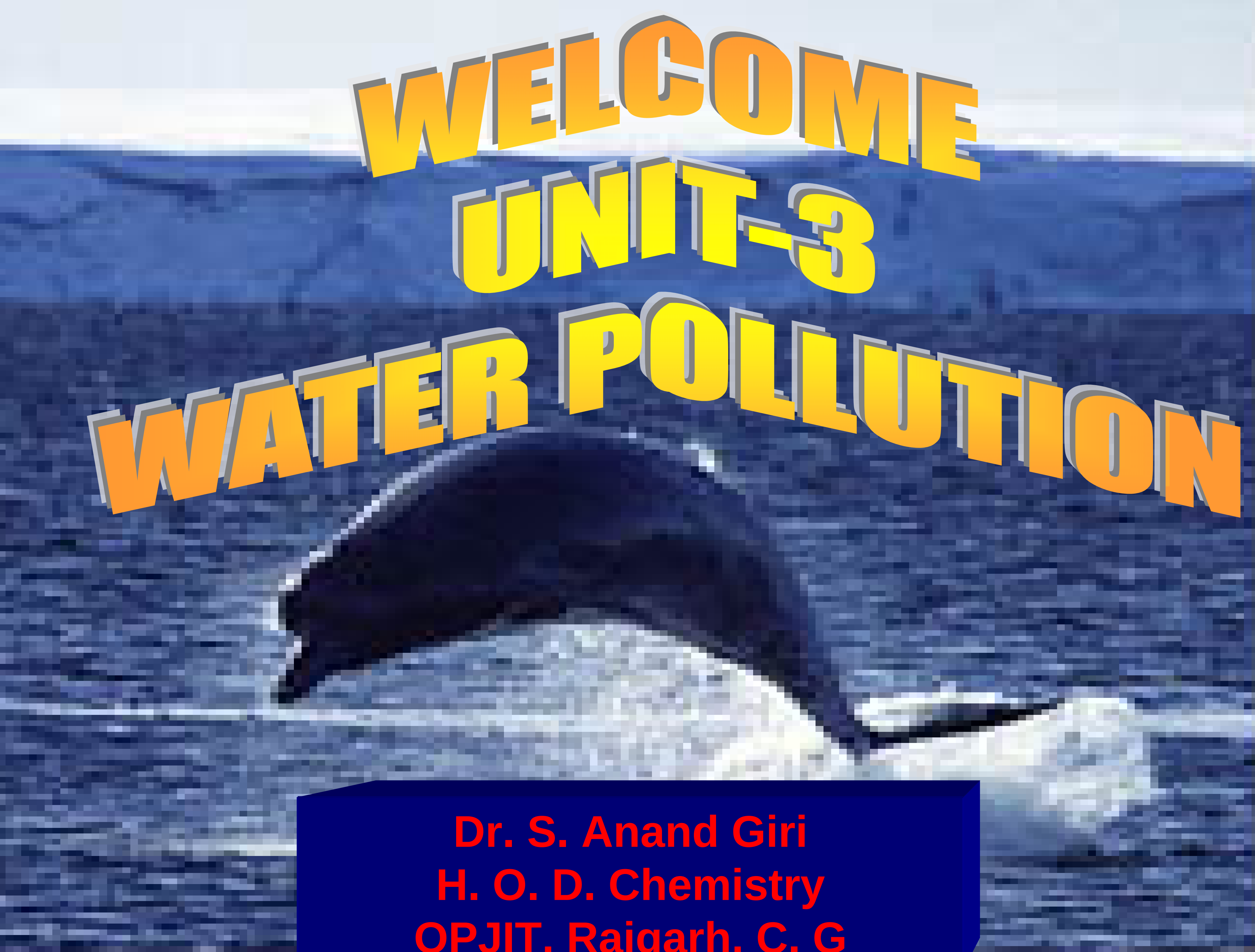

WELCOME
UNIT-3
WATER POLLUTION

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L-23 Introduction: Hydrosphere & natural water

- It includes all the surface and ground water resources like
- Oceans, seas, rivers, streams and other reservoirs.
- Earth is called the 'Blue Planet'
- about 80% of the earth is covered by water but,

L-23 Introduction: Hydrosphere & natural water

About 97% of the total water is

- locked-up in the oceans and seas,
- which is too saline to drink and for the direct use for
  - agricultural and
  - industrial purposes.

26/9

L-23 Introduction: Hydrosphere & natural water

- About 2% of the total water is locked up in glaciers And ice caps and-
- only 1% is available as fresh water.
- It also regulates the body temperature of all the living beings.

26/9

L-23 Introduction: Hydrosphere & natural water

- **Water is said to be 'universal solvent'.**
- **It can dissolve most of the**
- **natural elements and organic matters.**

26/5

L-23 Introduction: Hydrosphere & natural water

WATER is found in nature in different forms:

- **Rain water,**
- **ground water,**
- **river water,**
- **Lake water,**
- **spring water etc.**

Potential drinking water sources are either ground water or surface water.

26/9

L-23 Introduction: Hydrosphere & natural water

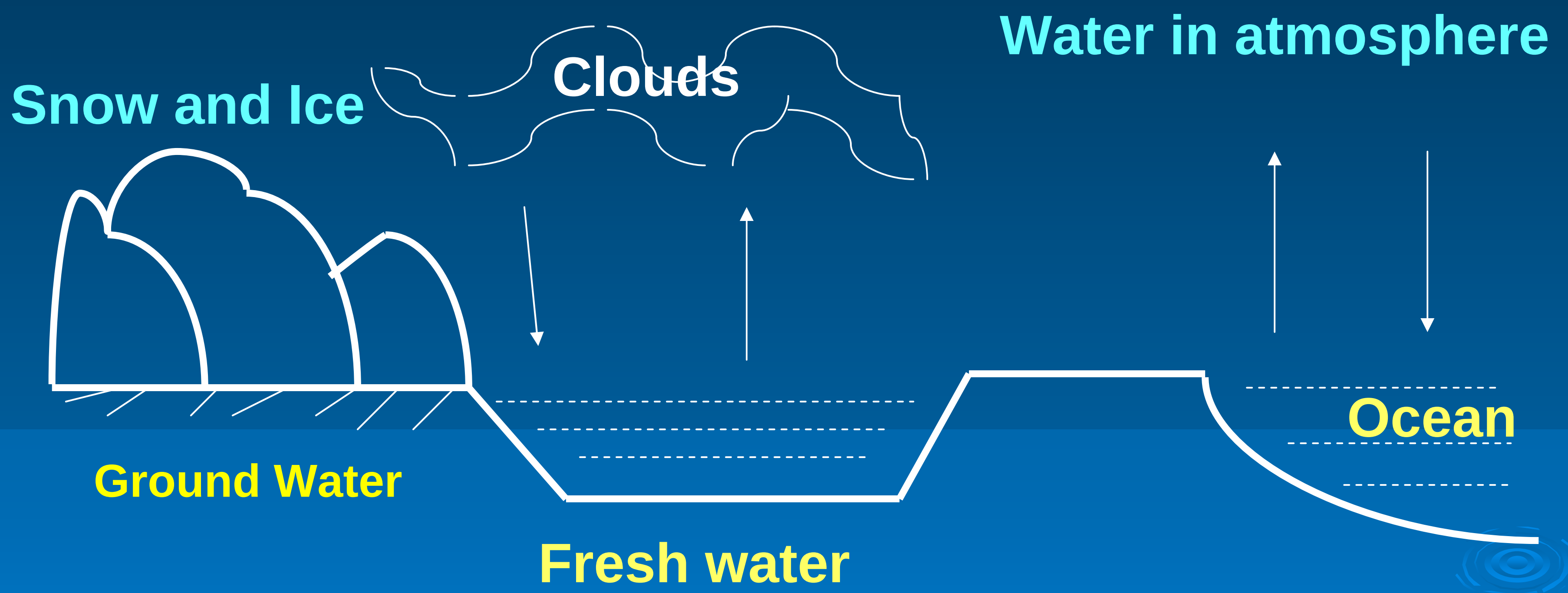
1. **Ground Water:**

"Water contained at the pores and cracks of the soil under the earth surface is called Ground water."

- coming from deep in the ground from the underground aquifers into which wells are bored.

26/9/06

GROUND WATER



L-23 Introduction: Hydrosphere & natural water

- Water in such aquifers is replaced very slowly.

underground

- The upper boundary of saturation zone is called water table or ground water level, formed due to-

26/9

- Downward flow of water through porous and permeable rocks.

L-23 Introduction: Hydrosphere & natural water

- The level of water table increases in wet season with increase in percolation and
- Decreases in dry season.
- Generally it is clear and colourless but contains dissolved inorganic salts.
- Ground water is free from bacteria because this is filtered out through the subsoil.

mineral water

Best to drink

26/9

L-23 Introduction: Hydrosphere & natural water

- Underground water sources are found in the form of **springs, wells, infiltration wells** and **glaciers.**
- This is of **immense importance** helps to maintain the levels of lakes and rivers.

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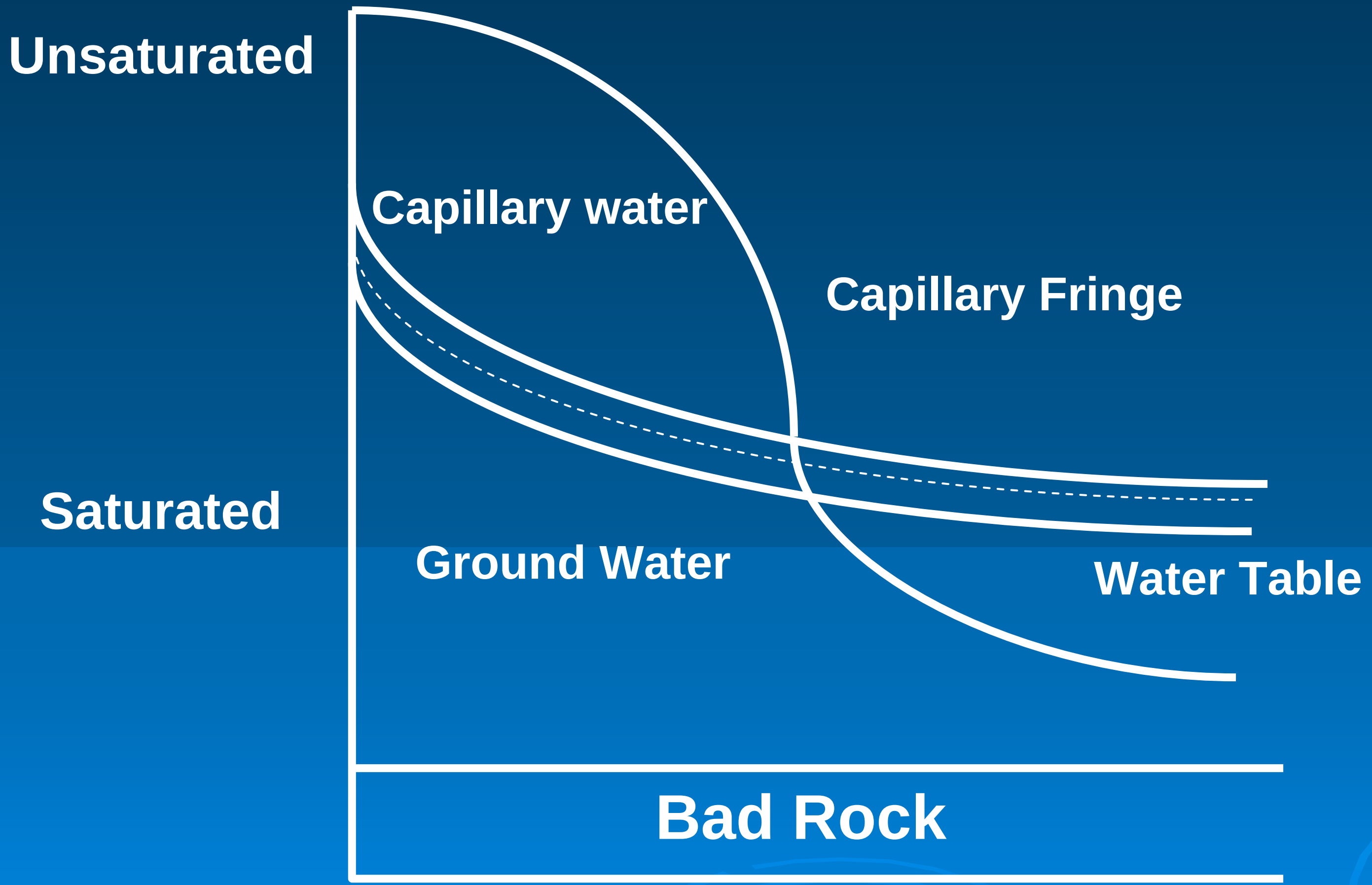
- Brought to surface **by digging wells** and is used for **domestic and agricultural** purposes.

