# Chapter 11

# Sewage Treatment Concepts

# Sanitation Ladder


Source : UNESCAP

# Objective of Sewage Treatment

- Produce an environmentally-safe fluid waste stream (or treated effluent) and a solid waste (or treated sludge) suitable for disposal or reuse.

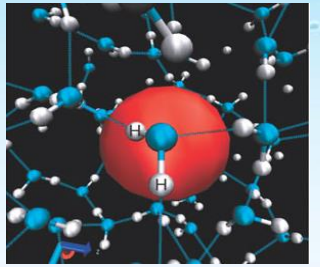
- Also reuse the treated water for non-potable purposes like flushing, irrigation and cooling tower if any.

"WATER, AIR is not inherited from our parents,
.....we have borrowed them from our Grand Children"

# Characteristic of Sewage

- pH
- BOD
- COD
- Dissolved Solids
- Suspended Solids
- Oil & Grease

- **Biological Oxygen Demand (BOD)**
  - Oxygen required by micro organisms to disintegrate the organics present in the effluent
- **Chemical Oxygen Demand (COD)**
  - Oxygen required by the chemicals present in the effluent for their oxidation



# Sewage Treatment

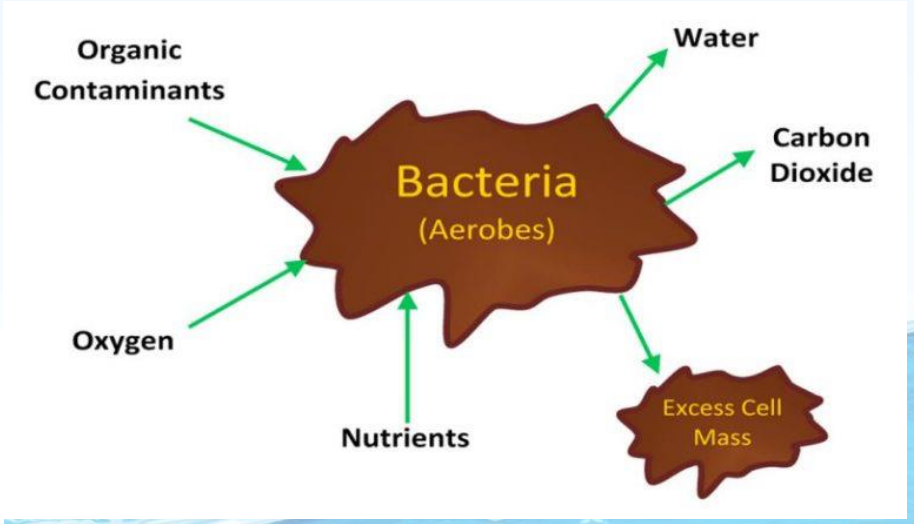
- Sewage treatment is the process of removing contaminants from domestic sewage.
- It includes physical, chemical, and biological processes to remove contaminants.

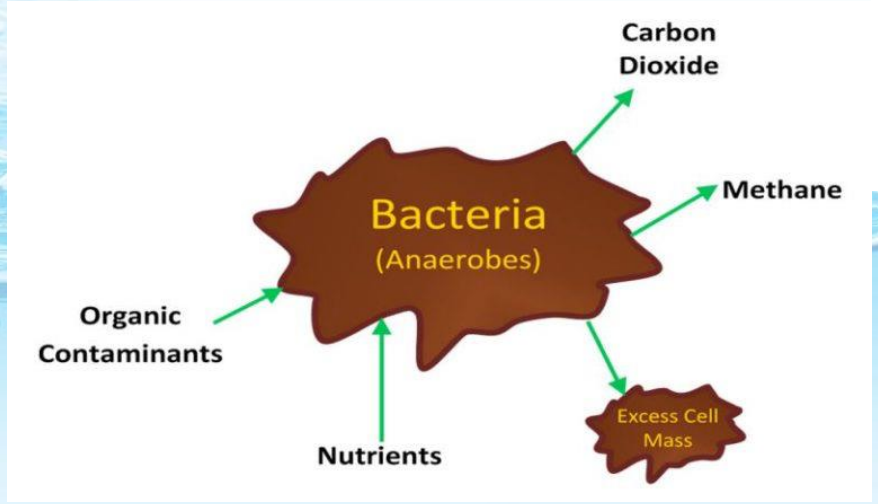
## Types of Treatment

- **Anaerobic treatment plants**
- **Aerobic treatment plants**

# Treatment Process Kinetics

Organic Material + Nutrients + $O_2$ — Aerobic Microbes → $NH_3$ + $CO_2$ + Biomass

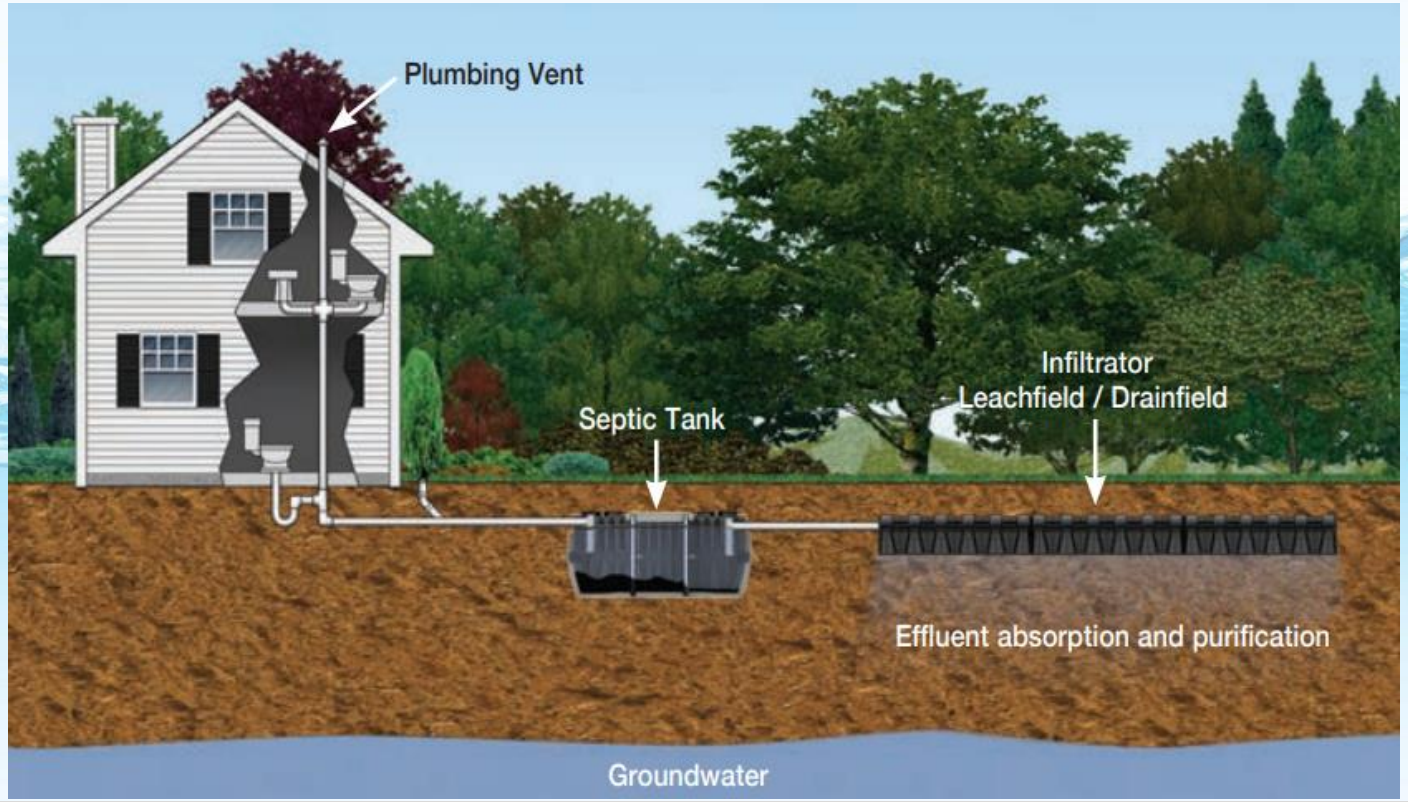



Organic Material + Nutrients — Anaerobic Microbes → $CH_4$ + $NH_3$ + $CO_2$ + Biomass

# Anaerobic Treatment – Septic Tank

- Code of Practice for Installation of Septic Tanks, IS : 2470 (Part 1) - 1985 (Reaffirmed 2001) - Design Criteria and Construction
- Septic tank offers a preliminary treatment of sewage prior to final disposal.



# Anaerobic Treatment – Septic Tank

- The maximum flow to the tank is based on the number of plumbing fixtures discharging simultaneously.
- The Fixture unit is a quantity in terms of which the load producing effect of different plumbing fixtures on the plumbing system are expressed on some arbitrarily chosen scale. In the design of septic tank, it is taken as 9 lpm.

