Water Pollution

Water Hyacinth

•The plant is native to South America
•One of the fastest growing plants known, water hyacinth reproduces primarily by way of runners or stolons, which eventually form daughter plants
•It also produces large quantities of seeds, and these are viable up to thirty years
•The common water hyacinth (Eichhornia crassipes) are vigorous growers known to double their population in two weeks.

COMMUNITY

Water hyacinth poses threat to Harike headworks

Varinder Singh & Gurbaxpuri
Tribune News Service

Amritsar, July 26
The growth of hyacinth in the Harike, built on the Beas and Sutlej, has started posing a threat to the 1953-built Harike headworks.

The water weed has engulfed water in a large part of the water body, particularly near the headworks. Sources in the Punjab Irrigation Department said the weed had grown to an extent that it could seriously damage the headworks.

The water weed had posed the same threat about 10 years ago when the state had to seek Army's help to remove it. Employees at the headworks said huge chunks of the weed had started floating around suddenly during the last week.

The growth was so rapid that it had covered almost all parts of the 31 gates beneath the 2,087-ft bridge, said Sohan Singh, a farmer.

A road safety missionary, Jagir Singh Sandhu, said the water hyasinth might prove to be a threat to the bridge.

He further said besides causing losses worth crores, the water hyasinth might disconnect this part from other parts of the country for years.

Harike was built at a point on the Beas and the Sutlej from where the canal water goes to Rajasthan and other parts of the country.

- Industrial utilization - Since the plant has abundant nitrogen content, it can be used a substrate for biogas production and the sludge obtained from the biogas. However, due to easy accumulation of toxins, the plant is prone to get contaminated when used as feed.
- The plant is extremely tolerant of, and has a high capacity for, the uptake of heavy metals, including Cd, Cr, Co, Ni, Pb and Hg, which could make it suitable for the biocleaning of industrial wastewater. In addition to heavy metals, Eichhornia crassipes can also remove other toxins, such as cyanide, which is environmentally beneficial in areas that have endured gold mining operations
- Water hyacinth is also observed to enhance nitrification in waste water treatment cells of living technology. Their root zones are superb micro-sites for bacterial communities

Sukhna choe or garbage dump?

Tribune (Chandigarh) 20100904

- **Garbage along the Sukhna choe. Tribune photos: Nitin Mittal**
- Zirakpur, September 3
  In the absence of a dumping ground, Zirakpur municipal council is disposing of garbage and other waste material along with Sukhna choe (seasonal rivulet) in Bishanpura village. This is causing a serious threat to residents of surrounding villages and also polluting the Sukhna choe.

TOP

50 YEARS OF INDEPENDENCE FEATURES

Ludhiana heading for a Bhopal-like tragedy

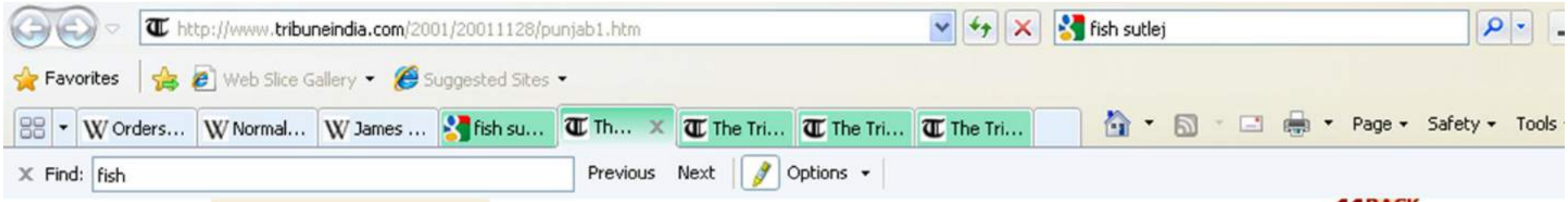
Punjab rivers are now heavily polluted

by A. S. Prashar

PUNJAB is much better placed than most other states as regards environmental pollution. But this is largely due to the fact that the border state has no major large and medium scale industrial units. This fact has otherwise been a sore point with the state government and its people for a long time.

Thermal plants, sugar manufacturing units and paper projects (as also a large number of small industrial units in the state) have been prevailed upon by the Punjab State Pollution Control Board to adopt pollution control measures.

The rising population, increasing traffic volume, haphazard growth of cities, perpetual shortage of funds, discharge of untreated solid wastes into the rivers and nullahs of Punjab are accentuating the pollution problem in Ludhiana, Jalandhar, Amritsar, Bathinda and other smaller urban settlements. Ludhiana, the industrial and commercial hub of Punjab, offers the worst example on the environment front. All indicators point towards an environmental disaster-in-the-making that is likely to be bigger than the Bhopal gas tragedy. Ludhiana city seems to be sitting on a “garbage



BACK

AGRICULTURE

Sutlej pollution: fish farmers seek action

Our Correspondent

20011128

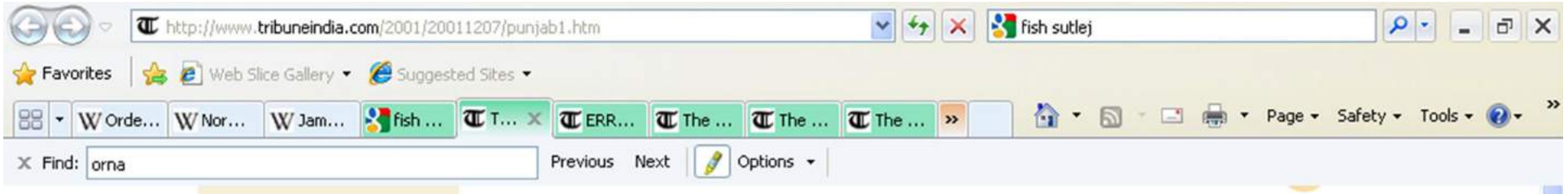
Ropar, November 27

The Fish Farmers Association, Punjab, had demanded that criminal cases should be registered against those responsible for the death of fish in the Sutlej. The president of the association, Wg Cdr Sukhcharan Singh Grewal, while talking to newspersons here today alleged that the fish dying in Sutlej due to the toxic wastes had damaged the reputation of the quality of fish being produced in the state. It would also have an adverse affect on the earning of fish farmers in the state.

In cases where industrial units are found guilty of causing pollution they are let off after payment of fines, which was not a permanent remedy to the problem of pollution. The pollution control board authorities should in fact book the culprits responsible for causing pollution for criminal offences.

A strict vigil must be maintained over the level of pollution in various rivers. There is continuous pollution of heavy metals in some areas of the Sutlej. These metals lead to slow poisoning of the fish, which is further carried to the consumers. The pollution control board authorities should constantly conduct random surveys in the rivers of the state to check the pollution levels in various rivers, he demanded.

The pollution in various rivers in the state has been affecting the fish for quite some time but the authorities concerned have not



20011207

TRIBUNE FOLLOW-UP

Low oxygen killed Sutlej fish: report

Lalit Mohan

Ropar, December 6
A lesser amount of dissolved oxygen, allegedly caused due to the release of some toxic effluent, caused the mass mortality of fish in the Sutlej waters near Naya Nangal. Mr Krishan Kumar, ADC, has stated this in his report submitted to the Punjab and Haryana High Court yesterday.

Earlier, the court, taking a suo motu notice of a news item published in The Tribune, had directed the ADC to conduct an inquiry into the reasons that led to the mass mortality of fish in the Sutlej. He was directed to visit the spot on three consecutive days and get the autopsy of the dead fish done.

The ADC said the Fisheries Department took two samples of water from the Sutlej on November 23. Prof M.S. Joshi of the Department of Zoology, Panjab University, tested these samples in the departmental laboratory of the department.

From the analysis of water, Professor Johl concluded that it was difficult for the fish to survive in the both samples as the level of dissolved oxygen was too low.

The normal value of dissolved oxygen in water should be 8-10 mg per litre. The much alkaline water found near the NFL's discharge point could cause damage to the skin and gills of the fish. If the conditions like it persisted in the water for 20 to 30 minutes, fish would die.

In case of second sample also, which was taken from 1 km

20061209

Budda nullah also polluting Sutlej

Vimal Sumbly
Tribune News Service

Ludhiana, December 8
Although an expert committee constituted by the Punjab State Human Rights Commission on the Budda nullah has looked into various aspects and also made some recommendations, more investigations need to be carried out about the intensity of pollution in the Sutlej by the nullah since it merges into the river at Walipur village.

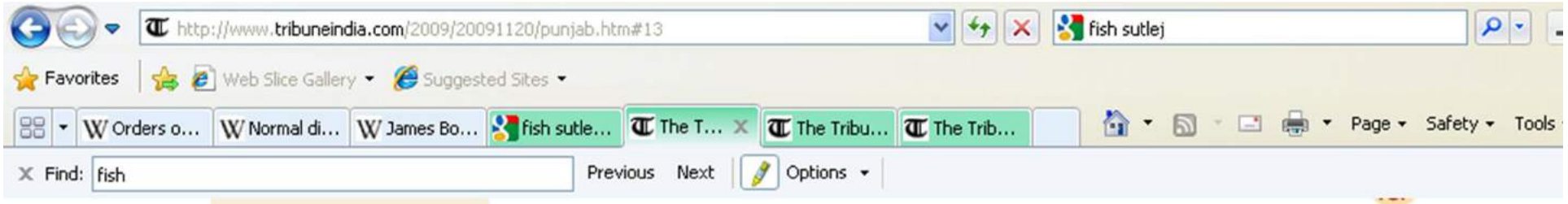
The water turns black at the Walipur confluence itself and continues up to the Harike lake where the Beas merges into the Sutlej. There is no fish in the Sutlej from Walipur to Harike. The Beas waters mix with the Sutlej to dilute the impact of the nullah.

Experts say a survey needs to be conducted to find out the level of toxicity in the Sutlej. The expert committee has restricted its investigation to Ludhiana and its outskirts.

They say even the quality of fish needs to be checked as it might be suffering from diseases due to pollution. It may also be hazardous to migratory birds.

The depth and distance of the pollution should also be taken into account.

Since the water is used for drinking and irrigation in Ferozepore, Faridkot, Muktsar and parts of Rajasthan, a study should be conducted about the impact on soil and the health of humans.



