Wastewater Treatment Options For The Food Processing Industry

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Food Processing Categories

- Fruit and Vegetable Industry
- Dairy Industry
- Meat Industry
- Speciality Foods Industry
- Brewery and Wine Industry

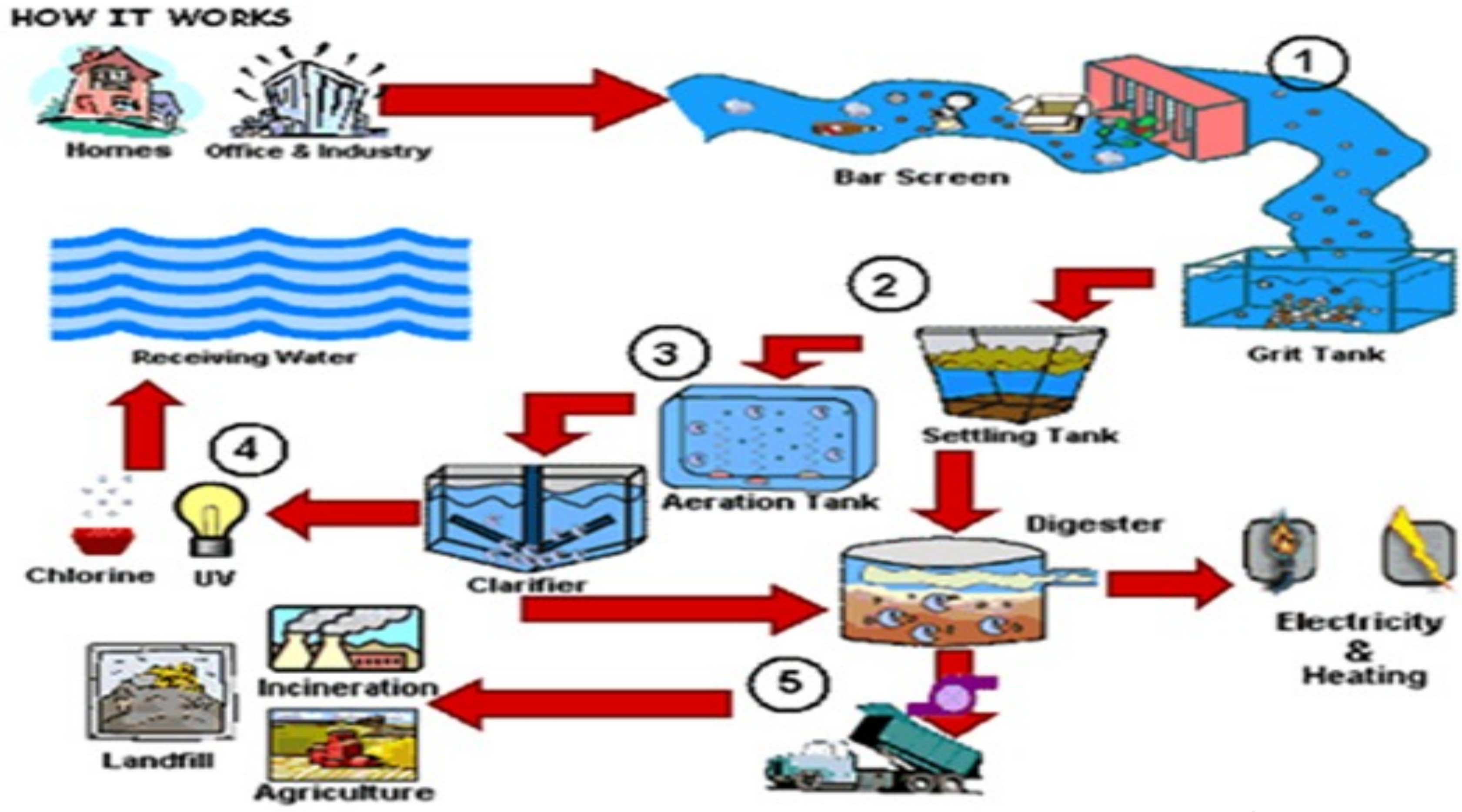
Chemical And Physical Parameters Of Concern

- Organics- Biochemical Oxygen Demand (BOD)
- Suspended Solids (SS)
- Fat, Oil and Grease (FOG)
- pH
- Nitrogen
- Phosphorus
- Temperature

Treatment Options

- Discharge directly to a municipal treatment plant
- Pretreatment and discharge to a municipal treatment plant
- Treatment plan on site
- Stream discharge or land application

Wastewater Treatment Plant Flow Diagram

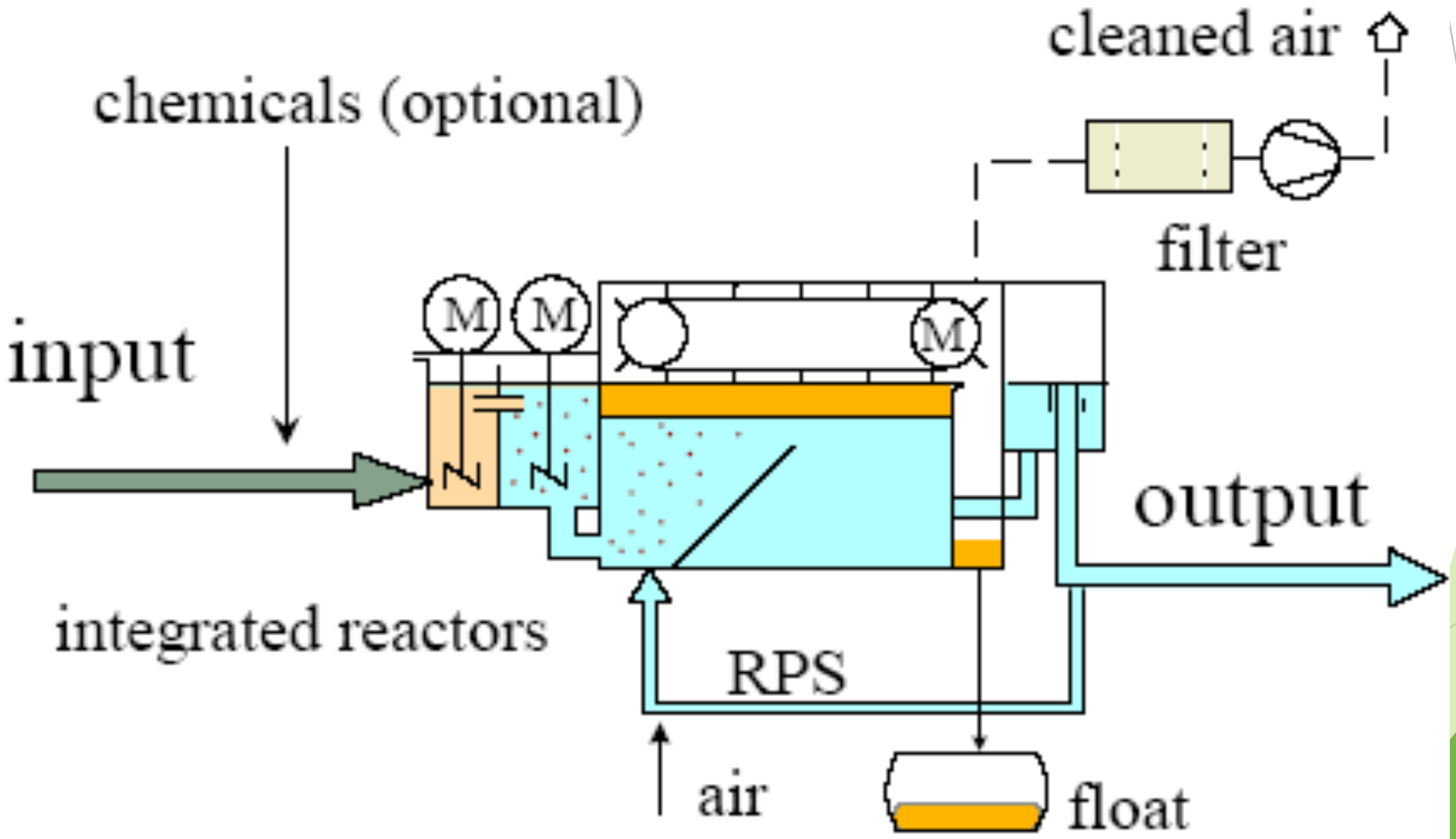


Picture Of Treatment Plant

Preliminary Treatment

- Flow Measurement -flow rate information needed for efficient operation, chemical addition, etc
- Flow Equalization – to cut down on flow variations for better treatment
- Screening – remove solids
- Dissolved Air Flotation – remove FOG