**TABLE 1 FIXTURE EQUIVALENT**

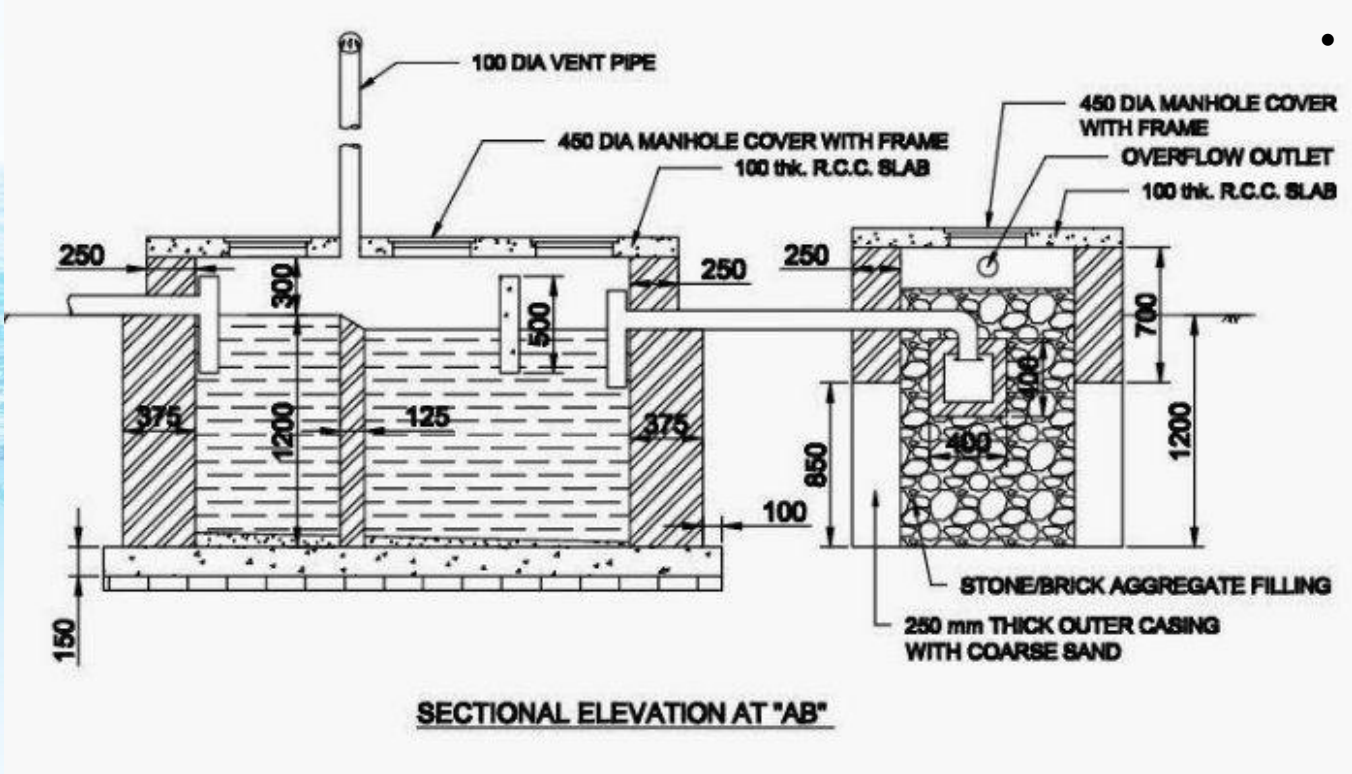
*( Clause 3.4.1.1 )*

| FACILITY | EQUIVALENT FIXTURE UNIT |
|---|---|
| Water closet | 1 |
| Bath | 1/2 |
| Wash basin/kitchen sink | 1/2 |
| Urinal ( with autoflush ) | 1 |
| Urinal ( without autoflush ) | 1/2 |
| Slop sink | 1 |
| Laboratory sink | 2 |
| Combination fixture | 1 |
| Shower bath | 1 |
| Bath tub | 2 |
| Drinking fountain | 1/2 |
| Ablution tap | 1/2 |
| Dish water | 1/2 |

- For rectangular septic tanks, the length of the tank shall be 2 to 4 times the width.
- For circular tanks the minimum diameter shall not be less than l.35 mtr and operating depth shall not be less than 1.0 mtr.

# Anaerobic Treatment – Septic Tank

- Septic tank designed on the basis of provides a detention period of 24 to 48 hours based on an average daily flow of sewage.
- If the capacity of a septic tank exceeds 2 KL the tank may be divided into two chambers by making of a fixed durable partition.




- The floor may be of cement concrete of minimum M15 grade and a minimum slope of 1 in 10 may be provided towards the sludge outlet to facilitate desludging.

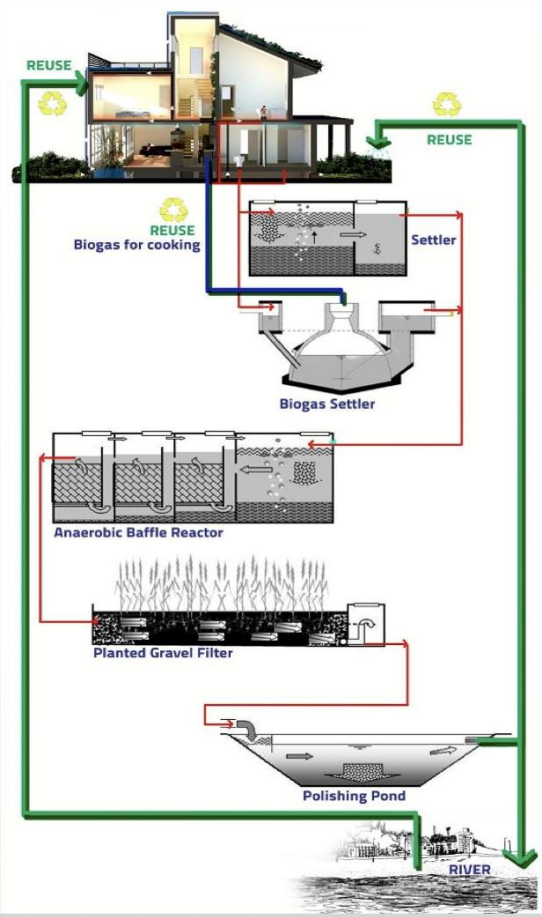
# Anaerobic – Other Treatment Methods

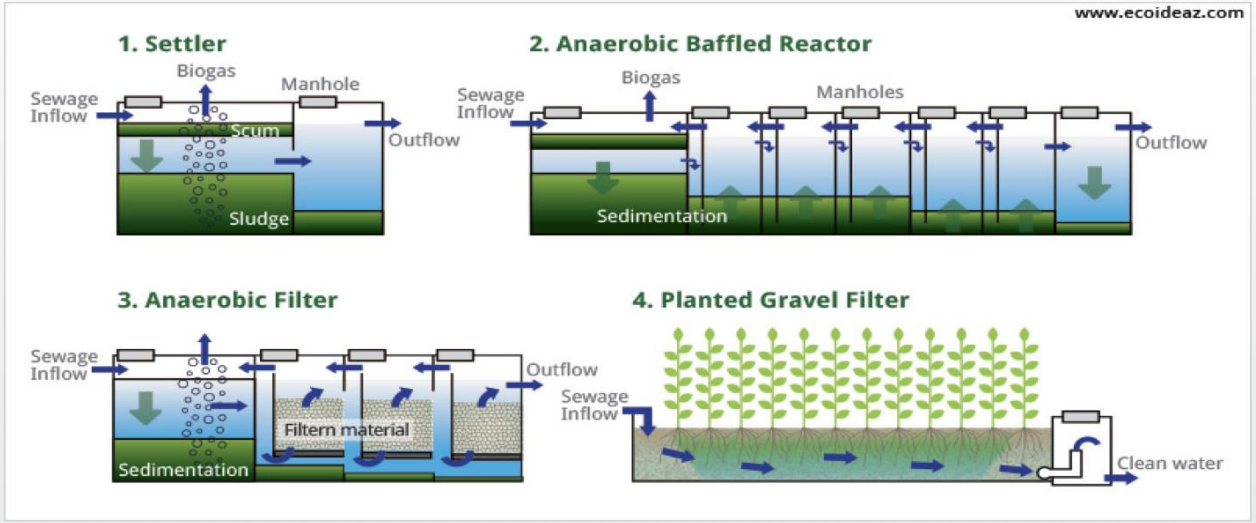
- There are many other type of anaerobic treatment practice.

| Type | Treatment | Wastewater type | Advantage | Disadvantage |
|---|---|---|---|---|
| Septic Tank | sedimentation, sludge stabilization | wastewater of settable solids | simple, durable, underground | low treatment efficiency |
| Imhoff Tank | sedimentation, sludge stabilization | wastewater of settable solids | simple, durable, underground | need regular de-sludging |
| Aerobic Filter | anaerobic degradation of SS and DS | pre-settled industrial and domestic wastewater with narrow COD/BOD ratio | simple, durable, underground, high treatment efficiency | costly, filter blockage |
| Baffled Septic Tank | anaerobic degradation of SS and DS | pre-settled industrial wastewater with narrow COD/BOD ratio | simple, durable, little permanent space, high treatment efficiency, relatively cheaper compared to anaerobic | required large space, less efficient compared to anaerobic |
| Horizontal Grave Filter | aerobic facultative, anaerobic degradation of SS and DS, pathogen removal | suitable for domestic and weak industrial wastewater when SS and DS already removed | high efficiency, no nuisance, no wastewater on ground | need permanent space, requited intensive maintenance with expertise, relatively costly |
| Anaerobic Pond | sedimentation, anaerobic degradation, sludge stabilization | strong or medium industrial wastewater | simple in construction, little maintenance required with flexible degree of treatment | occupy open land , can be a nuisance due to odour and mosquitoes |