20091120

Dead fish: PSHRC takes notice

More dead fish found

Tribune News Service

Nangal, November 19
The Punjab State Human Rights Commission has taken cognizance of the incident of death of thousands of fish in the Sutlej waters at Nangal. The commission has sought report in this regard from the state government, through the Chairman, Punjab State Pollution Control Board (PPCB), Patiala, and the Principal Secretary, Irrigation Department, Punjab, Chandigarh, by December 31.

Thousands of dead fish were found floating in the Sutlej waters yesterday morning. The death of the fish was reportedly due to high level of toxicity in the water.

A team of the Punjab State Pollution Control Board, headed by SDO Ramji Dass, has collected samples of water from various points in the river and also from the effluent discharge points of industrial units in the area.

Meanwhile, more dead fish were found floating in the Sutlej waters near Bela Dhyani village today. Stench was emanating from the dead fish. Many small dead fish were seen floating on the surface of water, while people continued to collect them for selling in the market.

Assistant director of the Fishery Department Sukhjinder Singh visited the spot and collected samples. He said the samples would be sent for testing to a laboratory at Chandigarh.

100510/punjab.htm#5 fish sutlej

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Previous Next Options

Once again, fish found dead in Sutlej

The nearby National Fertilizers Limited might have released its effluents into the river

Megha Mann
Tribune News Service

20100510

Nangal, May 9
Industrial wastes being dumped into the Sutlej have once again claimed aquatic life over an area of 10-12 km here.

A handful of dead prawns. Photo by writer

A large number of fish and prawns were found floating downstream the Nangal Dam towards Dadauli village near the effluent discharge area of National Fertilizers Limited (NFL) yesterday.

Today, SDM Nangal Lakhmir Singh and NFL officials visited the site that emitted foul smell, and met villagers who apprised them of the

20100521

Dead Fish in Sutlej

Ammonia behind Sutlej fish mortality

Megha Mann
Tribune News Service

Ropar, May 20
The samples of dead fish collected near Bela Dhiani village in Nangal on May 9 were found to contain high levels of ammonia.In a strong-worded letter to the chairman of the Punjab Pollution Control Board (PPCB) demanding stern action against erring people, Deputy Commissioner Ropar Arunjit Singh Miglani has stated that the incident of fish deaths had evoked strong protests from various organisations in the region against those industries that were "responsible" for it.

Miglani stated that the Fishery Department collected four samples of dead fish and sent the same to Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, for tests.

The samples were found to contain 0.186 mg per litre ammonia as against optimum range of less than 0.05 mg per litre. Miglani observed that since this report was based on the samples collected on May 9, it is obvious that the levels of ammonia must have been much higher on May 8.

20100713

NFL told to release fish seed into Sutlej

To deposit Rs 7.2 lakh with special panel before July 15

Megha Mann
Tribune News Service

Nangal, July 12
Taking strict note of National Fertilizers Limited repeatedly polluting the Sutlej waters and causing fish mortality, the district administration Ropar has directed it to release in it fish seed worth Rs 7.2 lakh for the rejuvenation of the water body.

Deputy Commissioner Arunjit Singh Miglani has constituted a committee that would ensure that quality fish seed is stocked into the Sutlej. The NFL has been directed to deposit Rs 7.2 lakh with the committee before July 15.

The committee comprises SDM Lakhmir Singh (chairman), assistant director fisheries Sukhwinder Singh (member secretary), a member from the NFL and an executive engineer from the headwater works, Ropar.

Directions have been issued that transparency should be maintained in the whole process aimed at rejuvenation of aquatic life in the river

20100815

Heavy silt discharge into rivers hits fish life

Kuldeep Chauhan
Tribune News Service

Mandi, August 14
With August-September being the peak fish breeding season, the heavy silt discharge triggered by large-scale construction of hydropower projects and cement companies on the Beas, Sutlej and their tributaries has pushed the once rich fish life to brink in these rivers.

The plight of fish life is understandable as the Fisheries Department has no study or data to know the exact dimension of damage done to the state's marine life by the hydropower and cement companies over the years.

The main culprits responsible for ruining the fish breeding habitats are the Bhakra Beas Management Board, HPSEB-run Larji power project, Sutlej Jal Vidyut Nigam Limited (SJVN), National Hydroelectric Power Corporation (NHPC), National Thermal Power Corporation (NTPC), JP hydro and Allain and Duhangan hydro company, revealed fishery experts

High toxic metal content in crops irrigated by nullah sewage

KS Chawla

Ludhiana, August 1
The indiscriminate use of untreated water, mostly polluted with industrial effluents, has led to the contamination of agricultural land around the Buddha Nullah, which passes through the industrial capital of Punjab.

The nullah, which runs 18 km through Ludhiana town, causes a number of problems for residents living along it, particularly during the monsoon.

Like every year, the municipal corporation this time, too, failed to get it cleaned before the onset of the monsoon. The Drainage Department is assigned the duty of cleaning the nullah.

According to a latest study conducted on the Buddha Nullah by the Department of Soils, Punjab Agricultural University, a high concentration of lead, chromium, cadmium and nickel has been found in the soil irrigated by the nullah sewage. Consequently, the crops grown in the area irrigated with sewage has a high toxic metal content, says Dr Yadvinder Singh, Professor and Head, Department of Soils, PAU.

The study has pointed out that leafy vegetables like spinach, Indian mustard, Indian clover and coriander accumulate relatively higher concentration of toxic elements in the sewage-irrigated soil as compared to the tube well-irrigated soil.

The Department of Soils has observed that the concentration of lead, chromium, cadmium and nickel in shallow underground water (handpump water) within 200m of Buddha Nullah was significantly higher than the permissible limits.

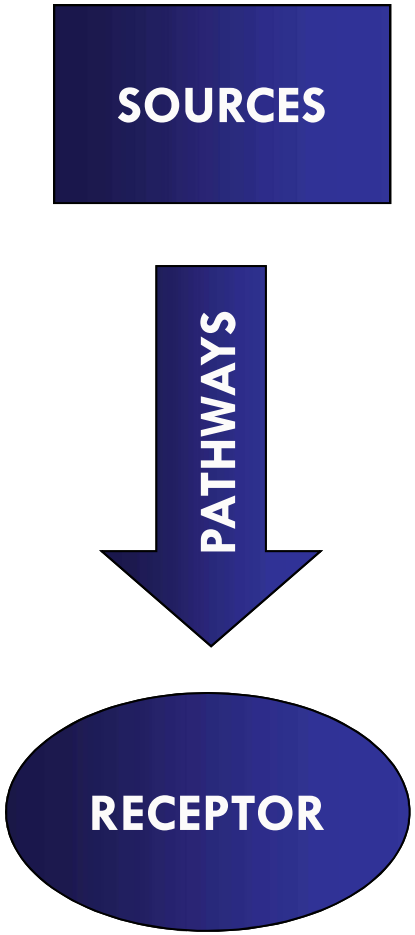
- Sources
  - Point – single large sources
  - Non-point - a diffuse source of pollution that cannot be attributed to a clearly identifiable, specific physical location or a defined discharge channel.
    - general runoff of sediments
    - pesticide spraying
    - fertilisers from farms an urban areas

- Contaminants affecting water bodies
  - Biodegradable organic matter
  - Suspended, colloidal and dissolved solids
  - Nutrients
  - Pathogens
  - Acidic, basic and ionic species
  - Soaps and detergents
  - Pesticides
  - Colour and odour causing substances
  - Volatile organics
  - Recalcitrant and refractory organics
  - Thermal / Radioactive material

- **Catagories**
  - ***fund pollutants***
    - *Degradable* – organic residuals that are broken down by bacteria
    - *Thermal* – injection of heat into water source
    - *Eutrophic* – excessive nutrients (nitrogen, phosphorous) leading to too much aquatic plant growth
    - *Persistent pollutants* – inorganic/synthetic chemicals that are only partially broken down
    - *Bacteria, viruses, artificial hormones* – from domestic and animal wastes
  - ***stock pollutants***
    - *Minerals and inorganic/organic chemicals* that cannot be removed by natural processes (lead, cadmium, mercury, some agrochemicals)

- Effects
  - Eutrophication
  - Food Chain contamination
    - Metals, organics, pathogens
  - Loss of biodiversity
  - Destruction of natural resources
- Monitoring of water bodies
  - Physico-chemical monitoring
  - Biological monitoring

- Imp. components of monitoring



VARIABLES

- Contaminants
- Concentrations
- Time
- Locations

- Rates of migration
- Time
- Loss and gain functions

- Types
- Sensitivities
- Time
- Concentrations
- Numbers

WATER POLLUTION

Nature and Characteristics

Physico-chemical characteristics

- Aggregate organics
  - Biochemical Oxygen Demand (BOD)
  - Chemical Oxygen Demand (COD)
  - Total Organic Carbon (TOC)
- Chemical
  - Organics – Proteins, carbohydrates, lipids, surfactants, phenols, pesticides, etc.
  - Inorganics – pH, chlorides, alkalinity, nitrogen, phosphorous, heavy metals,
  - Gases - oxygen, hydrogen sulphide, methane, etc.
- Physical
  - Solids, temperature, colour, odour, turbidity, oil and grease, conductivity
- **Sampling – Grab, composite & flow weighted composite**

Aggregate organics

- Dissolved Oxygen (DO)
  - Important measure of water quality
  - Oxygen is marginally soluble in water & inversely proportional to temperature
  - Maximum DO at water temparature of 16 deg.C is 10 mg/L
  - DO analysis measures the amount of gaseous oxygen (O_2) dissolved in an aqueous solution (Winkler's [iodometric] method)
  - Oxygen gets into water by diffusion from the surrounding air, by aeration (rapid movement), and as a product of photosynthesis.
  - As dissolved oxygen levels in water drop below 5 mg/l, aquatic life is put under stress.

