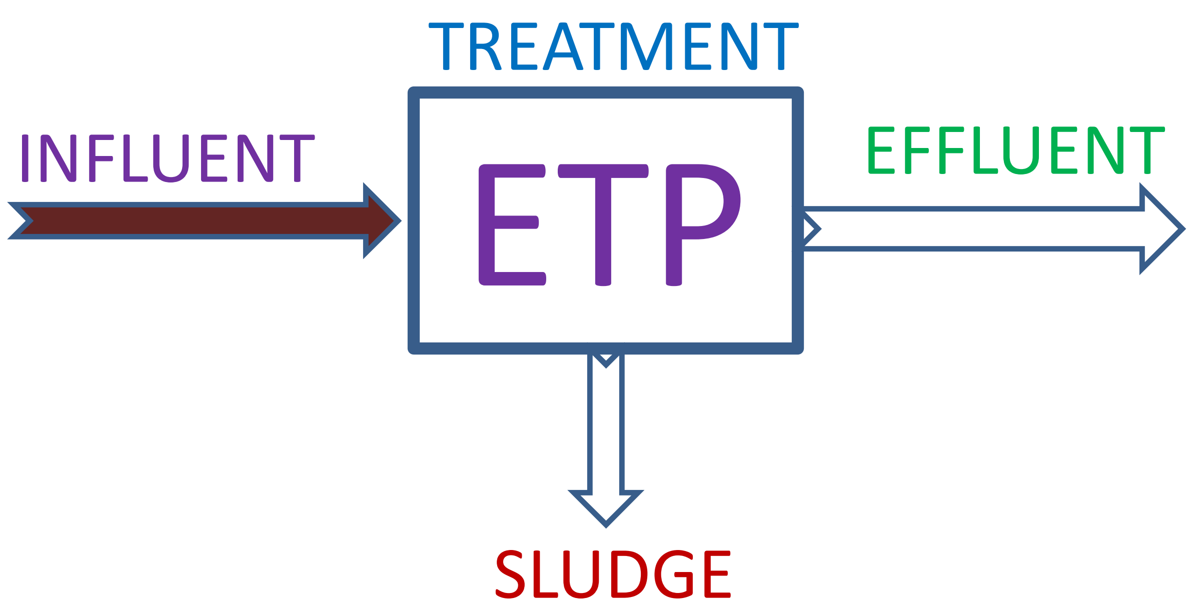
What is an ETP?

- **ETP (E**ffluent **T**reatment **P**lant) is a process design for treating the industrial waste water for its reuse or safe disposal to the environment.
- **Influent: Untreated** industrial waste water.
- **Effluent: Treated** industrial waste water.
- **Sludge: Solid part** separated from waste water by ETP.



Need of ETP

- To **clean industry effluent** and recycle it for further use.
- To **reduce the usage of fresh/potable** water in Industries.
- To **cut expenditure** on water procurement.
- To **meet the Standards** for emission or discharge of environmental pollutants from various Industries set by the Government and **avoid hefty penalties**.
- To **safeguard environment** against pollution and contribute in sustainable development.

Design of ETP

The design and size of the ETP depends upon:

- Quantity and quality of the industries discharge effluent.

- Land availability.

- Monetary considerations for construction, operation & maintenance.

- **Area dimension depends on:**
  - Quality of wastewater to be treated,
  - Flow rate
  - Type of biological treatment to be used .

- **In case of less available land,** CETP (Common Effluent Treatment Plant) is preferred over ETP

Treatment Levels & Mechanisms of ETP

- **Treatment levels:**
  - Preliminary
  - Primary
  - Secondary
  - Tertiary (or advanced)

- **Treatment mechanisms:**
  - Physical
  - Chemical
  - Biological

Preliminary Treatment level

Purpose: Physical separation of big sized impurities like cloth, plastics, wood logs, paper, etc.

Common physical unit operations at Preliminary level are:

- **Screening:** A screen with openings of uniform size is used to remove large solids such as plastics, cloth etc. Generally maximum 10mm is used.
- **Sedimentation:** Physical water treatment process using gravity to remove suspended solids from water.
- **Clarification:** Used for separation of solids from fluids.

Primary Treatment Level

Purpose: Removal of floating and settleable materials such as suspended solids and organic matter.

- **Methods:** Both physical and chemical methods are used in this treatment level.

- **Chemical unit processes:**

➢ Chemical unit processes are always used with physical operations and may also be used with biological treatment processes.

➢ Chemical processes use the addition of chemicals to the wastewater to bring about changes in its quality.

➢ Example: pH control, coagulation, chemical precipitation and oxidation.

Primary Treatment Level (cont…)

pH Control:

- To adjust the pH in the treatment process to make wastewater pH neutral.
- **For acidic wastes** (low pH): $NaOH$, Na_2CO_3, $CaCO_3$or $Ca(OH)_2$.
- **For alkali wastes** (high pH): H_2SO_4, HCl.

Chemical coagulation and Flocculation:

- Coagulation refers to collecting the minute solid particles dispersed in a liquid into a larger mass.

- Chemical coagulants like **$Al_2(SO4)_3$ {also called alum} or $Fe_2(SO4)_3$** are added to wastewater to improve the attraction among fine particles so that they come together and form larger particles called flocs.

- A chem**ical flocculent** (usually a **polyelectrolyte**) enhances the flocculation process by bringing together particles to form larger flocs , which settle out more quickly.

- Flocculation is aided by **gentle mixing** which causes the **particles to collide**.

Secondary Treatment Level

Methods: Biological and chemical processes are involved in this level.

Biological unit process

- **To remove, or reduce the concentration of organic and inorganic compounds**.
- Biological treatment process can take many forms but all are based around microorganisms, mainly bacteria**.**

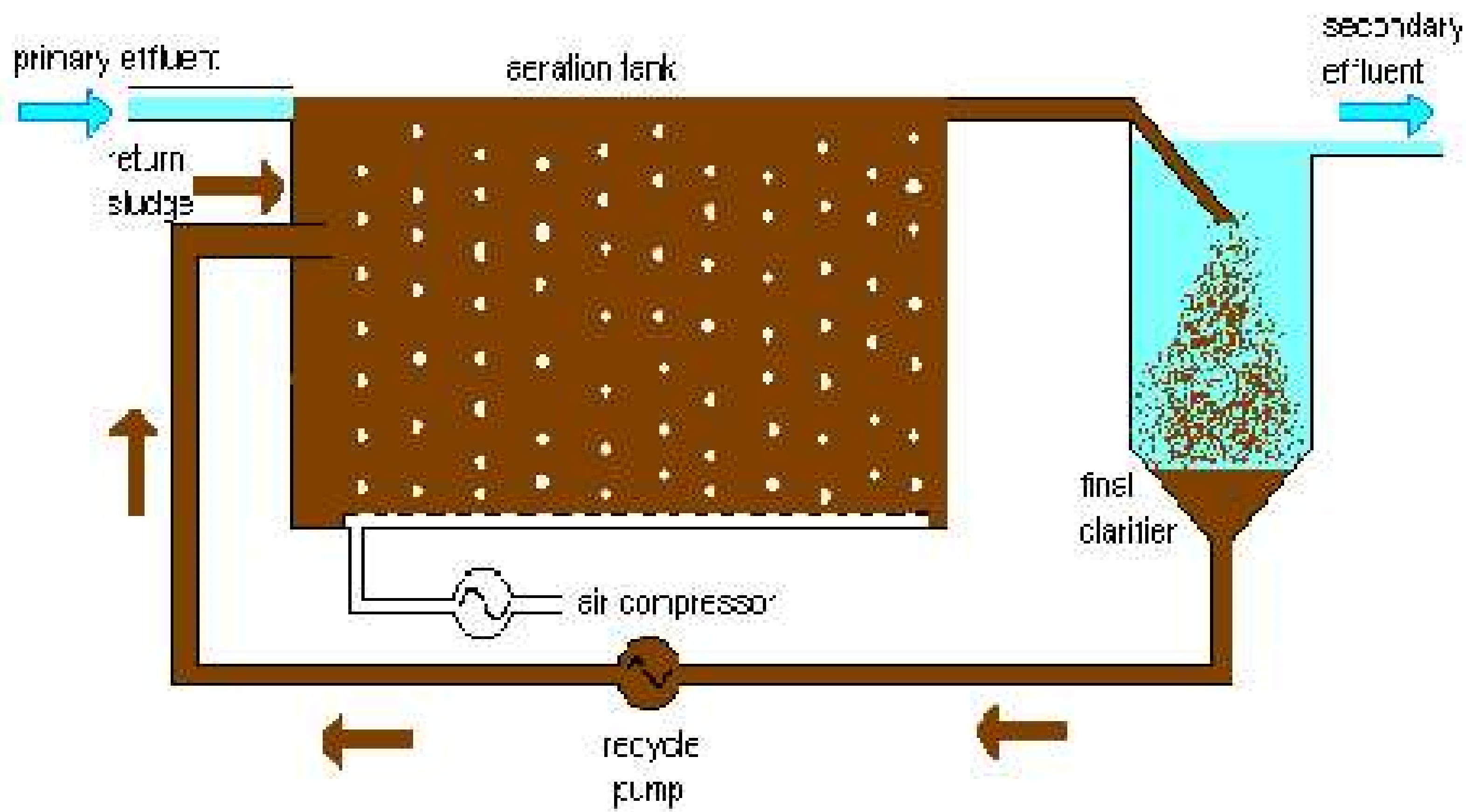
Aerobic Processes

- Aerobic treatment processes take place in the presence of air (oxygen).
- Utilizes those microorganisms (aerobes), which use molecular/free oxygen to assimilate organic impurities i.e. convert them in to **carbon dioxide, water and biomass.**