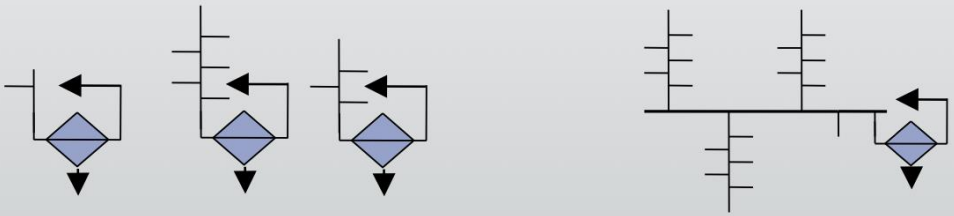
Source : UNESCAP

# Anaerobic – Decentralized Wastewater System



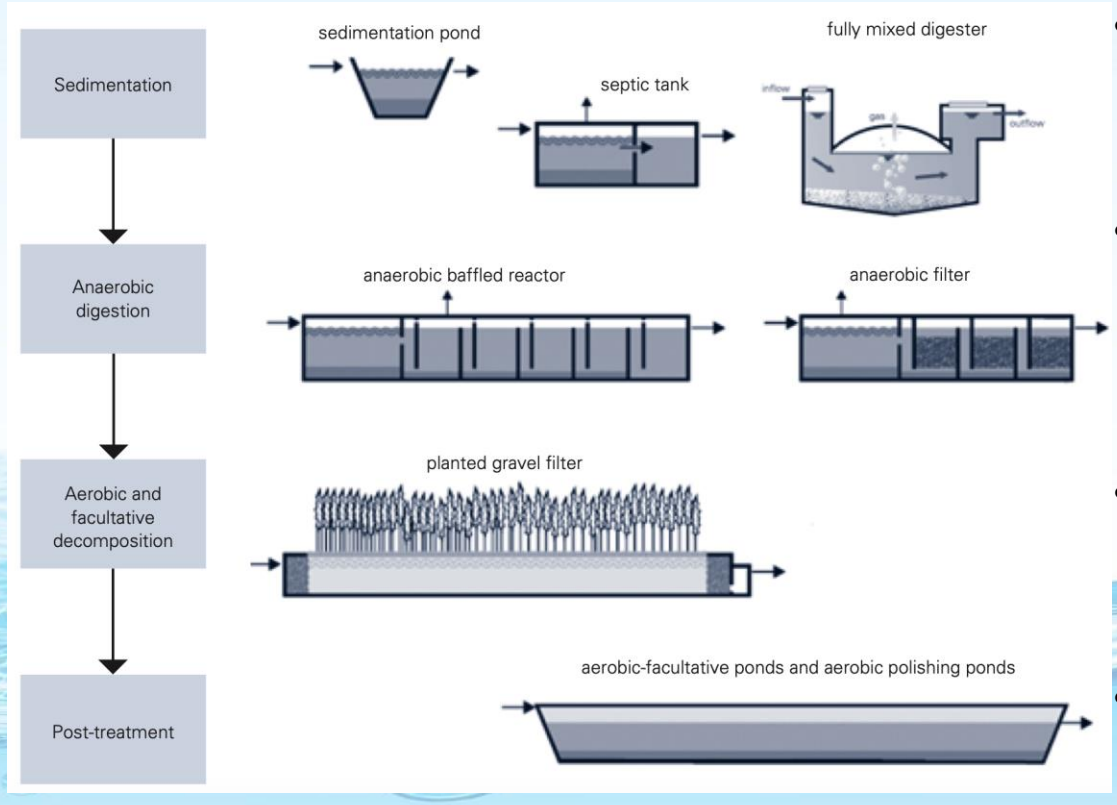




**DEWATS is the treatment of wastewater within the house premises.**




Source : UNESCAP

# Process of DEWATS

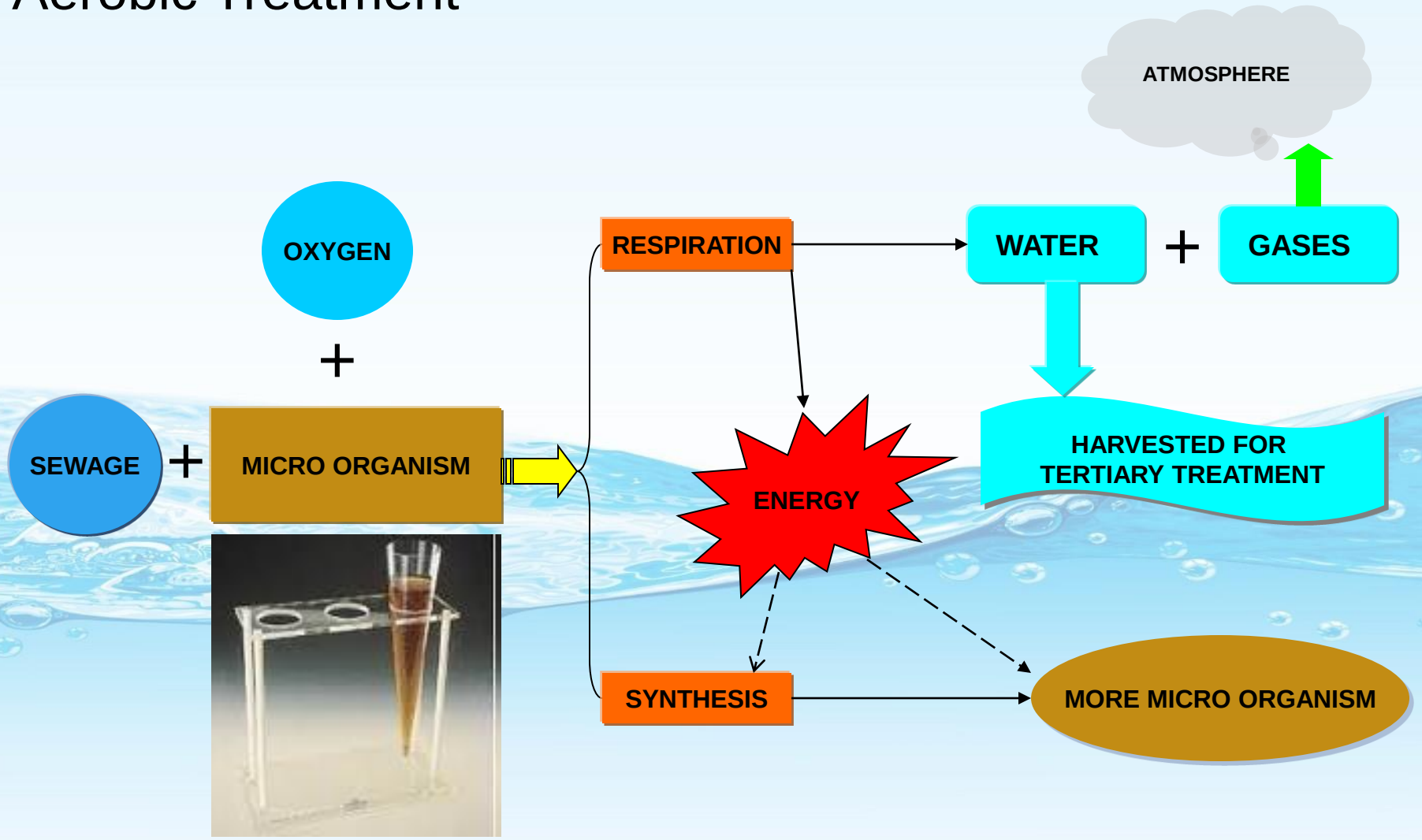



- primary treatment – in sedimentation ponds, settlers, septic tanks or bio- digester
- secondary treatment – in anaerobic baffled reactors, anaerobic filters or anaerobic and facultative pond systems
- secondary aerobic/facultative treatment – in horizontal gravel filters
- post-treatment – in aerobic polishing ponds

→ **Sedimentation** removal of easily settleable solids → **Anaerobic digestion** removal of easily degradeable organic solids → **Aerobic decomposition** removal of more difficult degradable solids → **Post-sedimentation** removal of digested solids and active bacteria mass

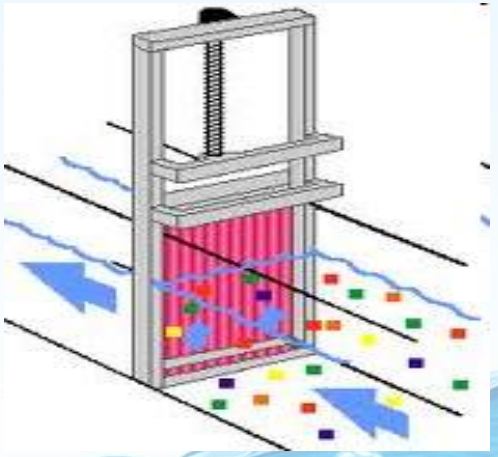
Source : BORDA & WEDC

# Aerobic Treatment



# Treatment Stages

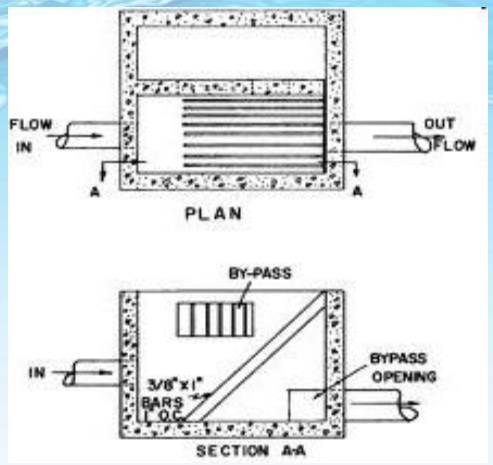
- Primary treatment
- Secondary treatment
- Tertiary Treatment