BOD

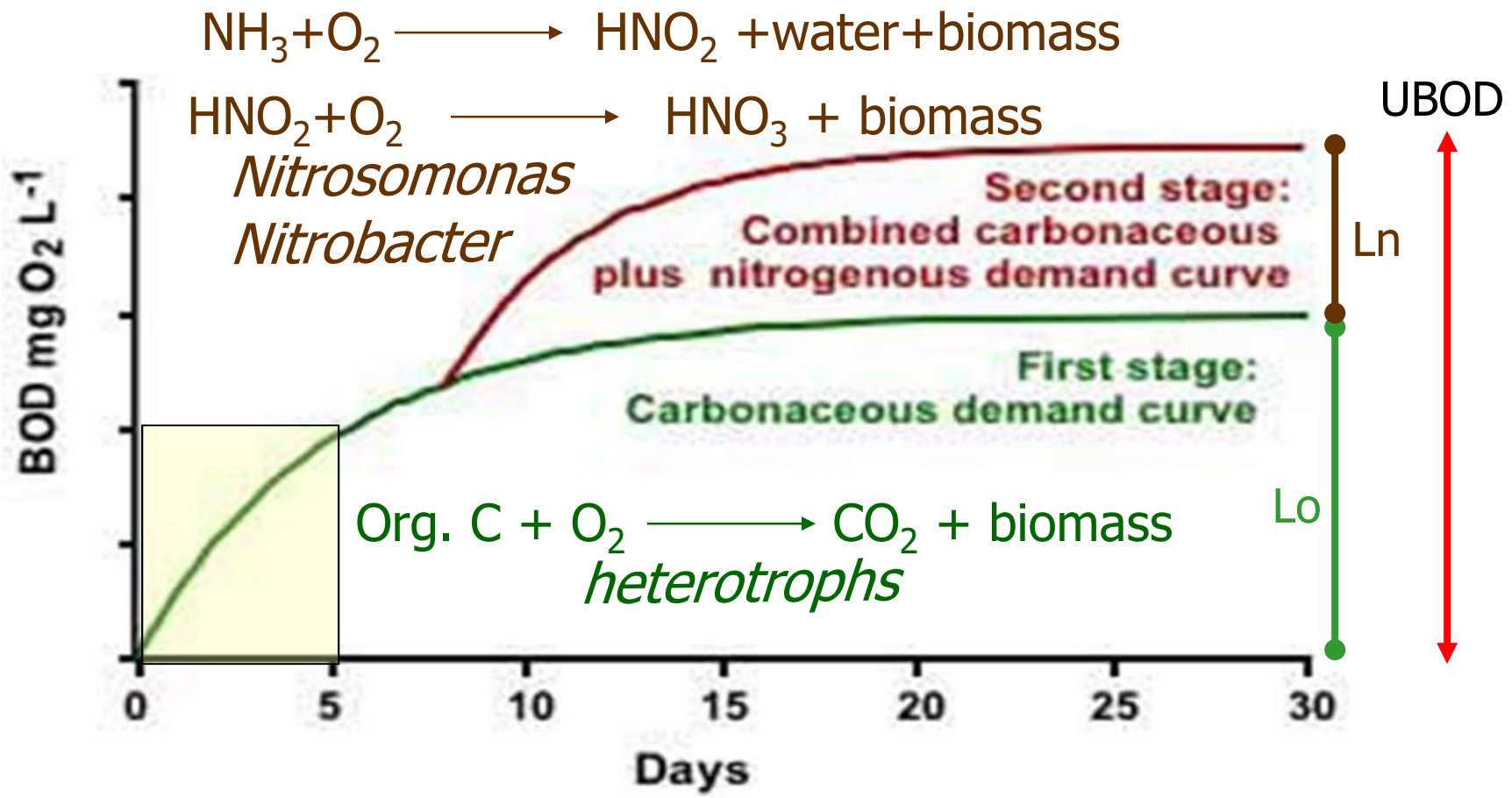
- The Biochemical (or Biological) oxygen demand (BOD) is a measure of the amount of dissolved oxygen required to break down the organic material in a given volume of water through aerobic biological activity. (By Micro-organism)

Aggregate organics

- Biochemical Oxygen Demand (BOD)
  - BOD is not a measure of any specific pollutant
  - A measure of amount of oxygen required by microorganisms engaged in stabilizing decomposable organic matter
  - Important factors of variations
    - Temperature; Time; Light
  - BOD measurements – BOD_5 & BOD_3
  - BOD_5 – BOD test carried out in dark at 20 deg.C for 5 days
  - Why 5 day BOD ?
    - Oxidation of biochemical oxygen demanding substances is an exponential decay curve
    - Decay constant is usually that most of these substances are oxidized (85%) in the first 5 days

Aggregate organics

- Biochemical Oxygen Demand (BOD)
  - Exponential decay curve



Aggregate organics

- Biochemical Oxygen Demand (BOD)
  - Features
    - It is a property measurement of the sample
    - Dependence of oxygen demand on nature and quantity of food
    - Dependence of oxygen demand on nature and amount of biodegrading organisms mainly bacteria
  - Limitations
    - Requirement of active, acclimatized seed
    - Pretreatment necessary if toxic compounds are present
    - 5 day BOD may or may not correspond with soluble org. matter usage
    - Applicable only to biodegradable organics

Method for the measuring of BOD

- **Dilution method**

  To ensure that all other conditions are equal, a very small amount of micro-organism seed is added to each sample being tested.
- **Undiluted: Initial DO - Final DO = BOD**
- **Diluted: ((Initial DO - Final DO)- BOD of Seed) x Dilution Factor**

Biochemical Oxygen Demand (BOD)

Amount of oxygen used by microorganisms to decompose organic matter in a water

Theoretical BOD can be determined by balancing a chemical equation in which all organic matter is converted to CO_2

Calculate the theoretical oxygen demand of 1.67×10^{-3} moles of glucose ($C_6H_{12}O_6$):

$$C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O$$ **general, unbalanced eqn**

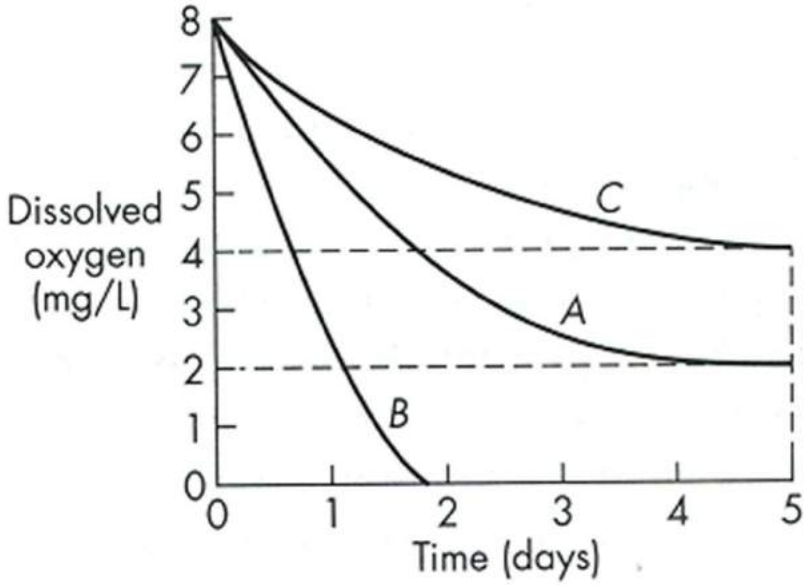
$$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$$

1.67×10^{-3} moles glucose/L x 6 moles O_2/ mole glucose x 32 g O_2/mole O_2

= 0.321 g O_2/L = 321 mg O_2/L

BOD = I - F

I = Initial DO
F = Final DO



If all the DO is used up the test is invalid, as in B above

To get a valid test dilute the sample, as in C above. In this case the sample was diluted by 1:10. The BOD can then be calculated by:

BOD = (I – F) D **D = dilution as a fraction**

D = volume of bottle/(volume of bottle – volume of dilution water)

BOD = (8 – 4) 10 = 40 mg/L

For the BOD test to work microorganisms have to be present. Sometimes they are not naturally present in a sample so we have to add them. This is called "seeding" a sample

If seed is added you may also be adding some BOD. We have to account for this in the BOD calculation:

$$BOD = [(I - F) - (I' - F')(X/Y)]D$$

Where: I' = initial DO a bottle with only dilution water and seed
F' = final DO of bottle with only dilution water and seed
X = amount of seeded dilution water in sample bottle, ml
Y = amount of seeded dilution water in bottle with only seeded dilution water

Example

Calculate the BOD_5 of a sample under the following conditions. Seeded dilution water at 20°C was saturated with DO initially. After 5 days a BOD bottle with only seeded dilution water had a DO of 8 mg/L. The sample was diluted 1:30 with seeded dilution water. The sample was saturated with DO at 20°C initially. After five days the DO of the sample was 2 mg/L.

Since a BOD bottle is 300 ml a 1:30 dilution would have 10 ml sample and 290 ml seeded dilution water.

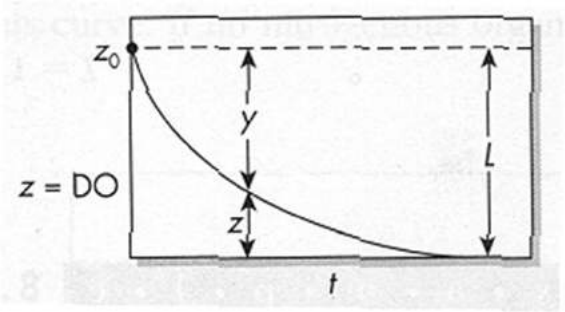
From the table, at 20°C, DO_{sat} = 9.07 mg/L

$$BOD_5 = [(9.07 - 2) - (9.07 - 8)(290/300)]\ 30 = 174 \text{ mg/L}$$

If we do a mass balance on the BOD bottle:

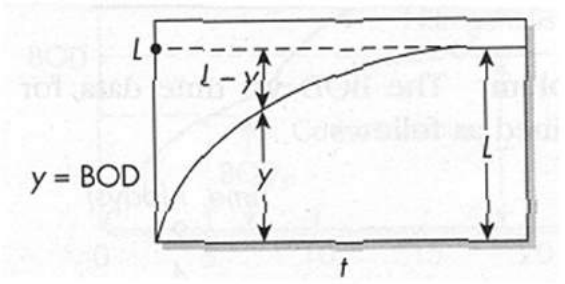
$$dz/dt = -r$$

Where: z = dissolved oxygen necessary for the microorganisms to decompose the organic matter



