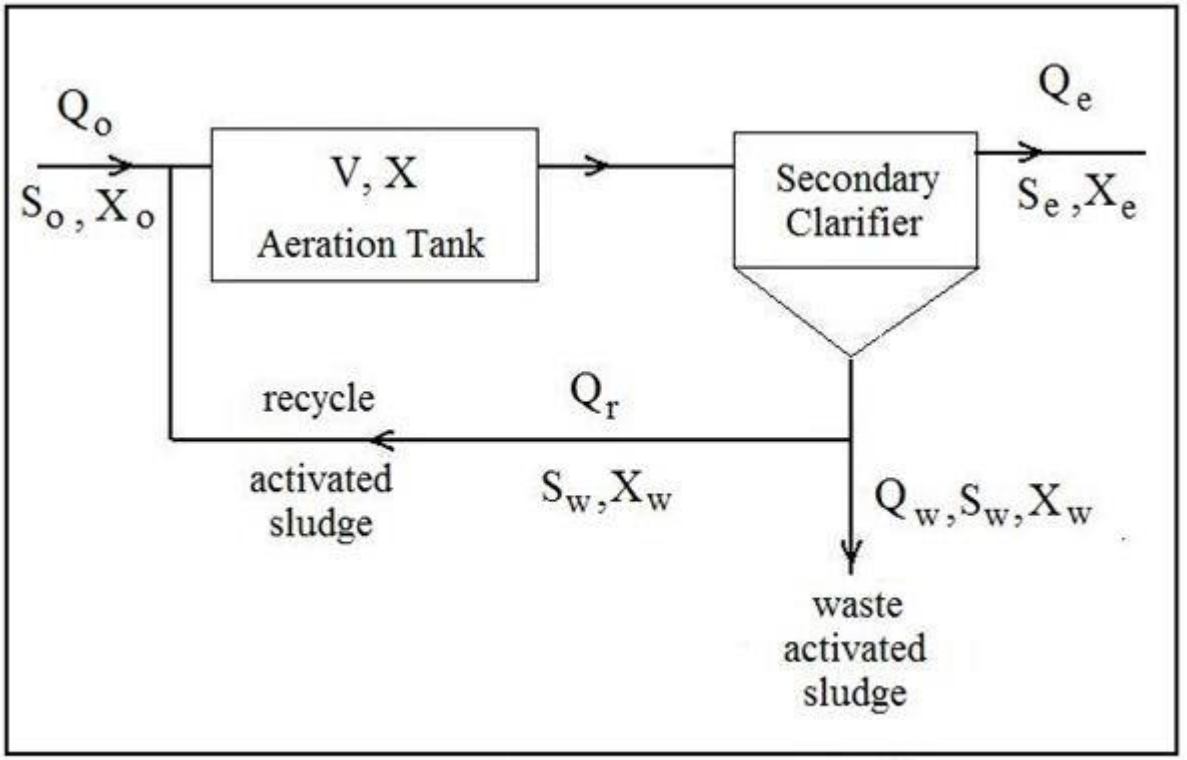
$$\text{New microbial cell tissue} + 5O_2 \rightarrow 5CO_2 + NH_3 + 2H_2O + energy$$

Secondary Treatment of Sewage

- Activated Sludge Process

Secondary Treatment of Sewage

- Activated Sludge Process



Activated Sludge Flow Diagram & Parameters

Secondary Treatment of Sewage

- Activated Sludge Process
- Activated sludge plant involves:
  - wastewater aeration in the presence of a microbial suspension,
  - solid-liquid separation following aeration,
  - discharge of clarified effluent,
  - wasting of excess biomass, and
  - return of remaining biomass to the aeration tank.