L-23 Introduction: Hydrosphere & natural water



Subsurface Water Zone

L-23 Introduction: Hydrosphere & natural water

2. **Surface Water :** " The quantity of water remaining on the surface after losses due to

- evaporation,
- percolation and
- transpiration etc.

is known as surface water or run off water.

26/9

The important sources are

- lakes,
- ponds,
- Streams,
- rivers,
- reservoirs etc.

The surface or run off water flows into nearby streams, rivers, lakes, wetlands and reservoirs available for our use.

L-23 Introduction: Hydrosphere & natural water

Surface water can be classified into :

i) Rain water

ii) River water

iii) Lake water

iv) Sea water or Ocean water

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L-23 Introduction: Hydrosphere & natural water

Hydrological Cycle or

- The water cycle is the most important of all the natural cycles in the biosphere.

- Water is a renewable natural resource as it is continuously renewed through natural hydrological cycle.

26/9

L-23 Introduction: Hydrosphere & natural water

Or we can define this as :

" Hydrological cycle is a global system that supplies and removes water from the earth's surface."

from one place to another

- The hydrological cycle collects, purifies and distributes the earth's fixed supply of water.

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L-23 Introduction: Hydrosphere & natural water

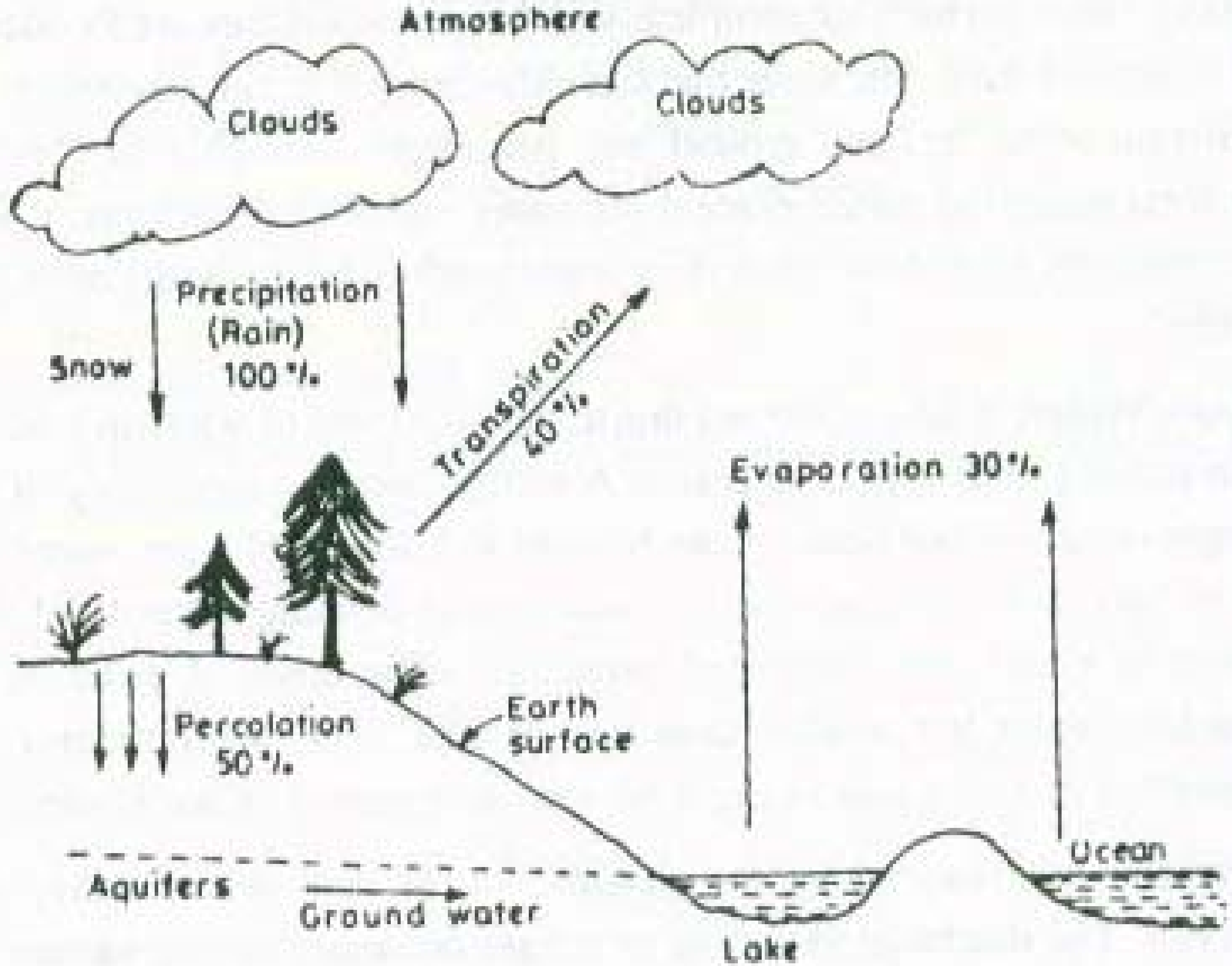

Fig. 4.3. Hydrologic Cycle

L-23 Introduction: Hydrosphere & natural water

- About 97% of the earth water resources is
- locked-up in the oceans and seas,
- which is too saline to drink and
- for the direct use for agriculture and for industrial purposes.
- About 2% of the water resources is locked in glaciers And ice caps and-

L-23 Introduction: Hydrosphere & natural water

- only 1% is available as fresh water.
- It also regulates the body temperature of all the living beings in biosphere.
- The water on which all of us depend totally i.e. the lakes, streams and the ground water is less than 1%.

26/9

L-23 Introduction: Hydrosphere & natural water

Hydrological Cycle:

- **Water is transferred to the earth's atmosphere through two reciprocal processes ;**
  - i) Evaporation
  - ii) Precipitation
- **The total amount of water on earth remains constant and the water cycle moves from one place to another.**

2d 9

L-23 Introduction: Hydrosphere & natural water

1. Evaporation :

- When the Sun rays (Solar energy) heats water on or near the surface of oceans, rivers, lakes, ponds, etc.
- the water evaporates and enters the atmosphere leaving behind the dissolved impurities.

26/9

L-23 Introduction: Hydrosphere & natural water

Transpiration:

- Water also vapourises through
- the tissues of plants specially from
- the leaf surface is called transpiration.

L-23 Introduction: Hydrosphere & natural water

2. Precipitation :

- Water returns to the land and other water bodies as precipitation in the form of rain, hail, snow and slit.

- During heavy rains water is collected in puddles, ditches and ponds and runs off into nearby streams, and rivers called run off water.

L-23 Introduction: Hydrosphere & natural water

- The run off water causes the

  Weathering of rocks

  and

  Erosion of soil

- Which moves various chemicals through other biogeochemical cycles.

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L-23 Introduction: Hydrosphere & natural water

- Some of the fresh water become locked in the glaciers and ice caps and

- some sink down under ground where it may be retained for hundred thousands years.

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L-23 Introduction: Hydrosphere & natural water

Influences of Terrestrial organisms.

- PLANTS help to reduce the soil erosion.
- Various matters in soil act as sponge to hold water in place for the plants.
- The water vapour transpired and evaporated into the air cools the atmosphere.

26/9

L-23 Introduction: Hydrosphere & natural water

- **HUMAN activities-** large quantities of fresh water withdrawn from natural sources for
- **irrigation, industries and domestic uses** leads to depletion of water bodies.

- **URBAN activities** in **heavily polluted areas** increase the rate of return of water to water bodies,

- Flooding **reduces the seepage** and ground water supply is reduced and

2619

- **Soil erosion** is increased.

Classification of water pollutants

L-24 Classification of Water Pollutants Inorganic & Organic

Classification of Water Pollutants:-

Water is used for various purposes including

uses of water

- bathing, washing,
- cleaning, cooking,
- cleaning of floors and equipments,
- industrial operations,
- agricultural needs and
- what not ?

29/9

L-24 Classification of Water Pollutants
Inorganic & Organic

- After using, it is **discharged as waste-water contaminated by various pollutants.**
- The water pollutants are **classified** into following categories:

➢ **Organic pollutants;**

➢ **Inorganic pollutants;**

➢ **Radioactive pollutants;** and

➢ **Suspended solids and sediments.**

— 29/5

L-24 Classification of Water Pollutants
Inorganic & Organic

Inorganic pollutants:-

- All water sources contain a variety of inorganic chemicals from:
- Geological formations,. — natural
- industrial discharges and agricultural run off. — anthropogenic

L-24 Classification of Water Pollutants
Inorganic & Organic

Inorganic pollutants in water include

- **inorganic salts,**
- **mineral acids,**

complexes also

- **metals or metal compounds,**
- **trace elements,**

29/9

L-24 Classification of Water Pollutants Inorganic & Organic

- metal complexes

  and

- organo metallic compounds.

slow fast

Poisonous

- Some are highly toxic
- and some are mildly toxic.

- The inorganic contaminants include :

L-24 Classification of Water Pollutants Inorganic & Organic

Aluminium	Chromium	
Ammonia	Copper	Selenium
Antimony	Cyanide	Sodium
Arsenic	Fluoride	Strontium
Asbestos	Lead	Sulphate
Barium	Manganese	Thallium
Beryllium	Mercury	Vanadium
Boron	Nickel	Zinc
Cadmium	Nitrate	Nitrite

L-24 Classification of Water Pollutants
Inorganic & Organic

- **Inorganic contaminants are mainly the metals found in water:**

- **Nitrates, phosphates and sulphates are the inorganic plant nutrients.**

unwanted water plants & micro organisms grow

detergents

L-24 Classification of Water Pollutants Inorganic & Organic

- The presence of these pollutants cause excessive growth of algae and other aquatic plants.
- These then die and decay and become oxygen demanding waste.

Organic
Biodegradable
29/9

L-24 Classification of Water Pollutants Inorganic & Organic

- The dissolved oxygen supply deplete and aquatic animals (fish) die.

- There are reports that drinking water with excessive nitrates reduce oxygen carrying capacity of blood and

- kill unborn children and infants especially under three months of age.

L-24 Classification of Water Pollutants Inorganic & Organic

Organic Pollutants:-

- Organic chemical compounds are of great importance to all life forms on this planet.
- Most of the substances [which living things are composed of]are organic compounds.
- The main foodstuffs such as fats, proteins, and carbohydrates, as well as

L-24 Classification of Water Pollutants Inorganic & Organic

- a number of materials and substances necessary for modern living such as
- cotton, petroleum, rubber,
- plastics, antibiotics, etc.

are all organic compounds.

L-24 Classification of Water Pollutants Inorganic & Organic

- But their **presence** in water is **not desirable** as they not only **impart taste, odour and colour to water,**
- but some of the **chemical** compounds discharged by **industries** are **toxic** and **carcinogenic too.**

Cancer causing

poisonous

29/9

L-24 Classification of Water Pollutants Inorganic & Organic

The organic pollutants may further be categorized as follows:

1. **Natural organic pollutants.**
2. **Sewage and industrial effluents.**
3. **Synthetic organic contaminants.**
4. **Microbiological pollutants.**
5. **Oil.**

L-24 Classification of Water Pollutants Inorganic & Organic

- **Natural Organic Pollutants:**
- **These come from the breakdown of naturally occurring organic materials, such as,** dead matters
- **decay of leaves, plants, dead animals, etc.**

/ excretion

- **Many plants and micro-organisms release organic matter through their metabolic processes.**

L-24 Classification of Water Pollutants Inorganic & Organic

Micro-organisms, algae and vegetation can also be source of

- **objectionable organic compounds e.g.,**
- **if there is a sudden die-off of the vegetation,**

decay

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- **water quality can become extremely bad.**

L-24 Classification of Water Pollutants Inorganic & Organic

Micro-organisms, algae and vegetation can also be source of

- objectionable organic compounds e.g.,
- if there is a sudden die-off of the vegetation, decay
- water quality can become extremely bad.