Primary treatment consists of

A. Screening

B. Collection and Equalization



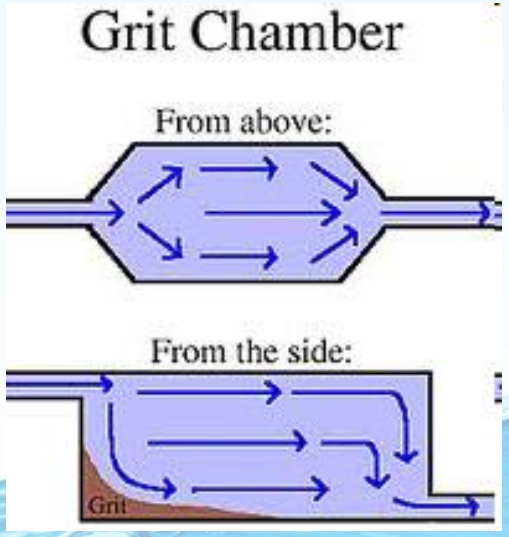

<u>Bar Screen Chamber</u>

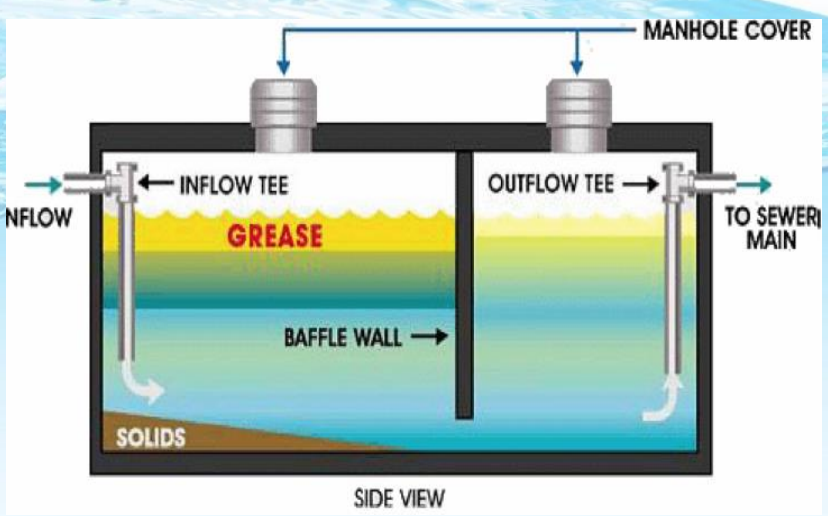
- Segregates plastics, rags, rocks, napkins and other floating objects

# Primary Treatment

**Grit Chamber** (optional)

- Settles and segregates smaller particles like sand – which are manually collected and hauled away



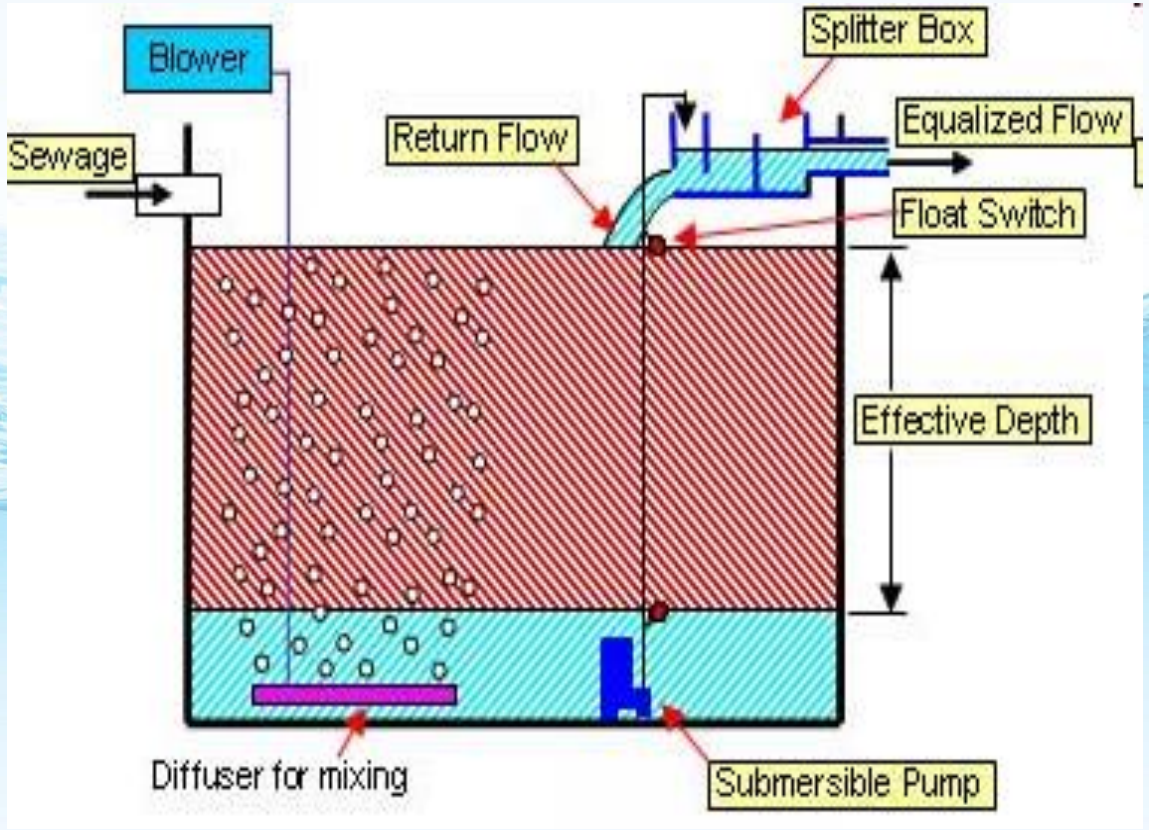

**Oil and Grease Trap (**optional**)**

- Segregates grease and oil which are removed using squeeze ‘s

# Primary Treatment

## Equalization Tank

- Flow to the equalization tank serves the dual purpose of collecting, storing and keeping the sewage fresh using diffused coarse bubble aeration for down stream treatment.



# Secondary Treatment

## Aeriation Tank

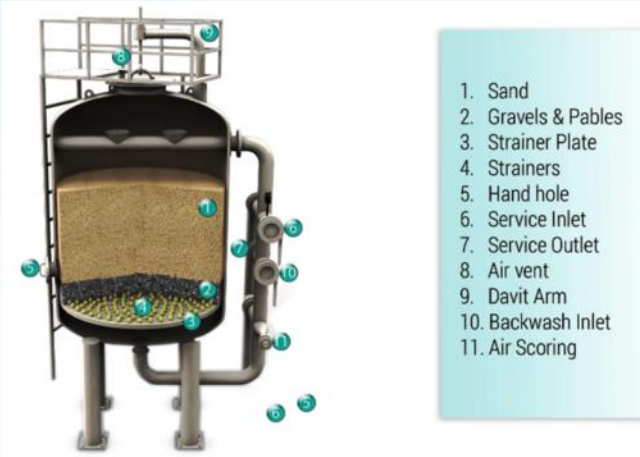
- Purely Biological
- Oxygen transfer
- Converting dissolved organics to settable biological solids

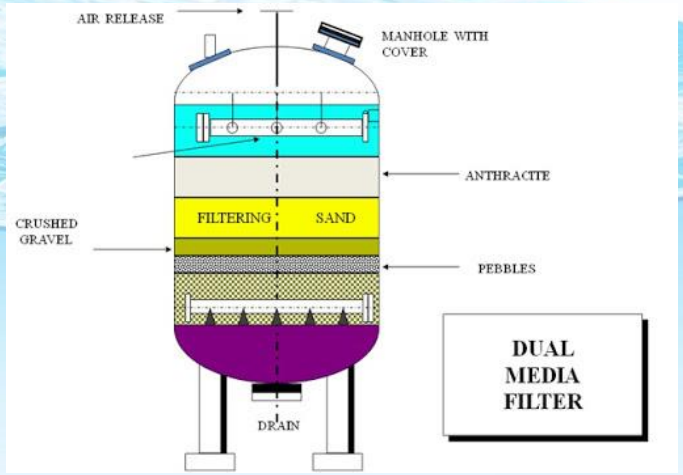
Source : PCA Water

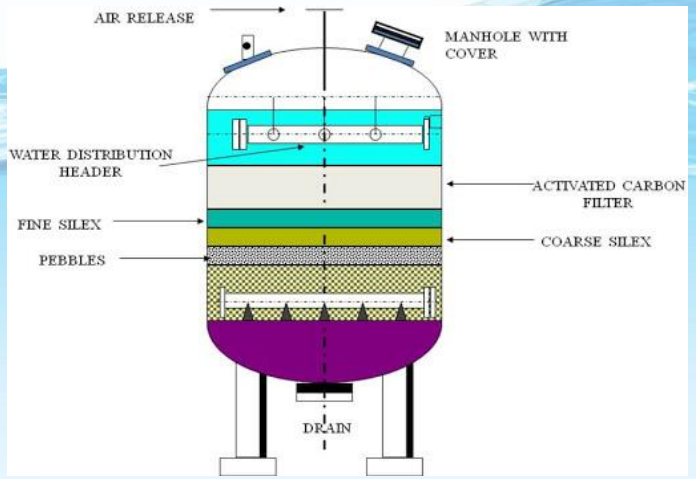
# Tertiary Treatment

## Filtration

- Pressure Sand Filter (**PSF**)
- Dual Media Filter (**DMF**)
- Activated Carbon Filter (**ACF**)