Dissolved Air Flotation

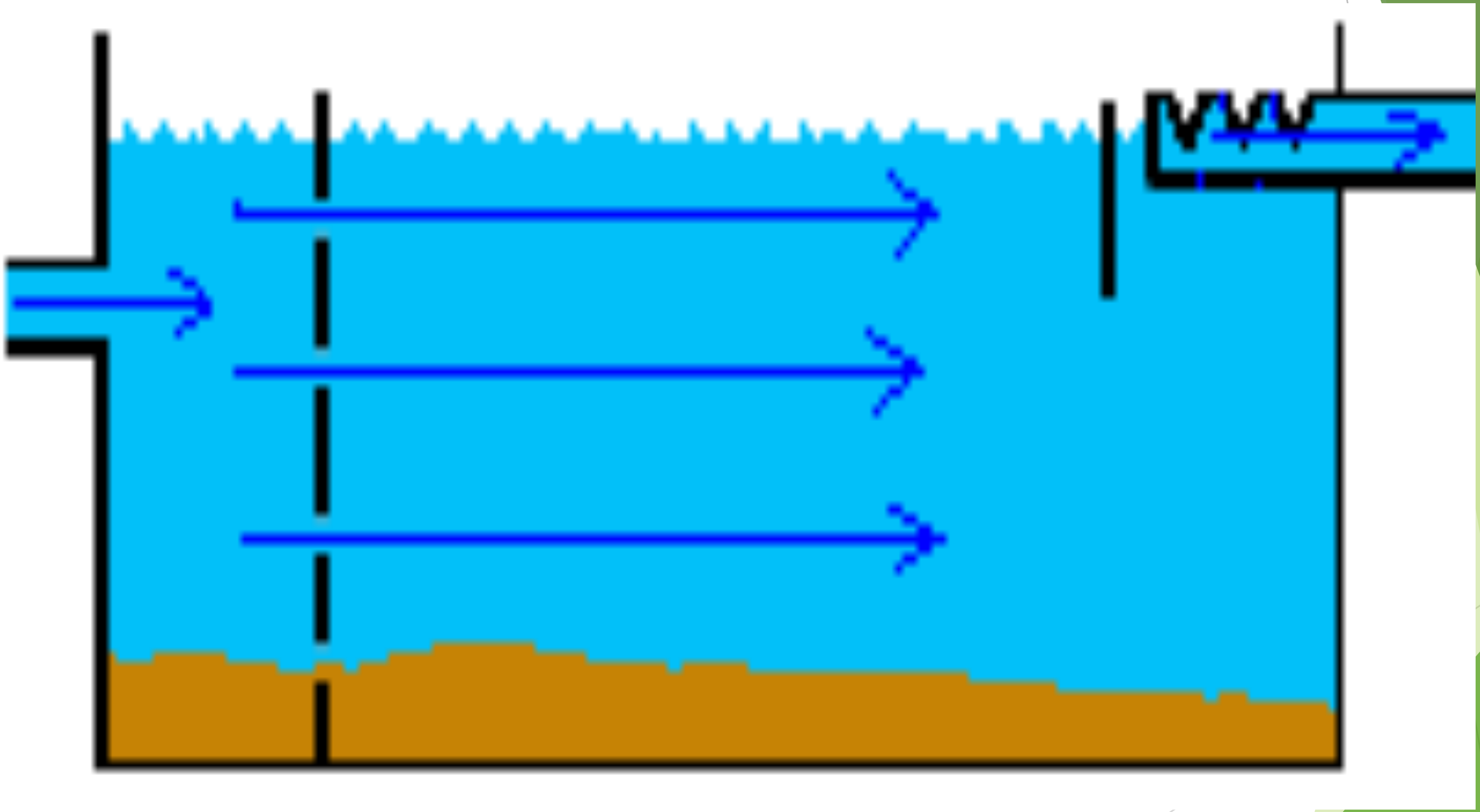


Primary Treatment

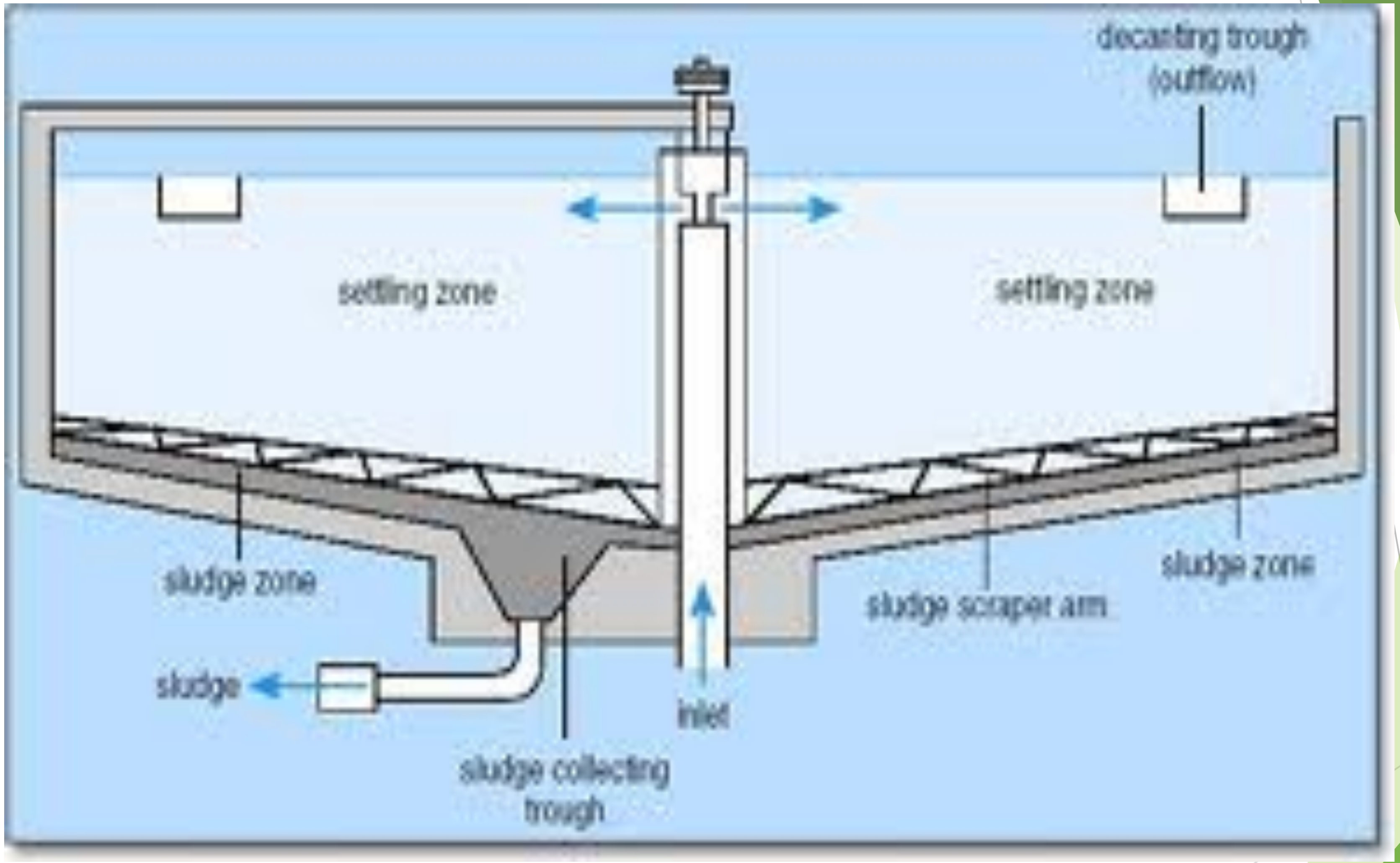
Primary treatment includes

- Screening
- Primary Sedimentation - designed to remove settleable solids and reduce the organic load (BOD) on the secondary units.

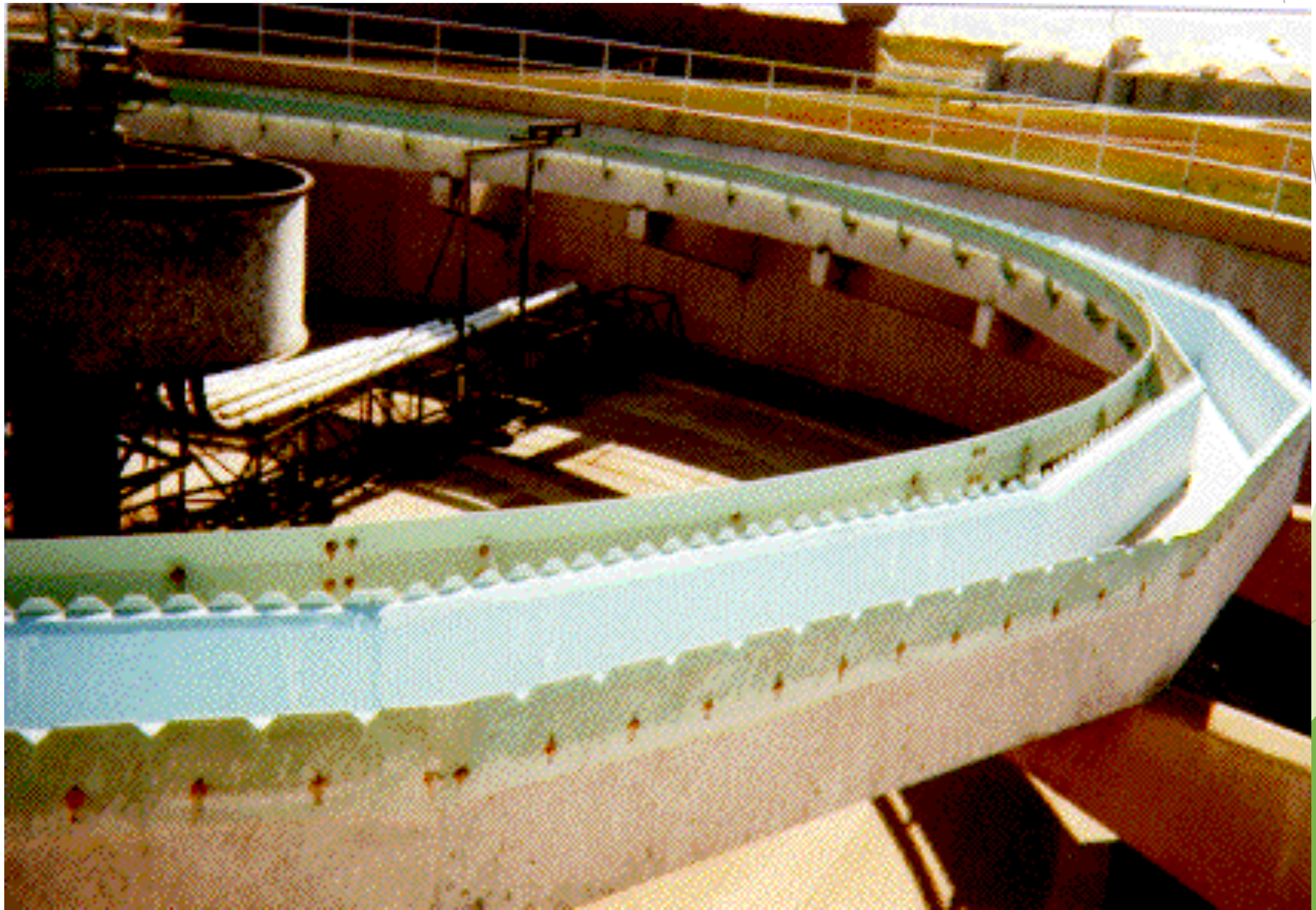
Rectangular Basin



Circular Basin


decanting trough
(outflow)
settling zone
settling zone
sludge zone
sludge zone
sludge scraper arm
sludge
inlet
sludge collecting
trough