Secondary Treatment of Sewage

- Activated Sludge Process
- Design elements:
  - Design of Aeration tank
  - Design of clarifier
  - Return sludge rate
  - Sludge wasting

Secondary Treatment of Sewage

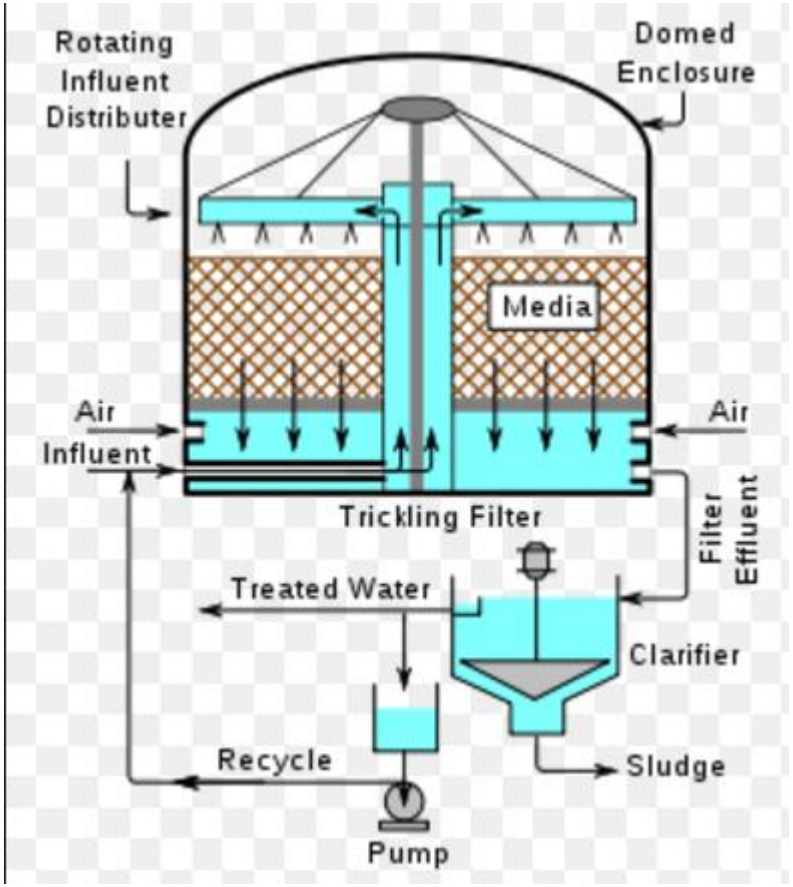
- Activated Sludge Process
- Key considerations in ASP design:
  - MLSS (mixed liquor suspended solids)
  - F/M Ratio
  - Oxygen transfer rate
  - Rate of sludge production
  - Aeration tank volume
  - Sludge recycle rate

Secondary Treatment of Sewage

- **Activated Sludge Process**
- Modifications to the conventional ASP
  - Tapered aeration
  - Step aeration
  - Contact stabilisation
  - Extended aeration
  - Complete mix