29/9

L-24 Classification of Water Pollutants Inorganic & Organic

2 **Sewage and Industrial Effluents:**

Organic pollutants are also discharged as municipal sewage and industrial effluents such as

- **food-processing units,**
- **paper mills,**
- **tanneries,**
- **slaughter houses, etc.**

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L-24 Classification of Water Pollutants Inorganic & Organic

Microbiological pollutants: Many different micro organisms such as-

- bacteria,
- viruses,
- protozoa,
- algae and
- Helminths

are found in polluted/untreated water.

L-24 Classification of Water Pollutants Inorganic & Organic

- The modern water treatment **removes or inactivates** known diseases causing organisms to **safe levels,**

- still it is **best if the source water is** as **free of contamination** as possible.

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L-24 Classification of Water Pollutants
Inorganic & Organic

- **The modern water treatment removes or inactivates known diseases causing organisms to safe levels,**

- **still it is best if the source water is as free of contamination as possible.**

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L-24 Classification of Water Pollutants Inorganic & Organic

- Table 4.1 lists the common water borne diseases along with the name of the organisms responsible and the primary source.
- It should be noted that, in most of the cases, human faeces is the main source of the organisms in water.

Table- 3.1 waterborne disease causing organisms

S. No.	Name of organism or group	Major disease	Primary source
01.	Salmonella Typhi (Bacteria)	Typhoid fever	Human faeces
02.	Schigella	Bacillary dysentry	Human faeces
03.	Vibrio Cholerae	Cholera	Human faeces
04.	E. Coli (Bacteria)	Gastroenteritis	Human & animal faeces
05.	Polioviruses	Poliomyelitis	Human faeces

Table- 3.1 waterborne disease causing organisms

S. No.	Name of organism or group	Major disease	Primary source
06	**Enteroviruses**	**Encephalitis**	**Human faeces**
07	**Hepatitis A virus**	**Hepatitis**	**Human faeces**
08	**Entamoeba-histo -lytica (Protozoa)**	**Amoebic dysentery**	**Human faeces**
09	**Echinococcus (Helminth)**	**Echinococc-osis**	**Human and animal faeces**
10	**Anabaena flos-aquae (B.G.Algae)**	**Gastrenteret -itis**	**Natural water**

L-24 Classification of Water Pollutants Inorganic & Organic

- So, the first step in preventing a disease out break is to **prevent human faeces from entering** water sources.

Regular

- The human waste can originate from a **point source** e.g. a **sewage outfall** or from

- A **non point source** e.g. flow of waster over the ground from a **failed septic** or **cesspool system.**

Accidental

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L-24 Classification of Water Pollutants Inorganic & Organic

OIL

Water pollution due to oil may due to

- oil entrained in refinery waste,
- spillage of oil during transportation,
- oil tankers accidents,
- intentional discharge of crude oil into seas/oceans,
- sewage containing oily contents, etc.

L-24 Classification of Water Pollutants Inorganic & Organic

Some of the common types of compounds present in crude oil are

- **Paraffins,**
- **Cycloparaffins,**
- **Aromatics,**
- **Naptho -aromatics etc.**

29/7

Classification of Water Pollutants
Synthetic and Radioactive

L-25 Classification of Water Pollutants Synthetic and Radioactive

- **Synthetic Organic Contaminants:** The man-made (anthropogenic) materials entering the water bodies with
- sewage and other wastes include both :

①

- volatile organic chemicals (VOC's) and

②

- synthetic organic chemicals (SOC's) .

L-25 Classification…
Synthetic and Radioactive pollutants

- The **VOC's** are industrial solvents, such as—

CCl_4 solvent

- **carbon tetrachloride** used as fire extinguisher and cleaning agent and
- **tetrachloroethylene** used as solvent and raw material.

$Cl_2C=CCl_2$

2915

L-25 Classification…
Synthetic and Radioactive pollutants

- In SOC's category, the most common organic pollutants are

- pesticides and herbicides, and other
- chemicals used in industrial processes e.g.

organic Aromatic

- ethyl benzene, toluene and styrene.

L-25 Classification…
Synthetic and Radioactive pollutants

- Most of the these chemicals are

- potentially toxic to
- poisonous
- plants, animals And
- human beings.

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L-25 Classification…
Synthetic and Radioactive pollutants

The most controversial organic pollutants are

- poly chlorinated bi phenyls (PCB's)
- and dioxin,
- which are very toxic and known to
- cause cancer even at low concentrations.

29/9

L-25 Classification…
Synthetic and Radioactive pollutants

Radioactive pollutants:-

Radioactivity found in water is mainly

Rocks & Hills

- due to natural sources,
- also added from various industrial and medical processes.

/anthropogenic

The human activities responsible for radio active pollution are

L-25 Classification…
Synthetic and Radioactive pollutants

1. Use of radioactive isotopes in

- **medical,**
- **Industrial,**
- **research applications and**
- **Mining.**

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L-25 Classification…
Synthetic and Radioactive pollutants

2. Use of radio active materials in
- power plants and
- nuclear weapons:

3. Processing of ores
- to produce usable radioactive substances.

L-25 Classification…
Synthetic and Radioactive pollutants

- Though all of the radioactive contaminants are **carcinogenic,**
- the **radionuclides** that are found in water and are **of concern** are

2919

- uranium,
- radium 226 and 228,
- radon and thorium 230 and 232.
- Out of these radon is generally found in public water supplies.

L-25 Classification…
Synthetic and Radioactive pollutants

Carcinogens

- Though all of the radioactive contaminants are **carcinogenic,**
- the **radionuclides** that are found in water and are **of concern** are
  - uranium,
  - radium 226 and 228,
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L-25 Classification…
Synthetic and Radioactive pollutants

- **Uranium,**
- **Radium 226 and 228,**
- **Radon and**
- **Thorium 230 and 232.**

29/10/06

Out of these Radon is generally found in public water supplies.


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L-26 Sources & effects of water pollution

Sources of Water Pollution:-

The main sources are

1. natural,
2. agricultural,
3. mining,
4. municipal,
5. industrial and
6. accidental:

6/10/06

L-26 Sources & effects of water pollution

1. Natural pollution in water is

- **due to aerial contaminants and**
- **due to rainfall or melting of ice.**

Decaying of plants, animals and

- **organic matter;**
- **leachates from animal excreta**

6/9/06

introduce micro-organisms in water.

L-26 Sources & effects of water pollution

2. Agricultural pollution of water is

- due to soil and silt washings from land surfaces,
- fertilizers,
- insecticides,
- pesticides and
- weed killers.

Run-off from farm lands

L-26 Sources & effects of water pollution

3. Mining pollution of water is

खान
खदान

Particle

- due to fines or tailings from ore washing,
- inert suspended solids,
- soluble toxic materials and
- acid drainage.

6/10/06

L-26 Sources & effects of water pollution

4. Municipal pollution of water is

due to sewage obtained from:

- **domestic premises,**
- **institutions,**
- **commercial and**
- **industrial buildings.**

Septic Tanks

Chemicals

Medical

Pathogen

Tanning

Poultry

fishery

Excreta

human

animal

Radiation

Chemical

L-26 Sources & effects of water pollution

5. Industrial pollution of water is due to the effluents coming from various industries such as:

- **food and drugs,**
- **chemical,**
- **materials and**
- **energy.**

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L-26 Sources & effects of water pollution

Accidental spillage of chemicals

- during loading and transit; and

Accidental leakage from

- industrial storage tanks,
- oil refineries etc.

6/10/06

L-26 Sources & effects of water pollution

The sources of water pollution can be divided into two categories, namely

1. **point sources and**
2. **diffused sources.** non-point

6/10/06

L-26 Sources & effects of water pollution

1. Point Sources:-

"Those sources which can be readily identified at a single location are known as point sources" e.g.

- industries,
- municipal sewage,
- treatment plants,
- combined sewer overflow,
- raw sewage discharges, etc.

6/10/06

L-26 Sources & effects of water pollution

This type of discharge can be

controlled,

and the water pollution can be

minimized,

- if the effluent from these sources are
- centrally collected,
- treated up to acceptable levels and
- reused.

L-26 Sources & effects of water pollution

Diffused sources or non-point sources ✓

- "These are the sources of generalized discharge of waste water whose location cannot be easily identified".

- Here, the pollutants scattered on the ground ultimately reach the water sources and cause water pollution.

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L-26 Sources & effects of water pollution

(Diffused sources or non-point sources)

For instance run-off from

- **agriculture lands,**
- **forestry,**
- **mining,**
- **construction, etc.**

6/10/06

L-26 Sources & effects of water pollution

(Diffused sources or non-point sources)

- This type of discharge of waste-water cannot be easily controlled.
- However, water pollution caused by the agriculture can be controlled by

- changing the crop patterns,
- tillage practice and
- advanced farm management practices

L-26 Sources & effects of water pollution

Effects of Water Pollution:-

- Water is a **vital resource** essential for sustaining life;

- therefore, its contamination has adverse effects on the health and environment of living beings human beings

6/10/06

L-26 Sources & effects of water pollution

Effects of Water Pollution☺

can be studied under the following heads:

- **Physical effects** 1
- **Oxidation effects** 2
- **Toxic chemical effects** 3
- **Chemical nutrient effects** 4
- **Micro-organisms effects** 5
- **Radionuclide effects** 6

6/10/06

L-26 Sources & effects of water pollution

(i) Physical Effects:

- solids due to suspended particle while cooling water from power stations and
- oily surface of films.

Solids may be

- inert material wastes or
- insoluble finely divided organic solids.

L-26 Sources & effects of water pollution

- **Inert material in water slowly accumulate and deposit on the river bed.**

These also cause

- **reduction in solar energy absorption**

thereby

- **decreased rate of photosynthesis**

Causing

- **low oxygen conditions on the river bed.**

L-26 Sources & effects of water pollution

Suspended materials also cause turbidity which

- reduces light penetration,
- reduce photosynthesis and
- restricts plant growth.
- also reduces food gathering capacity

and

- respiratory efficiency of aquatic animals.

Flora & fauna will reduce

L-26 Sources & effects of water pollution

Finely divided organic solids will be

- biodegraded and will cause

microbes O2

- reduction of the D.O. in water.

➢ All these physical effects will cause a

- disturbance of the balanced ecosystem.

L-26 Sources & effects of water pollution

Thermal Pollution

- Cooling water from power stations can cause a
- rise in water temperature and
- bring about thermal pollution.

Anabolism
Catabolism

- Affect the metabolic rate of physiological processes of the aquatic animals.

L-26 Sources & effects of water pollution

Increased temperature will

- **decrease in fresh water fauna**

population and

- **increase in flora population.**

- **More blue green algae and sewage fungus will grow resulting in plant death.**

L-26 Sources & effects of water pollution

- The **D.O. will be reduced** and

fresh water

- **biodegradation will increase.**

D.O.

- Both these factors will **cause oxygen deficiency** in water.

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L-26 Sources & effects of water pollution

- **Waste oil, fats and grease** will enter and form **thin film** on the water surface,

- prevent the exchange of oxygen with the atmosphere
- causing **reduction of water oxygen saturation.**

L-26 Sources & effects of water pollution

- Spillage from oil tankers in sea will cause
  - marine pollution and
  - shore contamination.

- A badly oiled shore can be largely
  - denuded of animal life and
  - sea weeds are also affected.

L-26 Sources & effects of water pollution

- Oil slicks are responsible for the
- death of many birds.
- affect the thermal insulation and
- resistance to cold,
- irritates digestive system and
- produce toxic effects.

6/10/06

L-26 Sources & effects of water pollution

(ii) Oxidation Effects:

There are two types of oxidation namely:

a) **Bacteriological Oxidation** by **the action of bacteria** upon organic pollutants.

Biodegradable

b) **Chemical oxidation** of other pollutants.

Non biodegradable

L-26 Sources & effects of water pollution

- In bacteriological oxidation

- sulphides are converted into sulphates,
- ammonia into nitrite and then to nitrate.