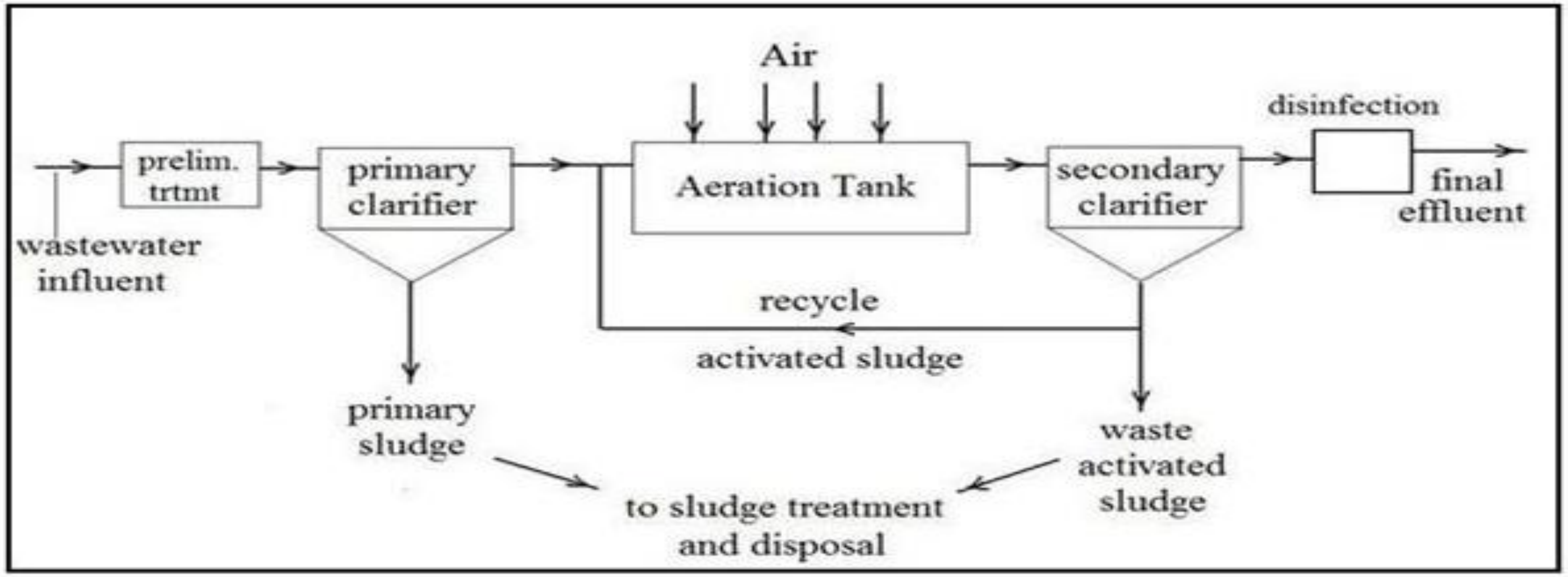
An Empty Primary Clarifier



Secondary Treatment

Activated Sludge

Activated Sludge Flow Diagram



Activated Sludge Wastewater Treatment Flow Diagram

Some Modifications To The AS System

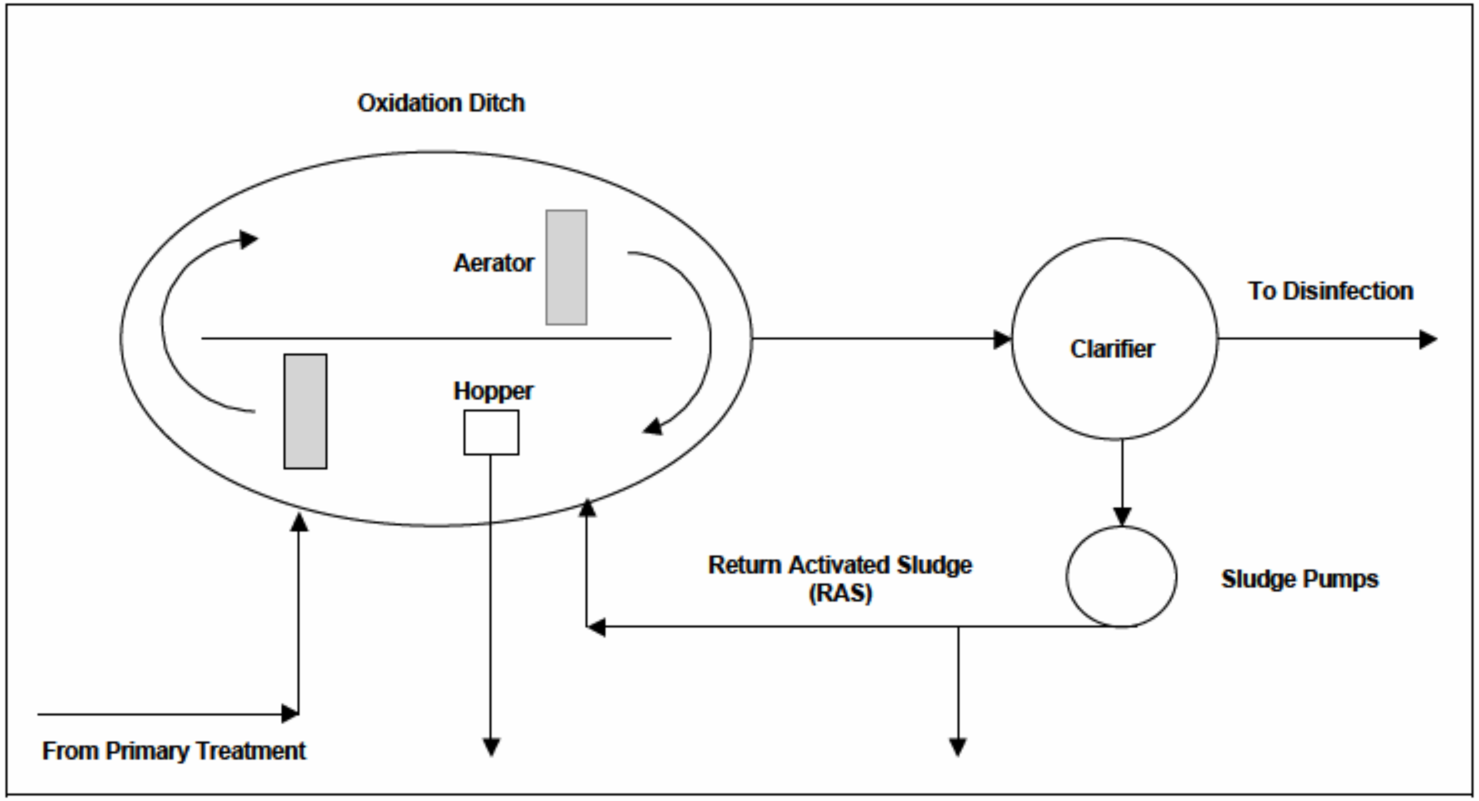
- Complete mix AS
- Contact stabilization
- Extended aeration
- Tapered aeration
- Pure oxygen systems
- Oxidation ditch
- Membrane bioreactors
- Sequencing batch reactors (SBRs)

Type Of Reactors

- Plug Flow
- Complete Mix

Primary aeration tank

Oxidation Ditch

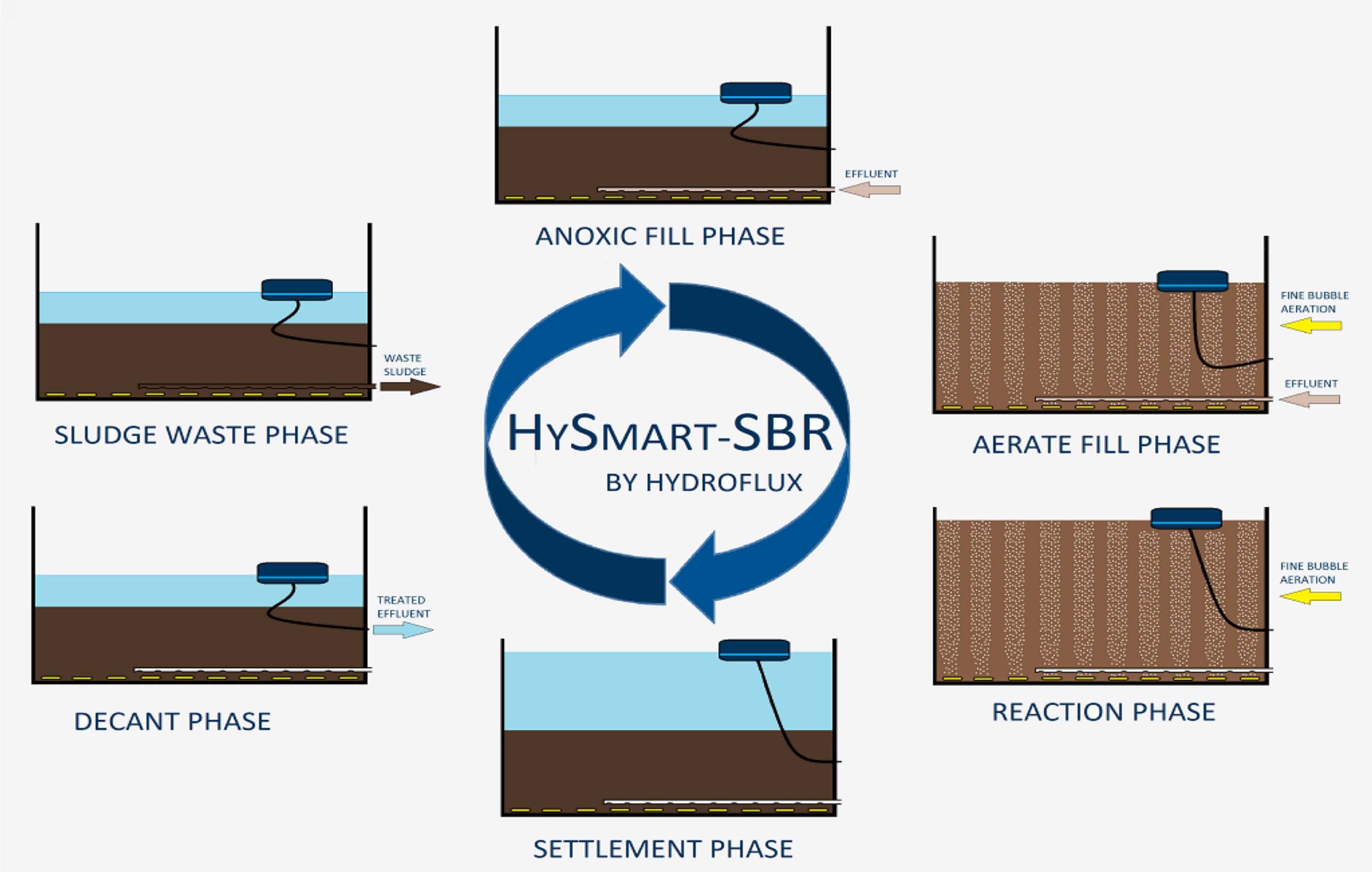


Source: Parsons Engineering Science, Inc., 2000.