Anaerobic Processes

- The anaerobic treatment processes take place in the **absence of air (oxygen).**
- Utilizes microorganisms (anaerobes) which do not require air (molecular/free oxygen) to assimilate organic impurities.
- The final products are **methane and biomass.**

Activated sludge process



Tertiary / Advanced Treatment

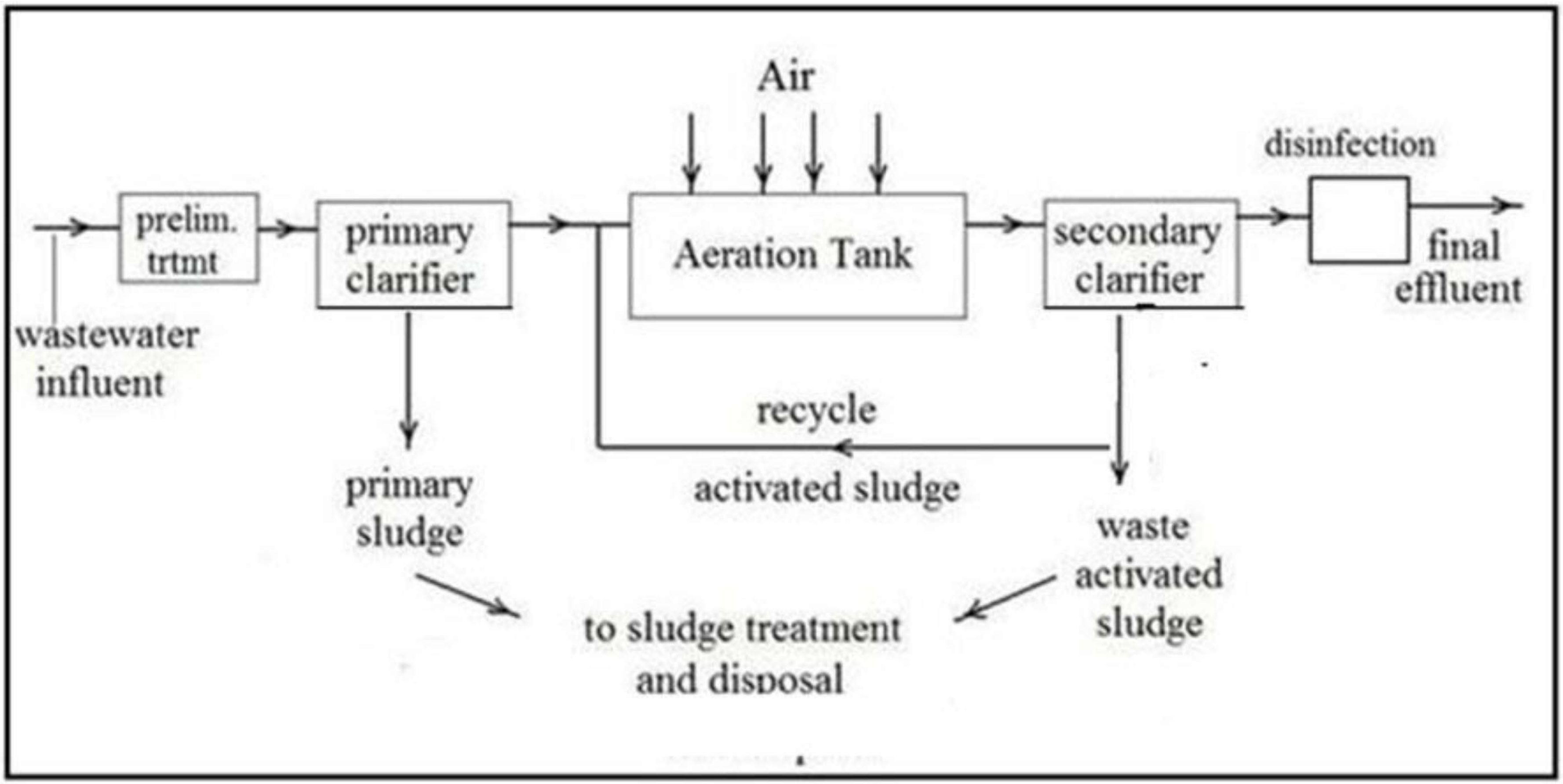
Purpose: Final cleaning process that improves wastewater quality before it is reused, recycled or discharged to the environment.

Mechanism: Removes remaining inorganic compounds, and substances, such as the nitrogen and phosphorus. Bacteria, viruses and parasites, which are harmful to public health, are also removed at this stage.

Methods:

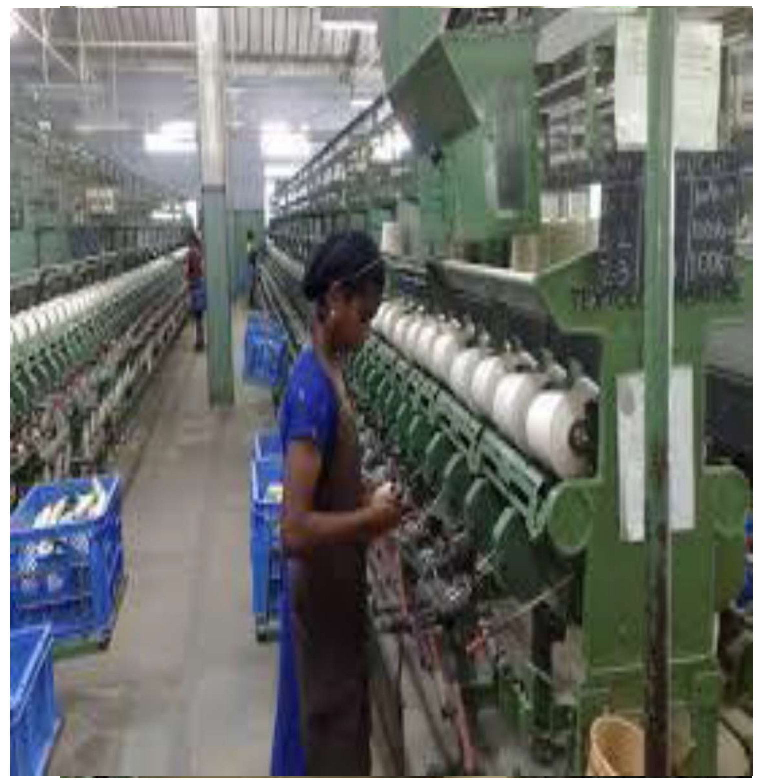
- **Alum:** Used to help remove additional phosphorus particles and group the remaining solids together for easy removal in the filters.
- **Chlorine** contact tank disinfects the tertiary treated wastewater by removing microorganisms in treated wastewater including bacteria, viruses and parasites.
- **Remaining chlorine** is removed by adding sodium bisulphate just before it's discharged.