If r is first order:

$$dz/dt = -k_1 t$$



Separate the variables and integrate:

$$z = z_0 e^{-k1 t}$$

Z is defined as the amount of oxygen still to be used by the microorganisms to degrade the waste. If we define y to be the amount of oxygen which already been used to degrade the waste:

$L = z + y$ **L = ultimate demand for O_2**

So: $z = L - y$

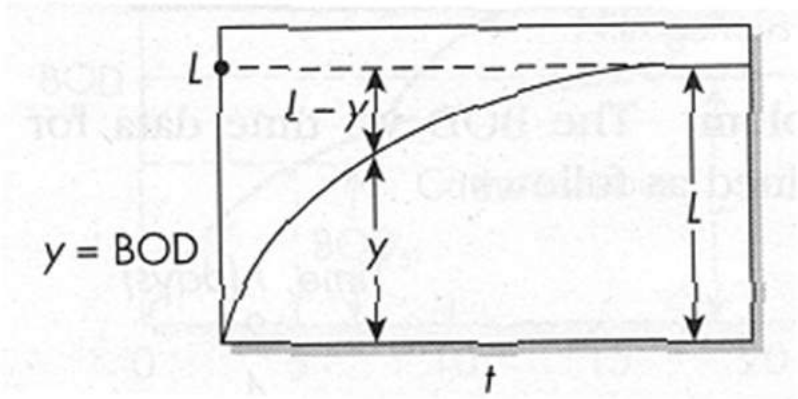
By substitution:

$$L - y = z_0 \, e^{-k1 \, t}$$

But $z_o = L$, so:

$$y = L - Le^{-k1 \, t}$$

Or $y = L(1-e^{-k1 \, t})$



A sample of wastewater has an ultimate BOD of 280mg/L and a 5-day BOD of 240mg/L.
Calculate 20-day BOD of this sample.

- Solution: $y_{20} = L_0 (1-e^{-k*20})$

First calculate k using given data

$y_5 = L_0 (1-e^{-k*5})$

$240 = 280 (1-e^{-k*5})$

$k = 0.39\ d^{-1}$

Then 20-day BOD:

$y_{20} = L_0 (1-e^{-k*20})$

$280 (1-e^{-0.39*20}) = 279.9$ mg/L

Aggregate organics

- Chemical Oxygen Demand (COD)
  - Amount of strong oxidant (Pot. Dicromate) reduced by waste
    - Expressed in equivalent amount of oxygen
  - UBOD vs COD – variations
    - Many organic materials are oxidizable with dicromate but not biochemically oxidizable ex. Pyridine, benzene & ammonia
    - Number of inorganic substances such as sulphides, sulphites, thiosulphates, nitrates and ferrous ions are oxidized by dicromate – creating inorganic COD

Aggregate organics

- Chemical Oxygen Demand (COD)
  - Useful for effluents containing
    - Caustics
    - Dyeing and textile discharges
    - Non-biodegradable organics
    - Paper mill discharges
    - Paints, plastics, metals and ammonia

Aggregate organics

- BOD and COD relationship
  - Acceptable level of variations $\pm$ 20% for BOD and $\pm$ 10% for COD
  - Reliable statistical correlation can be achieved when
    - Org. strength is higher
    - Diversity of dissolved organics is lower
  - COD values are higher than BOD values in nearly all cases
  - Greater BOD-COD ratio – higher the efficiency of organic treatment by biological methods

Physical Parameters - Solids

Total Solids (TS)	Residue remaining after wastewater sample has been evaporated and dried at a specific temperature (103 – 105 deg. C)
Total Volatile solids (TVS)	Burn off solids when TS is ignited to 500 deg.C
Total Fixed solids (TFS)	Left out solids after ignition of TS
Total suspended solids (TSS)	Portion of TS retained in filter of 2μm and measured after drying the filter paper at 105 deg.C
Total dissolved solids (TDS)	Solids that passed through 2μm which comprises of colloidal and dissolved solids

Physical Parameters - Solids

Volatile suspended solids (VSS)	Burn off solids when TSS is ignited to 500 deg.C
Fixed suspended solids (FSS)	Residue after TSS ignition
Total volatile dissolved solids (TVDS)	Solids that burn off when TDS is ignited to 500 deg.C
Fixed dissolved solids (FDS)	The residue of the TVDS
Settlable solids	Suspended solids that settle over time

Physical Parameters

- Particle Size Distribution
  - ***TSS is a broad parameter***
  - ***PSD is important in assessing the effectiveness of the treatment such as sedimentation, filtration and disinfection***
  - ***Analytical techniques – microscopy, particle (coulter) counters, chemical seperations***
- Turbidity
  - ***Measure of light transmitting properties of water***
  - ***Measurement is based on comparison of intensity of light scattered by sample vs that of standard (formazin solution)***
  - ***Analytical Techniques – Nephelometry***
- ***Units – Nephelometric Turbidity Units (NTU)***

Physical Parameters

- Colour
  - ***Measured by HACH spectrophotometer***
  - ***Units – Platinum Cobalt Units (PTU)***
- Temperature
  - ***An important parameter as it affects the chemical and biochemical reactions and the rates of these reactions***
- Electrical Conductivity
  - ***A measure of the ability of solution to conduct electric current***
  - ***EC is surrogate measure of TDS [TDS mg/L = EC x 0.55 to 0.70]***
  - ***Units - MilliSiemens/ meter***

Physico-chemical characteristics

- Aggregate organics
- Physical
- Chemical
  - Chlorides
  - Alkalinity
  - Nitrogen
  - Phosphorous
  - Sulphur
  - Metallic constituents

Physico-chemical characteristics

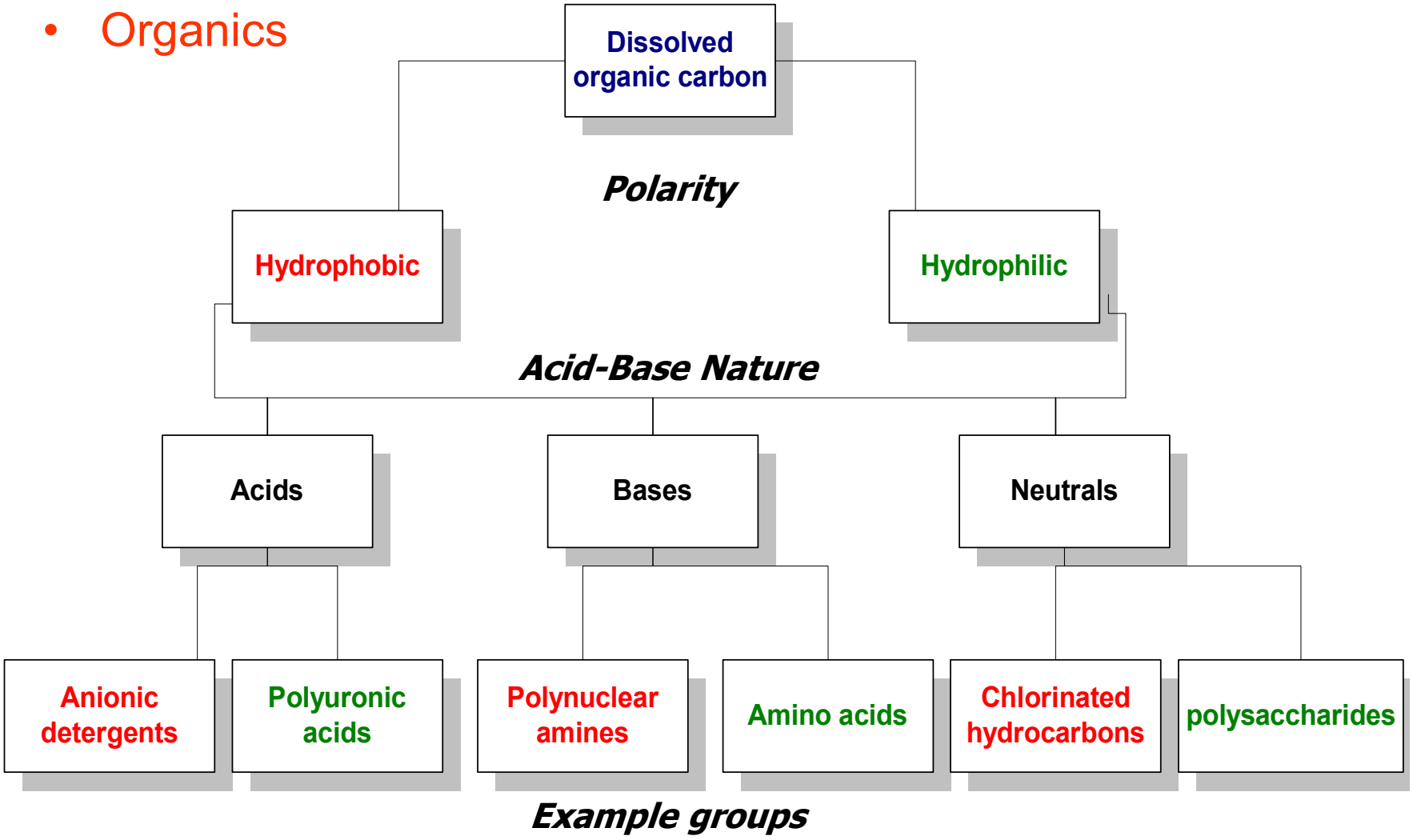
- Chlorides
  - Importance – reuse pattern
  - All sources of wastewater
  - Softeners for nullifying
- Alkalinity
  - Hydroxides, carbonates and bicarbonates
  - Common – Ca & Mg bicarbonates
  - Importance – Biological treatment
- Nitrogen
  - Importance – Nutrient
  - Forms – NH_3, NH_4^+, NO_2^- and NO_3^- & Org. N
  - Measurements – Amm. N., Inorg. N., Kjeldahl N., Org. N

Physico-chemical characteristics

- Phosphorous
  - Aqueous forms – Orthophosphates, polyphosphate & organic phosphates
  - Importance as nutrient
- Sulphur
  - Aqueous form – sulphate
  - Reduced to sulphide and further to hydrogen sulfide
  - Formation of sulphuric acid and pipe corrosion
- Metallic constituents
  - Priority pollutants – Cd, Cr, Cu, Fe, Pb, Mn, Hg, Ni & Zn
  - Micronutrients / Toxicants
  - Measurable forms – dissolved, suspended, acid extractable