FIGURE 1 TYPICAL OXIDATION DITCH ACTIVATED SLUDGE SYSTEM

Oxidation Ditch

Sequencing Batch Reactors

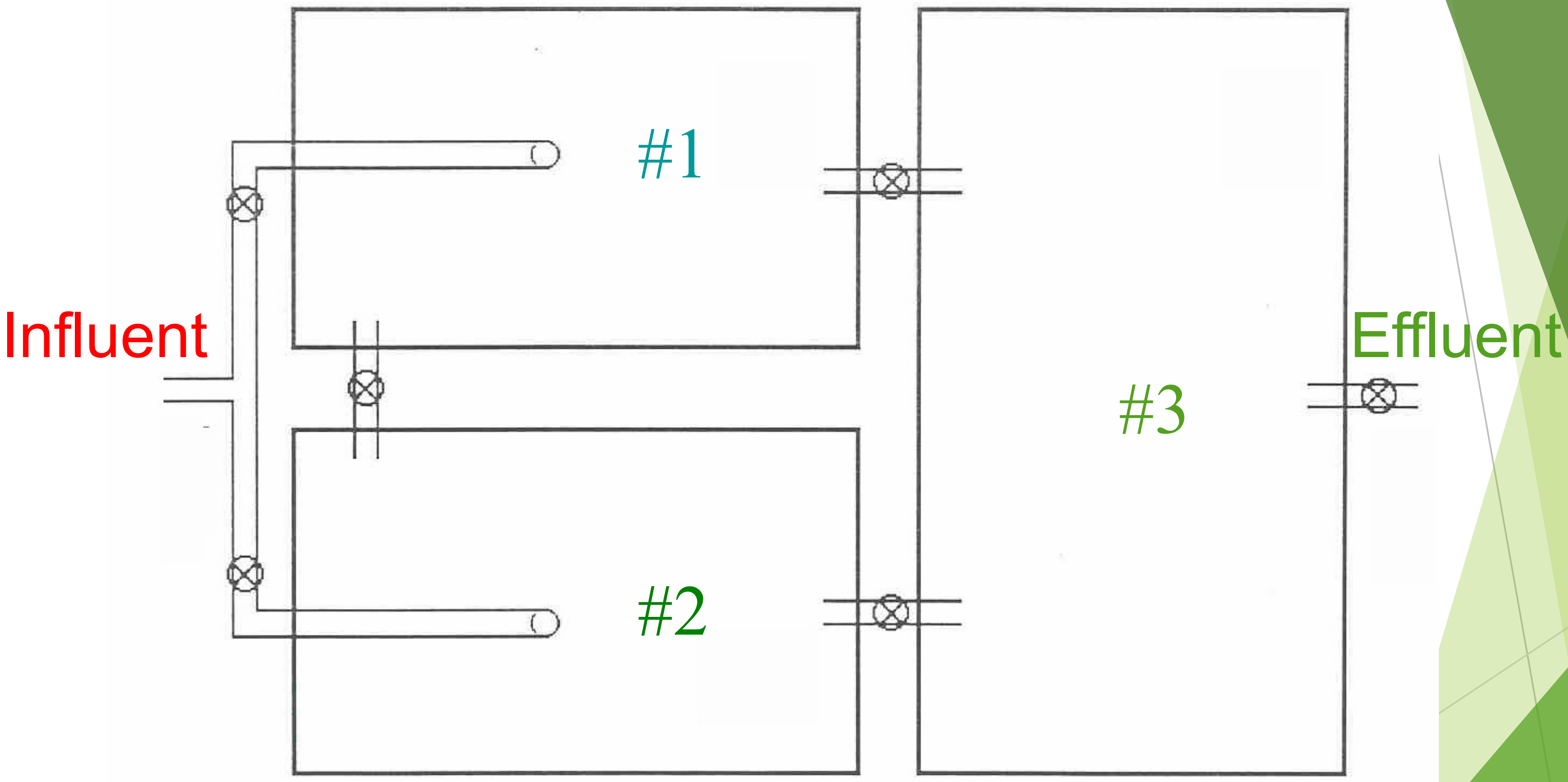


Lagoon Systems

Types Of Lagoons

- Aerobic lagoons
- Facultative lagoons
- Partial-mixed aerated lagoons
- Tertiary lagoons
- Anaerobic lagoons

Typical Lagoon System



Facultative Lagoon

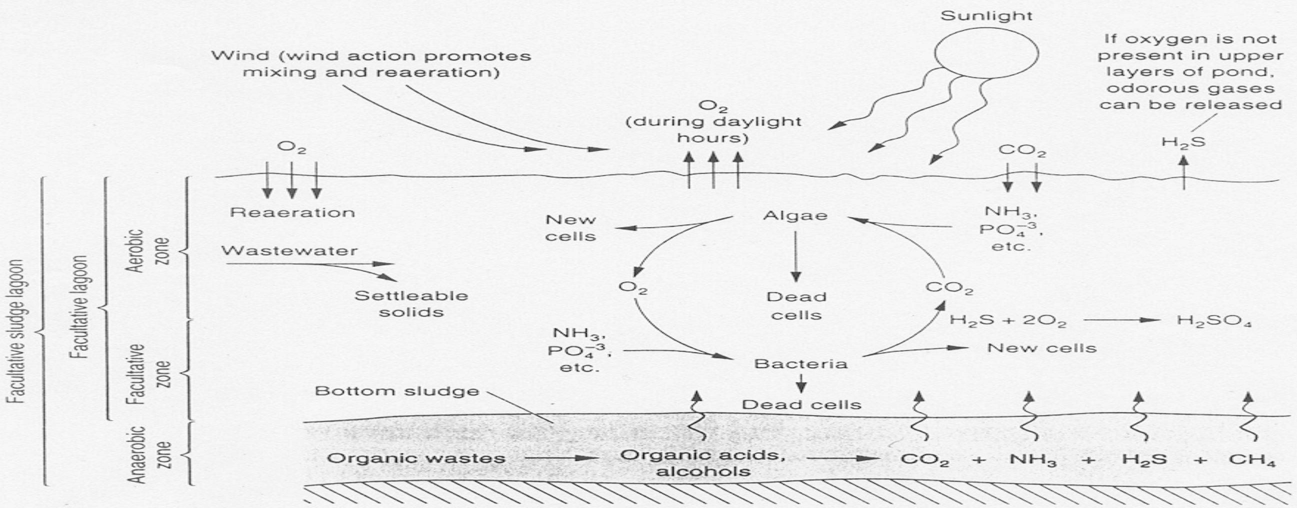
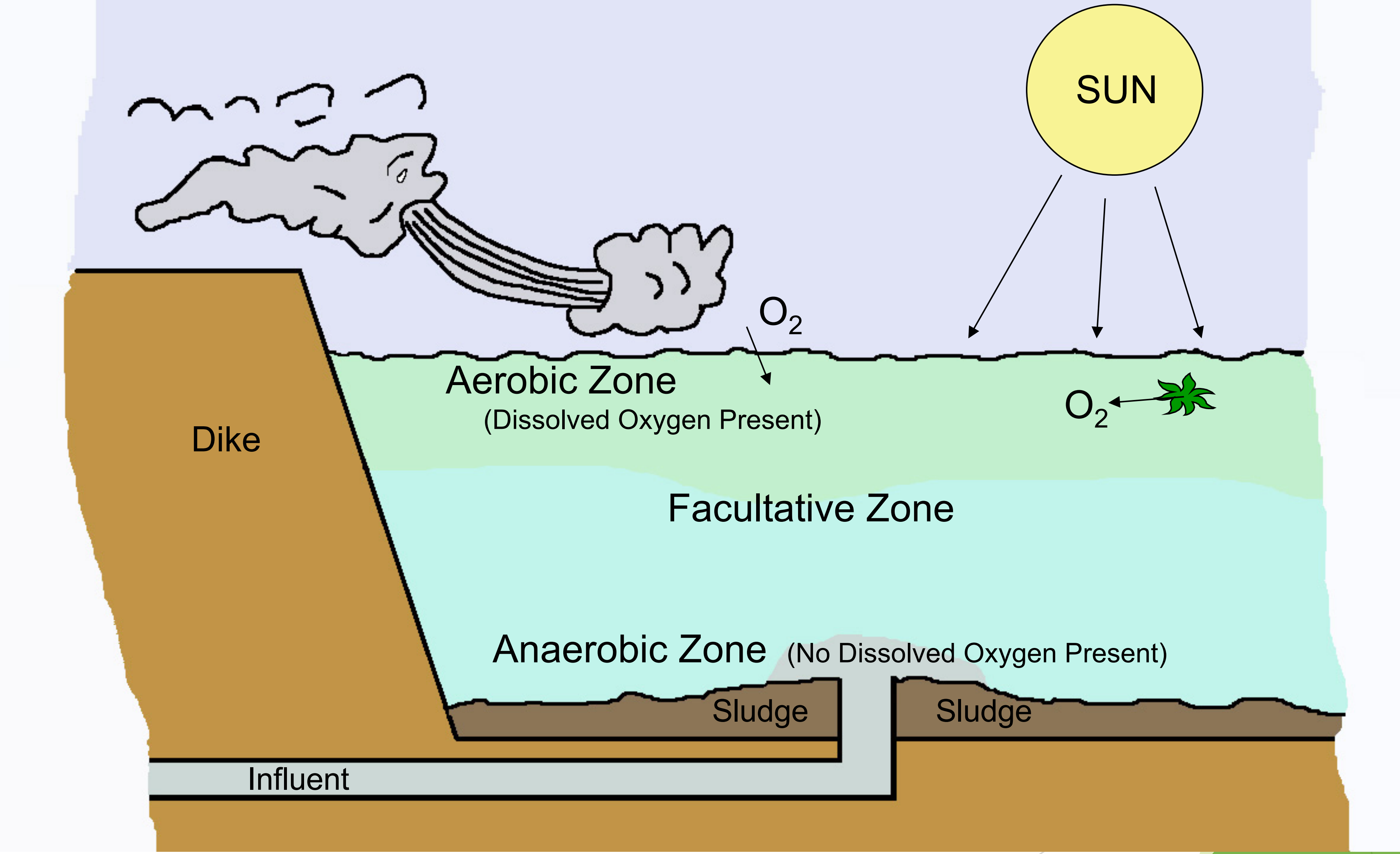


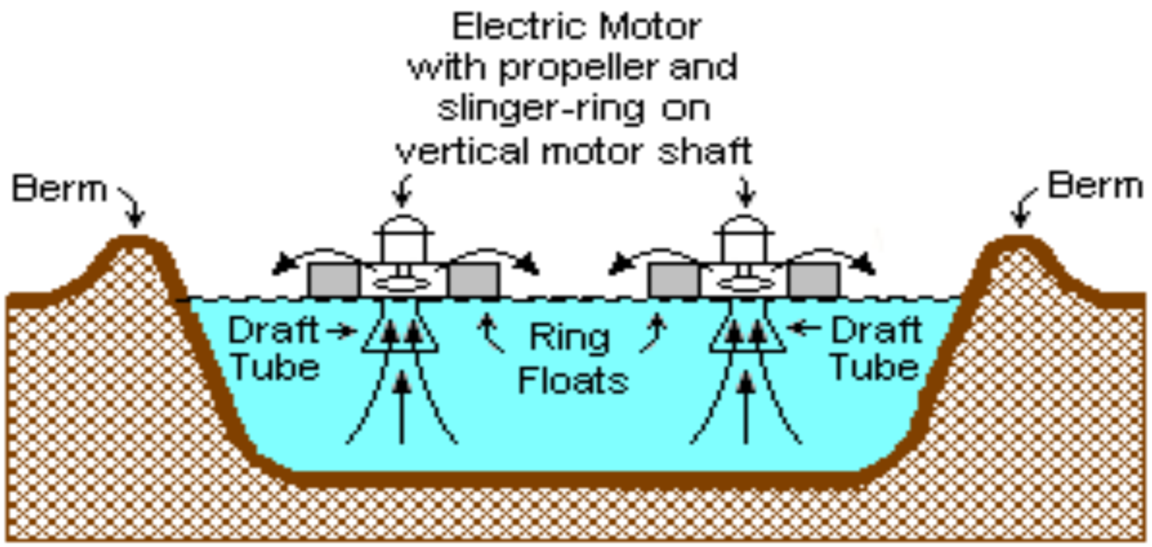
FIGURE 8-2
Definition sketch for the interactions occurring in a facultative lagoon (from Tchobanoglous and Schroeder, 1985).