Flow chart for ETP



Case Study

ETP Process Design for a typical Textile factory

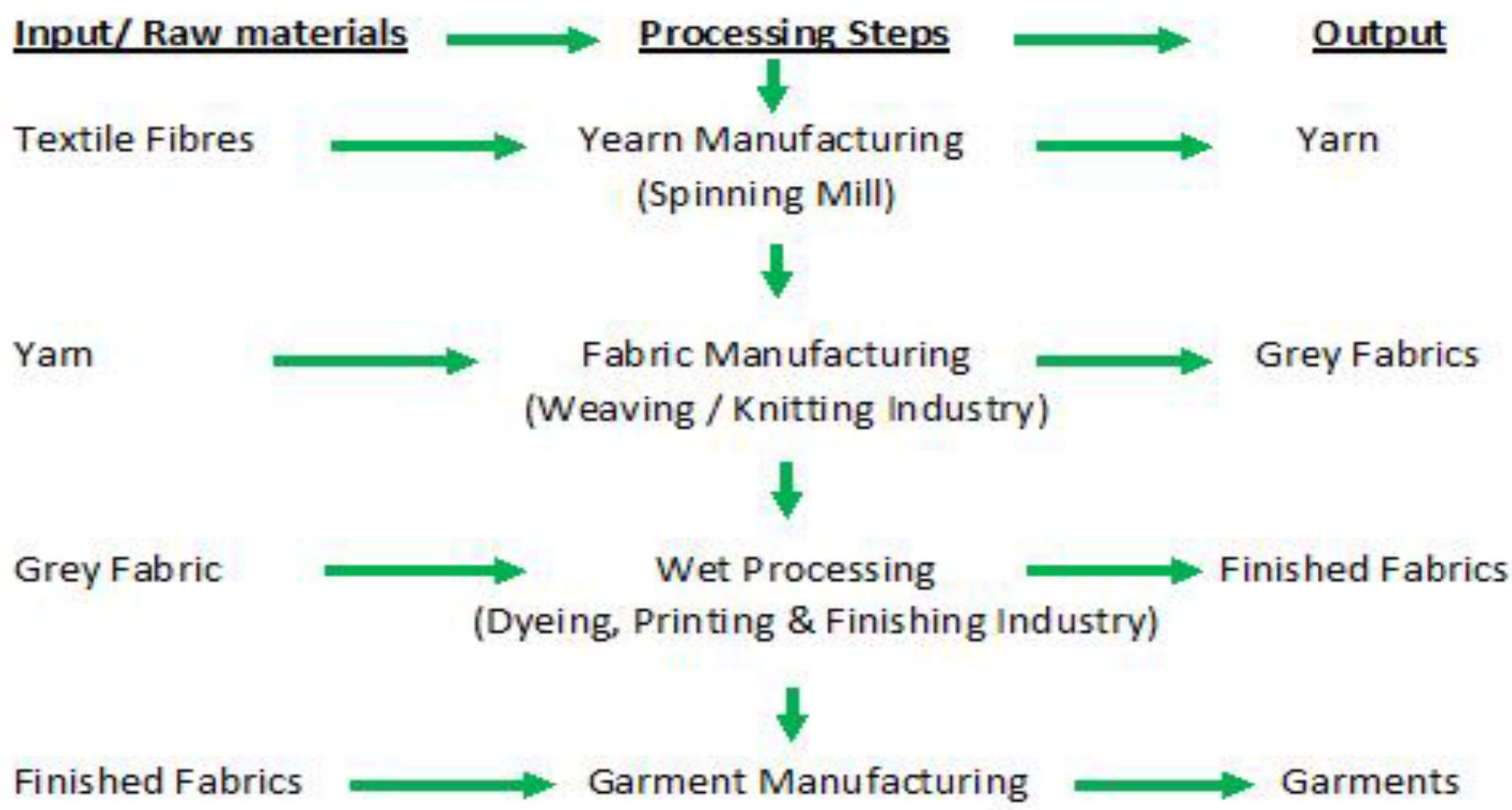


Textile industry Share

Country	Value in ($ billion)	Share (%)
China	94.4	32.1
EU27	76.6	26.1
India	15.0	5.1
United States of America	13.8	4.7
Korea Republic	12.4	4.2
Turkey	10.8	3.7
Pakistan	9.1	3.1
Indonesia	4.8	1.6
Vietnam	3.8	1.3
Bangladesh	1.6	0.5
Rest of the World	51.7	17.5
Total	294	99.9

Source: Ghaly A. E, Ananthashankar R., Alhattab M., and Ramakrishnan V. V., Production, Characterization and Treatment of Textile Effluents: A Critical Review, J Chem Eng Process Technol 2014, 5:1, http://dx.doi.org/10.4172/2157-7048.1000182

Textile production flow diagram



Water consumption in textile industries

Fabric	Water consumption (kg/kg)
Cotton	250-350
Wool	200-300
Nylon	125-150
Rayon	125-150
Polyester	100-200
Acrylic	100-200

Process	Water consumption (%)
Bleaching, finishing	38
Dyeing	16
Printing	8
Boiler house	14
Humidification (Spinning)	6
Humidification (weaving)	9
Sanitary, Domestic	9

Emission and waste generation from textile industry

Process	Emission	Wastewater	Solid Wastes
Fibre preparation	Little or none	Little or none	Fibre waste and packaging waste
Yarn spinning	Little or none	Little or none	Packaging wastes, sized yarn, fibre waste, cleaning and processing waste
Slashing/sizing	VOCs	BOD, COD, metals, cleaning waste, size	Fibre lint, yarn waste, packaging waste, unused starch-based sizes
Weaving	Little or none	Little or none	Packaging waste yarn and fabric scraps, off - spec fabric, used oil
Knitting	Little or none	Little or none	Packaging waste, yarn, fabric scraps.
Tufting	Little or none	Little or none	Packaging waste, yarn, fabric scraps, off-spec fabric
Desizing	VOCs from glycol esters	BOD from sizes lubricants, biocides, anti-static compounds	Packaging waste, fibre lint, yarn waste, cleaning and maintenance materials
Scouring	VOCs from glycol ester and scouring solvents	Disinfectants, insecticide recisues, NaOH,detergents oils, knitting lubricants, spin finishes,spent solvents	Little or none
Bleaching	Little or none	H_2O_2, stabilizers, high pH	Little or none
Singeing	Small amount of exhaust gases from the burners exhausted with components	Little or none	Little or none
Mercerising	Little or none	High pH, NaOH	Little or none
Heat setting	Volatilisation of spin finish agents-synthetic fibre manufacture	Little or none	Little or none
Dyeing	VOCs	Metals, salt, surfactants, organic processing assistants, cationic materials, colour, BOD, COD, sulphide, acidity/alkalinity, spent solvents	Little or none
Printing	Solvents, acetic acid- drying and curing oven emission combustion gases	Suspended solids, urea, solvents, colour, metals, heat, BOD, foam	Little or none
Finishing	VOCs, contaminants in purchased chemicals, formaldehyde vapours, combustion gases	COD, suspended solids, toxic materials, spent solvents	Fabric scraps and trimmings, packaging waste

Effluent characteristics from typical textile industry

Process	Composition	Nature
Sizing	Starch, waxes, carboxymethyl cellulose, polyvinyl alcohol.	High in BOD & COD
Desizing	Starch, waxes, carboxymethyl cellulose, polyvinyl alcohol.	High in BOD, COD, suspended solids, dissolved solids.
Scouring	Caustic soda, waxes, grease, soda ash, sodium silicate, fibres, sulfactants, sodium phosphate.	Dark colored, High pH, COD, dissolved solids.
Bleaching	Hypochlorite,Caustic soda, sodium silicate, hydrogen peroxide, sulfactants, sodium phosphate.	Alkaline suspended solids.
Mercerizing	Caustic soda.	High pH, low COD, high dissolved solids.
Dyeing	Various dyes, mordants, reducing agents, acetiv acid soap	Strongly colored, High COD, dissolved solids, low SS
Printing	Pastes, starch, gums, oil, mordants, acids, soaps.	Highly-colored, High COD, oily appearance, SS
finishing	Inorganic salts.	Slightly Alkaline, low BOD.