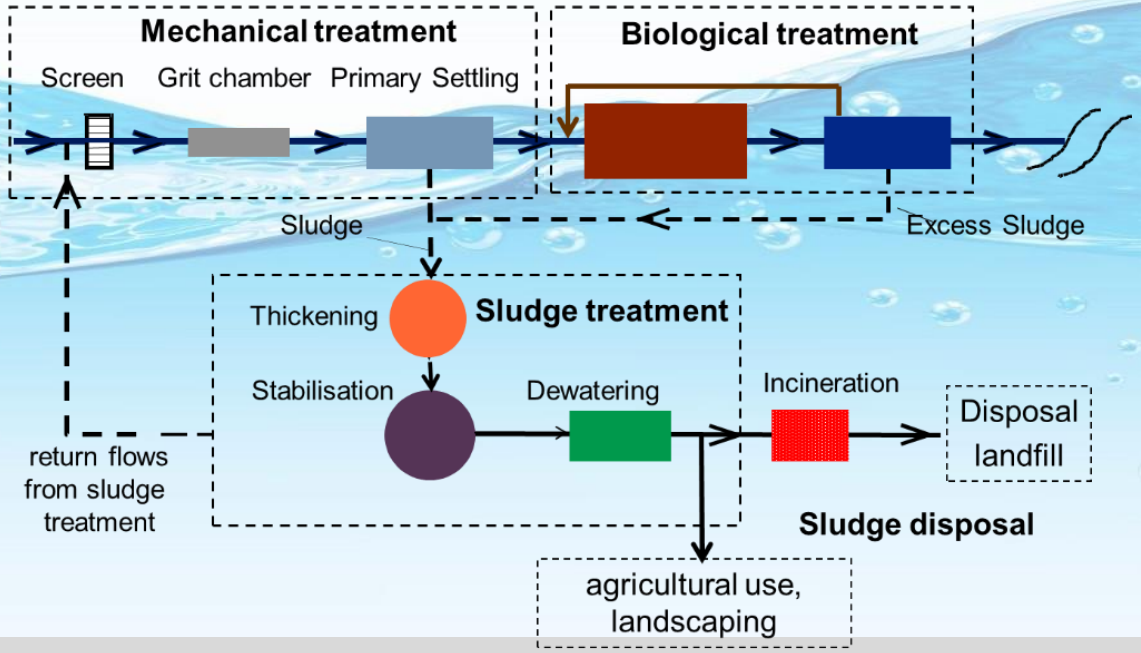


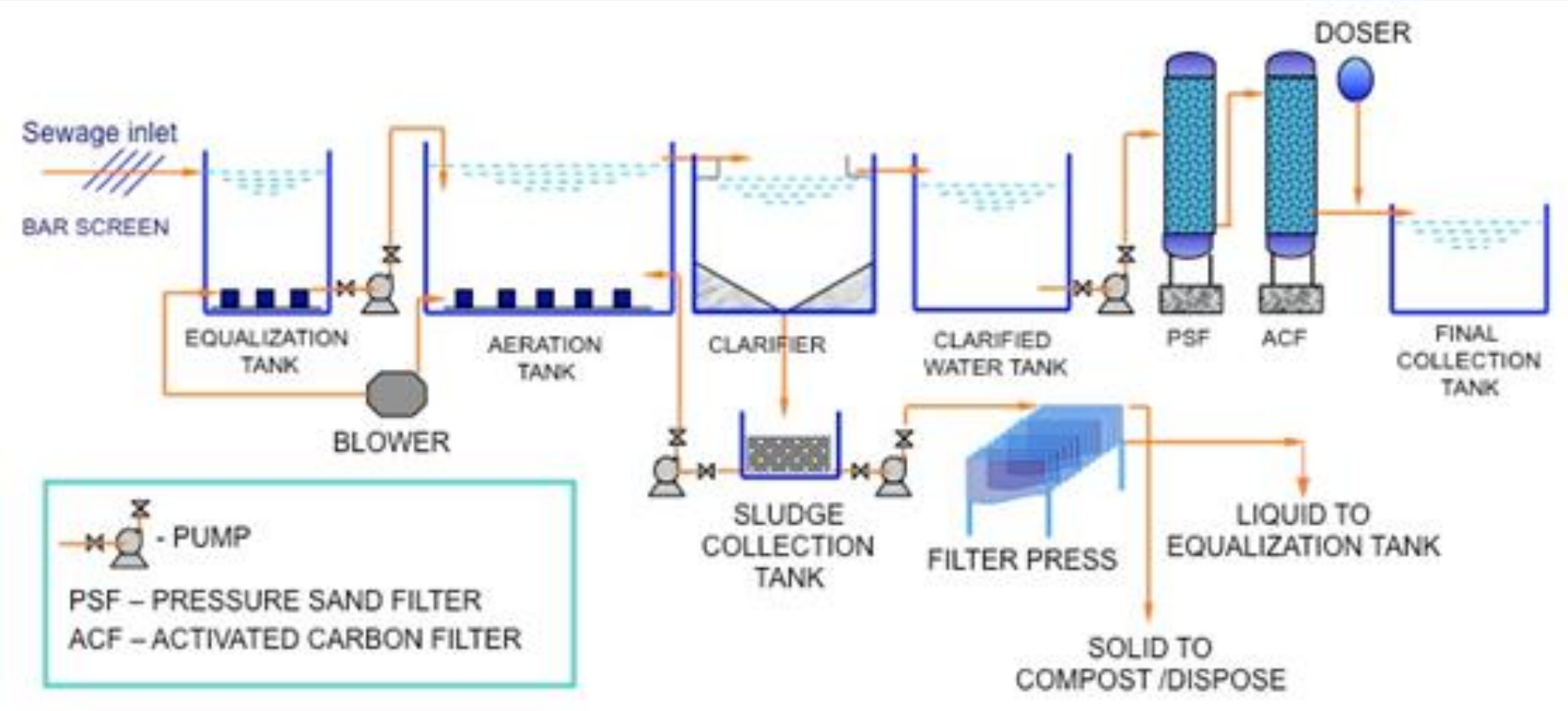



# Aerobic - Sewage Treatment Types

- Activated Sludge Process with Extended Aeration - ASP
- Fluidized bed Reactor- FBR/FBBR
- Sequential Batch Reactor - SBR
- Membrane Bio Reactor - MBR



# Treatment Schemes – ASP with Extended Aeration



# ASP with Extended Aeration

- Clarified water contains residues of biological matter
- Needs to be filtered before discharge
- Disinfection is mandatory.

# ASP with Extended Aeration

Parameters Limits (Standards for STP's design)

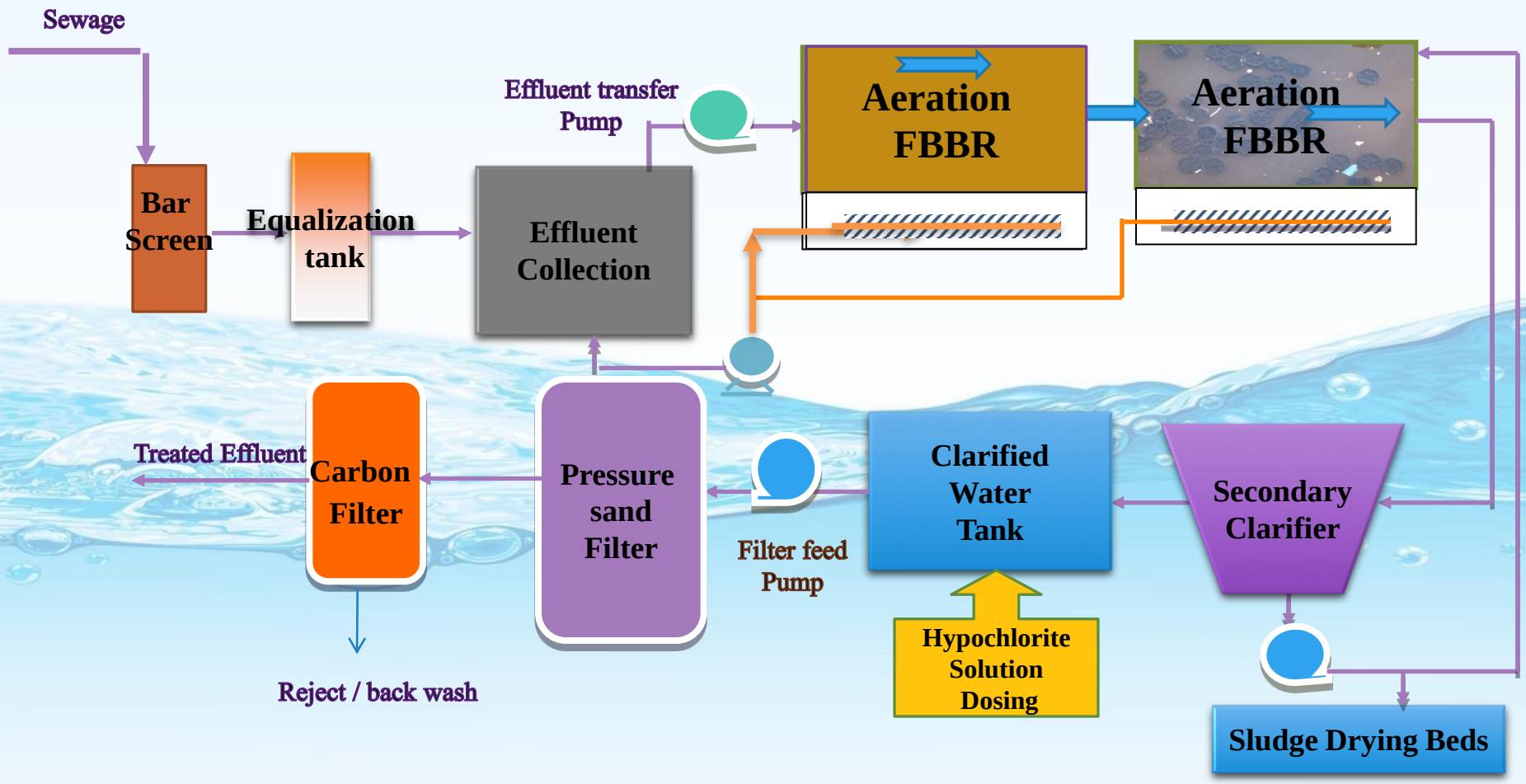
**MEETS CPCB STANDARS**

- pH – 6.5 ~ 9.0
- BOD < 10 mg/L
- COD < 50 mg/L
- TSS < 20 mg/L
- NH4-N < 5 mg/L
- N-total < 10 mg/L
- Fecal Coliform < 100 (MPN/100ml)
- Residual Chlorine > 1 mg/L