6 | 10 / 06

L-26 Sources & effects of water pollution

- **In chemical oxidation**
- **ferrous salts are converted into ferric salts,**
- **deposited as rusty red gelatinous masses associated with**
- **filamentous bacteria which are**
- **toxic to biological life.**

L-26 Sources & effects of water pollution

- Both types of oxidation involves the use of dissolved oxygen. It will cause

❖ increase in Biological Oxygen Demand (BOD) resulting

BOD

❖ deficiency of oxygen in water.

DO

L-26 Sources & effects of water pollution

(iii) Toxic Chemical Effects:

- Some organic and inorganic chemical substances are Poisonous
- toxic to plants, animals and humans.
- These toxic substances are **absorbed into the tissues** from polluted water.

6/10/06

L-26 Sources & effects of water pollution

- They can cause injury leading to death of living organisms.
- The effects will depend upon the
  - concentration,
  - period of action and the
  - metabolism of the organism.

L-26 Sources & effects of water pollution

- **Chemical Toxic Substances can be broadly classified as**

- **metals and salts,**
- **pesticides,**
- **acids and alkalis and**

- **organic compounds such as**
- **phenols, cyanides etc.**

L-26 Sources & effects of water pollution

- Very small quantities or traces of metals are required for normal growth and metabolism..
- If Threshold Limiting Value is exceeded then metals produce

  - physiological poisoning,
  - respiration difficulty
  - decreased photo-synthesis and growth.

L-26 Sources & effects of water pollution

a) Metallic toxicity may be caused by

- feeding on polluted marine bony and shell fish.
- Cadmium, mercury, lead, chromium etc.

may cause damage to

- liver, kidneys and brain

fatal

L-26 Sources & effects of water pollution

b) **Pesticides pollution is due to**

- **leachates from agricultural and Horticultural land and**
- **from food processing plants.**

- **DDT, one of the pesticides, produces harmful effect over the body.**

L-26 Sources & effects of water pollution

c) **Acids and alkalis** may

- change the pH value of water from its neutral value of pH 7.

- Most animals and plant grow between a pH value of 5 and 9.

- Changes in pH affect physiological processes and actions of toxins.

L-26 Sources & effects of water pollution

d) Polychlorinated biphenyls (PCB)

- are by-products of the plastic, lubricant rubber and paper industries.
- They are stable, insoluble in water, and soluble in oils.
- These substances are harmful to fishes, predatory birds, marine and shore birds.

L-26 Sources & effects of water pollution

e) Cyanides are very toxic

Som

- to all biological life, and probably
- prevent enzyme action and
- immobilize the nervous system in animals and humans.

f) Chlorophenols are toxic to bacteria and fish.

L-26 Sources & effects of water pollution

(iv) Chemical Nutrient Effects:

- Chemical nutrients are required by
- plants and animals
- for maintaining their growth and metabolism.

- Nitrates and phosphates occur in water in small quantities.

L-26 Sources & effects of water pollution

- sufficient to maintain balanced biological growth.
- The nutrient's levels slowly rise due to bio-degradation of dead organic mater.
- The rise in nutrients is called ageing or **Eutrophication.**

L-26 Sources & effects of water pollution

Phosphorus is required for the

- photosynthesis process in plants,
- for respiration and the
- production of nuclear DNA.

amino acids

N

- **Nitrogen** is an
- essential constituent of proteins.

L-26 Sources & effects of water pollution

- Increased concentrations of nitrates and phosphates in water
- increase the rate of growth of plants and animals.
- Unicellular green and blue green algae and blanket weed
- reduces light penetration and
- restricts deoxygenation of water.

L-26 Sources & effects of water pollution

- It causes adverse conditions for
  - river and canal navigation, and
  - for swimming, bathing and fishing.

- Nitrates are taken into body by food and drink and excess will
  - cause blood diseases and
  - gastric cancer.

6/10/06

L-26 Sources & effects of water pollution

(v) Micro-organism Effects:

Pathogens

Wastes that are discharged into water contain

Hospitals
Institutes

- pathogenic organisms capable of transmitting human diseases.

Table

- Bacteria responsible for cholera, typhoid fever, bacillary dysentery, gastroenteritis etc.

L-26 Sources & effects of water pollution

- Viruses cause
  - poliomyelitis,
  - infective hepatitis and
  - Aseptic meningitis (Echo and Coxsackie viruses).
- Round worm,
- beef and pork tape worms also cause diseases.

L-26 Sources & effects of water pollution

(vi) Radio-Nuclide Effects:

The development of nuclear energy is

- producing more radioactive wastes
- being disposed off.
- with long half lives.
- which enter water bodies.

L-26 Sources & effects of water pollution

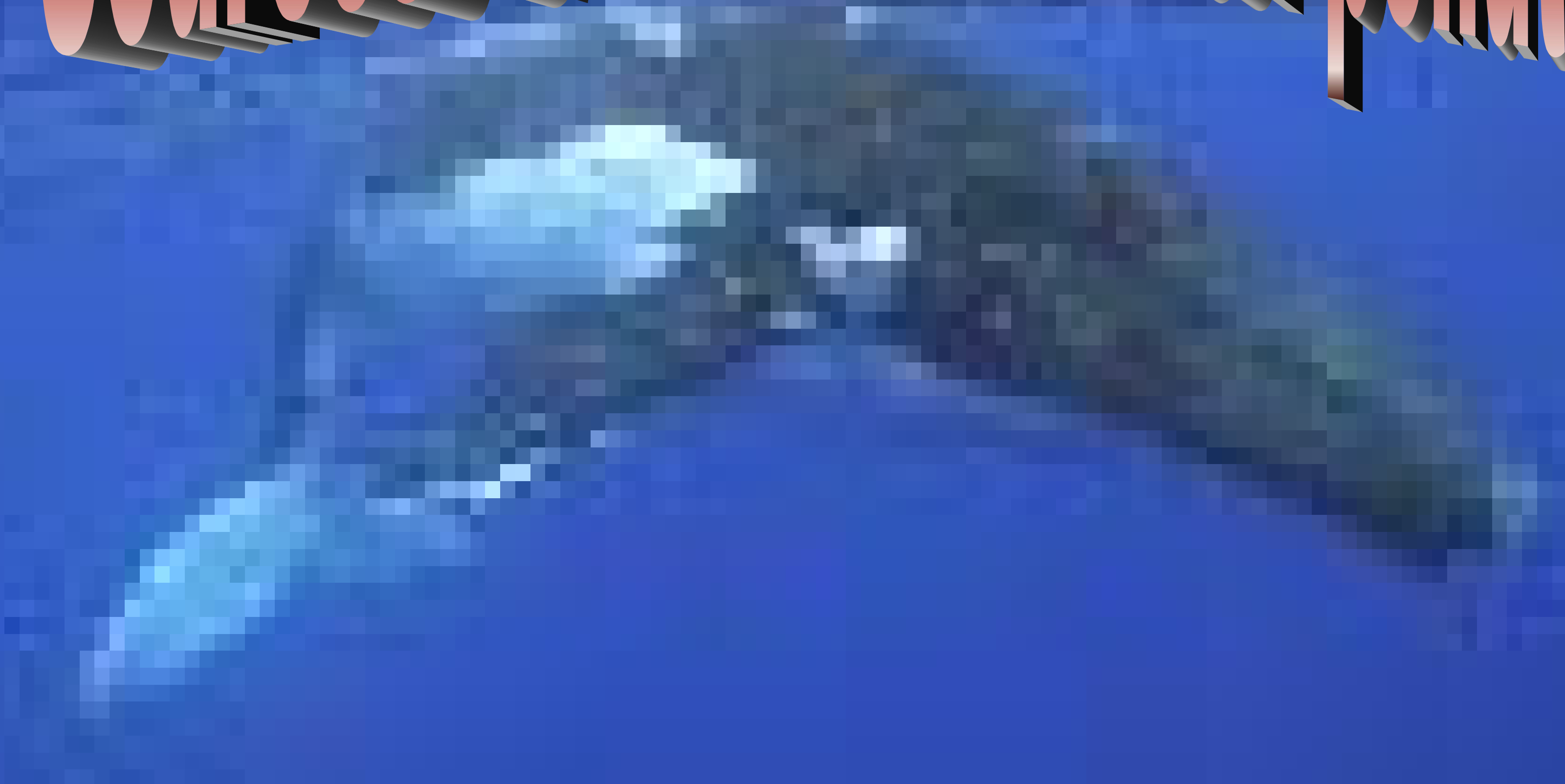
In brief, water pollution can lead to

- spread of epidemics like cholera, jaundice, dysentery, typhoid, etc.;
- can cause nervous disorder due to the presence of
- metals like mercury, lead, copper etc. discharged from industrial effluents;

L-26 Sources & effects of water pollution

- can affect **biological processes** of **humans and animals** if
- they **consume water contaminated** by the release of dyes, etc.; and,
- last but not the least, **increases water treatment costs.**

Sources & effects of water pollution



L-27 Types of water pollution

On the basis of nature of the substances water pollution can be divided into four categories.

1. **Physical Pollution**
2. **Chemical pollution**
3. **Biological Pollution**
4. **Physiological Pollution**

L-27 Types of water pollution

1. **Physical Pollution:**

   caused due to change in physical properties of water, e.g.

- **colour, turbidity, taste, odour etc.**
- **Foam and thermal pollution is also included.**
- **Coloured industrial wastes**

6/10/06

L-27 Types of water pollution

(Physical pollution)

Human faeces

- **Bacterial contamination due to sewage is most serious amongst all.**

Chemically

- **Foam may be serious as it may carry pathogens.**

L-27 Types of water pollution

2. Chemical pollution:

this is found generally due to
the industrial effluents containing

inorganic or organic chemicals such as

- acids,
- alkalies,
- toxic chemicals etc.

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L-27 Types of water pollution

(Chemical pollution)

- **dissolved or suspended inorganic compounds**
- **Suspended or dissolved organic compounds Causing change in**

  - **acidity, alkalinity**
  - **or pH of water**

acid

SO_2 NO_2

and

- **Due to dissolved gases like O_2 or CO_2 etc.**

L-27 Types of water pollution

3. **Biological Pollution:** due to the presence of

- Pathogenic bacteria,
- fungi,
- protozoa
- Viruses,
- worms etc.

Hospitals & Institutions

Sources are

Domestic sewage and industrial wastes.

L-27 Types of water pollution

- Solid human excreta and
- decomposable organic matter

  of sewage are best medium.

  Create

- Infections of gastro-intestinal tract,
- polio and
- hepatitis.

(see tables)

L-27 Types of water pollution

4. Physiological Pollution: This is caused by several chemical agents e.g.

- chlorine,
- SO_2 ,
- phenols,
- hydroxy benzene etc.

Chlorinated water usually changes

- phenol to ortho or parachlorophenol which have offensive odour.

L-27 Types of water pollution

Second type of pollution

- Pollution of streams/river
- Pollution of lakes
- Ocean pollution
- Ground water pollution

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L-27 Types of water pollution

1. **Pollution of streams/rivers**

- **River has the capacity of self purification.**
- **It is divided into 4 zones**

1.zone of degradation

2.zone of active decomposition

3.zone of recovery

4.zone of cleaner water

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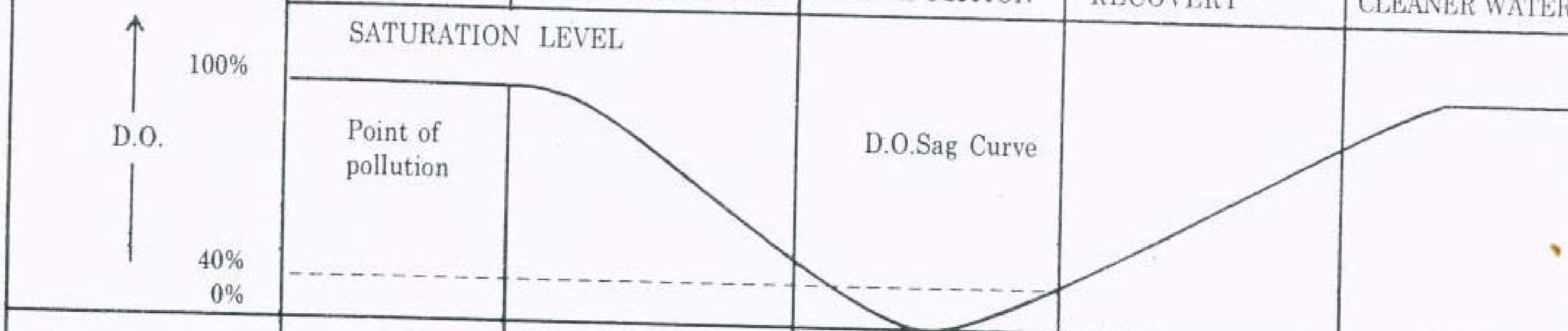
		← ZONES OF POLLUTION →			
	CLEAN WATER	ZONE OF DEGRADATION	ZONE OF ACTIVE DECOMPOSITION	ZONE OF RECOVERY	ZONE OF CLEANER WATER



PHYSICAL INDICES	Clean water	Dark and turbid water	Darker and grayish colour; turbid water	Clearer and less turbid water	Clear water
CHEMICAL INDICES		Floating solids; bottom sludge; DO reduces to 40% of sat. value; high BOD.	Evolution of gases like CH_4, H_2S, CO_2 etc.; sludge coming to the surface forming ugly scum at the top; DO reduces to zero ; anaerobic decomposition.	Small amount of granular sludge; DO increases ; BOD decreases	No Sludge; DO reaches to saturation level.
BIOLOGICAL INDICES		Algae disappear, fungi, bacteria, protozoa appear ; tolerant fishes may be present; sludge worms.	Algae, fungi absent; mostly anaerobic life; fish absent ; sludge worms and larvae present.	Bacterial population decreases ; Algae, protozoa, etc. and tolerant fishes reappear.	Usual clear water plankton present ; Game fish, etc., present.