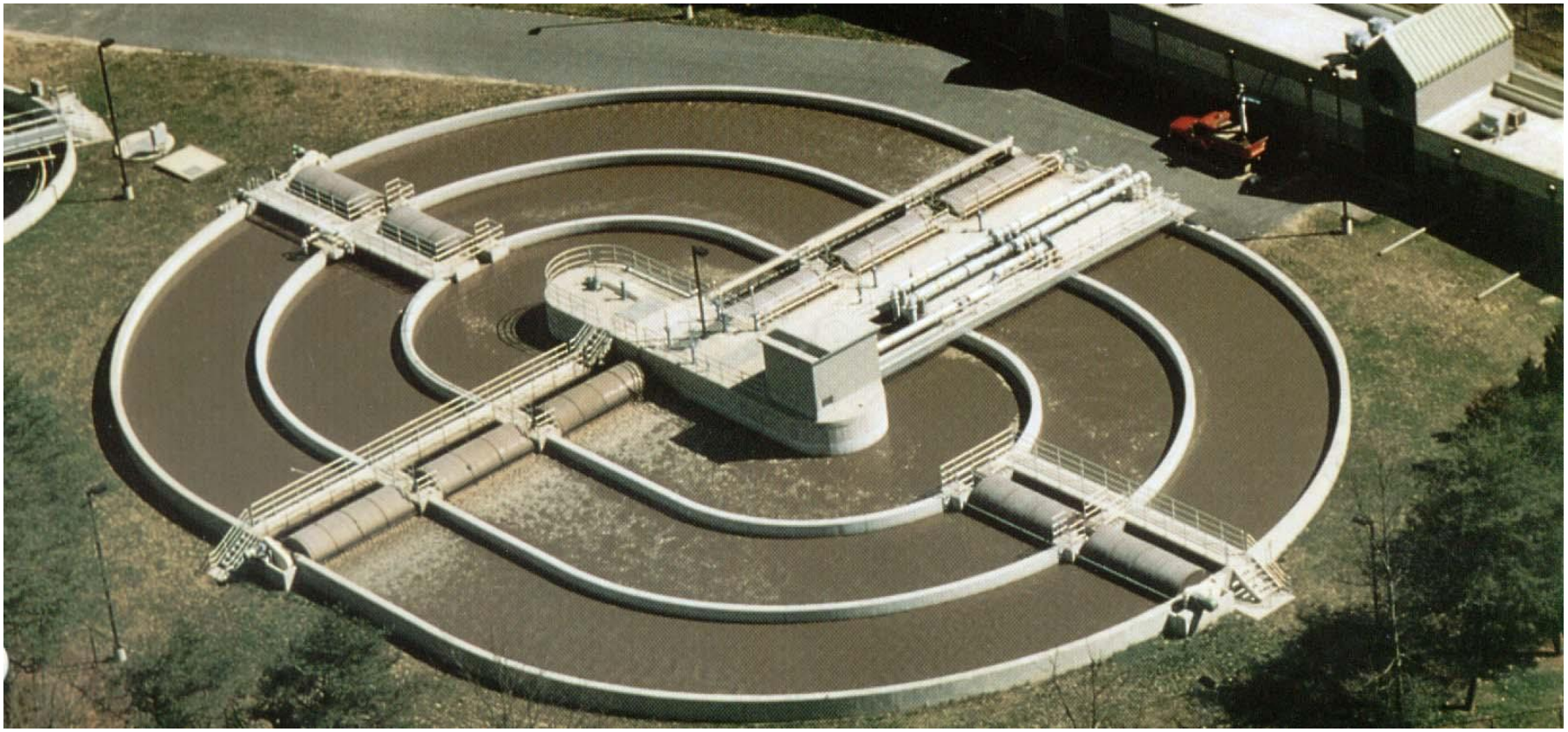
Secondary Treatment of Sewage

- Trickling filters



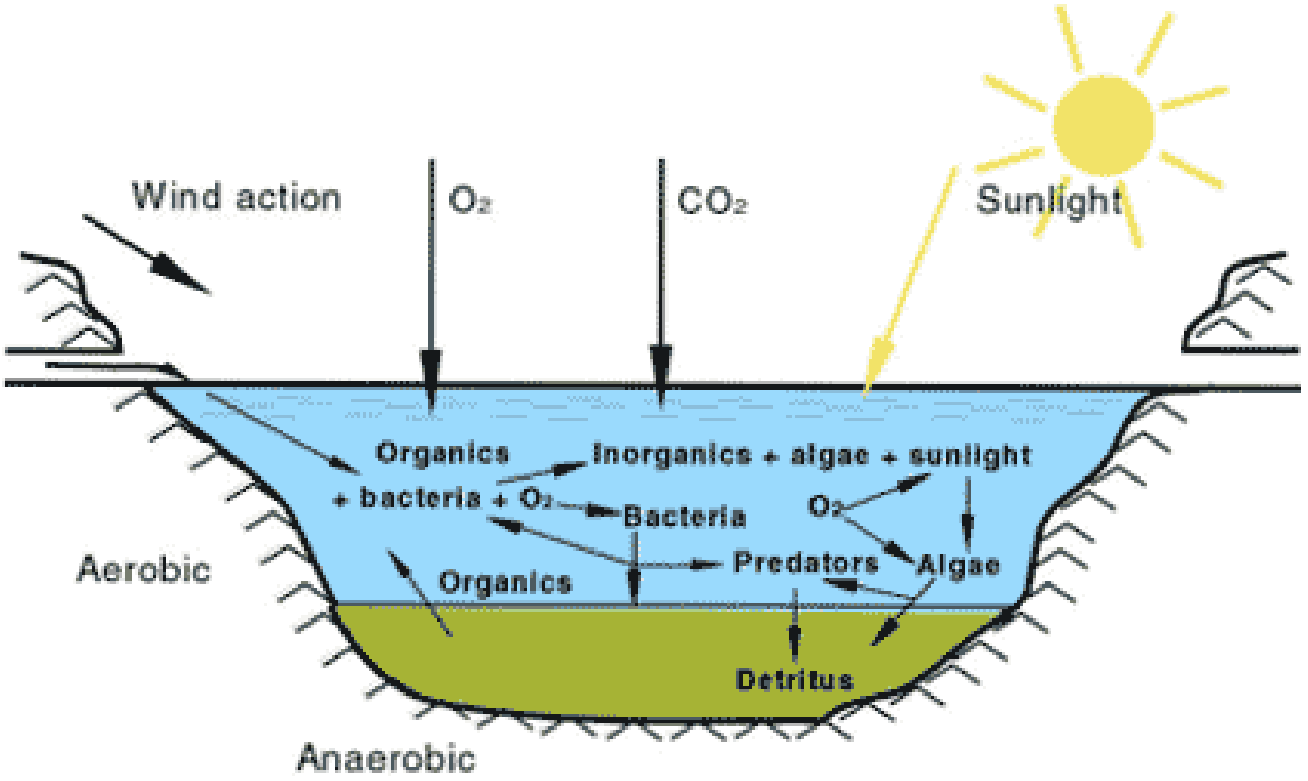
Secondary Treatment of Sewage

- Oxidation Ditch



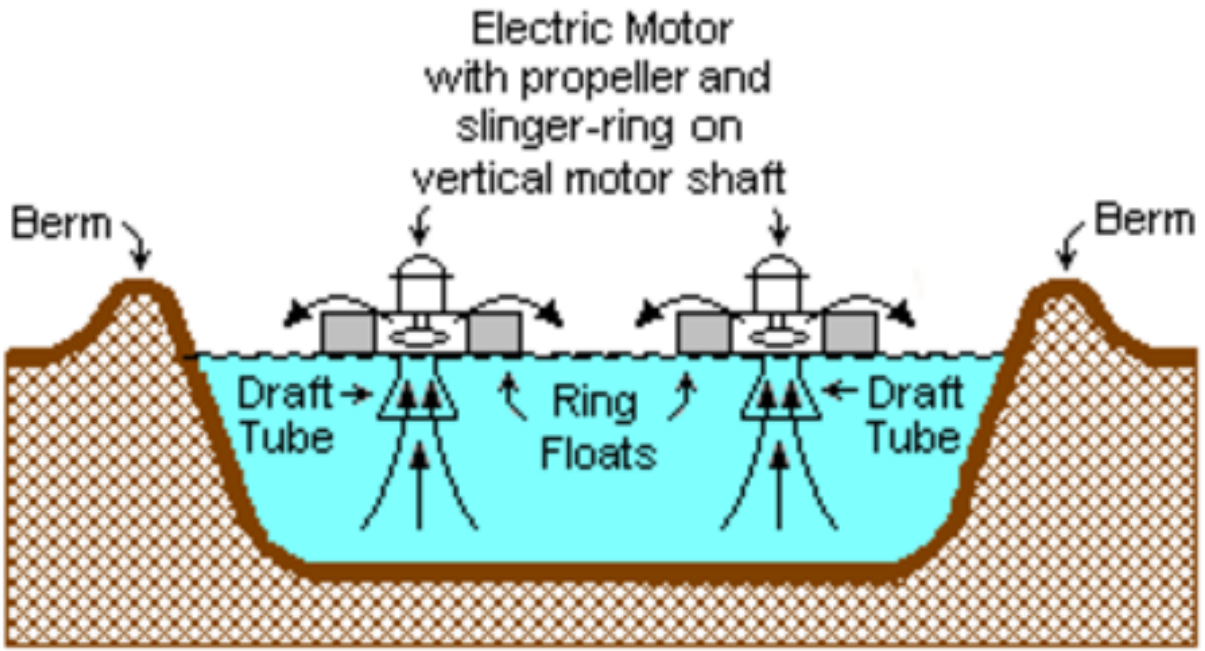
Secondary Treatment of Sewage

- Oxidation Ponds (Stabilisation Ponds)



Secondary Treatment of Sewage

- Aerated Lagoons



A TYPICAL SURFACE – AERATED BASIN

Note: The ring floats are tethered to posts on the berms.