# ASP with Extended Aeration - Limitations

- MLSS values – 3500 – 4500 ppm
- Sludge carry over in the treated water
- Media filter efficiency max 100 Microns
- Colloidal Particles – Poor SDI
- Difficult to maintain consistent treated water quality
- Smell in the Treated effluent
- Upset in system due to inlet variations
- Large area and huge civil works required

# Fluidized Bed Bio Reactor - FBBR



# FBBR Media

- PP media
- Wheel type design with serrations
- Maximums surface area
- Dimensions 21 mm dia x 16 mm ht

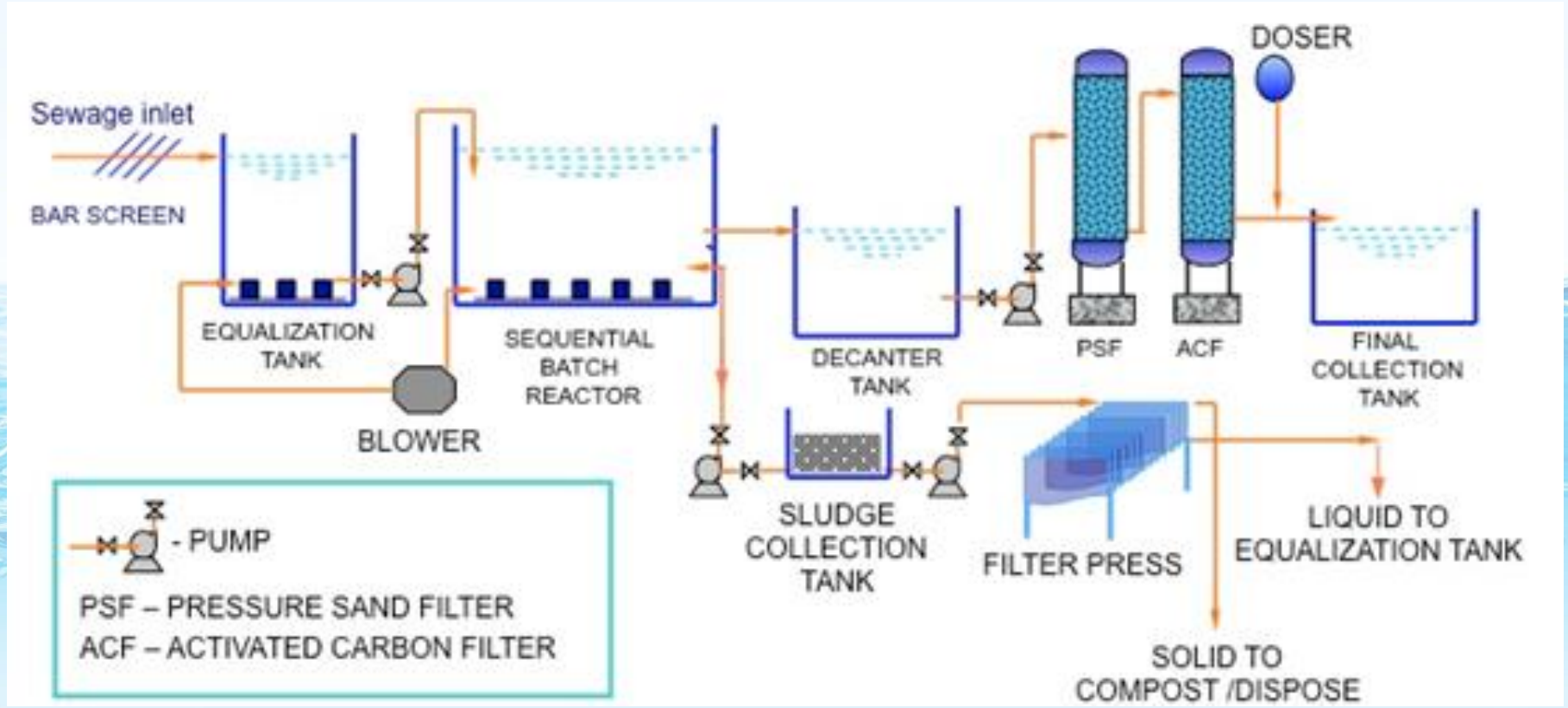
# ASP v/s FBBR

- Reduction in Civil works
- Smaller foot print as media provides large surface area
- Two stage Bio Digestion better removal efficiency
- Lesser sludge generation

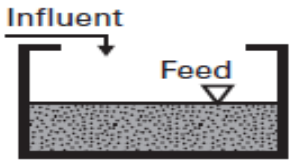
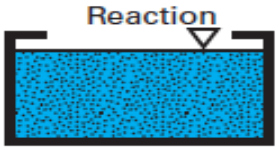
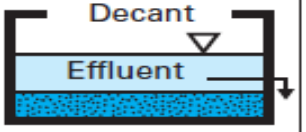
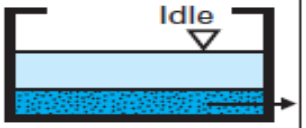
# Limitation : FBBR

- Relies on Media Surface for microbiological growth – Restriction Sludge retention time
- Sludge removal is by settling in Secondary Clarifier – Sludge bulking, particulate carryover problems still remain
- Disinfection is mandatory for treated sewage
- Final Filtration is by Sand Filters and Carbon Filters

# Sequential Batch Reactor - SBR

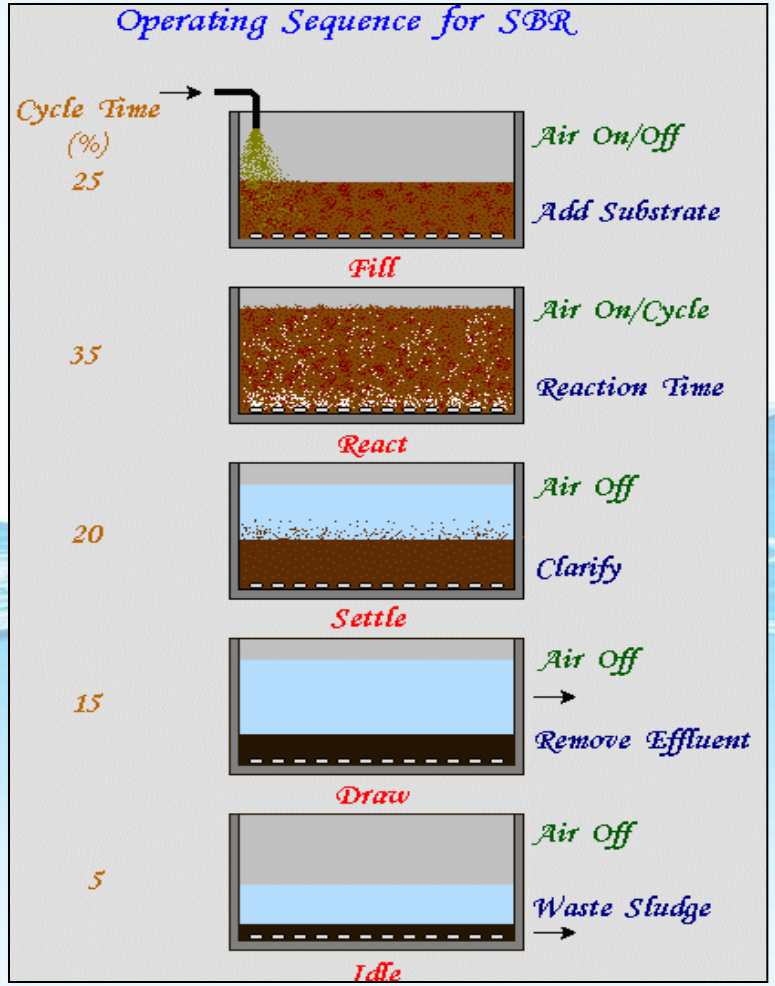


# Operation Cycle of SBR

| Sequence | Volume taken up (as a % of capacity) | Sequence duration (as a % of cycle) | Cycle stage | Object of the sequence | Air |
|---|---|---|---|---|---|
| 1 | 60 to 100 | 33 |  | Substrate input (denitrification) | With or without (optional) |
| 2 | 100 | 33 |  | Carbon removal (and nitrification) | With |
| 3 | 100 | 16 |  | Clarification | Without |
| 4 | 100 to 65 | 14 |  | Treated water removal | Without |
| 5 | 65 to 60 | 4 |  | Excess sludge | Without |

# SBR - Advantages

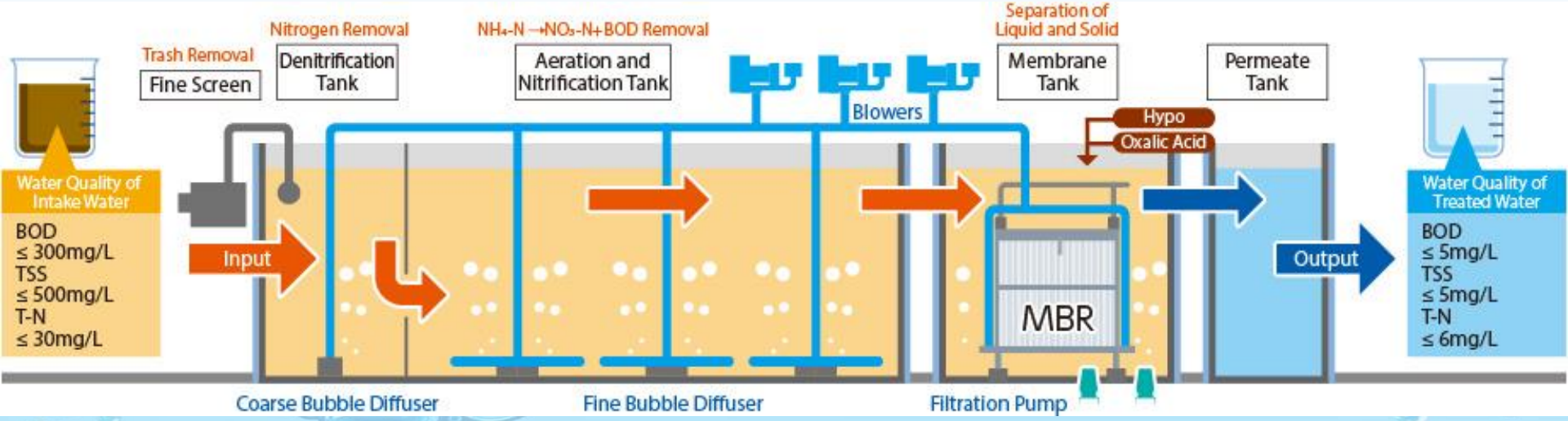
- Time controlled opearation
- No sludge recirculation
- Perfect quiscent settling
- Optimum energy efficienecy
- State of the art controls
- Biological nutrient removal
- No clarifies / settling tank