Waste water characteristics: Process-wise

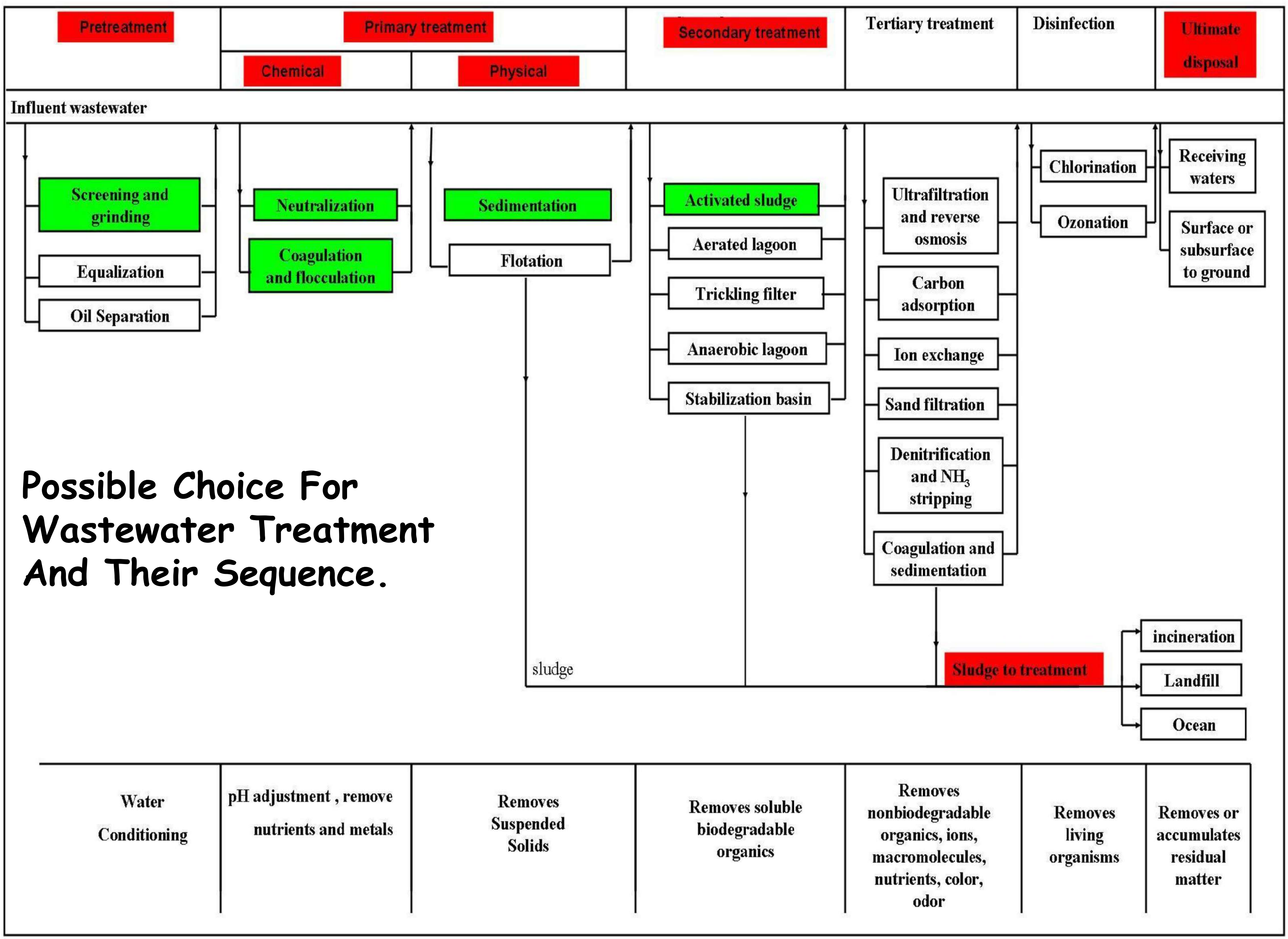
Source of effluent generation	Parameters		
	pH	COD (mg/L)	BOD (mg/L)
Process Effluent			
Desizing	5.83-6.50	10000-15000	1700-5200
Scouring	10-13	1200-3300	260-400
Bleaching	8.5-9.6	150-500	50-100
Mercerizing	8-10	100-200	20-50
Dyeing	7-10	1000-3000	400-1200
Wash Effluent			
After beaching	8-9	50-100	10-20
After acid rinsing	6.5-7.6	120-250	25-50
After dyeing (hot wash)	7.5-8.5	300-500	100-200
After dyeing (acid & soap wash)	7.5-8.64	50-100	25-50
After dyeing (final wash)	7-7.8	25-50	
Printing washing	8-9	250-450	115-150
Blanket washing of rotary printer	7-8	100-150	25-50

Important Characteristics of Wastewater from Textile Industry

Parameter	Range
pH	6-10
Temperature (°C)	35-45
Total dissolved solids (mg/L)	8,000-12,000
BOD (mg/L)	80-6,000
COD (mg/L)	150-12,000
Total suspended solids (mg/L)	15-8,000
Total Dissolved Solids (mg/L)	2,900-3,100
Chlorine (mg/L)	1,000-6,000
Free chlorine (mg/L)	<10
Sodium (mg/L)	70%
Trace elements (mg/L)	
Fe	<10
Zn	<10
Cu	<10
As	<10
Ni	<10
B	<10
F	<10
Mn	<10
V	<10
Hg	<10
PO_4	<10
Cn	<10
Oil & grease (mg/L)	10-30
TNK (mg/L)	10-30
NO_3-N (mg/L)	<5
Free ammonia (mg/L)	<10
SO_4 (mg/L)	600-1000
Silica (mg/L)	<15
Total Kjeldahl Nitrogen (mg/L)	70-80
Color (Pt-Co)	50-2,500

Human carcinogenic compund

Aromatic Amine Group	Human Carcinogenic Evidences
1-Napthylamine	Slight/Mixed
2-Napthylamine	Good
2,5-Diaminotoluene	Slight
3,3'-Dichlorobenzidine	Slight/Mixed
3,3'-Dimethoxybenzidine	Slight/Mixed
3,3'-Dimethylbenzidine	Slight
4-Biphenylamine	Good
4-Nitrobiphenyl	Slight/Mixed
4,4'-Methylenebis (2-chloroaniline)	Slight
Auramine	Slight
Benzidine	Good
Magenta	Slight
N-Phenyl-2-napthylamine	Slight
N,N-Bis(2-chloroethyl)-napthylamine	Good


Pretreatment
Primary treatment
Chemical
Physical
Secondary treatment
Tertiary treatment
Disinfection
Ultimate disposal
Influent wastewater
Screening and grinding
Equalization
Oil Separation
Neutralization
Coagulation and flocculation
Sedimentation
Flotation
Activated sludge
Aerated lagoon
Trickling filter
Anaerobic lagoon
Stabilization basin
Ultrafiltration and reverse osmosis
Carbon adsorption
Ion exchange
Sand filtration
Denitrification and NH_3 stripping
Coagulation and sedimentation
Chlorination
Ozonation
Receiving waters
Surface or subsurface to ground
Possible Choice For Wastewater Treatment And Their Sequence.
sludge
Sludge to treatment
incineration
Landfill
Ocean
Water Conditioning
pH adjustment , remove nutrients and metals
Removes Suspended Solids
Removes soluble biodegradable organics
Removes nonbiodegradable organics, ions, macromolecules, nutrients, color, odor
Removes living organisms
Removes or accumulates residual matter

ETP Plant Operation

1. Screen chamber:

Remove relatively large solids to avoid abrasion of mechanical equipments and clogging of hydraulic system.

2. Collection tank:

The collection tank **collects the effluent water** from the screening chamber, stores and then pumps it to the equalization tank.

3. Equalization tank:

- The effluents do not have similar concentrations at all the time; the pH will vary time to time.
- Effluents are stored from **8 to 12 hours** in the equalization tank resulting in a homogenous mixing of effluents and helping in neutralization.
- It **eliminates shock loading** on the subsequent treatment system.
- Continuous mixing also **eliminates settling of solids** within the **equalization tank**.
- **Reduces SS, TSS.**

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ETP Plant Operation

4. Flash mixer:

Coagulants were added to the effluents:

1. **Lime:** **(800-1000 ppm)** To correct the **pH upto 8-9**
2. **Alum:** **(200-300 ppm)** To **remove colour**
3. **Poly electrolyte:** **(0.2 ppm**) To **settle the suspended matters & reduce SS, TSS.**

The addition of the above chemicals by efficient rapid mixing facilitates homogeneous combination of flocculates to produce microflocs.

5. Clarriflocculator:

In the clarriflocculator the water is circulated continuously by the **stirrer**.

- Overflowed water is taken out to the aeration tank.
- **The solid particles are settled down**, and collected separately and dried; this **reduces SS, TSS**.
- Flocculation provides **slow mixing** that leads to the **formation of macro flocs**, which then **settles out** in the clarifier zone.
- The settled solids i.e. primary sludge are pumped into sludge drying beds.

ETP Plant Operation

6. Aeration tank:

- The water is passed like a thin film over the different arrangements like staircase shape.
- **Dosing of Urea and DAP is done.**
- Water gets direct contact with the air to dissolve the oxygen into water.
- **BOD & COD values of water is reduced up to 90%.**

7. Clarifier:

- The clarifier **collects the biological sludge.**
- The overflowed water is called as treated effluent and disposed out.
- The outlet water quality is checked to be within the accepted limit as delineated in the **norms of the Bureau of Indian standards.**
- Through pipelines, the treated water is disposed into the environment river water, barren land, etc.