Physico-chemical characteristics

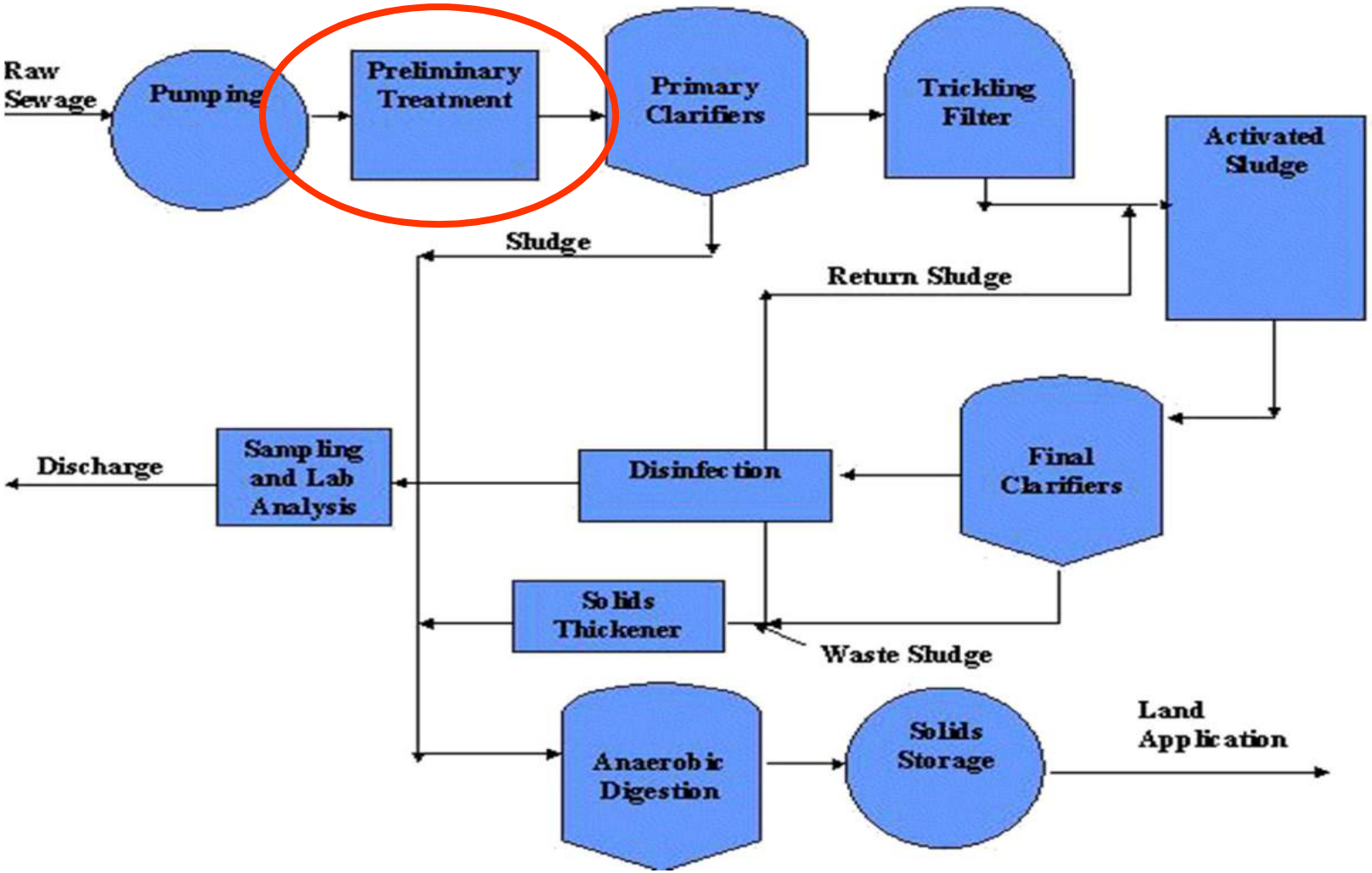
- Organics



- Minimata disease
  - Hg dumped into water → Methyl mercury by bacterial action
  - MeHg accumulated in fish – 1953 people suffered numbness of body parts, vision and hearing problems and mental disorders
  - Disease occurred due to consumption of MeHg contaminated fish caught from Minimata bay, Japan
  - Claimed 50 lives and permanently paralysed 700
- Itai-itai
  - Caused by Cd contaminated rice in Japan – rice fields were irrigated with effluents of Zn smelters and drainage water from mines
  - Affected bones, liver, kidney, lungs, pancreas and thyroid

- Blue baby syndrome
  - Caused by excess Nitrate present in drinking water – also called methaemoglobinemia
  - A part of haemoglobin is converted into non-functional oxidized form
- As poisoning
  - In Bangladesh and West Bengal – excess As compounds in ground water cause skin diseases and cancer

Typical Unit Operations of a Wastewater treatment plant



Screen

- First unit operation
- Objective
  - Removal of coarse and fine objects, which may get entangled in mechanical equipment e.g., grit chambers, sedimentation tanks, etc.
  - protection of pump impellers.
- Coarse screenings
  - Rocks, twigs, leaves, paper, plastic rags and other materials

Comminution

- Objective
  - Grind up coarse solids without removing from the flow
  - Cut to a uniform size
- Types of Comminutors
- Vertical rotating drum screen :
  - consists of rotating drum with slots for the wastewater to pass through
  - Stationary semicircular screen grid mounted in a rectangular channel with rotating circular cutting discs
  - A unit rotating with two large diameter vertical rotating shafts equipped with cutting blades
  - A unit containing conical shaped screen grid, the axis which is located parallel to the channel flow
- Barminutors: to intercept screenings and disintegrate them

Flow Equalization

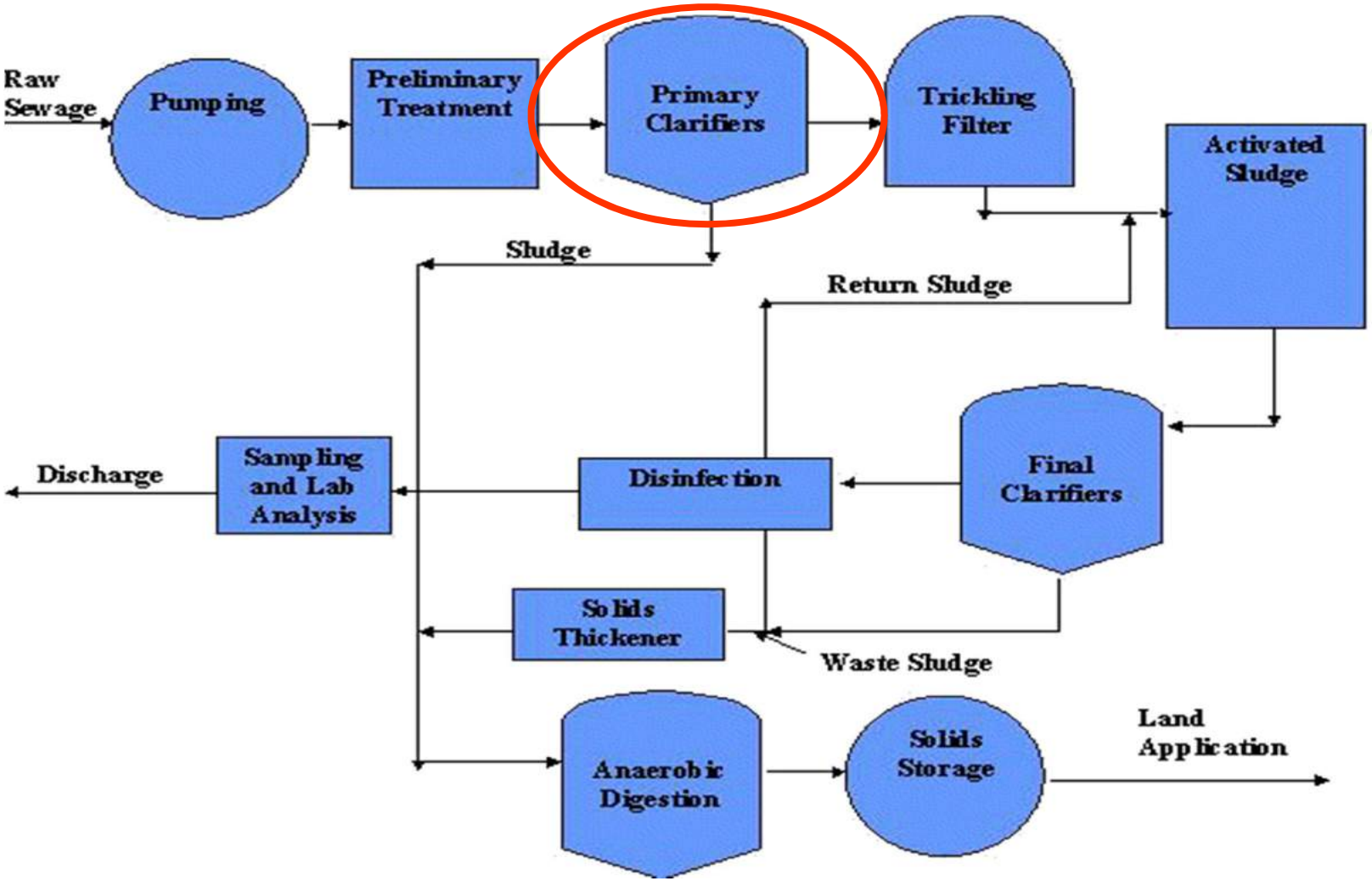
Objectives

- The objectives of flow equalization basins are
  - ***to dampen the diurnal flow variation,***
  - ***as well as variations caused by inflow/infiltration,***
  - ***To achieve a nearly constant flow rate through the downstream treatment processes,***
  - ***to dampen the strength of wastewater constituents by blending the wastewater in the equalization basin,***
  - ***and to maintain operational control.***

Oil & Grease Removal

- **Objectives :**
  - Protect tank walls of subsequent sewage treatment plant facilities from grease deposits.
  - Protect the biological processes, especially air diffusers from grease deposits.
  - They adversely affect bacteria and protozoa life which is essential in bio-treatment.
  - They are difficult to digest, hence the cost of digestion is increased.
  - Oil and grease remover is absolutely necessary, if there is no primary settling in sewage treatment plant.