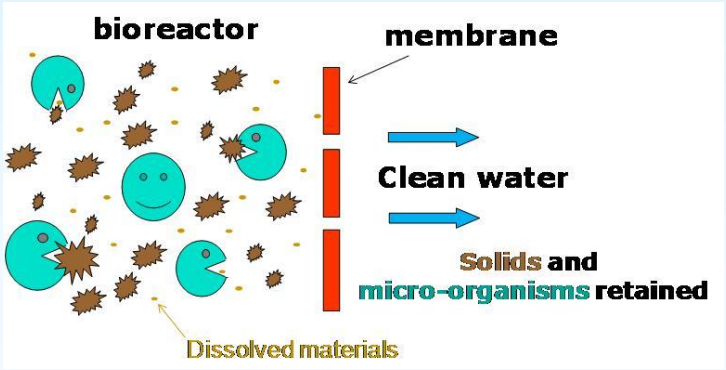
# SBR - Advantages

- SBRs can consistently perform nitrification as well as denitrification and phosphorous removal.
- SBR's have large operational flexibility
- Sludge bulking problem is avoided
- System requires less space than extended aeration plants of equal capacity

# Membrane Bio-Reactor - MBR



# MBR- Concept




❖ **Common Steps**

- Screening, oil removal and equalization
- Biological aeration (size smaller due to Higher MLSS)

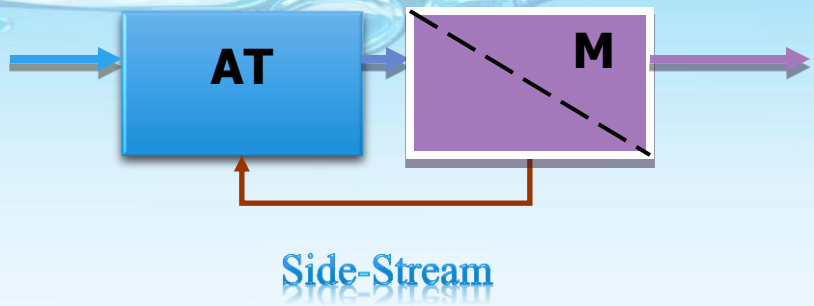
❖ **Membrane Bio Reactor**

- Eliminates secondary clarifier and sludge recirculation and tertiary filtration
- Utilizes fine pore membrane in the UF range for filtering out treated water.
- Membranes are back washable and tolerant to strong cleaning chemicals

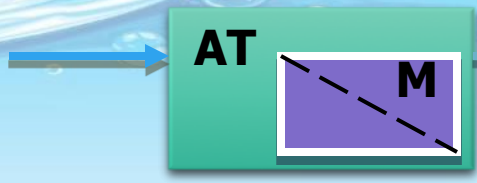
# MBR - Principle

❖ **MBR Combines**

- Biological aerobic degradation-to degrade organics
- Membrane separation - to separate the biomass & to achieve absolute filtration

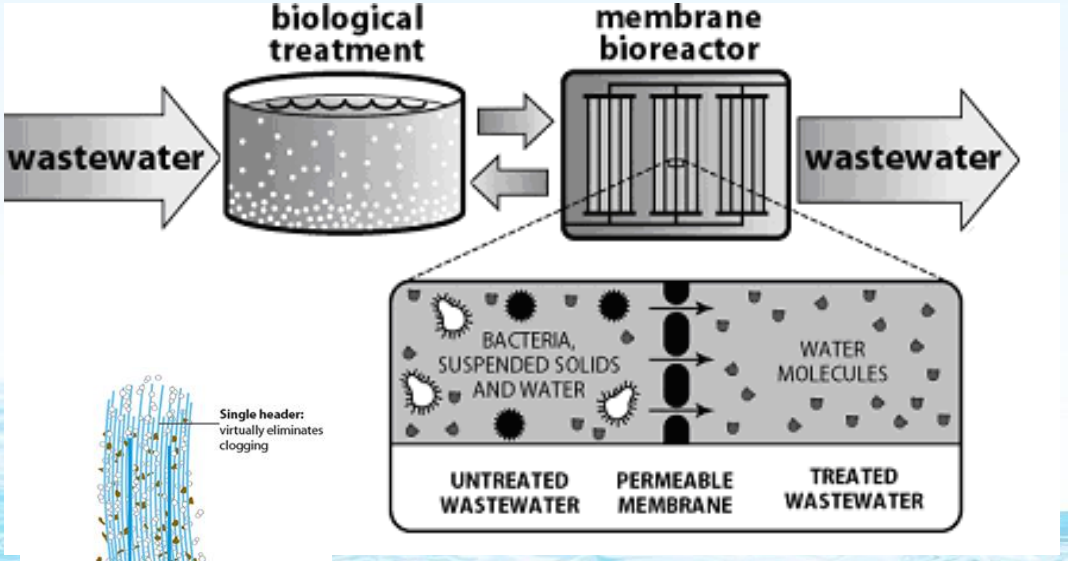


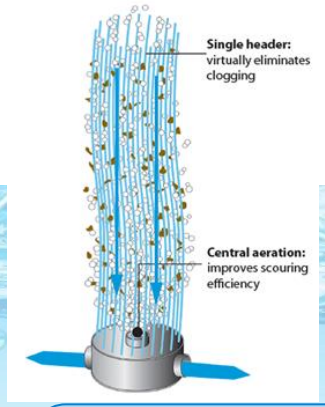

Side-Stream




Submerged

# MBR - Attributes



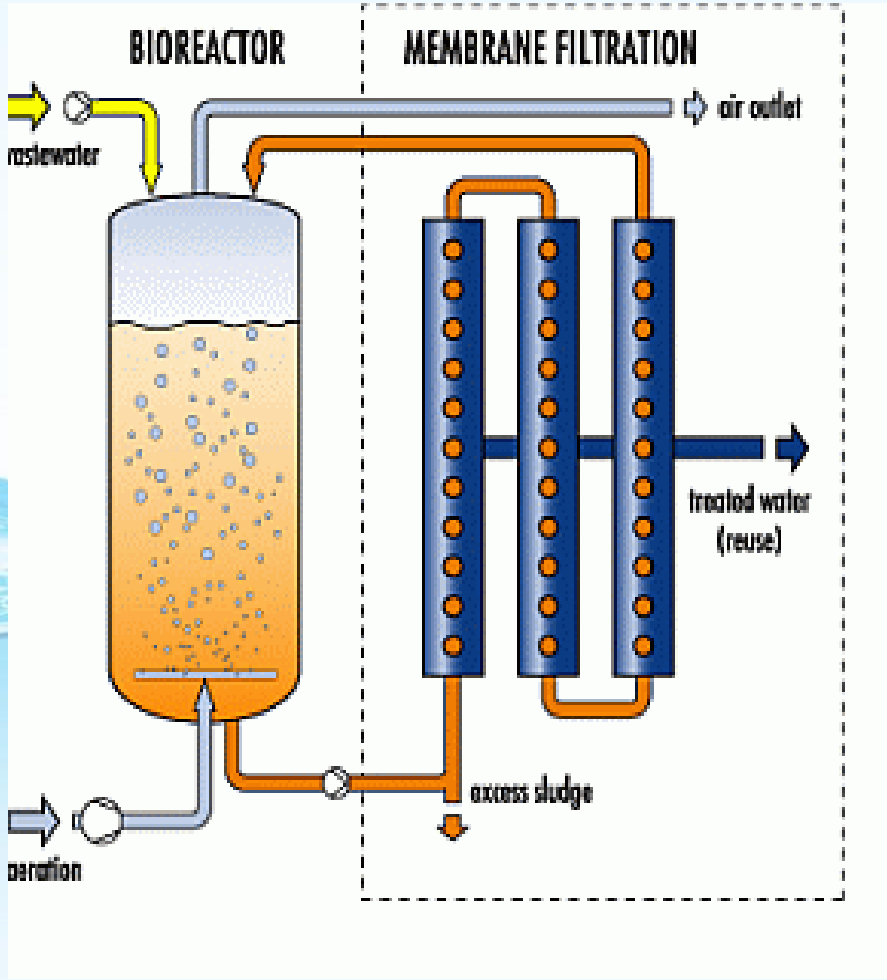

Absolute dead end filtration 0.02 micron ultra – filtration range
Isolates bacteria / virus 10000 molecular weight cut off filtration