ETP Plant Operation

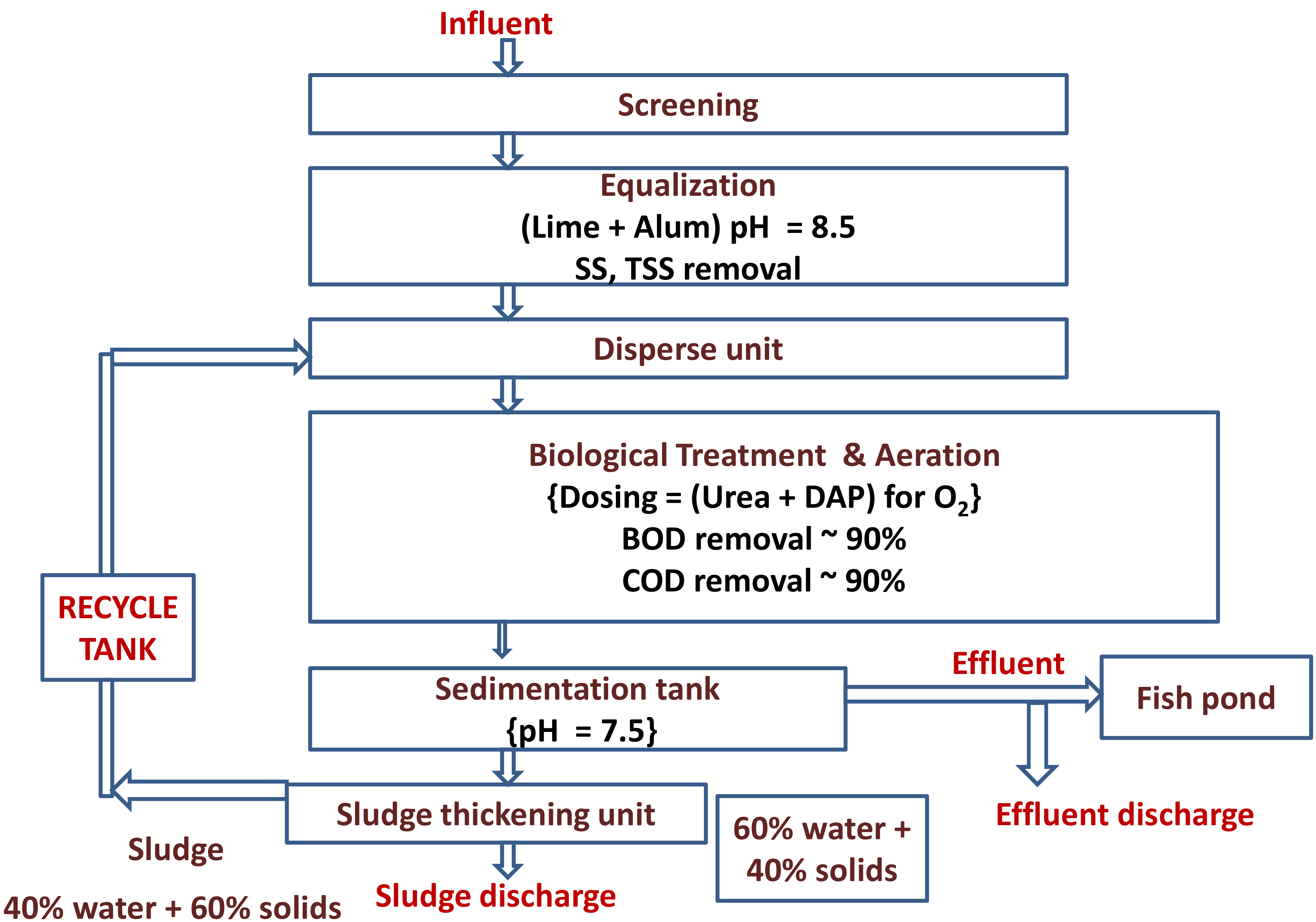
8. Sludge thickener:

- The inlet water consists of **60% water + 40% solids**.
- The effluent is passed through the centrifuge.
- Due to **centrifugal action**, the solids and liquids are separated.
- The sludge thickener reduces the water content in the effluent to **40% water + 60% solids.**
- The effluent is then reprocessed and the sludge collected at the bottom.

9. Drying beds:

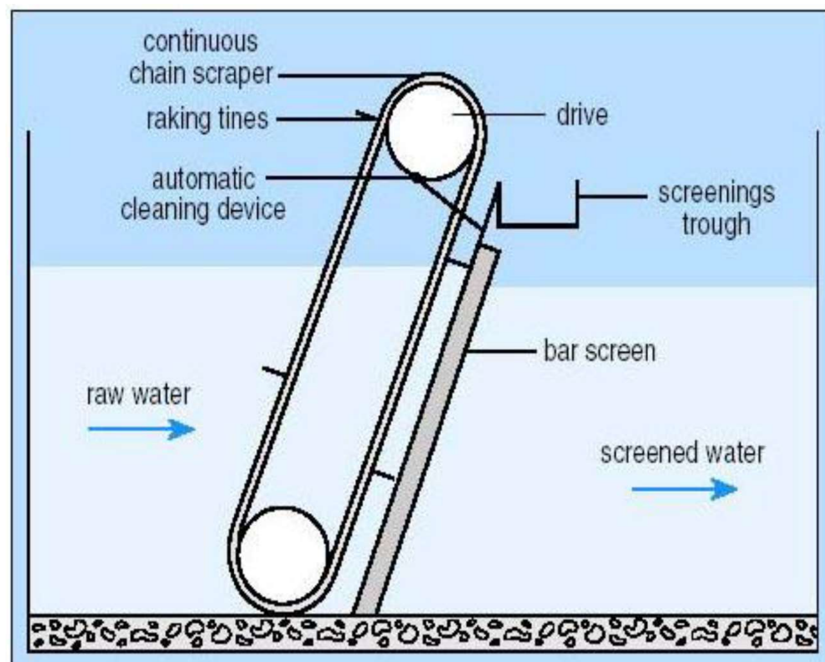
Primary and secondary sludge is dried on the drying beds.

FLOW CHART OF ETP



SCREENING

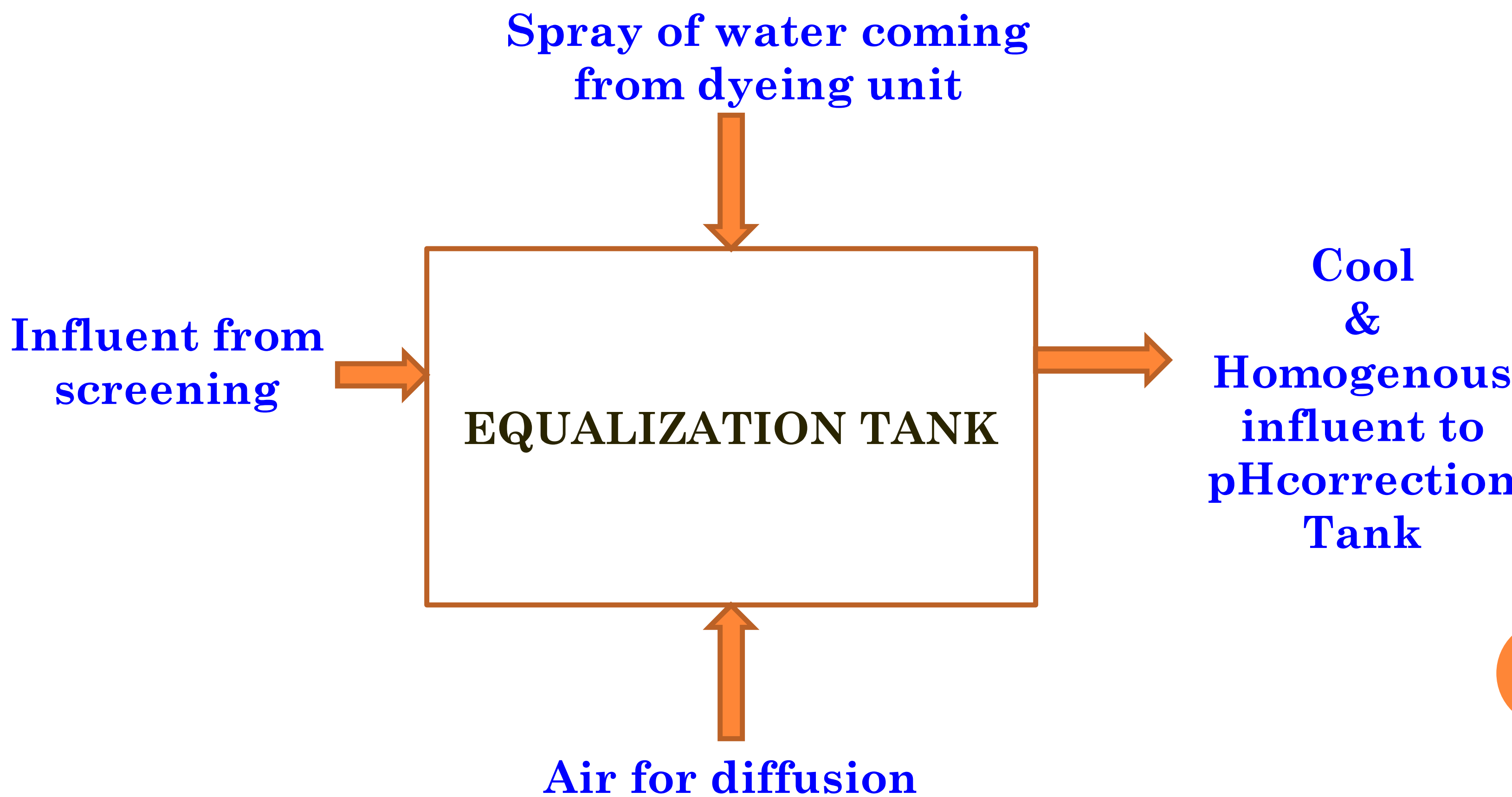
- Screening is the filtration process for the separation of coarse particles from influent.
- Stainless steel net with varying pore size can be utilized.
- Screens are cleaned regularly to avoid clogging.