Secondary Treatment of Sewage

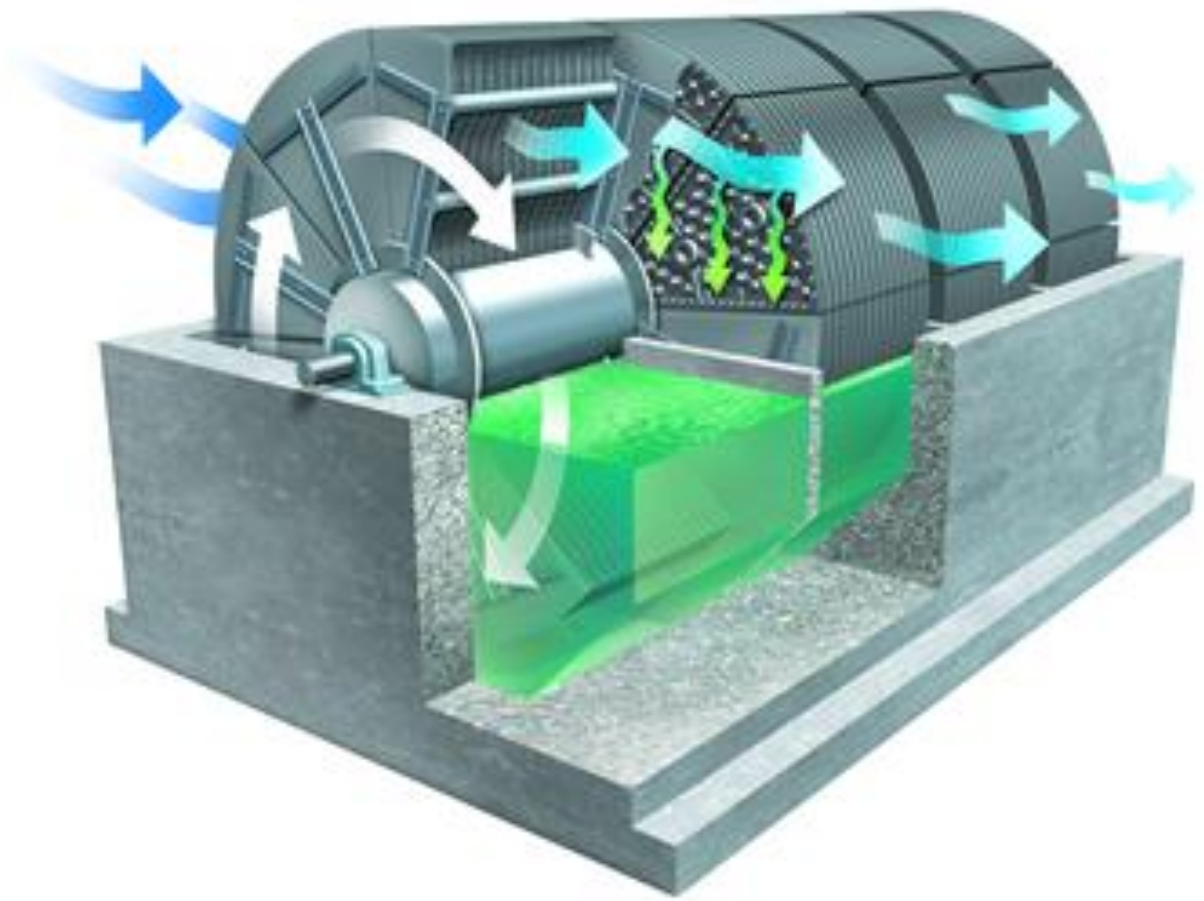
- Aerated lagoons

Table 5.12 Some Characteristics of Aerated Lagoons

No.	Characteristics	Facultative Aerated Lagoons	Fully Aerobic	Extended Aeration System (for comparison)
1.	Detention time, days	3 - 5	2 - 3	0.5 - 1.0
2.	Depth, m	2.5 – 5.0	2.5 – 4.0	2.5 - 4.0
3.	Land required, m^2/person	0.15 - 0.30	0.10 - 0.20	
4.	BOO removal efficiency %	80 - 90	50 - 60	95 - 98
5.	Overall BOD removal rate, K (A)	0.6 – 0.8	1-1.5	20 - 30
6.	Suspended solids in lagoon, mg/l	40 - 150	150 - 350	3,000 - 5,000
7.	VSS/SS	0.6	0.8	0. 6
8.	Desirable power level (B)	0.75	2.75 - 6.0	15 - 18
9	Power requirement, kWh/person/year	12 - 15	12 - 14	16 - 20