Zonal Relationships in a Lagoon



Aerated Lagoon



A TYPICAL SURFACE – AERATED BASIN

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

Nitrogen And Phosphorus Removal

Nitrogen Removal Systems

WASTEWATER "TREATMENT" Of Nitrogen

N

Primary Effluent (Secondary Influent)

Organic Nitrogen (Less)

Ammonia

Nitrification

Nitrification of Ammonia Occurs in Two Steps

NH_3-N → NO_2-N

Ammonia N → Nitrite N

Nitrosomonas

*Autotrophic Bacteria Utilize Inorganic Compounds

(and CO_2 as a Carbon Source)

NO_2-N → NO_3-N

Nitrite N → Nitrate N

Nitrobacter

Biological Denitrification

- Nitrate Reduction: NO_3 → NO_2 → NO → N_2O → N_2
- Wastewater/methanol/acetate reduction of NO_3
  - $C_{10}H_{19}O_3N + 10NO_3 \rightarrow 5N_2 + 10CO_2 + 3H_2O + NH_3 + 10OH$
  - $5CH_3OH + 6NO_3 \rightarrow 3N_2 + 5CO_2 + 7H_2O + 6OH$
  - $5CH_3COOH + 8NO_3 \rightarrow 4N_2 + 10CO_2 + 6H_2O + 8OH$

N Removal Technologies

1. Single Process for Nitrification-Denitrification
2. Separate Stage Nitrification
3. Separate Stage Denitrification

- These systems can be either suspended growth or attached growth systems or hybrid systems

Modified Ludzack-Ettinger System

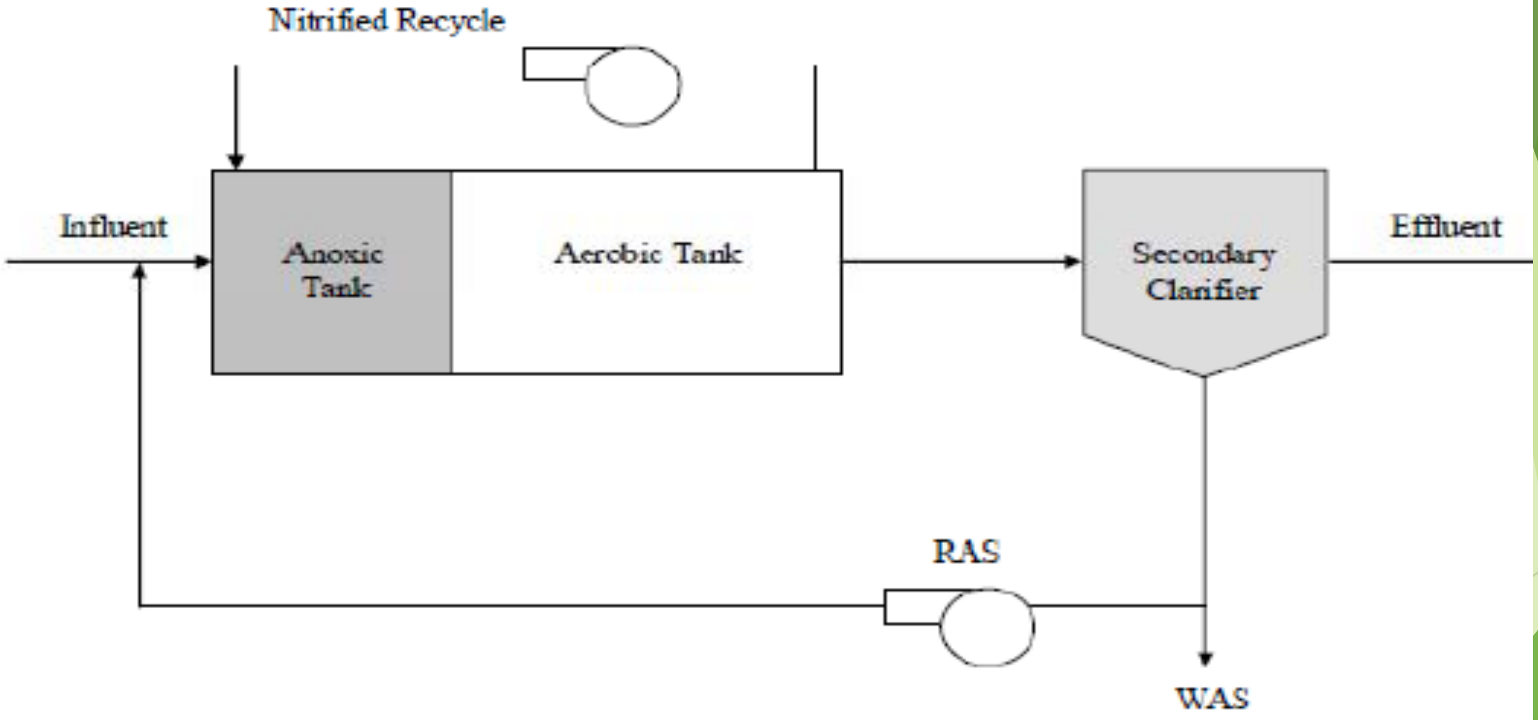


Figure 6-1. Modified Ludzack-Ettinger (MLE) process.
RAS = Return activated sludge; WAS = Waste activated sludge
Source: USEPA 2008b Figure 2-3

Downflow Denitrification Filter

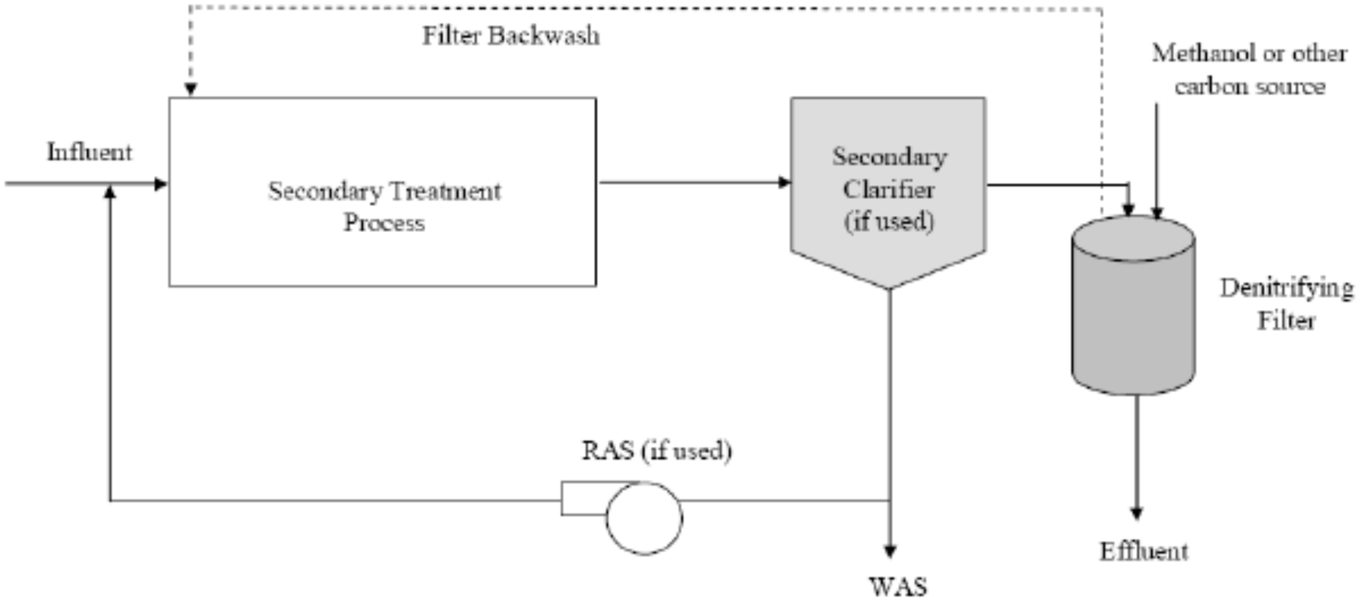


Figure 6-7. Downflow denitrification filter.
Source: USEPA (2008b), Figure 2-1

Upflow Sand Filter

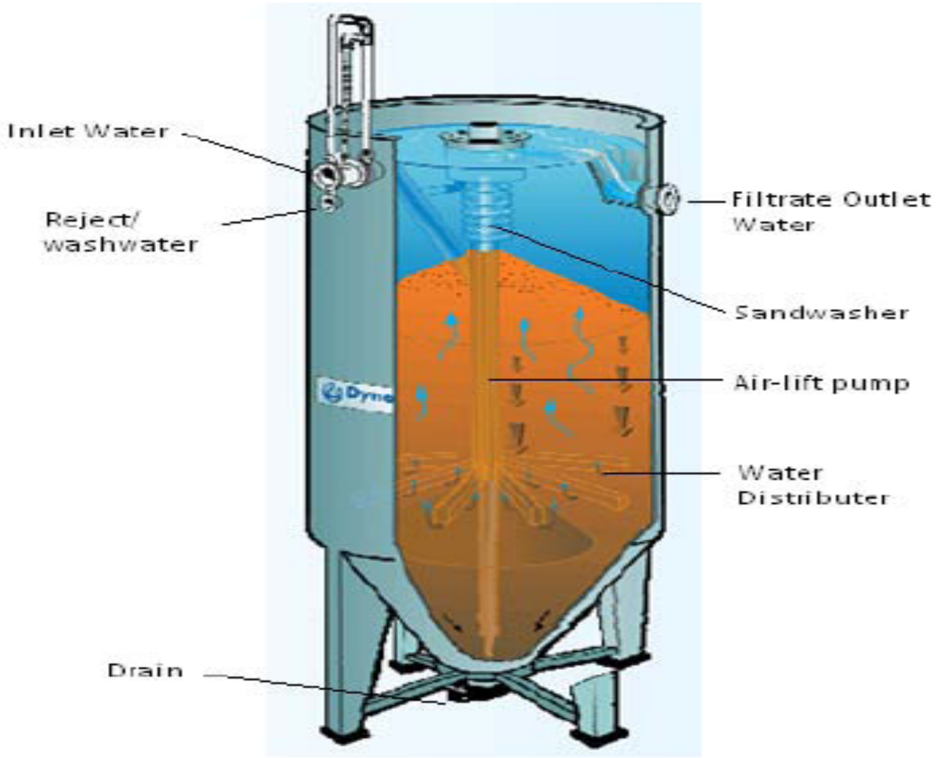


Figure 6-8. Continuous backwash upflow sand (CBUS) filters.
Source: Feldthusen 2004. © Nordic Water Products AB. Used with permission

Phosphorus Removal

- Biological
- Chemical Precipitation

BIOLOGICAL PRINCIPLES

- Normal cellular uptake in aerobic respiration

  C : N : P ratios 100 : 5 : 1

  BOD : Total N : Total P

- Certain facultative microorganisms, when subjected to anaerobic conditions, can survive by assimilating and storing fermentation products (measured as soluble BOD). In the process, energy in the form of ATP (Adenosine Triphosphate) is used and dissolved (ortho) phosphorus is released from the cells.