EQUALIZATION TANK

- Equalization makes the waste water homogenous.

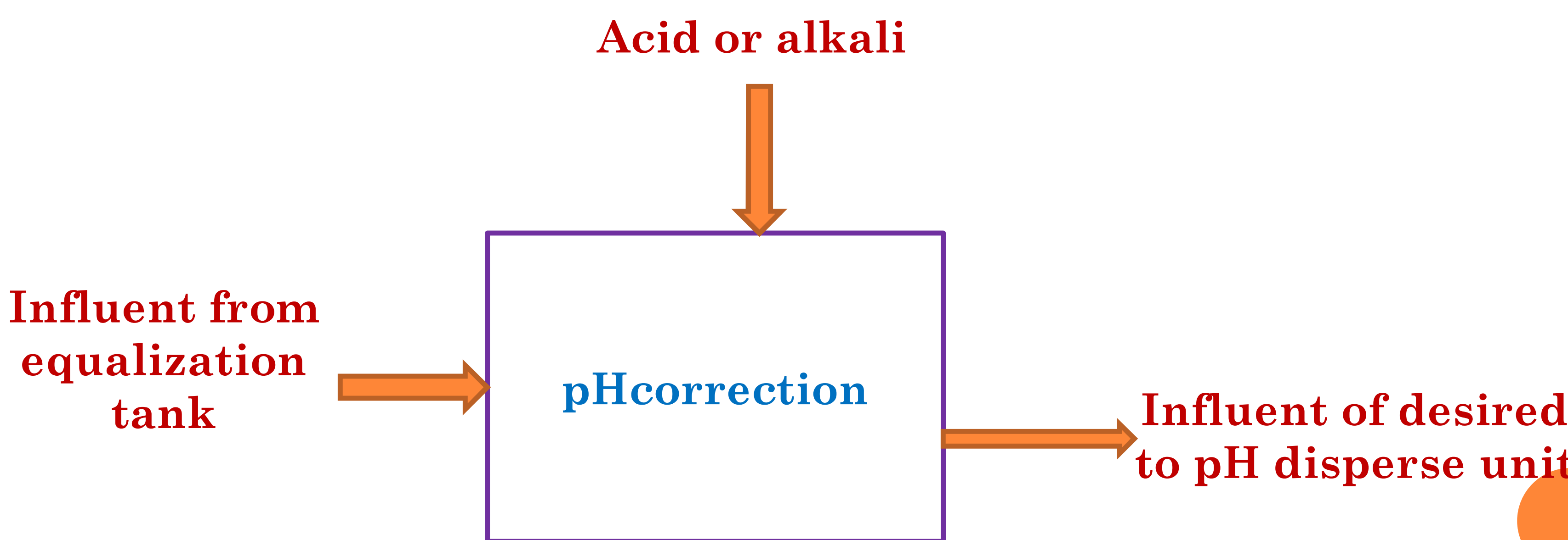
- Retention time depends upon the capacity of treatment plant. (Generally 8-16 hours)



pH Correction

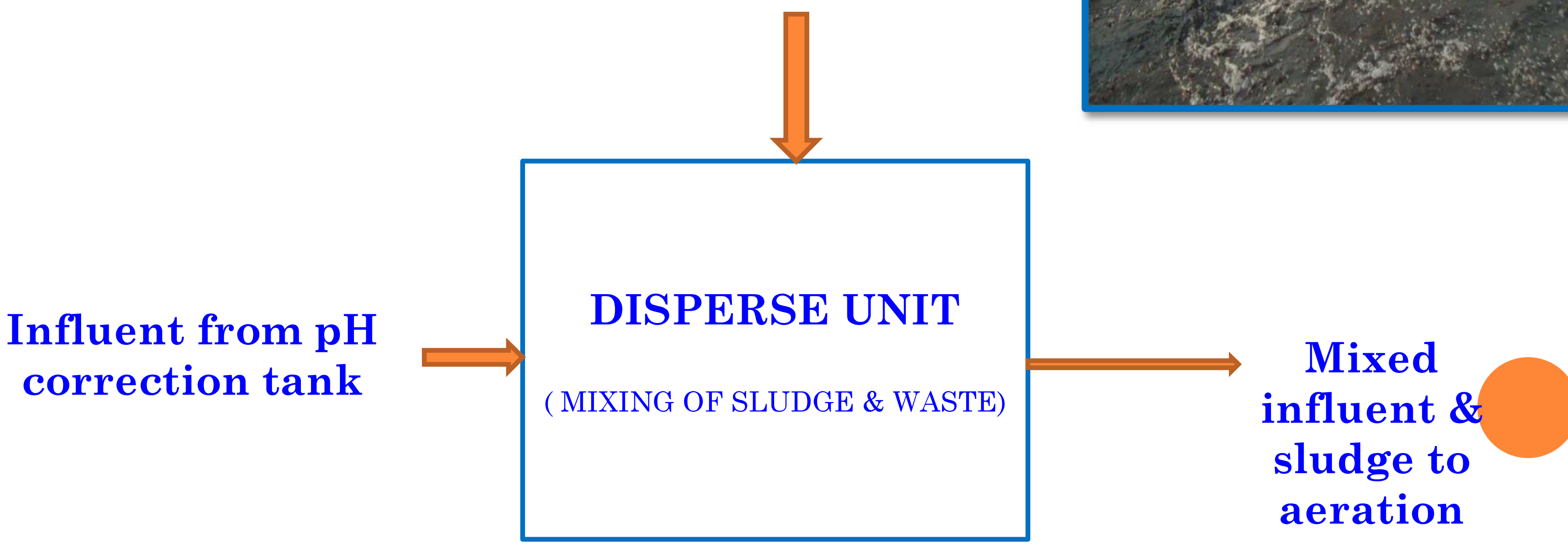
- In this tank pH of the influent is corrected to meet the standard.

- Acid or alkali is added to the effluent to increase or decrease the pH.