Typical Unit Operations of a Wastewater treatment plant



Primary clarification/sedimentation

Principle routes of SS removal (particle dia. > 1mm)

- Sedimentation
- Floatation
- Filtration and Screening
- Hydrocyclones and Centrifuges

Principle route of SS removal (particle dia. < 1mm - colloids)

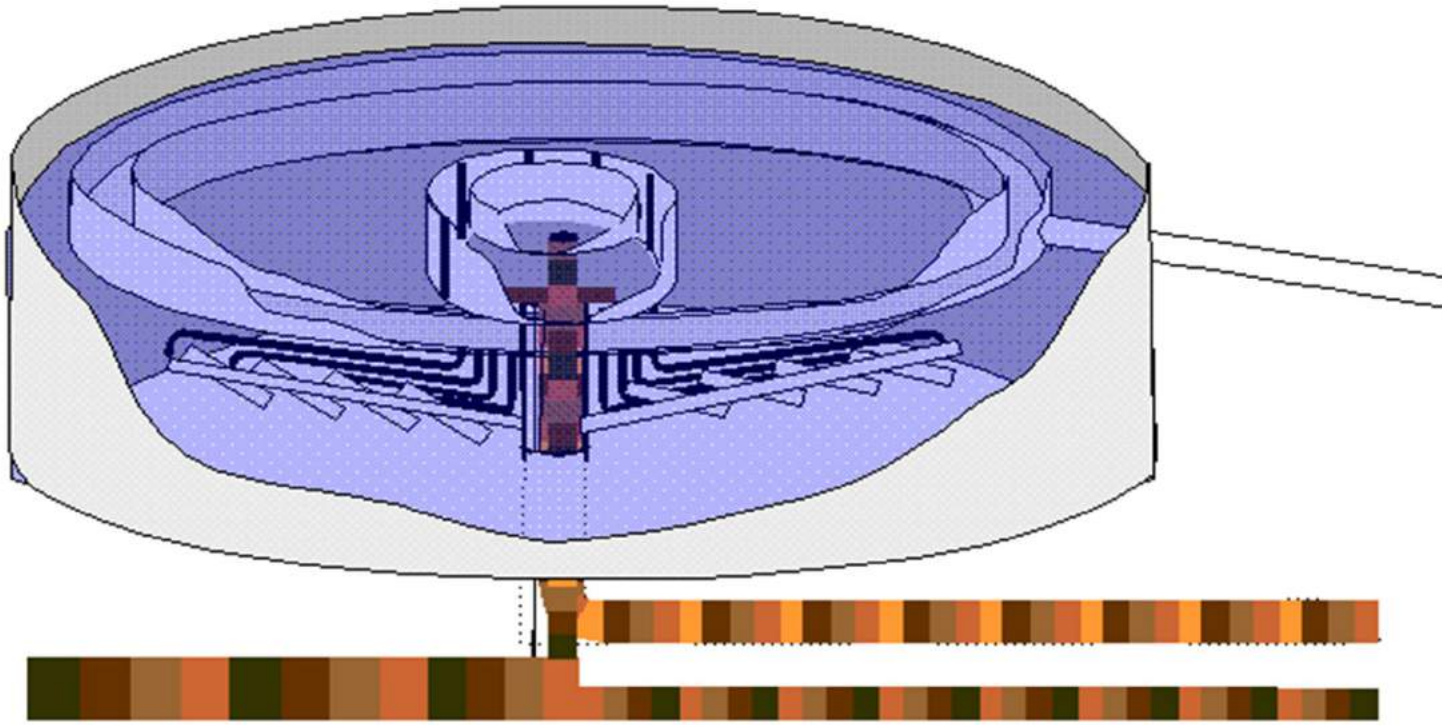
- Coagulation / flocculation

Primary clarification/sedimentation

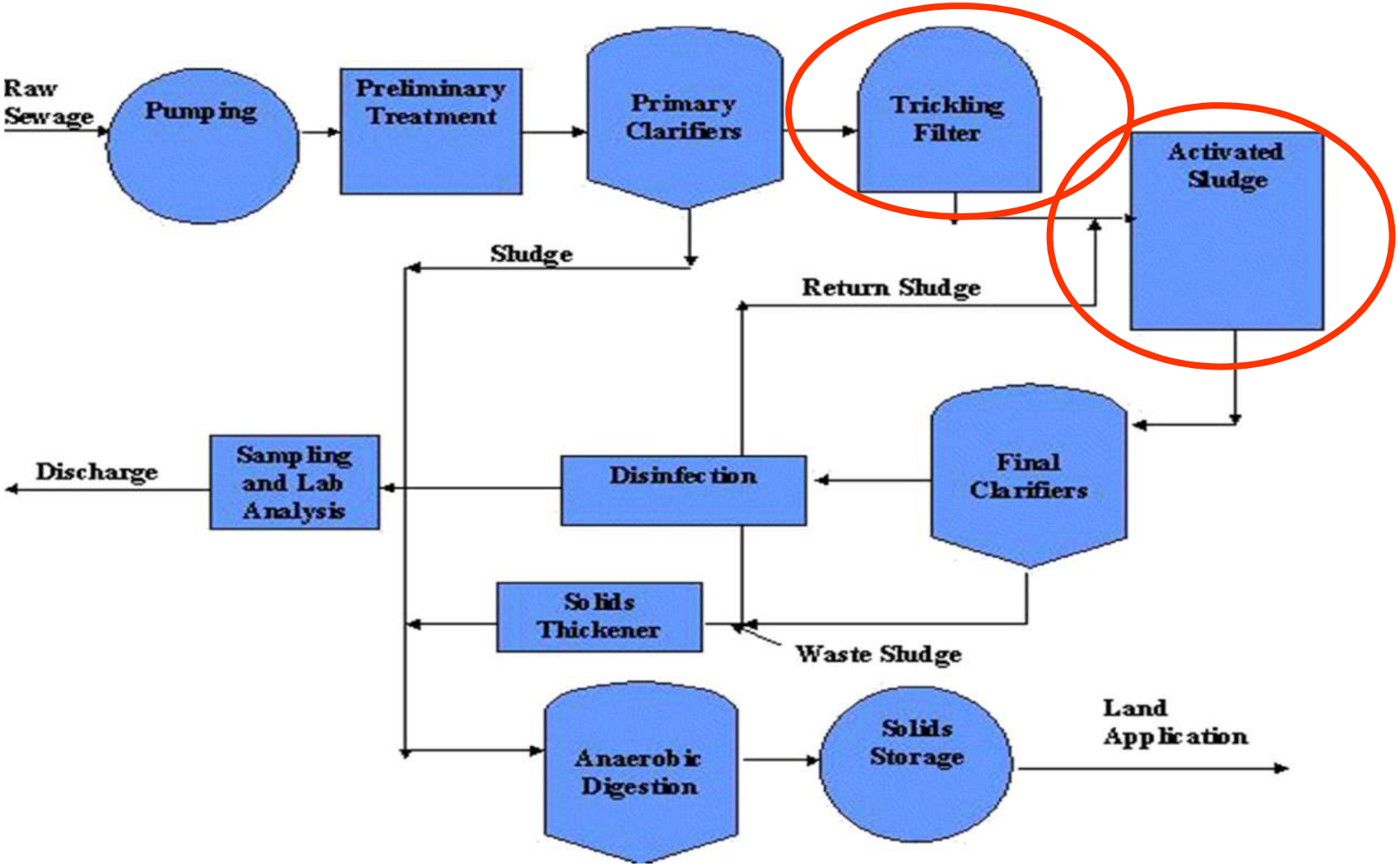
Colloids (particle dia. < 1 mm)

- Cannot be removed from suspension by ordinary physical separation processes
- Very slow settling characteristics of colloids (Brownian motion hinders their settlement under the effect of gravity)
- Contribute large parts of pollution and specific cause of turbidity (higher ratio of surface area to mass)
- Surface properties such as electrical charges play more important role than sedimentation under gravity

- Sludge removal – circular clarifier
  - ***Scraper or plower***



Typical Unit Operations of a Wastewater treatment plant



Fundamentals

- Objectives
  - To coagulate and remove non-settlable colloidal solids
  - To stabilize organic matter/substances
  - To remove trace toxic organics
  - To remove nutrients
  - To reduce inorganic concentration

- All these carried out by microbes
  - *Based on form of carbon required*

    Autotrophs (photo-auto/chemo-auto) &

    Heterotrophs (photohetero/chemohetero)
  - *Based on energy source*

    Phototrophs & Chemotrophs (chemo-organo/chemo-auto)
- reactions catalyzed microbial enzymes
  - Hydrolytic, oxidative and synthetic