Secondary Treatment of Sewage

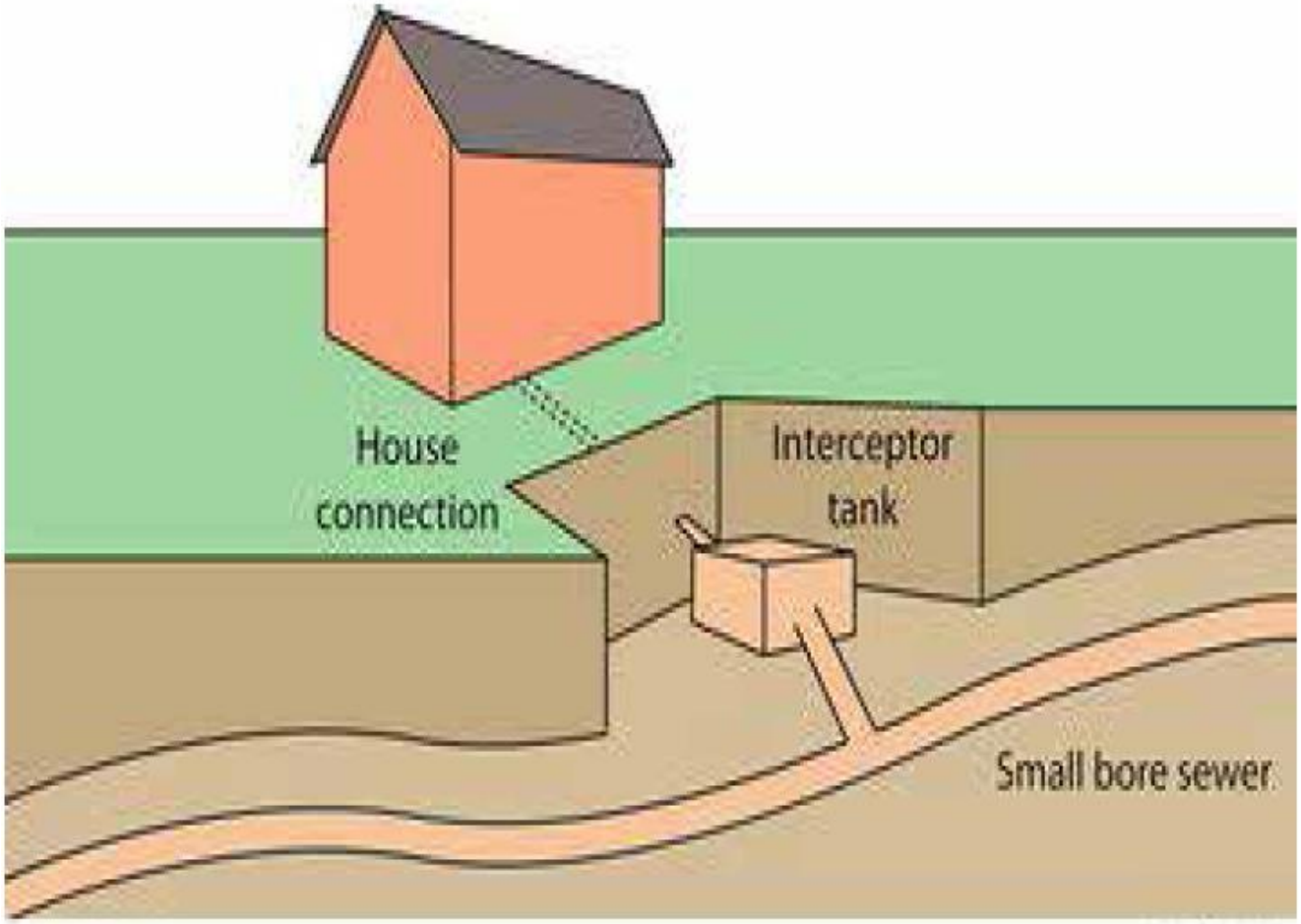
- Rotating biological Contactors



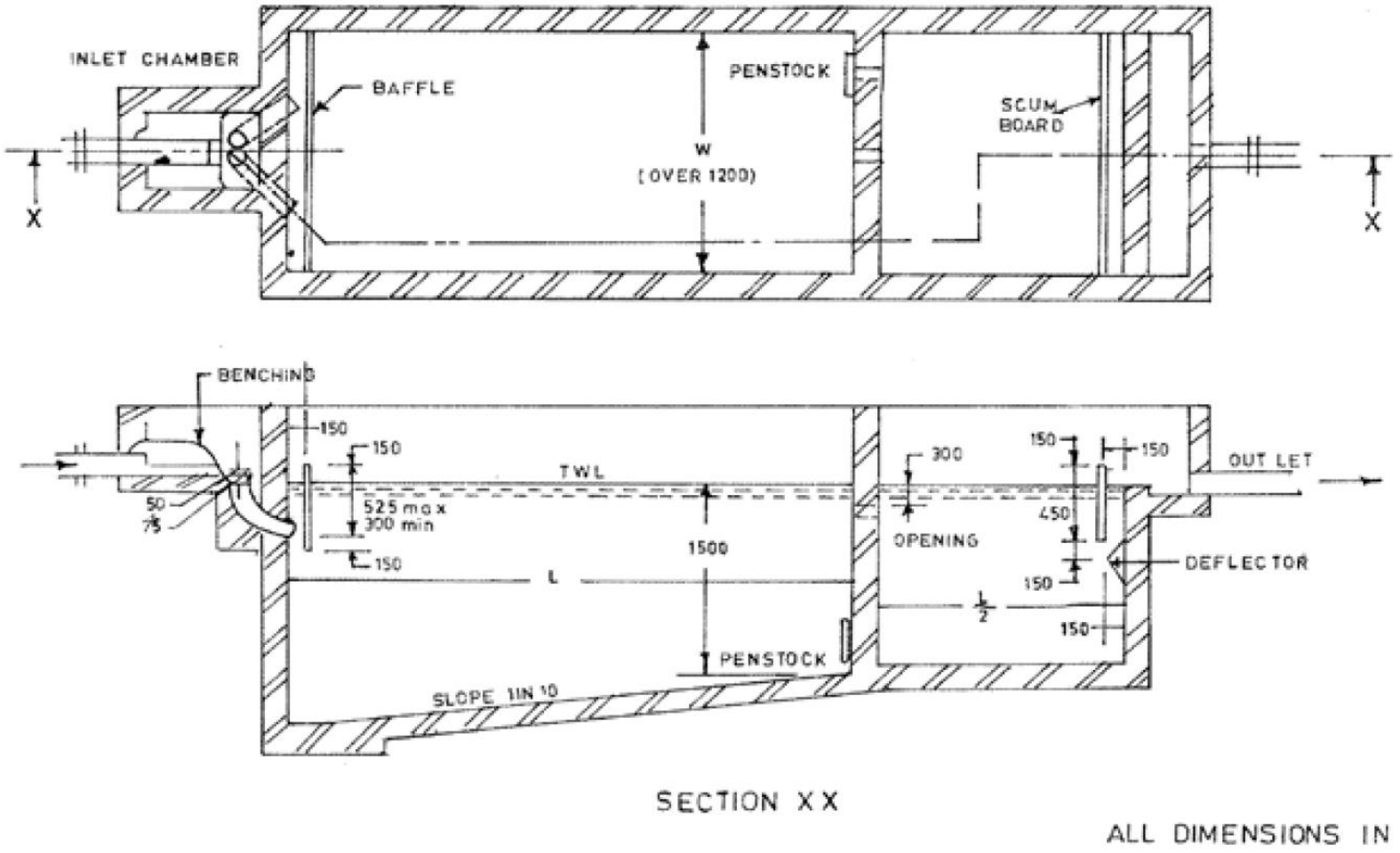