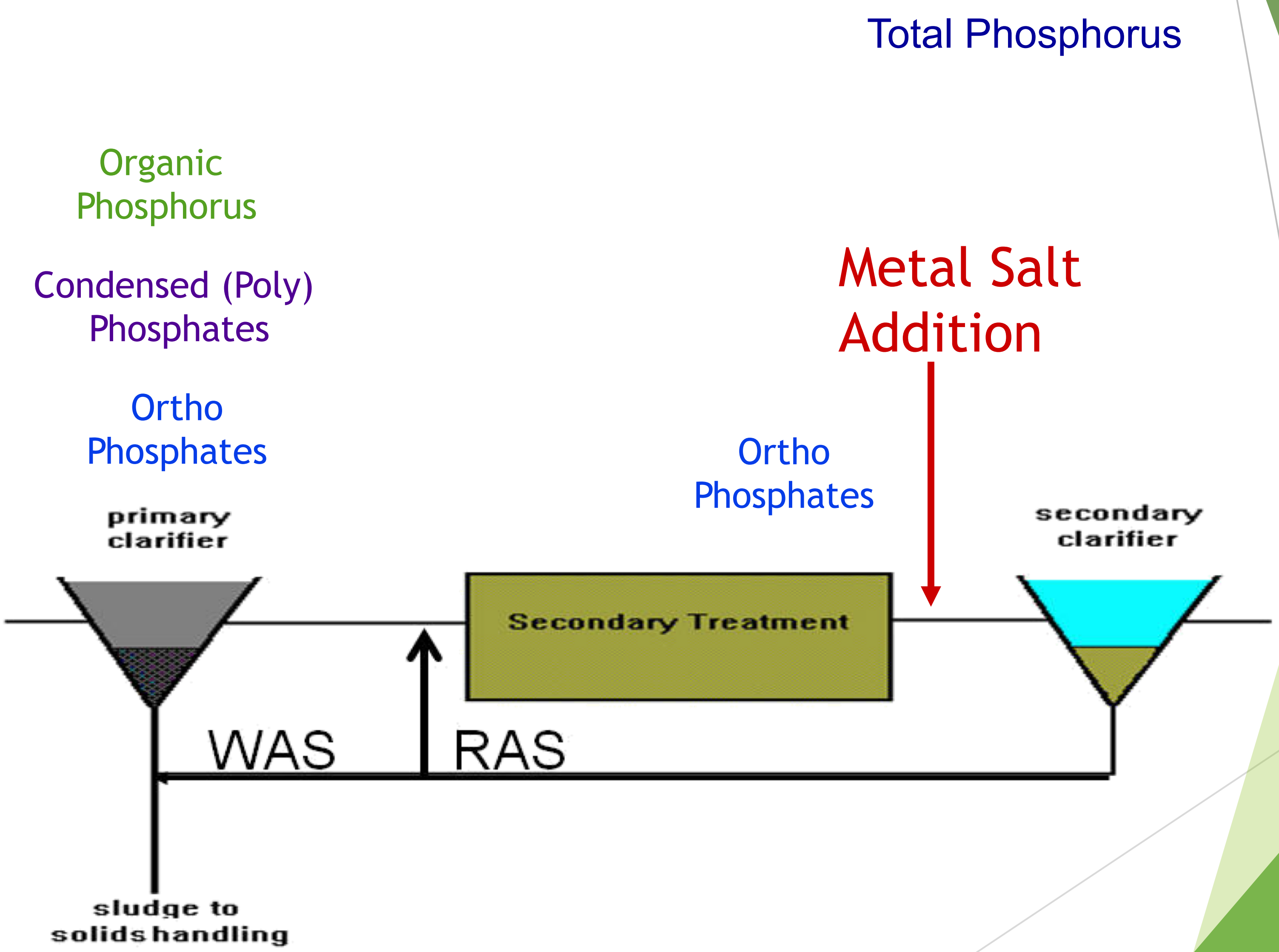
- When these microorganisms ("stressed" under anaerobic conditions) come in contact with dissolved phosphorus under aerobic conditions, they "take up" excess phosphorus beyond normal amounts required for cell growth. Phosphate Accumulating Organisms (PAO).

EBPR

Initial Anaerobic Stage → PAOs grab organics / Release cellular PO_4

Aeration → Uptake PO_4 for Energy Production & Storage

Chemical Phosphorus Removal



Other Phosphorus Removal Processes

Chemical - Most organic & inorganic P readily removed by ppt.

- P in aqueous phase
  - Alum ($Al_2(SO_4)$) – most expensive & mostly used
  - Ferric salts ($FeCl_3$) – highly corrosive nature
  - Lime ($Ca(OH)_2$ – excess sludge produced (cost to dispose)
- P onto suspended solids
  - Polymers (with Alum or Fe salts)

Filtration

- Used in conjunction with biological or chemical processes ($P < 1$ mg/L)

STEPS

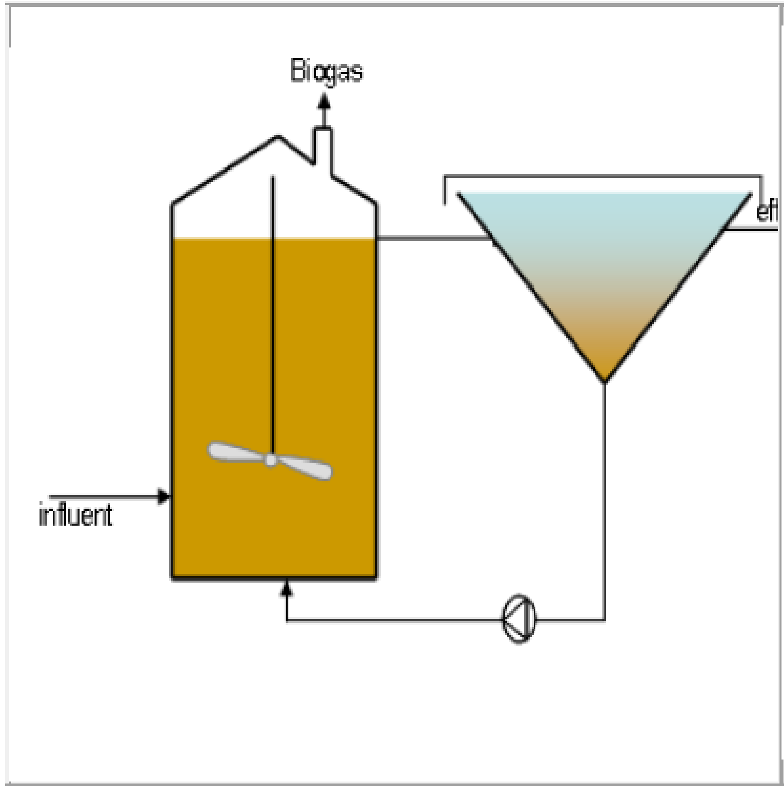
Anaerobic Treatment Systems

- Anaerobic Lagoon
- Anaerobic Contact Reactor
- Anaerobic Filter
- Upflow Anaerobic Sludge Blanket (UASB)
- Expanded Granular Sludge Bed
- Anaerobic Sequencing Batch Reactor

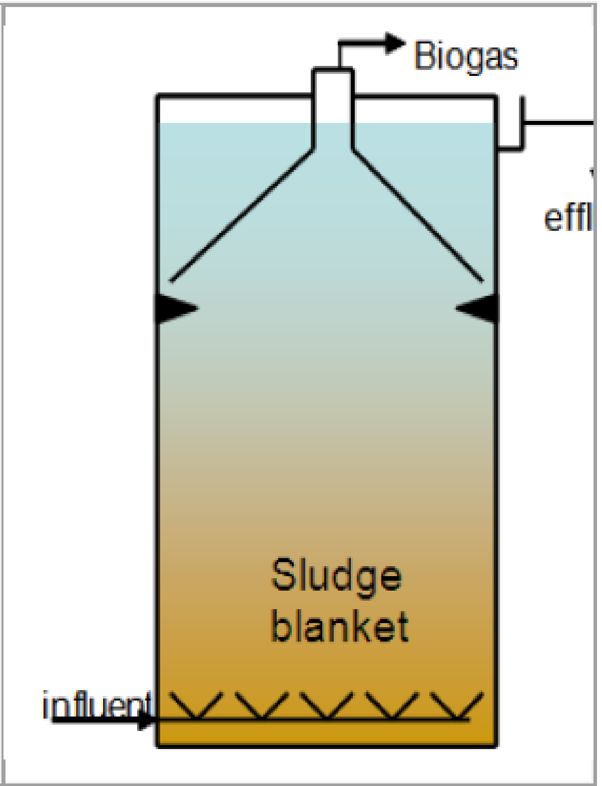
Anaerobic Systems

- Require less energy then aerobic systems
- Low sludge production
- Produce biogas that can be used
- Cannot meet effluent discharge standards