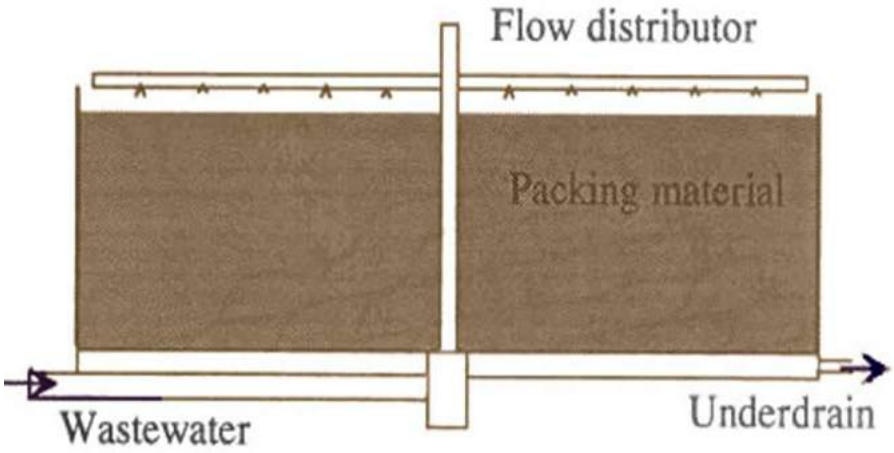
Fundamentals

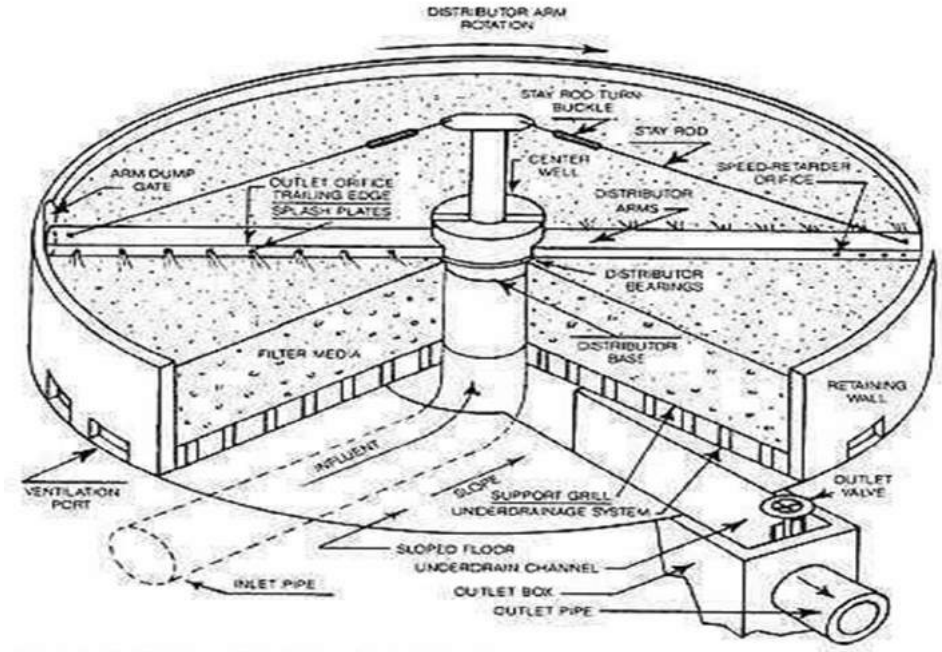
- Most of the enzymatic reactions involve redox reactions i.e., addition/removal of oxygen/hydrogen
- The electron acceptor is based n surrounding medium and cellular characteristics
  - In anaerobic reactions – an oxidized compound is electron acceptor
  - In aerobic reactions – oxygen is acceptor
- Environmental factors that influence microbial growth
  - Temperature
    - Psychrophilic – (-10 to 30 deg.C) opt. 12–18 ^{0}C
    - Mesophilic – (20 to 50 deg.C) opt. 25-40 ^{0}C
    - Thermophilic – (35 to 75 deg.C) opt. 55-65 ^{0}C
    - facultatives

Trickling filters

- A trickling filter (TF) is a wastewater treatment system that biodegrades organic matter and can also be used to achieve nitrification.
- The wastewater trickles through a circular bed of coarse stones or plastic material. A rotating distributor (a rotating pipe with several holes across it) evenly distributes the wastewater from above the bed.
- The microorganisms in the wastewater attach themselves to the bed (also known as the filter media), which is covered with bacteria.
- The bacteria break down the organic waste and remove pollutants from the wastewater.

Trickling filters





- Process microbiology
  - ***Bacteria – Aerobic and anaerobic***
  - ***Predominant facultative bacteria belong to Acromobacter, Flavobacterium, Pseudomonas***
  - ***In slime layer – Sphaerolitus & Beggiotoa***
  - ***In lower layer – Nitrosomonas & Nitrobacter***
  - ***Fungi – Fusarium, mucor, Pencillium, Geotrichum, yeasts***
  - ***Algae - Chlorella, Ulothrix & Rhormodium***

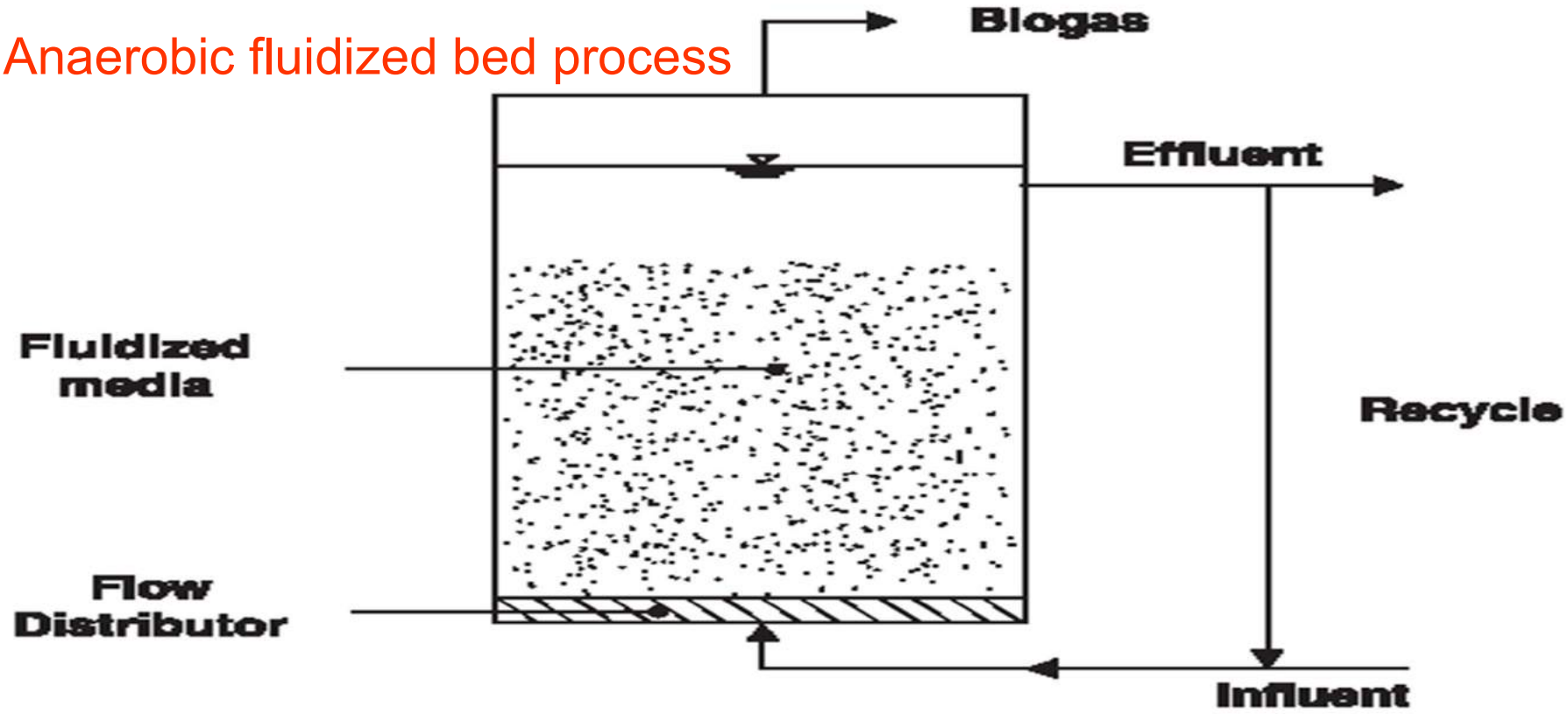
Activated sludge processes (ASPs)

- Process Microbiology
- ASP is an aerobic, continuous flow, treatment system that uses sludge with active populations of microorganisms to breakdown organic matter in w/w
- Activated sludge is a flocculated mass of microbes
- Bacteria involved in ASP primarily belong to gram –ve bacteria belonging to genera such as *Pseudomonas, Zooglea, Flavobacterium*
- *Protozoans* include flagellates, amoeba, ciliates which control free swimming bacterial population

Activated sludge processes (ASPs)

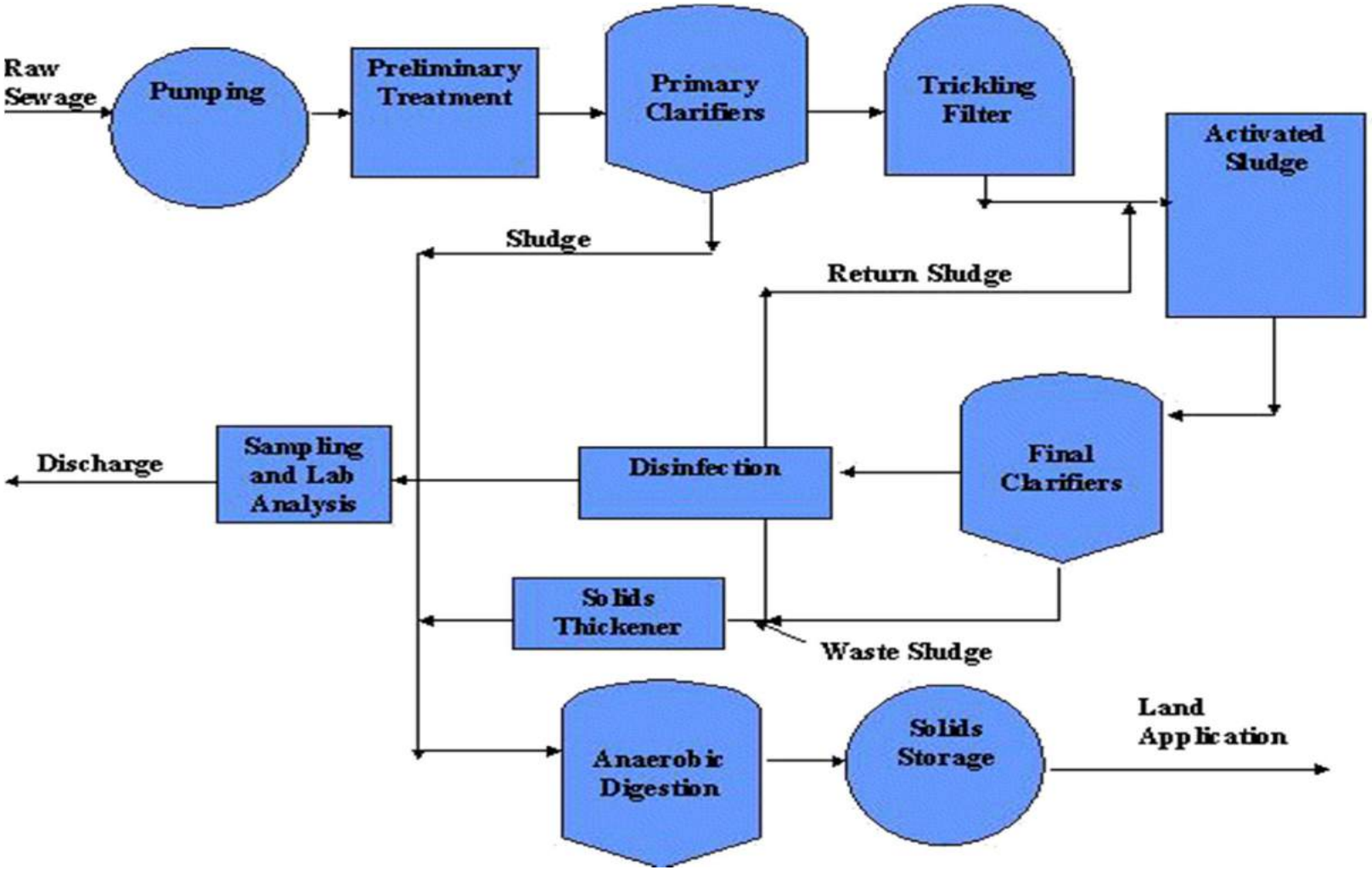
- The organic load (generally coming from primary treatment operations such as settling, screening or flotation) enters the reactor where the active microbial population (activated sludge) is present.
- The reactor is continuously aerated.
- The mixture then passes to a secondary settling tank where the cells are settled.
- The cells are recycled in order to maintain sufficient biomass to degrade the organic load as quickly as possible.