Fig. Zones of Pollution in a River/Stream, and Indices of Self-purification.

L-27 Types of water pollution

Zone of degradation

- In this zone water is observed in turbid & dark in colour.
- Sludge deposits are observed .
- Anaerobic decomposition will set up to occur.

L-27 Types of water pollution

- **DO reduction reaches to 40%.**
- **Protozoa appear**
- **Tolerant fishes live**
- **High BOD is seen**

L-27 Types of water pollution

Zone of active decomposition

- This zone is said to be the heavy polluted area.

- **DO concentration falls to zero**

micro-organisms

- At upper layer anaerobics are seen

Bottom

- At down area aerobics are present

- **Algae is absent**

L-27 Types of water pollution

- **Carbon dioxide, ammonia gases are seen in excess.** CO_2, NH_3 CH_4 ↑

- **Fungi are also present leading to grayish masses.**

- **Fishes absent**

- **Larvae is seen**

L-27 Types of water pollution

Zone of recovery

- In this river will try to recover the purity.
- Water is observed clearer.
- Small deposits are seen.
- DO increases
- BOD decreases
- Bacterial population decreases
- Fishes will reappear.

L-27 Types of water pollution

Zone of cleaner water

- Water is very clear
- DO reaches to saturation level
- Normal conditions are observed

L-27 Types of water pollution

Zone of Cleaner Water:-

- The river/stream resumes the appearance of natural water.
- The DO conc. will rise up to saturation value, and
- The usual plankton of clear waters will appear
- Game fishes, less tolerant type, will reappear.

L-27 Types of water pollution

- During the recovery process
- coliforms and pathogens will be reduced.

- But, it is certain that some will survive and
- will be present in the zone of cleaner water.

- Therefore, it confirms that

- water once contaminated by pathogens
- will not be safe to drink unless
- it is properly treated .

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L-27 Types of water pollution

Pollution of lakes

- The zones seen are
- Littoral 1
- Limnetic 2
- Profoundal 3
- benthic 4

28/10

L-27 Types of water pollution

1 Littoral zone

- It has many phytoplankton
- Sun light can reach up to bottom
- It is shallow water region.

2 Limnetic zone

- It is a open water zone.
- Plants grow in this region

L-27 Types of water pollution

Profundal zone

- This is the deeper area here light penetration is not seen
- Life is not seen here.

No light
no photosynthesis
no plants &
no animals

Benthic zone

This deals with decomposers

L-27 Types of water pollution

L-27 Types of water pollution

Ocean pollution

Ground water pollution

L-28 Trace elements in water

Trace Elements:-

- Mg is required for photosynthesis.
- Nitrogen is an essential for proteins.
- Nitrates are taken into body by food and drink and
- excess will cause blood diseases and gastric cancer.

27/10/06

L-28 Trace elements in water

Trace Elements:-

- Industrial effluents might contain elements injurious to health
- causing serious health hazards.
- Hence, their analysis is very important.

27/10

L-28 Trace elements in water

Mercury (Hg) :-

Mercury is highly toxic pollutant and it can lead to

Poisoning

malfunctioning

- renal disorder and
- mental disorder.

0.01 ppm is the maximum permissible concentration of mercury.

.

L-28 Trace elements in water

Sources of Hg

to water bodies

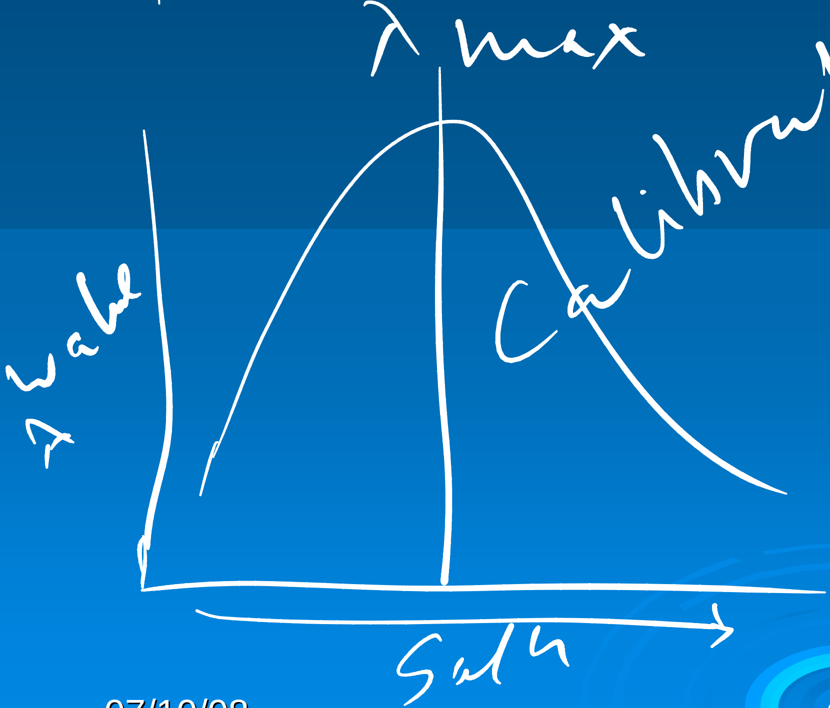
- **Rayon industry and industries manufacturing**
- **medicinal products**

- **Hg is analysed Spectrophotometrically**

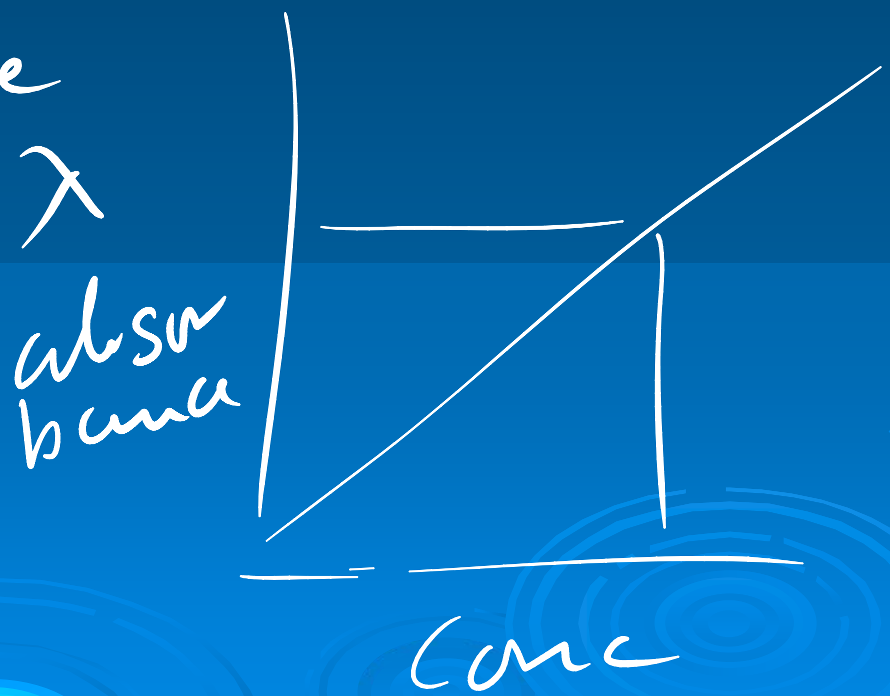
Blank 0.1 N .01 N .05 N

coloured

M + R $\longrightarrow$ complex



Calibrate



V - Violet

I - Indigo

B - Blue

G - Green

Y - Yellow

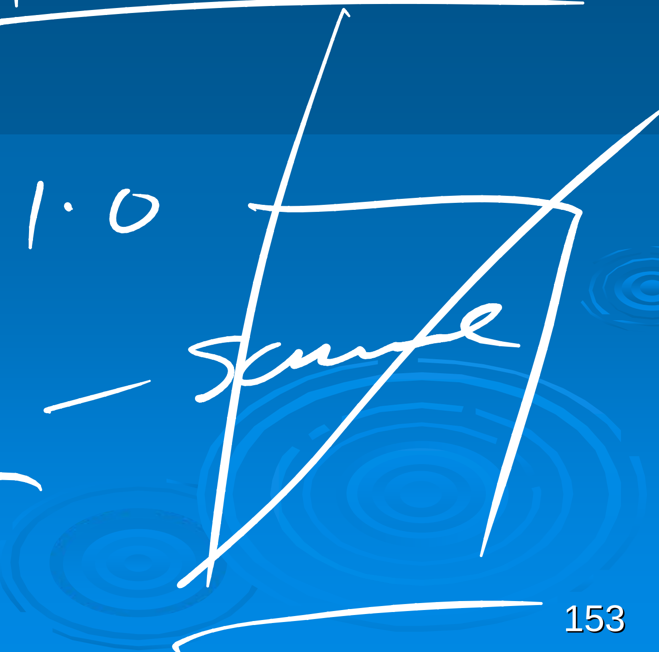
O - Orange

R - Red

λ

0.1

λmax



L-28 Trace elements in water

- Hg forms orange red colour complex with dithiozone
- in chloroform at
- pH of about 1.
- measured spectrophotometrically
- at 490 nm.

λmax

27/10/06

L-28 Trace elements in water

Lead (Pb):-

Lead is highly toxic to all forms of life.

adding जमा

Death fatal जहर

- It is a cumulative poison.
- 0.1 ppm is the limiting concentration of Pb in drinking water.

L-28 Trace elements in water

Sources

- Lead paint industry,
- printing industry,
- electroplating waste and
- mine waters

are the sources of lead to water streams.

L-28 Trace elements in water

- Lead is also analysed spectrophotometrically.
- with dithiozone at pH 11.5 to form
- lead dithiozonate which is
- soluble in chloroform.
- The absorbance is measured at 510 nm.
- This method is known as dithiozone method.

L-28 Trace elements in water

Chromium (Cr):-

- Cr (+VI) is more toxic than Cr (+III).

  It can cause
- dermatitis,
- lung cancer,
- chest problems and
- ulceration

generally in alkaline water. 27/10

L-28 Trace elements in water

- **0.05 ppm is the max. permissible conc. of Cr in drinking water.**

SOURCES of Cr in water :

- **Leather tanning industries,**
- **glass and ceramic industries,**
- **electroplating and**
- **paint industries**

L-28 Trace elements in water

Chromium (+vi) is determined by

Spectrophotometrically

- S – Diphenyl carbazide in
- acidic conditions to form
- reddish violet coloured complex.

The coloured complex is measured

- spectrophotometrically at
- 540 nm.

λ_{max}

L-28 Trace elements in water

For estimation of total Cr,

- Cr (+III) is first oxidised to Cr (+IV) by
- permanganate and then
- analysed by the same method as discussed above

L-28 Trace elements in water

Arsenic (As):-

- cumulative poison and is
- carcinogenic. cancer

- 0.05 ppm is the max. permissible conc. of As in drinking water.