Anaerobic Processes

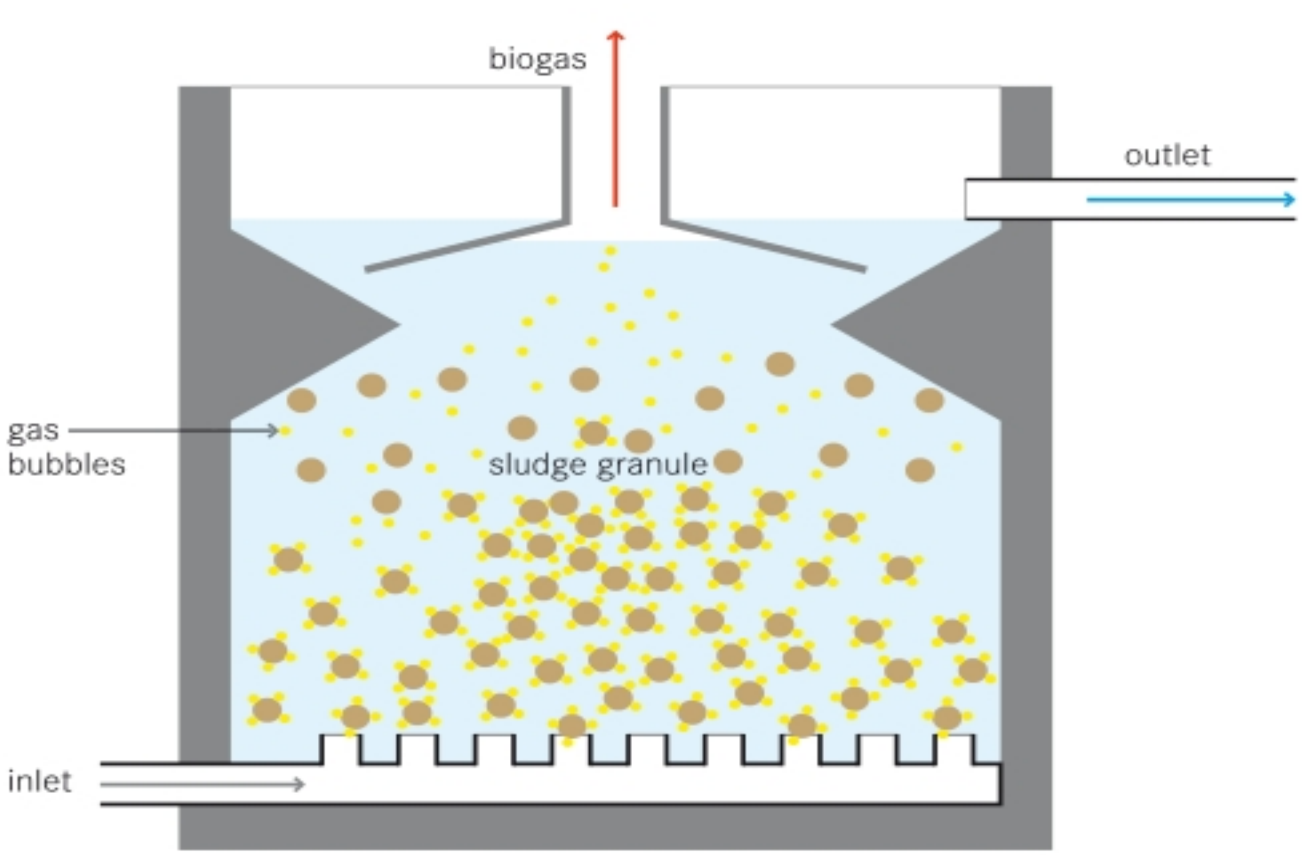


Anaerobic contact reactor

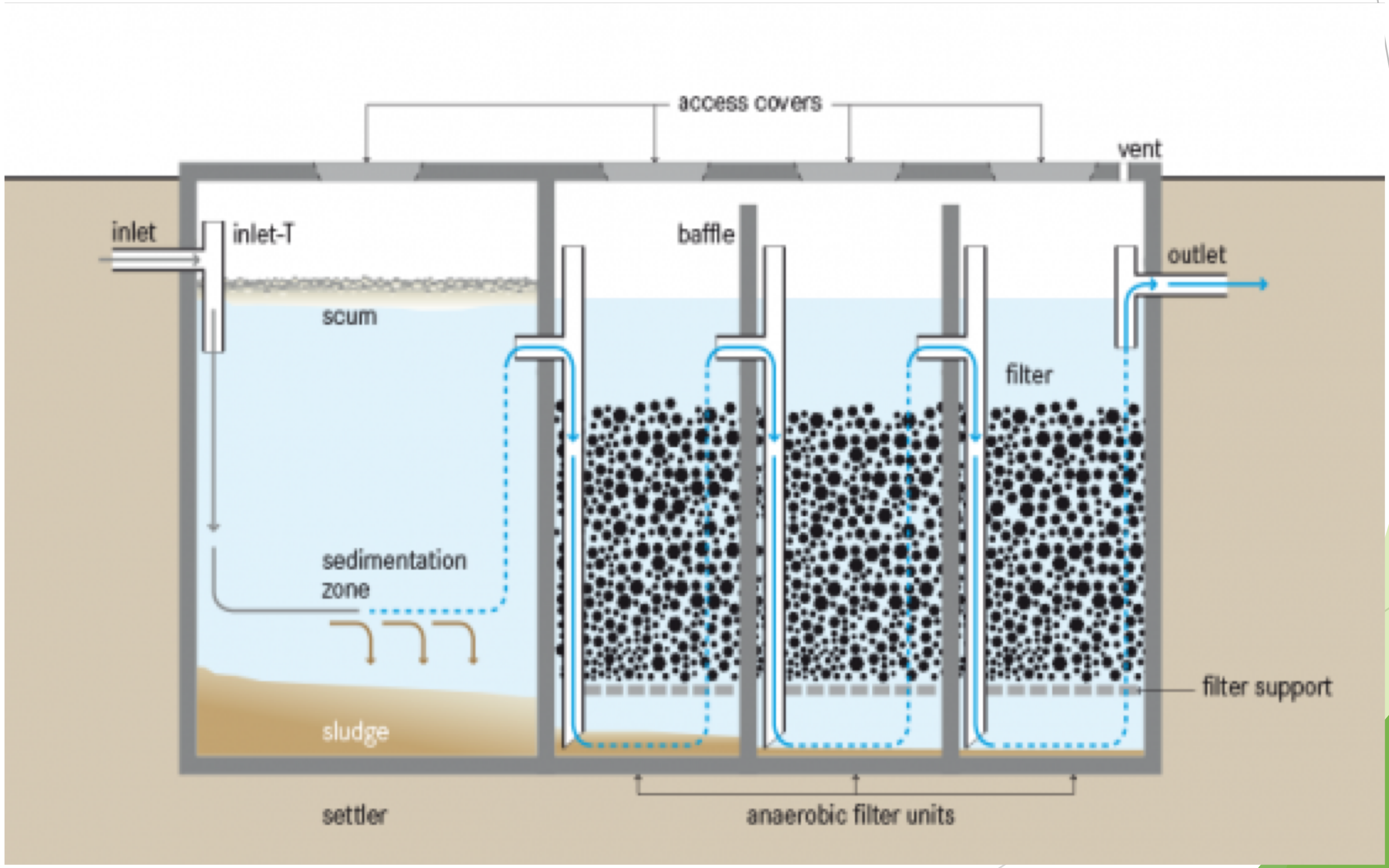


Upflow reactor

Upflow Anaerobic Sludge Blanket



Anaerobic Filter



Membrane Bioreactors

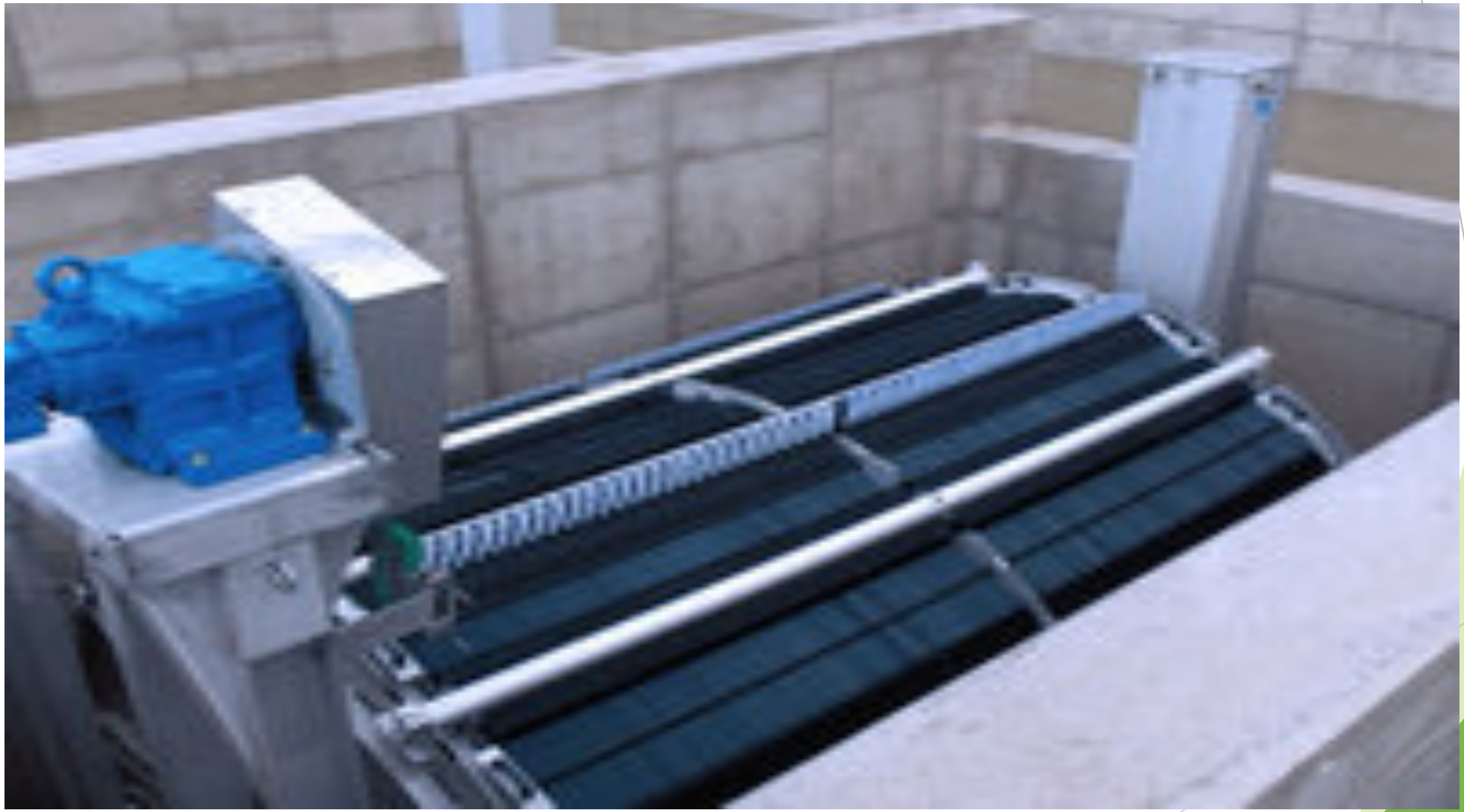
Membrane Classification Processes

1. Microfiltration
2. Ultrafiltration
3. Nanofiltration
4. Reverse Osmosis
5. Dialysis
6. Electrodyialysis

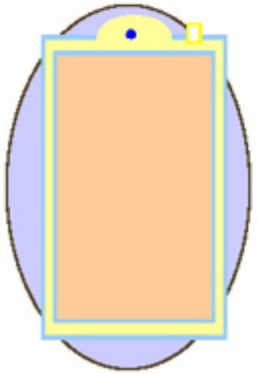
Membrane Bioreactors In U.S.

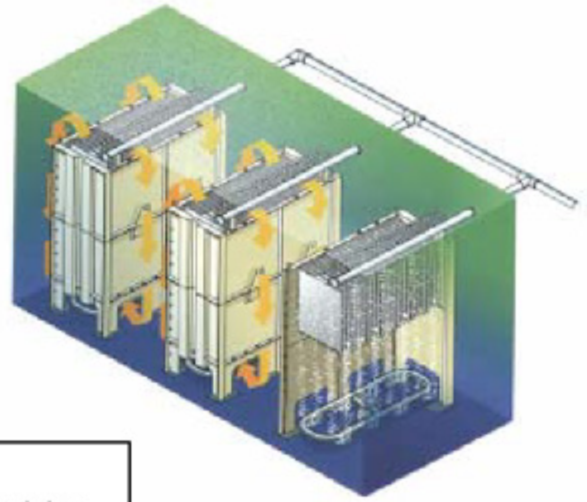
1. Zenon Environmental
2. US Filter
3. Kubota Corporation
4. Mitsubishi Rayon Corporation
5. Huber Technology

Huber Bioreactor



Kubota Membrane Bioreactor





Average Pore Size	0.4µm
Membrane Material	Chlorinated polyethylene
Membrane Panel	ABS resin
Dimension	0.49×1.0m
Effective Area of Membrane	0.8 m^2/per sheet

(Fig. 1 Membrane Cartridge with its specifications and a view of the submerged flat sheet membrane bioreactor system)