DISPERSE UNIT

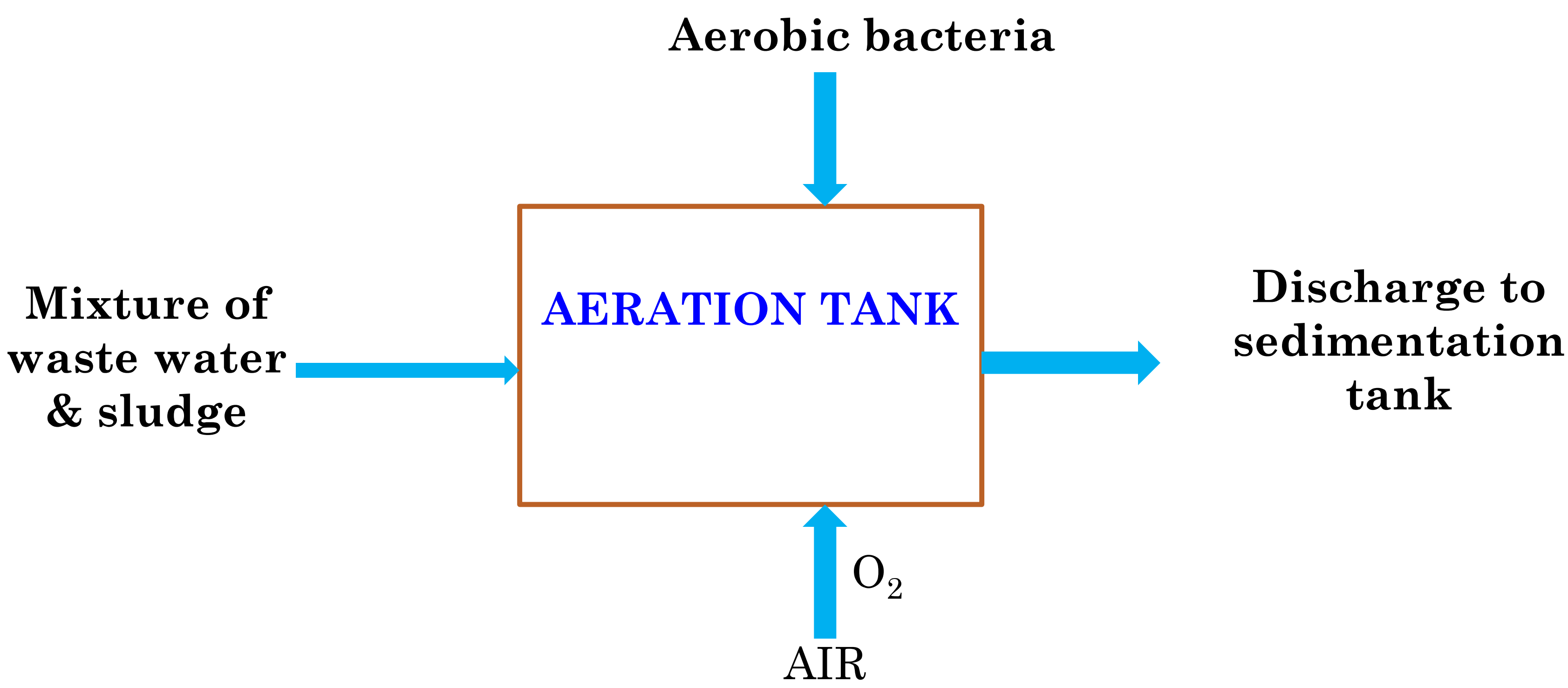
Disperse tank mixes the sludge coming from recycle tank with waste water for to proper aeration.



AERATION

- Function of aeration is oxidation by blowing air.
- Aerobic bacteria is used to stabilize and remove organic material presents in waste.

SCHEMTIC DIAGRAM OF AERATION



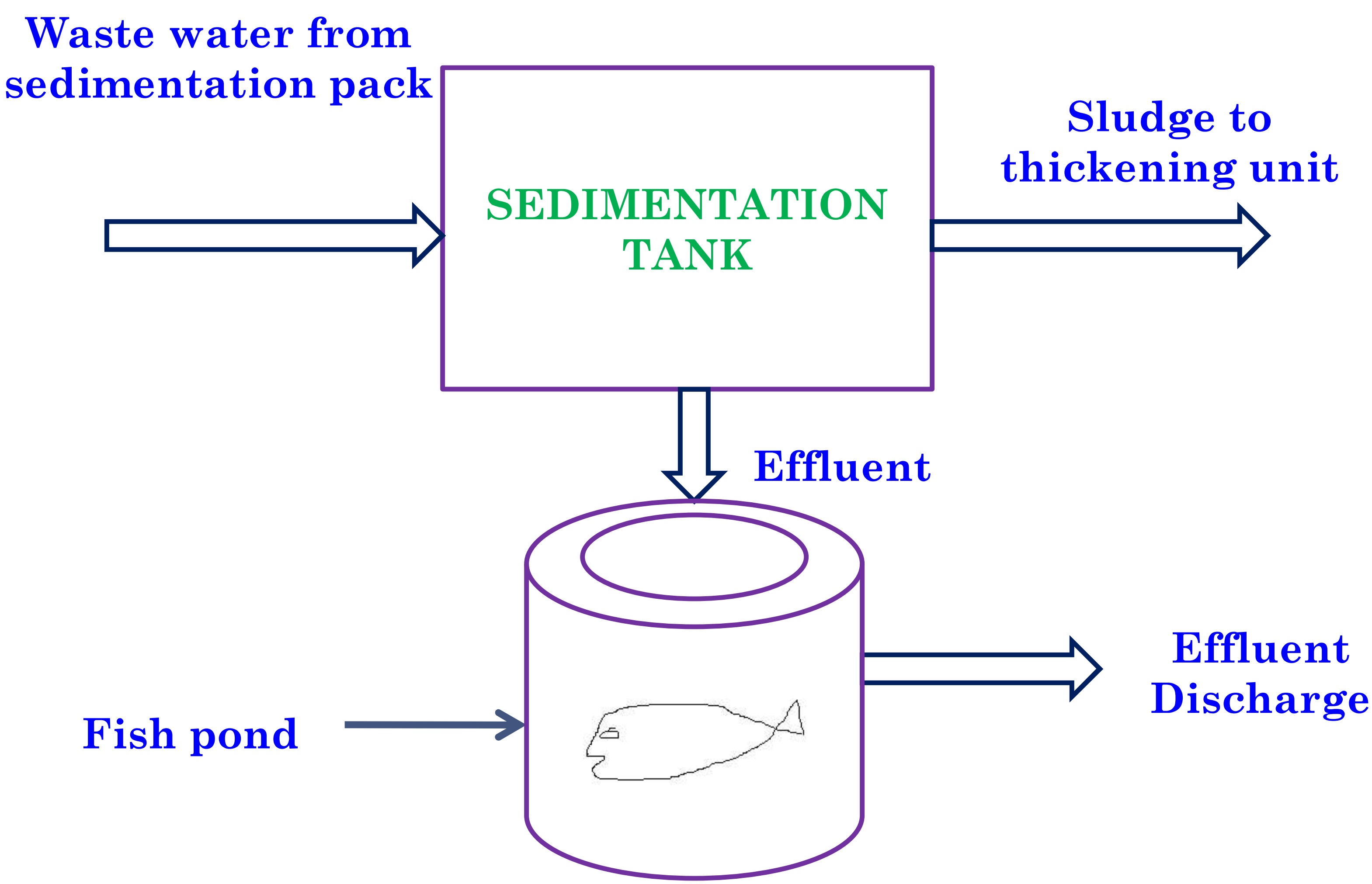
REACTION IN AERATION TANK:

$$\text{ORGANIC MATTER} + O_2 \xrightarrow[\text{NUTRIENT}]{\text{BACTERIA}} CO_2 + HO_2 + \text{HEAT}$$

SEDIMENTATION TANK

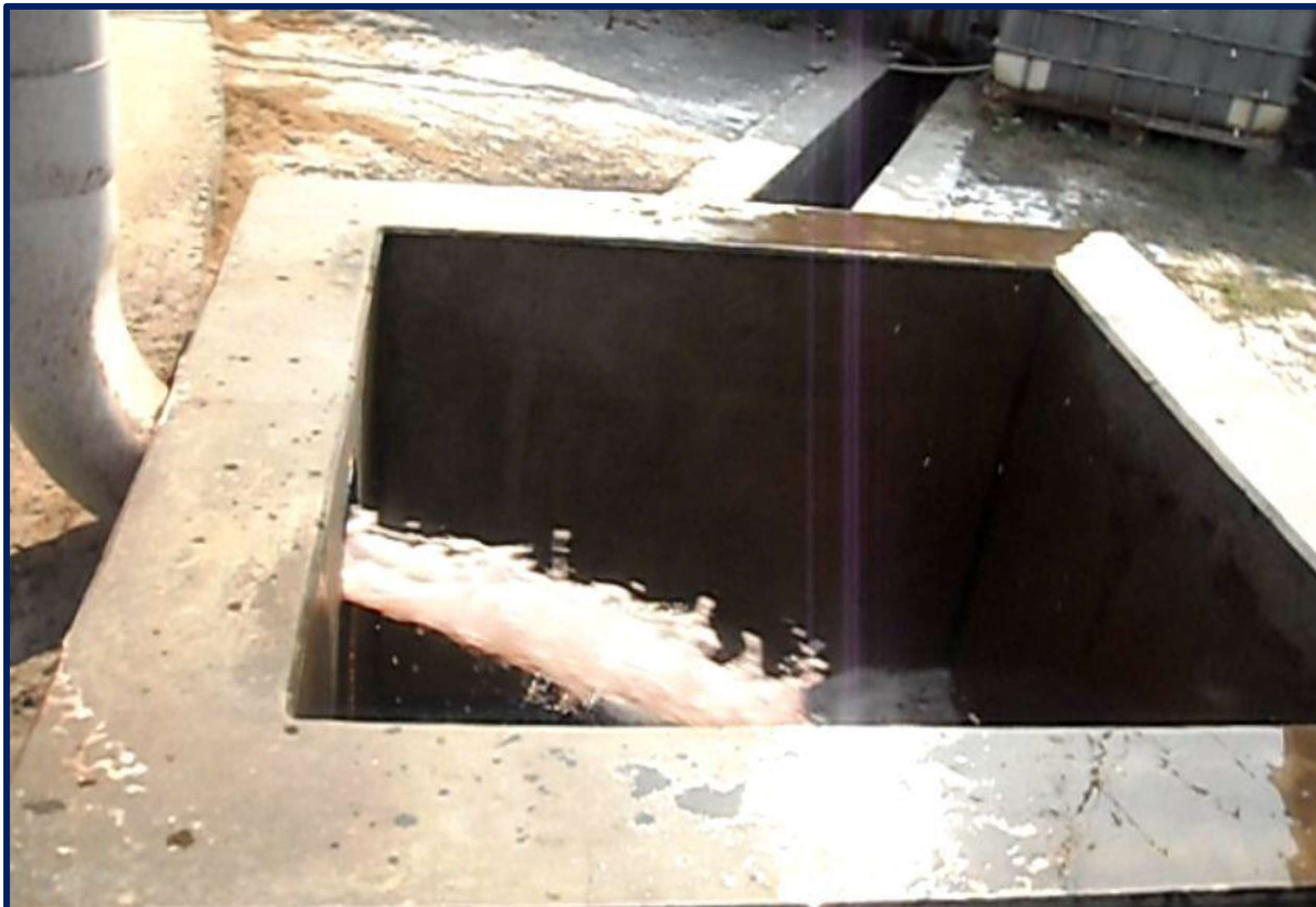
- In this tank sludge is settled down.
- Effluent is discharged from plant through a fish pond.
- Sludge is passed to the sludge thickening unit.