Sources

- Paper, pulp, glass and medicines
- pharmaceutical industries 27/10

L-28 Trace elements in water

Silver diethyl dithiocarbamate method.

- **Arsenic is reduced to arsine in acidic medium by zinc.**
- **And then reacted with diethyl dithiocarbamate.**
- **The red colour complex is**
- **analysed spectrophotometrically at**
- **535 nm.**

L-28 Trace elements in water

Cadmium (Cd):-

It is highly toxic and causes injury to

- kidney,
- pancreas,
- liver.

Gall Bladder

Bile juice

Insulin

- It is a cumulative poison and can remain in body for >10 years.

- The WHO limit for Cd in drinking water is 0.05 ppm.

L-28 Trace elements in water

Sources :

Cadmium salts are usually present in

- effluents of textile,
- electroplating and
- chemical industries.

- Determined spectrophotometrically.
- Cd forms intense pink to red coloured complex with dithiozone
- extracted with chloroform and measured
- at 518 nm. λ_{max}

L-28 Trace elements in water

S. No.	Element	Sources	Nature	Injurious to	Max. Limit
01.	Hg	Rayon, medicines	Highly toxic to all lives	Renal functions Mental disorder	0.01 ppm
02.	Pb	Paint, printing mining, electroplating	Toxic, Cumulative poison	Fatal (causing death)	1.0 ppm
03.	Cr	Leather, glass, ceramic, paint Electroplating	Toxic	Dermatitis, Cancer, ulcer	0.05 ppm
04.	As	Paper, pulp, glass, Pharmaceuticals	Cumulative, carcinogenic	Cancer	0.05 ppm
05.	Cd	Textile Chemical Electroplating	Toxic, Cumulative Poison	kidney, pancreas, liver.	0.05 ppm

L-28 Trace elements in water

Spectrophotometric Analysis of Trace Elements found in water

S. No.	Element	Reagent	Solvent	pH	Absorbance(nm) λmax	colour
01.	Hg	Dithiozone	$CHCl_3$	1.0	490 nm	Pink
02.	Pb	Dithiozone	$CHCl_3$	11.5	510	Orange Red
03.	Cr +VI	S-Diphenyl Carbazide	---	Acidic (oxidation)	540	Red violet
04.	As	Diethyl dithio Carbamate	---	Acid/Zn (Reduction)	535	red
05.	Cd	dithiozone	$CHCl_3$	---	518	Pink red

L-28 Trace elements in water

Minamita Tragedy (1950)

- Minamita a small coastal town in Japan
- People found their cats behaving strange-twitching, stumbling, jerking
- Named as 'dancing cats'
- Due to brain damage now known as
- methyl mercury poisoning.

L-28 Trace elements in water

- Chisso Chemical plant used to release Hg in the river minamita bay.
- Fishes containing 50 ppm Hg consumed by people caused

महामारी

- epidemic of nervous diseases.
- Japan, Sweden & Canada are still suffering.

27/6

L-28 Trace elements in water

- Blue baby syndrome Add
  is caused by nitrates converting into nitrides (methaemoglobinemia)

- Flourosis is caused by excess flourine in water

- Cadmium causes itai itai in Japan

Significance & Determination of D.O., B.O.D. & C.O.D.

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

Dissolved Oxygen (D.O.):-

- Oxygen
  is one of the most common dissolved gases in water.
- Dissolved oxygen (D.O.) is absolutely vital for the support of
- fishes and other aquatic life in water bodies.

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

Oxygen can enter and get dissolved in water in three ways:

1. Natural aeration. directly from the atmosphere,
2. through photosynthesis. by algae,
3. by mechanical equipments (aerators) during water treatment methods.

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

D.O. is always present in natural waters.

Natural

During Summer at high temperature when solubility of O_2 is minimum.

Solubility of O_2 is

- directly proportional to the pressure and
- inversely proportional to the temperature..

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

Most critical conditions of D.O.

- 14.6 mg/litre at 0^0 C to
- 7 mg/litre at 35^0 C under 1 atm. pressure.

The D.O. levels of

- 8mg/litre is taken as the maximum
- under critical conditions.

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

- Further, the solubility of oxygen is less in salt containing water,

  & so solubility of O_2 decreases

- from fresh water
- to estuary
- to the sea water.

decrease

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

The D.O. in water is determined by the **Winkler's method or iodometric method,**

- which is an Redox process
- carried out chemically
- To liberate iodine in
- amount equivalent to
- the quantity of D.O. originally present.

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

principle [Winkler's method or

[iodometric method],

The D.O. oxidizes the KI to I_2,

which is titrated against

standard Hypo solution i.e sodium thiosulphate. But

O_2 in molecular state cannot oxidize iodine and so

$MnSO_4$ as oxygen carrier is added to the solution.

principle

- When $MnSO_4$ is added to the water sample containing alkaline KI

  $Mn(OH)_2$ is formed

  $$MnSO_4 + 2KOH \longrightarrow Mn(OH)_2 + K_2SO_4$$

- This $Mn(OH)_2$ is oxidised to form

  Mn oxide (basic)

- By consuming DO from water sample

  $$2Mn(OH)_2 + O_2 \longrightarrow 2MnO(OH)_2$$

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

After this sulphuric acid is added .

- then the basic manganic oxide liberates I_2

H_2SO_4

- This liberated I_2 is equal to DO

$$MnO(OH)_2 + H_2SO_4 \longrightarrow MnSO_4 + 2H_2O + [O]$$

$$2KI + H_2SO_4 + [O] \longrightarrow K_2SO_4 + H_2O + I_2$$

27/10

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

$$MnO(OH)_2 + H_2SO_4 \longrightarrow MnSO_4 + 2H_2O + [O]$$

$$2KI + H_2SO_4 + [O] \longrightarrow K_2SO_4 + H_2O + I_2 \uparrow$$

The liberated iodine is titrated with a standard hypo solution , using starch as an indicator

$$2Na_2S_2O_3 + I_2 \longrightarrow Na_2S_4O_6 + 2NaI$$

DO is expressed in mg/l or ppm

27/10

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

- **Procedure:**

- **Take 250 ml sample solution in a bottle. Immediately add 2ml of mangnous sulphate and 2ml of alkaline KI solution to it and stopper the bottle.**

$$[\ MnSO_4 + 2KOH \longrightarrow Mn(OH)_2 + K_2SO_4]$$

$$2Mn(OH)_2 + O_2 \longrightarrow 2MnO(OH)_2$$

- **When the ppt is settled add 2ml of Conc. HCl and shake the bottle to dissolve all the ppt. Allow the yellow solution to stand for 5 minutes.**

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

- **Procedure:**

$$[\ MnSO_4 + 2KOH \longrightarrow Mn(OH)_2 + K_2SO_4]$$

$$2Mn(OH)_2 + O_2 \longrightarrow 2MnO(OH)_2$$

- **When the ppt is settled add 2ml of Conc. HCl and shake the bottle to dissolve all the ppt. Allow the yellow solution to stand for 5 minutes.**

$$MnO(OH)_2 + H_2SO_4 \longrightarrow MnSO_4 + 2H_2O + [O]$$

- $2KI + H_2SO_4 + [O] \longrightarrow K_2SO_4 + H_2O + I_2$

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

- **Procedure (contd.)**
- **Take 100 ml of this solution and titrate against N/100 hypo solution using starch as indicator. End point is the disappearance of blue colour.**

$$2Na_2S_2O_3 + I_2 \longrightarrow Na_2S_4O_6 + 2NaI$$

Let V_2 ml of hypo solution is used

Normality of hypo solution = N_2 = 1/100

Normality of sample water = $N_1 = \dfrac{N_2 V_2}{V_2}$

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

Normality of sample water $= N_1 = \dfrac{N_2\,V_2}{V_1}$

$$= \frac{1/100 \times V2}{100} = \frac{V2}{10{,}000}$$

Since equivalent weight of O_2 is 8

Hence strength of $O_2 = N_1 \times 8$ gm/L

$= N_1 \times 8 \times 1000$ mg/L

$= \dfrac{V2 \times 8 \times 1000}{10{,}000}$ mg/L

= amount of D.O. = $0.8\,V_2$ ppm

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

Significance of Dissolved Oxygen:-

1. D.O. is the factor which determines the extent of pollution

brought about by anaerobic micro organisms.

2. It is highly important that

aerobic conditions must be maintained: otherwise,

The anaerobic micro organisms will develop nuisance conditions.

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

3. D.O. measurements are vital for maintaining aerobic conditions in natural waters.

4. and in anaerobic treatment processes to purify domestic (or municipal) and industrial waste waters.

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

D.O. determination is the most important taste/examination used by the environmental engineers.

- This test is the basis of the BOD test (to evaluate to pollutional strength of domestic and industrial waste waters).

27/10

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

- The rate of biochemical oxidation can be measured by

  - determining residual D.O. in a system at various intervals of time..

  - Since all the aerobic treatment processes depend upon the D.O.

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

D.O. determinations are indispensable

as a

- means of controlling the rate of aeration
- to maintain aerobic conditions

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

- D.O determinations also serve as the means of control of river/stream pollution.

- As it is desirable to maintain conditions favourable for the growth and reproduction

- of fishes and other aquatic organisms,

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

- The raw or treated waste must have at least 4mg/litre of D.O. before its disposal into river/stream;
- otherwise, nuisance will be created near the disposal site and also the aquatic life (fishes etc) may perish.

Sharma


Biochemical Oxygen Demand (B.O.D)

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

Biochemical Oxygen Demand (B.O.D):-

- The organic waste present in water is of two types:

a) biologically active or biologically degradable

Bio degradable

that which can be oxidised by bacteria.

b) biologically inactive

that which cannot be oxidised biologically,

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

In waste water treatment,

- If oxygen is furnished to sewage
- containing bacteria,
- aerobic decomposition of
- biologically active unstable organic matter will occur
- until the oxygen demand is satisfied.

27/10

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

- The amount of oxygen used during this process is known as the

  biochemical oxygen demand (BOD).

- It is an important indication of the amount of organic matter present in the sewage.

27/10

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

If the available oxygen falls short of the requirements,

- the organic matter putrefies or
- decomposes anaerobically and
- produce foul conditions.

Thus, (i) B.O.D. indicates the nuisance potential of sewage and
(ii) the load imposed on the sewage treatment plant or disposal system.

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

- Method: The D.O. content of the sample is measured **before and after incubation** at **20^0C for 5 days.** If the sample doesn't contain O_2 oxygen is supplied to it and BOD is measured.

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

❖ first-stage B.O.D

If the oxygen supply is made available,

- The reduction of the B.O.D. proceeds rapidly
- for 6 to 7 days and
- then slows down until
- the end of about 20 days.