Rural Wastewater treatment systems

- Septic tank
- Constructed wetlands
- Lagoons
- Waste stabilisation ponds

A schematic diagram of Small bore sewer



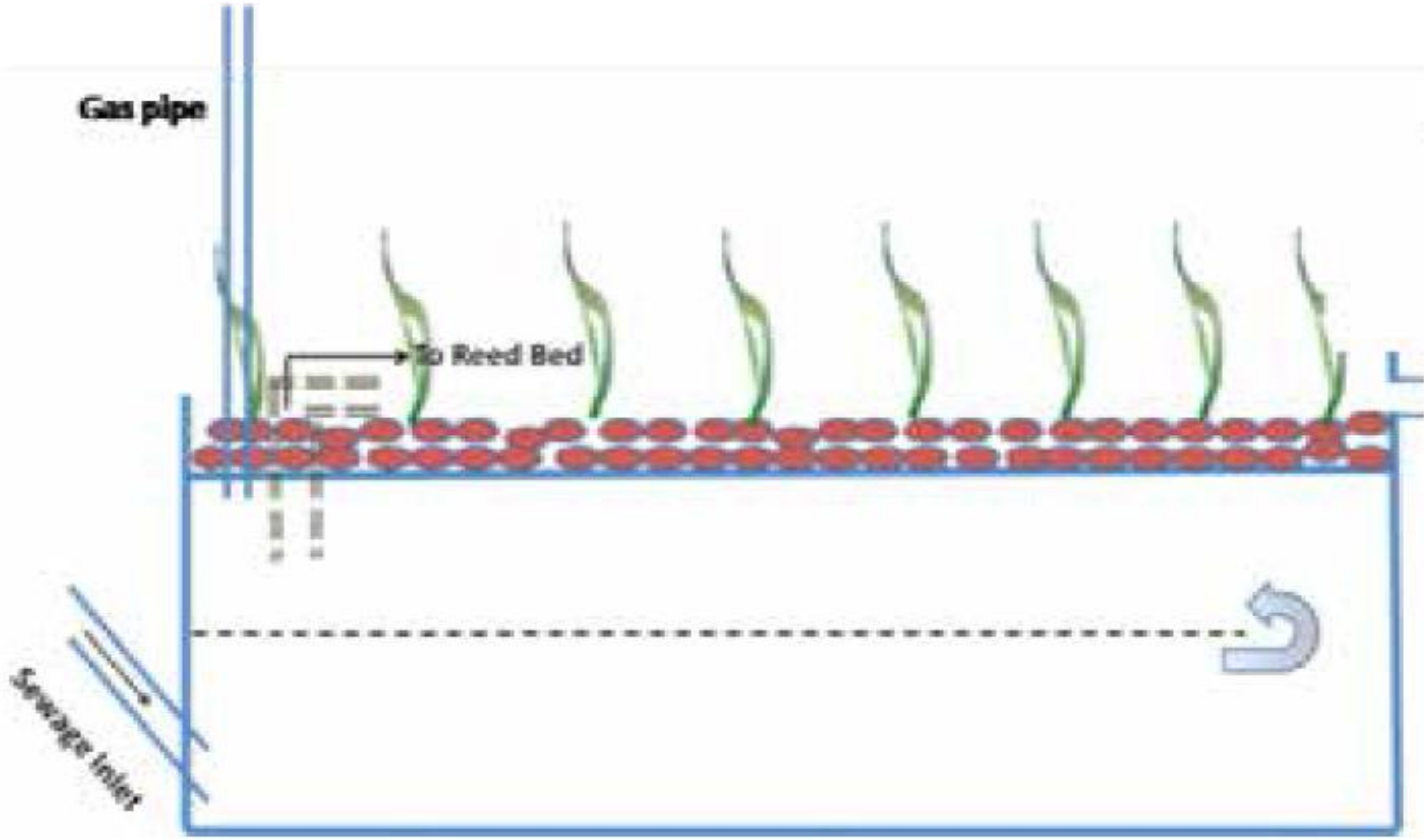
Septic Tank



SECTION XX

ALL DIMENSIONS IN mm

Wetland/Reed bed systems



Waste stabilisation pond

Thank you