SCHEMTIC DIAGRAM OF SEDIMENTATION TANK



Fish Pond is used to see survival of fishes to ascertain fitness of water for disposal

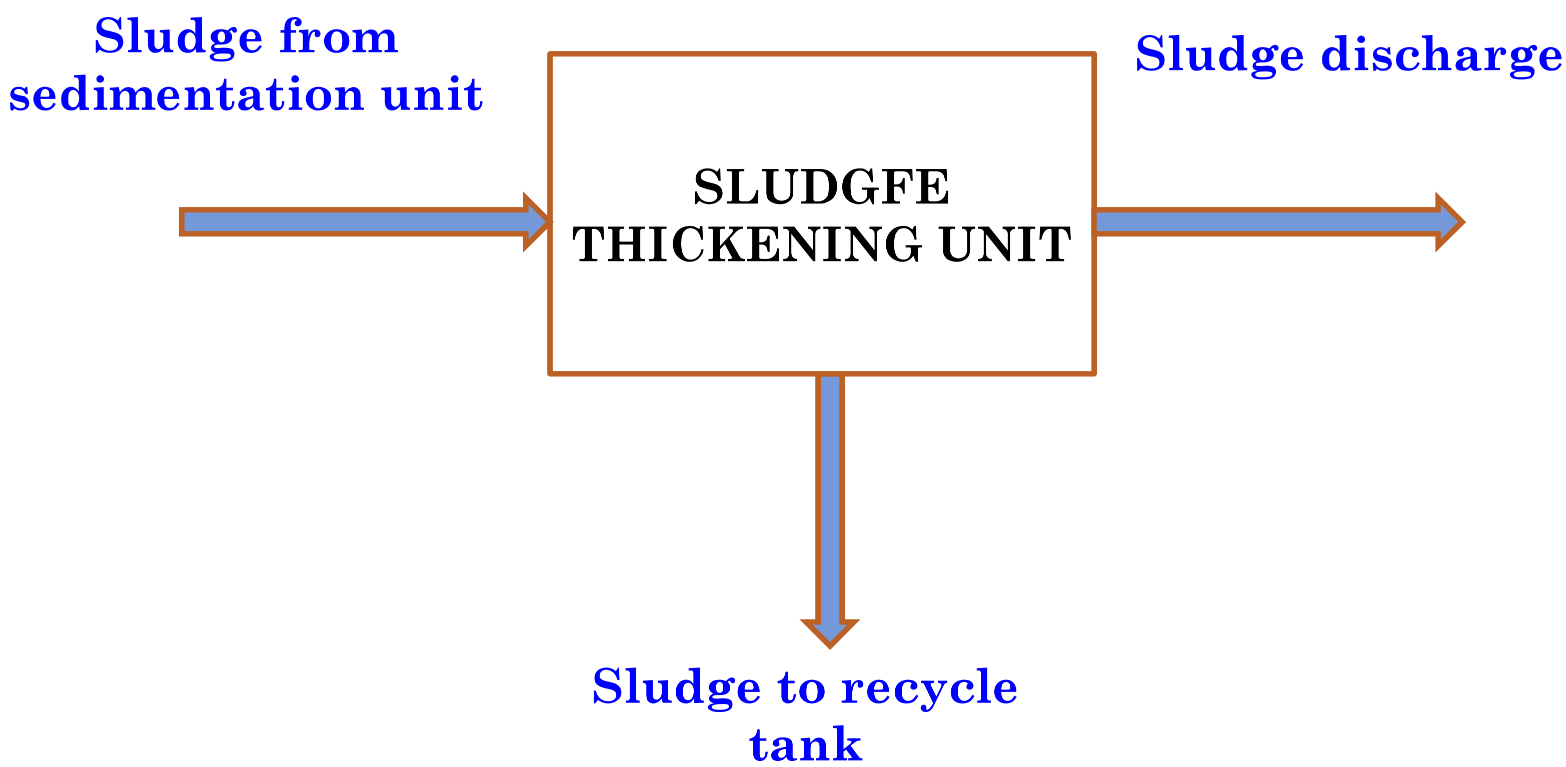
EFFLUENT DISCHARGE



SLUDGE THICKENING UNIT

- **Here sludge is dried and discharged.**
- **Partial amount of sludge is returned back to the aeration tank from thickening unit through recycle tank called return sludge tank and disperse tank.**

SCHEMTIC DIAGRAM OF SLUDGE THICKENING UNIT



DRIED SLUDGE

RETURN SLUDGE TANK

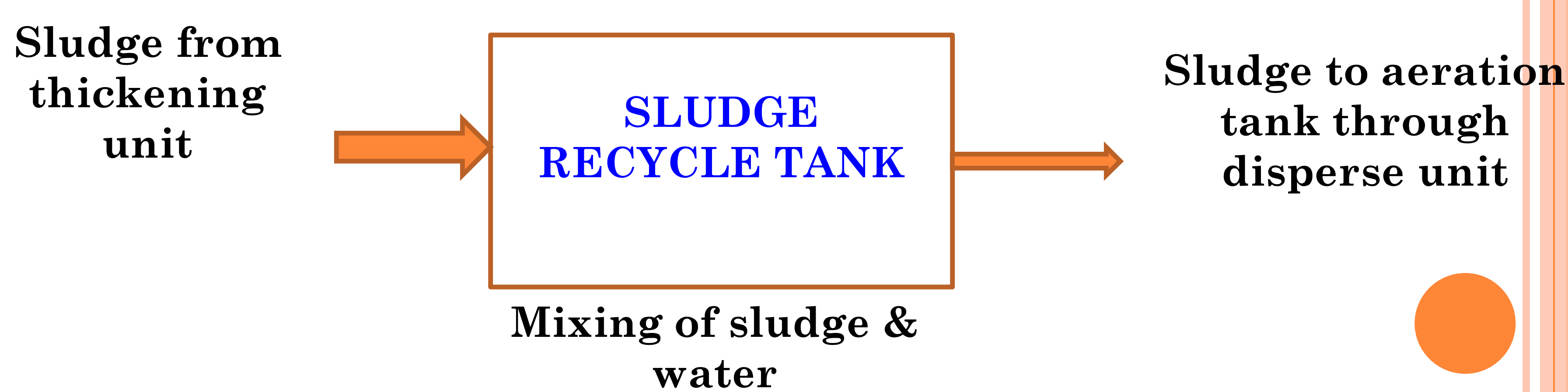
Function of return tank or recycle tank is to mix water with sludge

This mixture is then passed to aeration tank through disperse tank.

ADVANTAGE OF RECYCLE SLUDGE TO AERATION TANK

- Sludge again oxidized to minimize the pollution from sludge.

- Alive bacteria of sludge is again used in aeration to utilize this bacteria.



PERMISSIBLE STANDARDS IN INDIA

S.No.	Parameter	Permissible limits (disposal to inland surface water)
1	pH	5.5 to 9.0
2	TSS	<100 mg/l
3	Oil & Grease	<10 mg/l
4	BOD	<30 mg/l
5	COD	<250 mg/l


Thank You