27/10

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

❖ first-stage B.O.D

The oxygen demand during the first 20 days

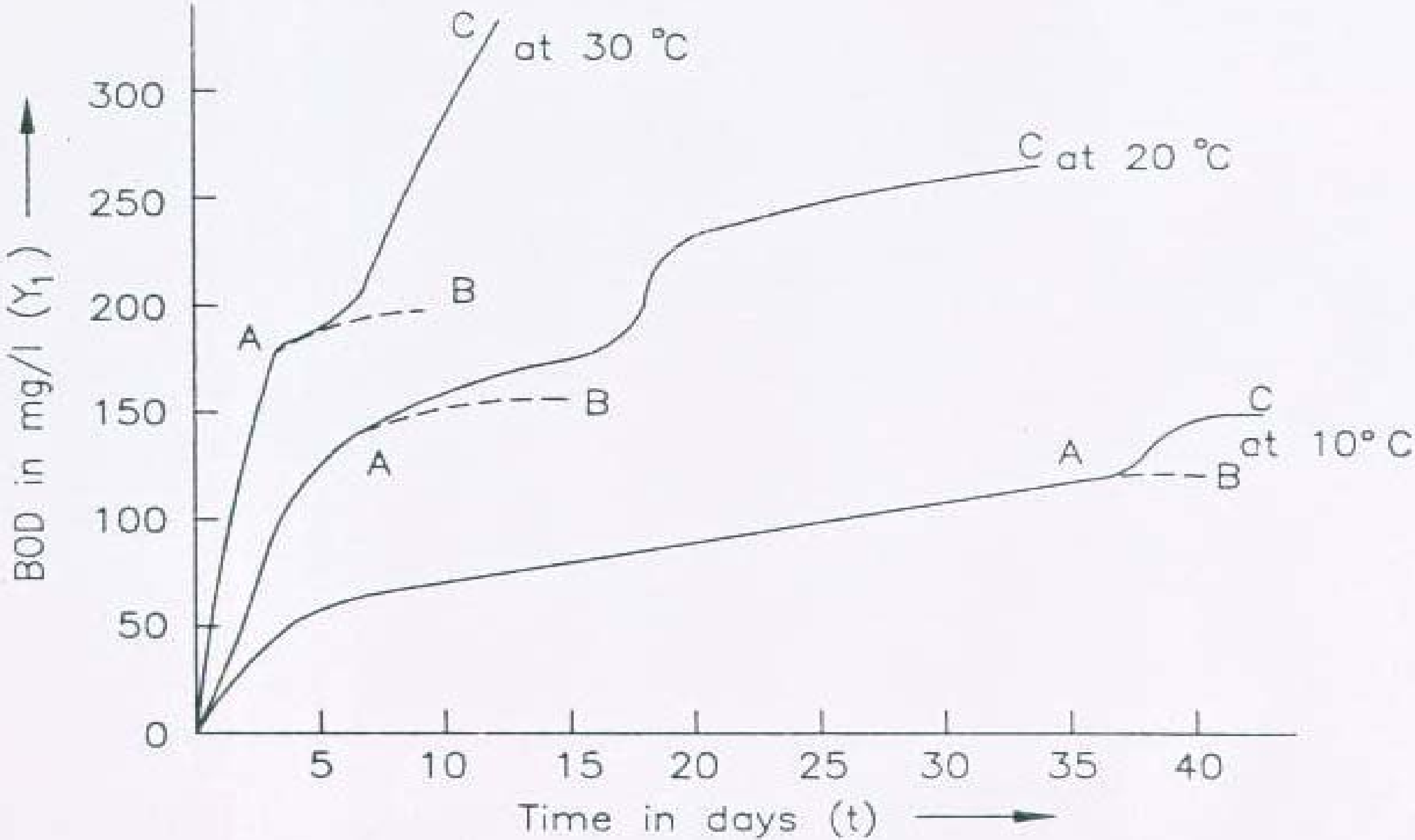
- is due to the oxidation of carbonaceous organic matter to CO_2 and water, and is known as the

❖ ‘first-stage demand’ or

❖ ‘initial demand’ or

❖ ‘carbonaceous-demand’ or

❖ ‘first-stage B.O.D



OAB represents 1st-stage B.O.D. curve

AC represents 2nd-stage B.O.D. curve

OAC represents combined B.O.D. curve

Fig. Cummulative B.O.D. curves at different temperatures.

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

Figure

- OAB represents 1st stage B.O.D. curve.
- AC represents 2nd stage B.O.D. curve.
- OAC represents combined B.O.D. curve.

- It has been observed that the aerobic decomposition of biologically active organic matter proceeds in two stages.

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

first-stage B.O.D

During 20 days, about 99% of carbonaceous matter is oxidised,

- so first-stage B.O.D. is taken as ultimate B. O. D.

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

The later demand is due to the

- oxidation of more resistant nitrogenous matter,

It takes a prolonged period, and is known as the

- ‘Nitrogenous demand’ or
- ‘second – stage demand’. Or
- ‘second – stage B.O.D.’.

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

- For all practical purposes the reaction period is taken as
- 5 days at 20^0C.

This is written as

- BOD 5 at 20^0C,

This is taken as the

- standard demand, 27/10

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

- and is about 50% to 70% of the total demand.

- The B.O.D. of a sewage sample can be determined as:

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

$$\text{BOD 5 at } 20^0\text{C (in mg/l)} = (D_1 - D_2) \times f$$

Where

D_1 = DO of diluted sewage sample before incubation, mg/l.

D_2 = DO of diluted sewage sample after 5 days incubation at 20^0C mg/l

f = Dilution factor

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

f = Dilution factor =

$$\left(\frac{\text{Vol. of diluted sample}}{\text{Vol. of undiluted sewage sample}}\right)$$

Dilution of sewage is carried out by pure aerated water.

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

- (add)
- Theory of BOD
- In biological degradation of sewages , the organic matter e.g. acetic acid is converted into $CO_2 + H_2O$

$$CH_3COO^- + 2O_2 \longrightarrow CO_2 + H_2O + HCO^-_3$$

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

$$BOD = \frac{D_1 - D_2}{A} \times B \text{ mg/l}$$

$\frac{B}{A} = f$

A =volume of sample before dilution

B= volume of sample after dilution

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

Limitations of BOD Test

1. Before BOD pre treatment of the sewage is necessary for toxic wastes.

2. Applicable only for biodegradable organic matters.

27/10

Limitations of BOD Test

1. Applicable only for biodegradable organic matters.

2. The time required is too long and arbitrary.

3. Before BOD pretreatment is necessary.
   As the sewage may contain toxic waste.

4. The effect of nitrifying bacteria should be reduced.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L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

Chemical Oxygen Demand (COD):-

It gives the amount of oxygen required for chemical oxidation of organic matter,

- **biologically active as well as**
- **biologically inactive,**

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present in the sewage.

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

- Potassium dichromate ($K_2Cr_2O_7$) or
- potassium permanganate ($KMnO_4$) are used as
- oxidising agents
- to destroy the organic matter.

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

ADVANTAGES

COD test has several advantages over BOD test, e.g.

(1)
- it takes only 3 hours;

(2)
- industrial wastes do not respond to BOD test,
- respond to COD test ;

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L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

Advantages

- where the presence of toxic materials interfere with the BOD,

3

- the COD test is very useful.

DISADVANTAGE

- The biggest, and the only, disadvantage of this test is that-

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

- active

disadvantages:

- it cannot differentiate biologically oxidisable and

- inactive

- biologically inert organic matter;

and in sewage treatment, biologically active organic matters quantity is of utmost importance.

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

Definition of Chemical oxygen demand

"COD is the amount of oxygen (expressed in mg/L or ppm)

- consumed under specified conditions
- In the oxidation of organic and oxidisable inorganic matter,

($HgSO_4$)

- corrected for the influence of chlorides".

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

In COD test,

- The sample is oxidized with **potassium dichromate** ($K_2Cr_2O_7$) (a strong oxidising agent).

- Oxidation of both biologically oxidisable and biologically inert material in water sample takes place.

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

Oxidation of both biologically oxidisable and biologically inert material in water sample takes place.

Hence,

- COD value for a given sample is always higher than BOD value.
- Time required time for COD test is shorter.
- hence COD test is advantageous.

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

COD determination.

- A **known volume** (say 25 ml) of the waste water sample is
- **refluxed for 1 ½ hours** with a known excess of standard

  $K_2Cr_2O_7$ (1N)
- **potassium dichromate** (say 1 N) in a
- **50% sulphuric acid** solution and

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

and

- in presence of silver sulphate (Ag_2SO_4)
- as catalyst
- and mercuric sulphate $HgSO_4$
- to suppress chloride ion interference.

$HgCl_2$

Cl^- free

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

- The organic matter of the sample is
- oxidised to H_2O, CO_2 and NH_3 .
- The excess dichromate is
- titrated with a standard solution of
- ferrous ammonium sulphate,
- $[FeSO_4 . (NH_4)_2 SO_4 . 6H_2O]$.

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

$$Sample + K_2Cr_2O_7 \xrightarrow{Ag_2SO_4\text{(catalyst)}} CO_2 + Water + ammonia$$

Sewage in50% H_2SO_4 $HgSO_4$ to eliminate Cl^- interference

$$K_2Cr_2O_7 + \text{Ferrous Ammonium Sulphate} \longrightarrow \text{Salt}$$

Remaining

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

- This experimentally measured amount of $K_2Cr_2O_7$ (which is consumed)
- is used to calculate the COD

O_2

i.e. the equivalent oxygen required

- by the waste water
- for degradation of the pollutants.

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

Mathematically,

COD = $$\frac{(V_b - V_t) \times N \times 8}{V_e} \times 100\text{mg/L}$$

1000

Where

- Vb and Vt are the volumes of ferrous ammonium sulphate consumed in the blank and test experiments.
- N is normality of ferrous ammonium sulphate and
- Ve is the volume of effluent sample taken.

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

Example:-

Ve

A 25 ml of a sewage water sample was refluxed with 10 ml of 0.1 N. $K_2Cr_2O_7$ solution in presence of dil. H_2SO_4 Ag_2SO_4 and $HgSO_4$.

The unreacted dichromate required 6.5 ml of 0.1 N ferrous ammonium sulphate.

Vt

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L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

- 10 ml of the same $K_2Cr_2O_7$ solution and 25 ml of distilled water, under the same conditions as the sample, Vb
- required 27 ml of 0.1 N ferrous ammonium sulphate.
- Calculate the COD of the sewage water sample.

Solution:- Given Vb = 27 ml

Vt = 6.5 ml

N = 0.1 Normal

And Ve = 25 ml.

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

Solution:- Given $V_b = 27$ ml

$V_t = 6.5$ ml

N = 0.1 Normal

And $V_e = 25$ ml.

Mathematically,

1000

COD = $$\frac{(V_b - V_t) \times N \times 8}{V_e} \times 100\,\text{mg/L}$$

COD = $$\frac{(27 - 6.5 \times 0.1 \times 8)}{25} \times 1000 = 0.656\,\text{ppm}$$

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

Importance of COD:-

1. COD is another index of pollution which measures,

- the effect of pollutants on DO.

2. COD value is not affected by the presence of toxins and

- other unfavourable conditions for the growth of micro-organisms.

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

3. Due to rapid determination, COD is

- very important parameter in
- management and design of the treatment plants.

4. COD values are taken as basis for efficiency of treatment plants.

L-29 Limitations of C.O.D.

Limitations of COD:-

1. COD value is a **poor measure** of **strength of organic matter** as O_2 is also used in the

- **oxidation of inorganic matter** such as
- **nitrates, sulphates, reduced metal ions** etc.

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

2. Although cellulose can be oxidized

but

- benzene, pyridine and

other

- cyclic organic compounds
- do not get oxidized by this test..

L-29 Significance & Determination of D.O., B.O.D. & C.O.D.

3. COD test does not differentiate between bio-inert and active biodegradable materials.

4. It also does not indicate the rate at which the

- biologically oxidisable materials stabilize.


EUTROPHICATION

L-30 Eutrophication

EUTROPHICATION

- Eutrophication term is derived from the
- Greek word eutrophos which means
- well nourished or enriched.

- This enrichment leads to
- natural aging of lakes.

L-30 Eutrophication

DEFINITION

"C. H. Weber" described eutrophication as ;

"Eutrophication is a phenomenon through which a nutrient bog or a shallow depression changes into leached bog deficient in nutrients".

28/10

L-30 Eutrophication

- Eutrophication is the stepped up addition of phosphates and nitrates
- because of human activities might happen in a few decades-
- which takes place in
- thousands to billions of years by natural process.

28/10

L-30 Eutrophication

- During summer overloading of shallow lakes and reservoirs with
- plant nutrients produces
- dense growths of plants like
- water chestnuts and
- water hyacinths near the shore.

L-30 Eutrophication

- also causes population explosion of
- algae blooms,
- or floating algae especially the
- blue green algae which give water
- An appearance of green soup and

28/10

L-30 Eutrophication

- release substances to make
- water taste and smell bad.
- D.O. is depleted in the surface layer and near the shore.

28/10

L-30 Eutrophication

- **At the bottom when large masses of algae die and fall,**
- **are decomposed by aerobic bacteria D.O. is again used up and**

  depleted
- **other aquatic life die of oxygen starvation..**

L-30 Eutrophication

- Excess nutrients if continued to flow
- the bottom water becomes foul and
- devoid of animals,
- anaerobic bacteria take over and
- release smelly products.