Anaerobic fluidized bed process

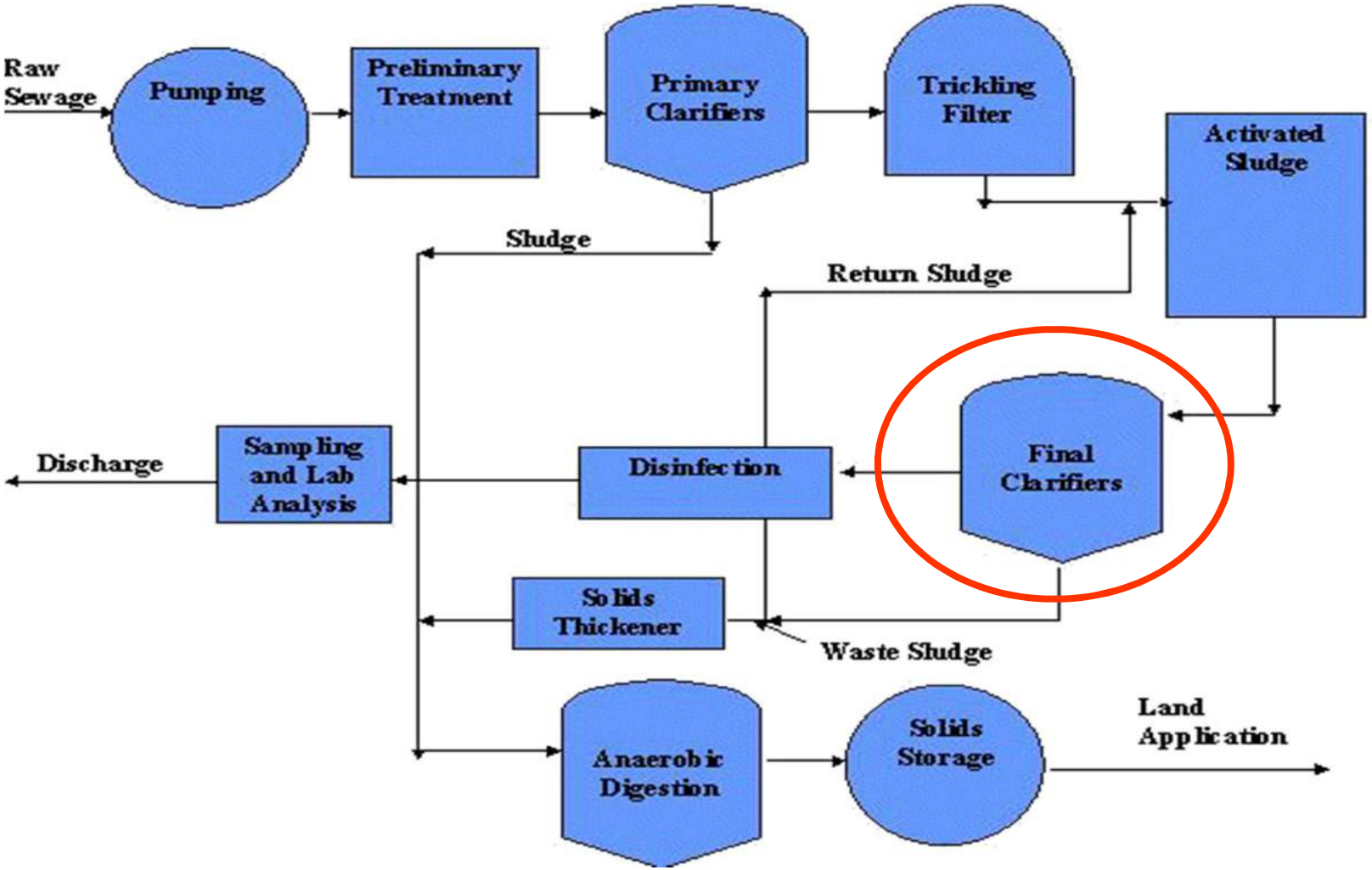


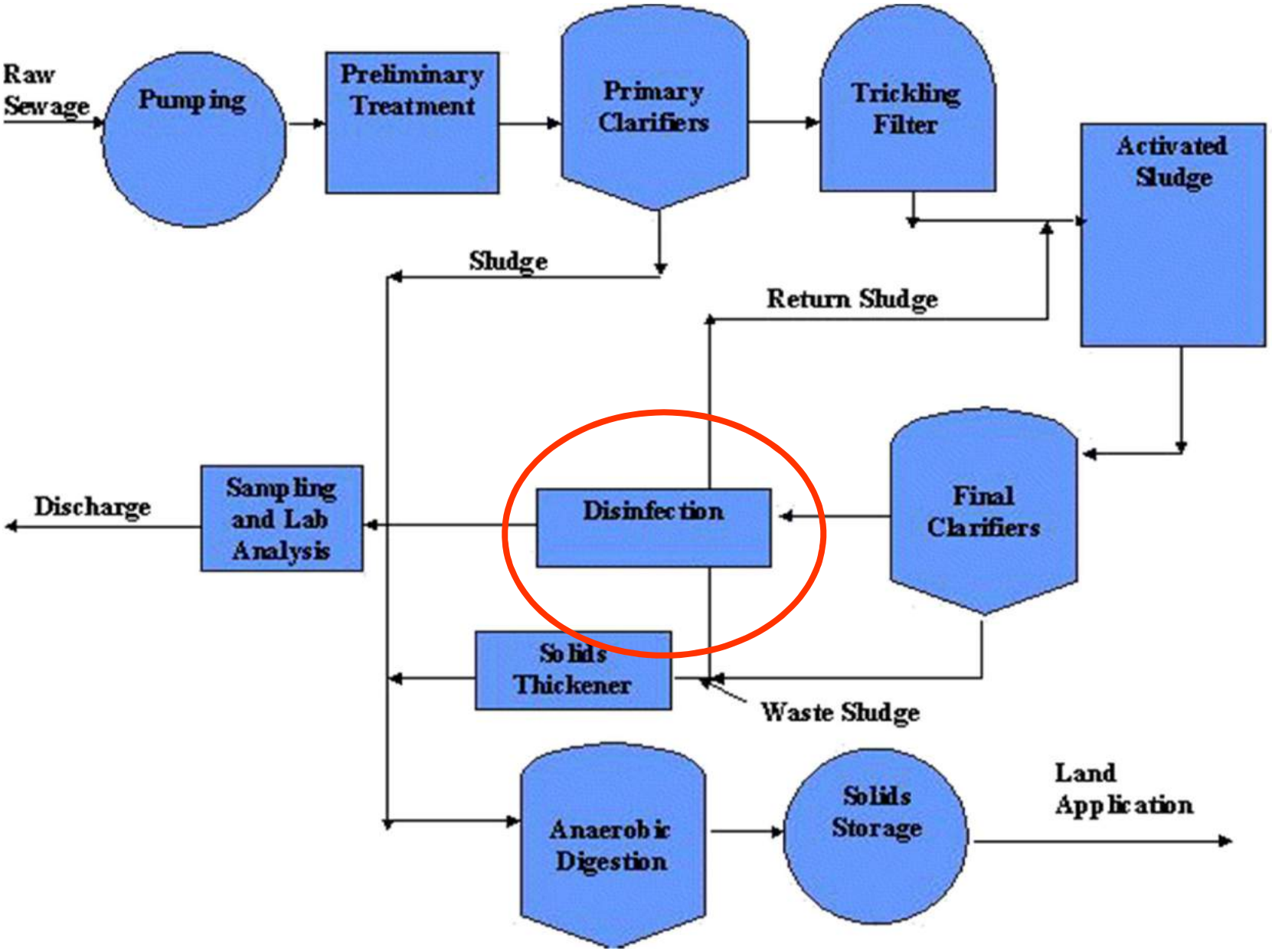
- A combination of suspended growth and attached growth process
- Anaerobic microbes grow on the surface of the medium, expanding the apparent volume of the medium; hence this reactor is also designated an "expanded bed reactor"

Typical Unit Operations of a Wastewater treatment plant



Typical Unit Operations of a Wastewater treatment plant




Raw Sewage
Pumping
Preliminary Treatment
Primary Clarifiers
Trickling Filter
Activated Sludge
Sludge
Return Sludge
Discharge
Sampling and Lab Analysis
Disinfection
Final Clarifiers
Solids Thickener
Waste Sludge
Anaerobic Digestion
Solids Storage
Land Application