Membrane Tanks

Application

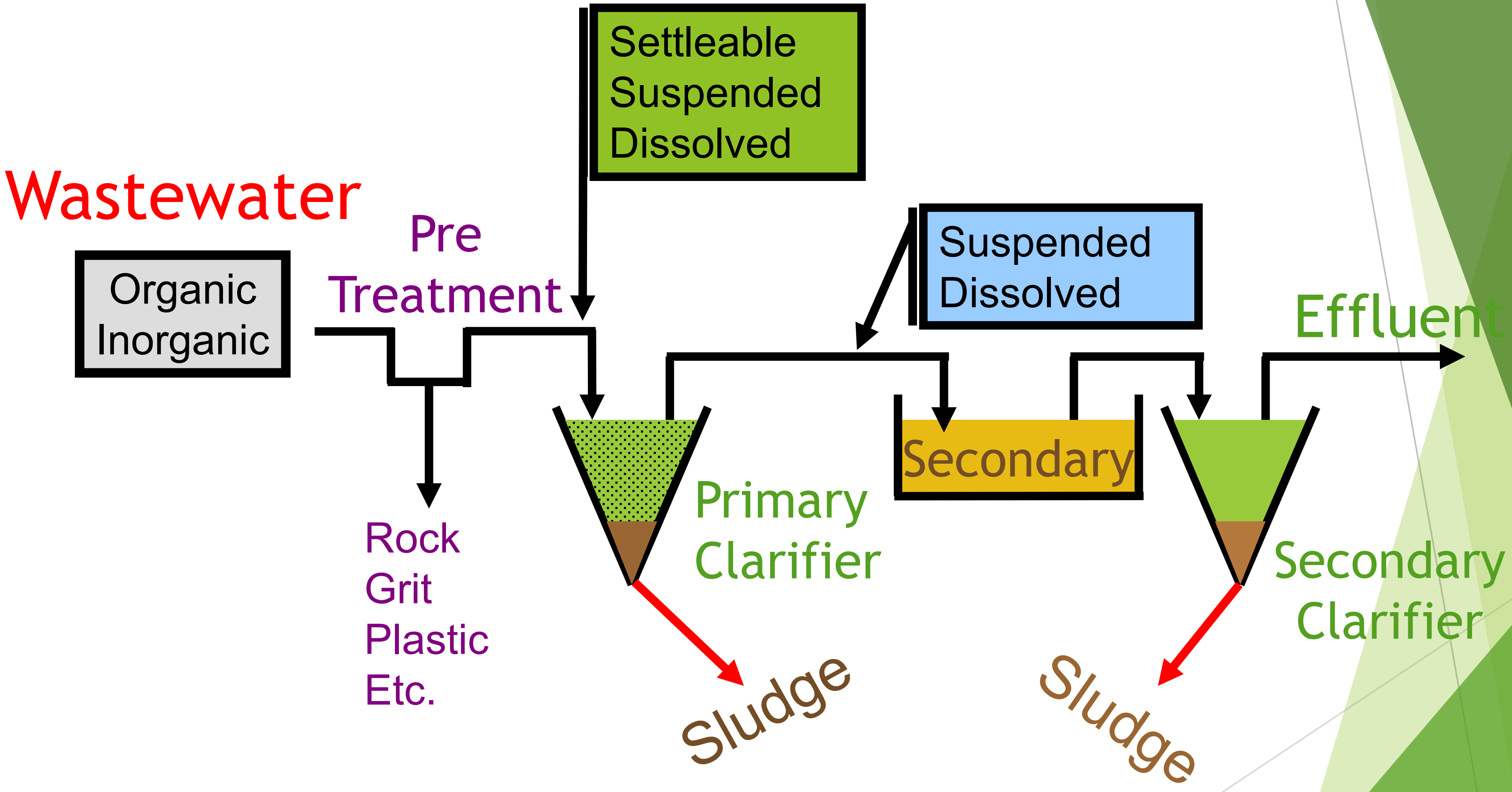
- Replace activated sludge
- Replace sand filtration after conventional activated sludge

Effluent Quality

- BOD – 5- 10 mg/l
- Total N – 3mg/l
- Phosphorus – 0.1 – 0.5 mg/l
- Turbidity – 0.2 NTU
- Remove bacteria and viruses

Sludge Treatment And Disposal

Removal of These "Pollutants" Produces "Residuals" Often called "Sludge"



Note: These residuals are sometimes called "Biosolids", however that term is usually reserved for sludge that has been "stabilized" and meets specific requirements (pathogen reduction, vector attractions, metals concentration)

ANAEROBIC DIGESTION

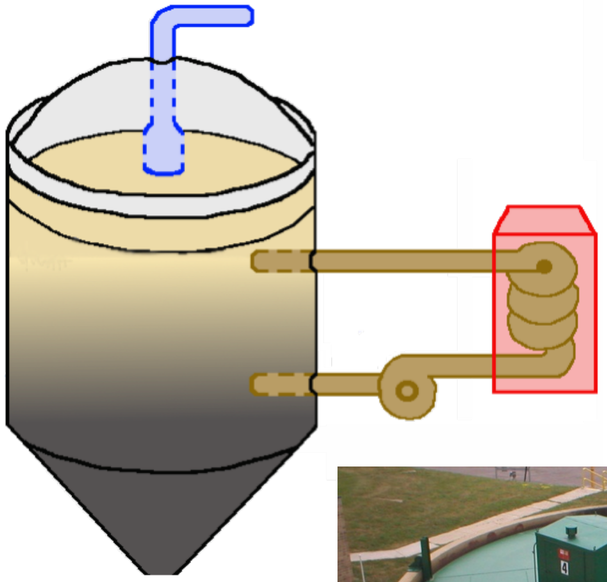
Advantages

- Low operating costs
- Proven effectiveness
- Burnable gas produced

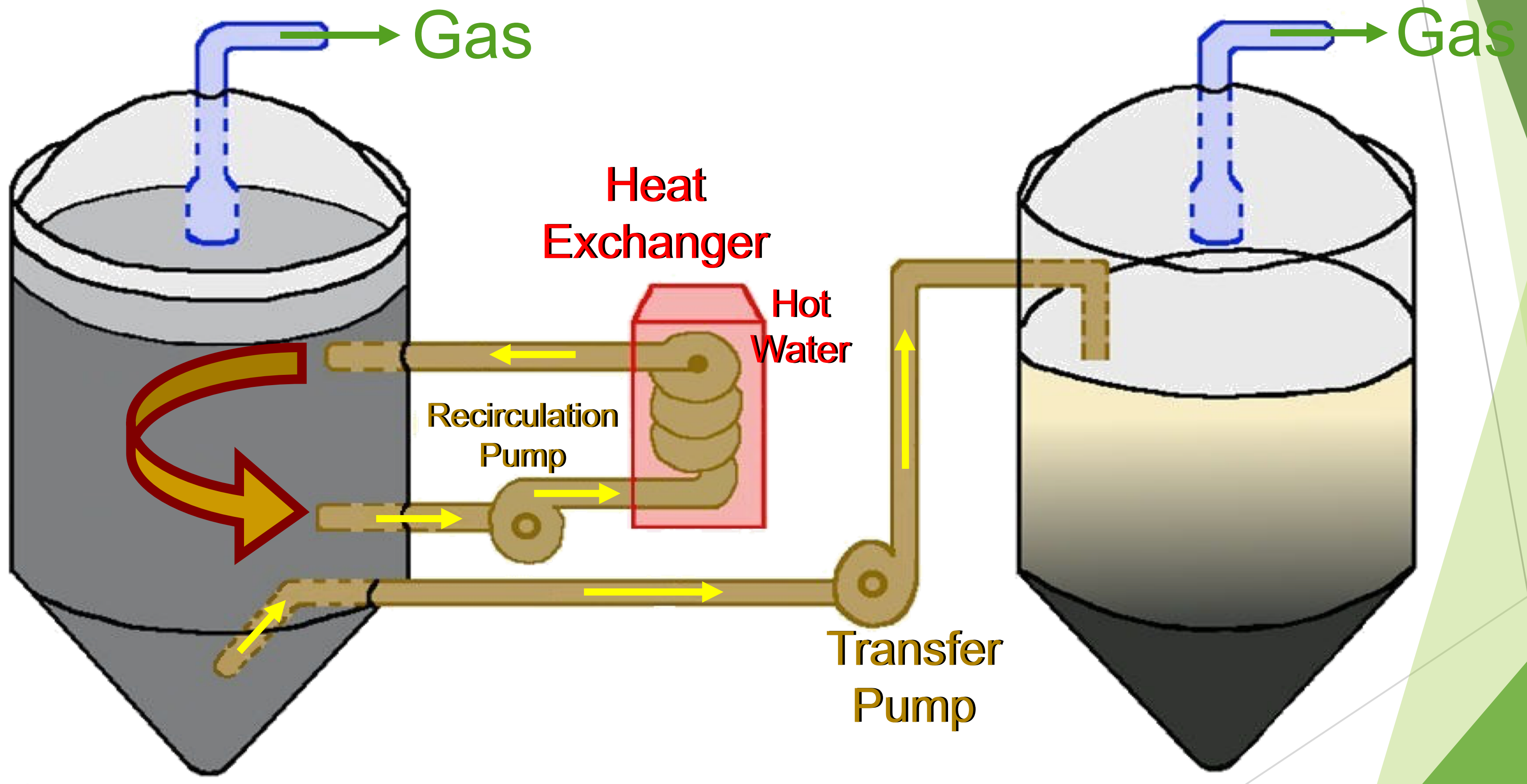
Disadvantages

- Long start-up time
- Affected by changes in loading and conditions
- Explosive gas produced

ANAEROBIC DIGESTION



TYPICAL "Two-Stage" ANAEROBIC DIGESTER SYSTEM

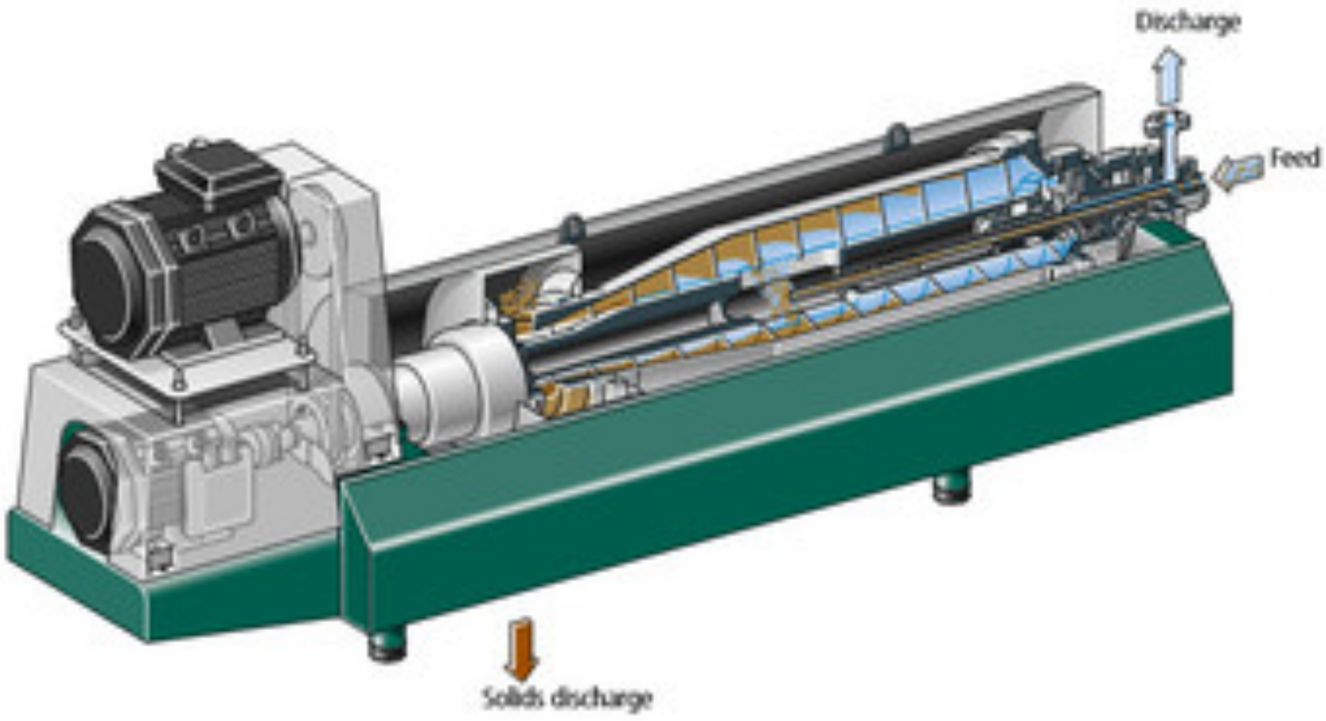


Note: Two-Stage System here refers to two separate tanks (One for the treatment process and one for water-solids separation)

Sludge Dewatering And Disposal

- Belt Filter Press
- Centrifuge
- Sand Drying Beds
- Dewatered sludge may undergo composing before disposal
- Land application is the most common method of disposal

Centrifuge



Belt Filter Press