# Side Stream MBR

Membranes are housed
In plant room outside
Aeration tank

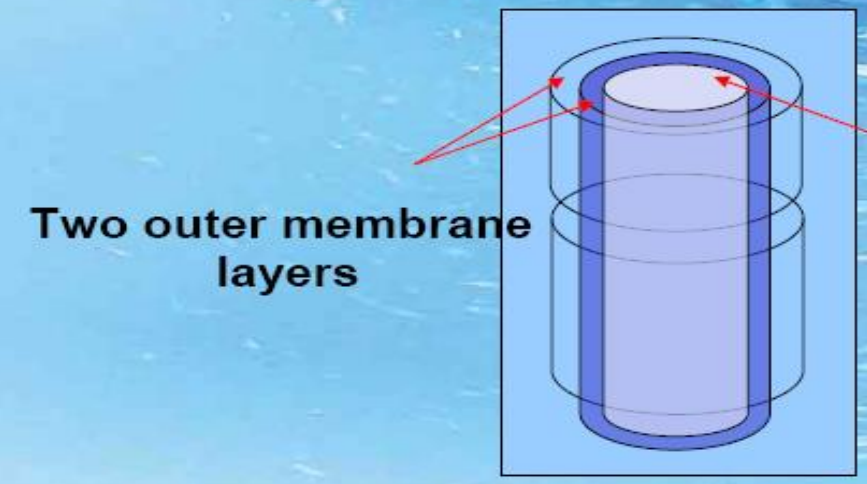
Easy to isolate
And carry out the
Operation

Simple stand alone
Process fully
Automated



# Side Stream MBR - Installation

# Fiber Construction



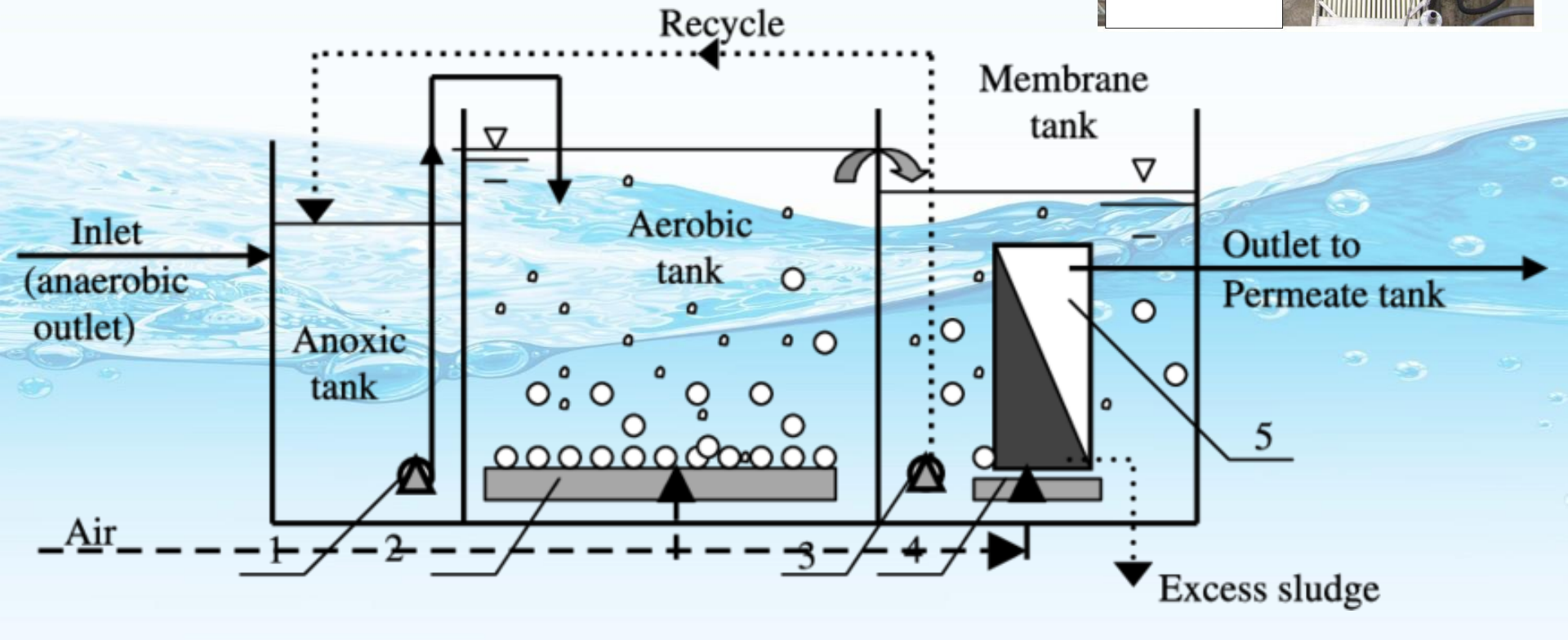

**Fiber structure**

1) Two outer layers provide extra barrier in case of damage to outermost layer
2) Three layered structure provide added fiber strength

**Fiber properties**

1) PVDF membranes
2) Hydrophilic
3) High chlorine tolerance
4) High tensile strength

# Submerged Module Installation

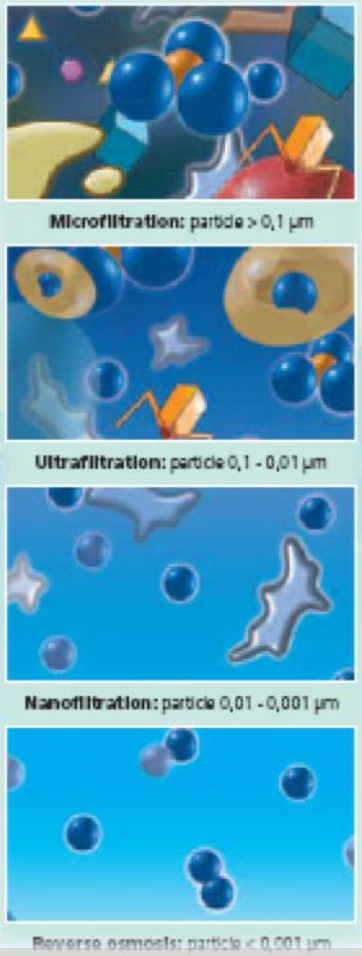



# Treated Water Comparison

# MBR - Advantages

Superior Treated Water Quality

- Safe rejection of Bio Mass
- Enhanced Standard of Hygiene through barrier filtration
- Consistent BOD levels of 3-7 ppm
- Ultra filtered water free of pathogens.
- Sludge Density Index (SDI) < 3 achieved consistently



# MBR - Advantages

Process Superiority

Can tolerate larger input variations

Aeration tank MLSS levels

8000 - 10000 ppm

Sludge can be wasted directly to sludge handling equipments.

Reduction in aeration tank size

Aeration system can handle higher loads

# MBR - Advantages

- Low SDI in treated water
- Modular units facilitate easy plant expansion
- Eliminates filters – No Back wash waste.
- Removes difficult pre treatment for downstream Recycle systems
- Disinfection only based on specific requirement

# Comparison on Treated water quality

| PARAMETERS | ASP | FBR | SBR | MBR |
|---|---|---|---|---|
| **BOD (mg/L)** | < 10 | < 10 | < 10 | < 5 |
| **TSS (mg/L)** | <30 | <20 | <10 | <5 |
| **COD (mg/L)** | <100 | <50 | <60 | <20 |
| **Turbidity (NTU)** | <2 | <2 | <2 | <2 |

# Comparison on Technologies

| ITEMS | ASP | FBR | SBR | MBR |
|---|---|---|---|---|
| **Bar screen chamber** | Required | Required | Required | Required |
| **Oil & Grease trap** | Required | Required | Required | Required |
| **Equalization tank** | Required | Required | Required | Required |
| **Anoxic tank** | Required | Not Required | Not Required | Required |
| **Aeration tank** | Required | Required | Required | Required |
| **Settling tank** | Required | Not Required | Not Required | Not Required |
| **Pre- Filtration tank** | Required | Required | Required | Not Required |
| **Sludge Holding tank** | Required | Required | Required | Required |
| **Plant room** | Required | Required | Required | Required |

# Functional Performance Attributes of Various Treatment

| ATTRIBUTES | ASP | FBR | SBR | MBR |
|---|---|---|---|---|
| **Reliability of technology** | Good | Good | Good | Good |
| **Quality of treated water** | Good | Excellent | Excellent | High Quality |
| **Process Kinetics** | Well established | Well established | Well established | Well established |
| **Space Required** | | | | |
| **Efficiency** | Better | Excellent | Excellent | Excellent |
| **Sophistication of Operation** | Nil | Partial | Partial | High |
| **Man power required to operate the plant** | No specific skill required | No specific skill required | No specific skill required | High level skill required |

# Quality of Water required for HVAC

| TEST ITEM | MAKE UP WATER | CONDENSOR WATER | CHILLED WATER |
|---|---|---|---|
| | | | |
| Ph | 6.0 - 8.0 | 7.2 - 8.5 | 7.2 - 8.5 |
| | | | |
| TOTAL HARDNESS | MAX 50 | LESS THEN 200 | MAX 80 |
| (CACO3) ppm | | | |
| | | | |
| TOTAL ALKANITY | LESS THEN 80 | LESS THEN 100 | LESS THEN 100 |
| (CACO3) ppm | | | |
| | | | |
| CHLORIDE ION (ppm) | LESS THEN 50 | LESS THEN 200 | LESS THEN 50 |
| | | | |
| TOTAL ION(FE) (ppm) | LESS THEN 0.3 | LESS THEN 1.0 | LESS THEN 0.3 |
| | | | |
| SILICA (SiO2)(ppm) | LESS THEN 30 | LESS THEN 50 | LESS THEN 30 |
| | | | |
| TDS(ppm) | MAX.250 | MAX.1500 | MAX 1200 |
| | | | |

# THANK YOU

ANY QUESTIONS?

Compiled by Technical Committee - IPA

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