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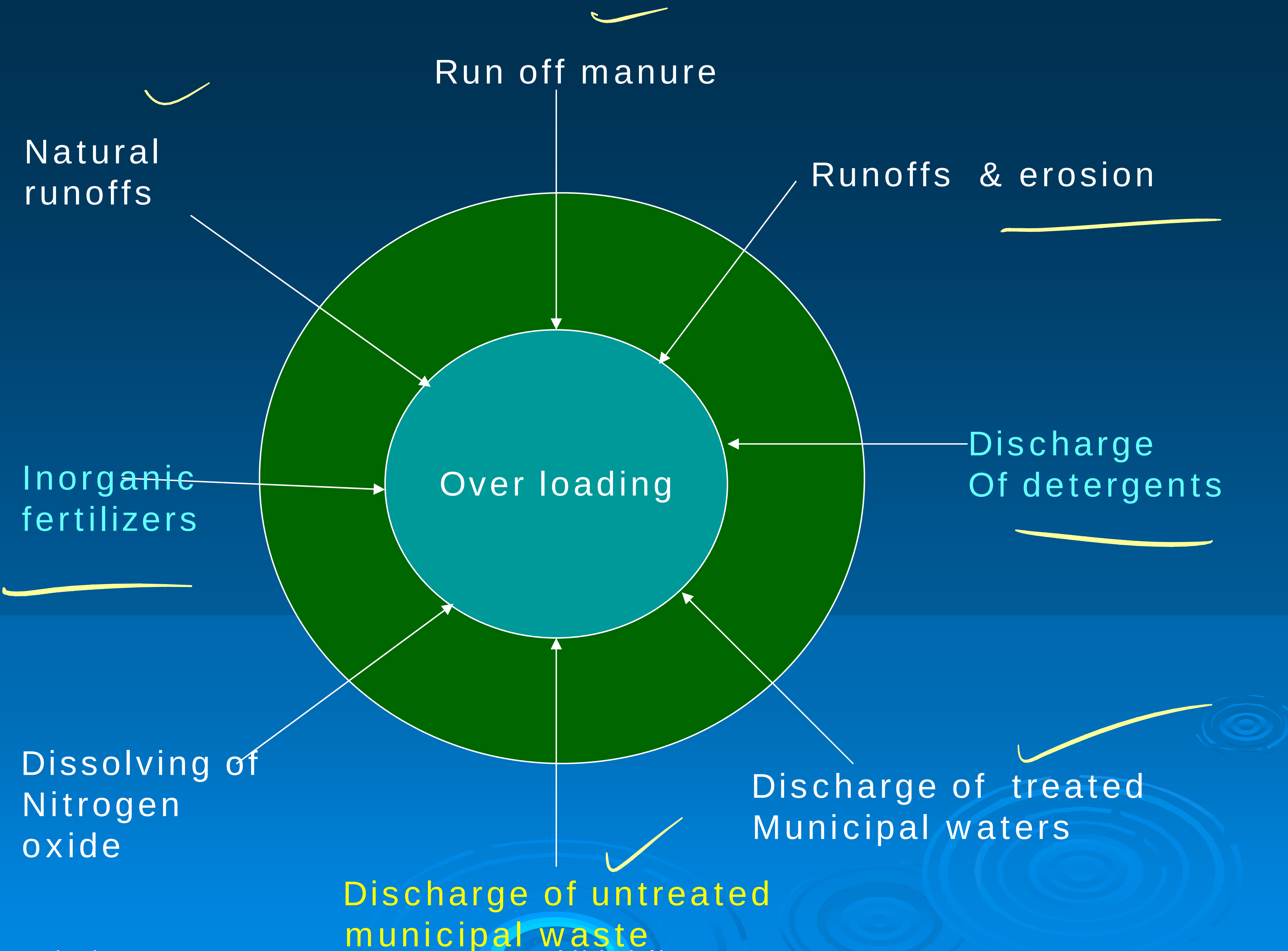
Run off manure
Natural runoffs
Runoffs & erosion
Inorganic fertilizers
Over loading
Discharge Of detergents
Dissolving of Nitrogen oxide
Discharge of treated Municipal waters
Discharge of untreated municipal waste

L-30 Eutrophication

TYPES OF EUTROPHICATION

There are two types of eutrophication:

1. **Natural Eutrophication**
2. **Cultural Eutrophication**

28/10

L-30 Eutrophication

Natural Eutrophication:

- The process of **natural lake aging due to nutrient enrichment** is called natural eutrophication.

Thousand years

- In this process **oligotrphic lake** is converted into a **eutrophic lake.**

L-30 Eutrophication

Cultural Eutrophication :

- When lake aging is speeded up by human activities
- cultural eutrophication takes place which causes :
- Addition of 80% Nitrogen and 75% Phosphorus to the lakes and streams.

L-30 Eutrophication

EFFECTS OF EUTROPHICATION

- In India Kashmir Lake and
- Nainital Lake are
- undergoing a rapid eutrophication
- as a result of
- sewage, domestic waste and detergent addition.

L-30 Eutrophication

- Dal, Hussain Sagar and Nagin lakes are seriously chocked by
- Eutrophication
- During eutrophication the lake becomes Oxygen deficient
- causing death of fishes, fish habitats and death of lakes.

L-30 Eutrophication

- Phytoplankton are most sensitive and
- their population decreases rapidly due to eutrophication.
- It leads to the disruption of food chains and food web.

L-30 Eutrophication

CONTROL OF EUTROPHICATION

- Recycling of nutrients can be checked through harvest.
- Algae food webs should be disrupted.
- Sewage and detergent wastes should be treated before disposal.
- Algae blooms should be removed.
- Algae growth be controlled.

2/10

L-31 Preliminary and primary water treatments

- All the pollutants are ultimately
- assimilated by the water body.

When the waste water,

- is large in volume and
- strong in character,

the purifying capacity

- may not be sufficient.

L-31 Preliminary and primary water treatments

Objective of Waste Water Treatment:-

- As we know, the waste water is finally disposed off in water bodies (i.e. rivers, streams, lakes and oceans).
- The waste water are then purified by the natural agencies like
- air, sunlight, bacteria and other micro-organism, etc., and

30/10

L-31 Preliminary and primary water treatments

- For satisfactory disposal the waste water treatment plants,
- act as unloading stations
- where all the undesirable and nuisance causing elements
- in the waste water are removed.

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L-31 Preliminary and primary water treatments

- Which can be accepted by the water bodies without getting degraded.
- Hence, waste water treatment plants
- supplement to the natural purifying power/capacity of the water bodies, and
- help in maintaining their normal utilities.

30/10

L-31 Preliminary and primary water treatments

Classification of Sewage Treatment Process:-

- Preliminary Treatment.
- Primary Treatment.
- Secondary or Biological Treatment, and
- Tertiary or Final Treatment.

30|10

L-31 Preliminary and primary water treatments

1. PRELIMINARY TREATMENT
2. PRIMARY TREATMENT
3. SECONDARY or BIOLOGICAL TREATMENT
4. TERITARY TREATMENT

L-31 Preliminary and primary water treatments

- **Preliminary Treatment:-** Preliminary treatment is carried out for the removal of the floating materials e.g.

Big

- leaves of trees,
- pieces of rags,
- paper, wood,
- dead animals, etc., and….

30/10

L-31 Preliminary and primary water treatments

- the heavy settleable inorganic solids
- such as sand, grit, etc. and
- the fats, oils and greases

  from the waste water.

30/10

L-31 Preliminary and primary water treatments

Preliminary treatment reduces the

- **BOD about 15 to 30%,**
- **solids about 40 to 60%,**
- **and the bacterial load**
- **about 10 to 20%.**

L-31 Preliminary and primary water treatments

- The preliminary treatment processes are
- screening,
- grit chamber and
- skimming tanks.

The screenings, grit and skimmings are generally disposed off by burial or burning.

L-31 Preliminary and primary water treatments

Screening (preliminary treatment)

- It is usually the first operation.
- different screens to trap and remove
- the floating materials like
- leaves of trees,
- paper,
- wood material etc,

Dead animals etc

otherwise these materials shall damage the pumps and interfere the flow of water.

L-31 Preliminary and primary water treatments

filter

Screen is a device with

- **openings of uniform size for**
- **removing bigger suspended or**
- **floating matter present in waste water.**

Screeners are of two types

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1. **Coarse Screeners**
2. **Fine Screeners**

L-31 Preliminary and primary water treatments

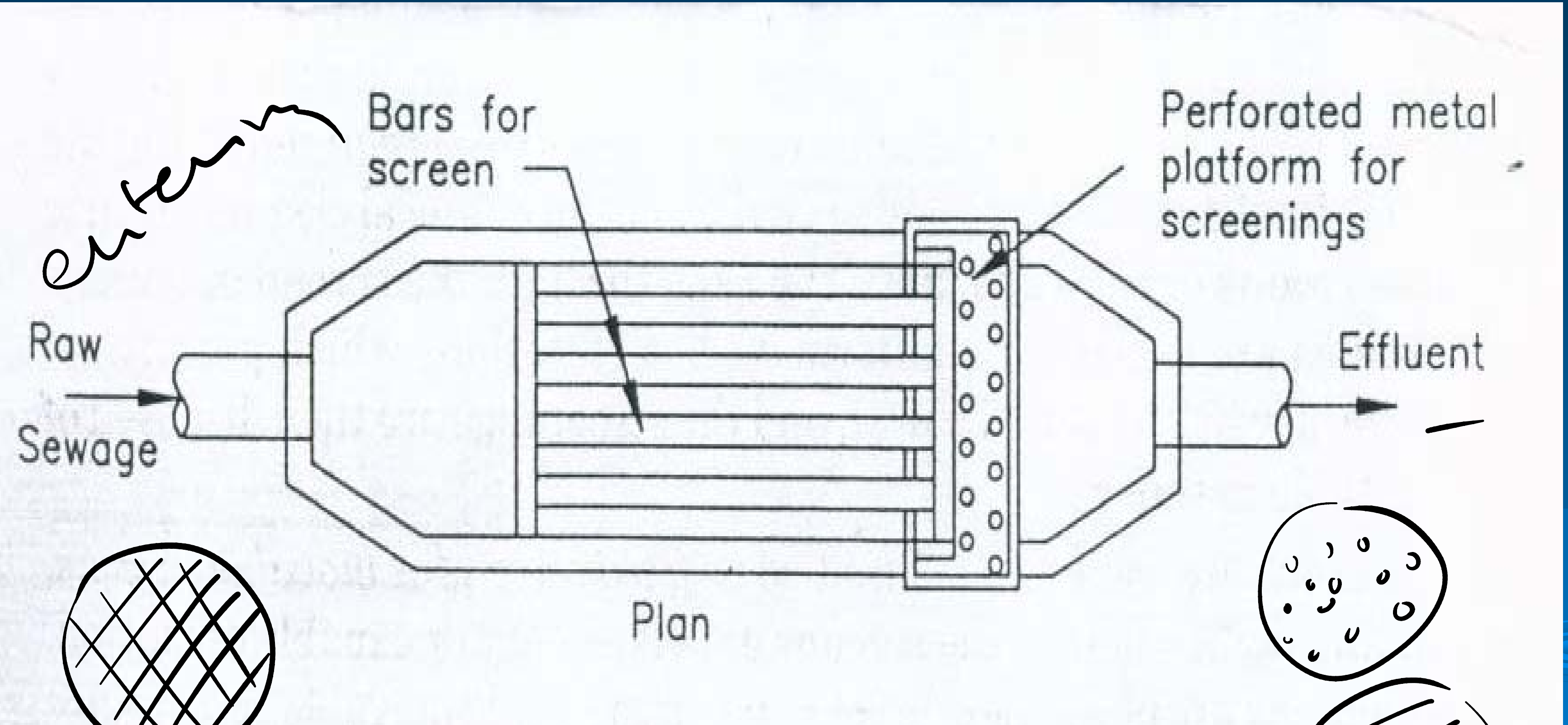

Fig. Fixed Bar-screen (coarse or medium).

L-31 Preliminary and primary water treatments

	Coarse Screeners		Fine screeners
01	Coarse Screen have the opening of 75-150 mm at head of the pumps.	01	These screens have openings of 20 mm.
02	The principal function is to prevent the entry of floating matter such as logs, timber or large sized material etc.	02	These are mechanically cleaned devices using perforated plates, closely spaced bars made of corrosion resistant metals.

L-31 Preliminary and primary water treatments

Contd.

	Coarse Screeners		Fine screeners
03	Since screening doesn't contain any good amount of matter, its disposal can be carried out easily.	03	These are capable of removing as much as 20% of the suspended solids from sewage.

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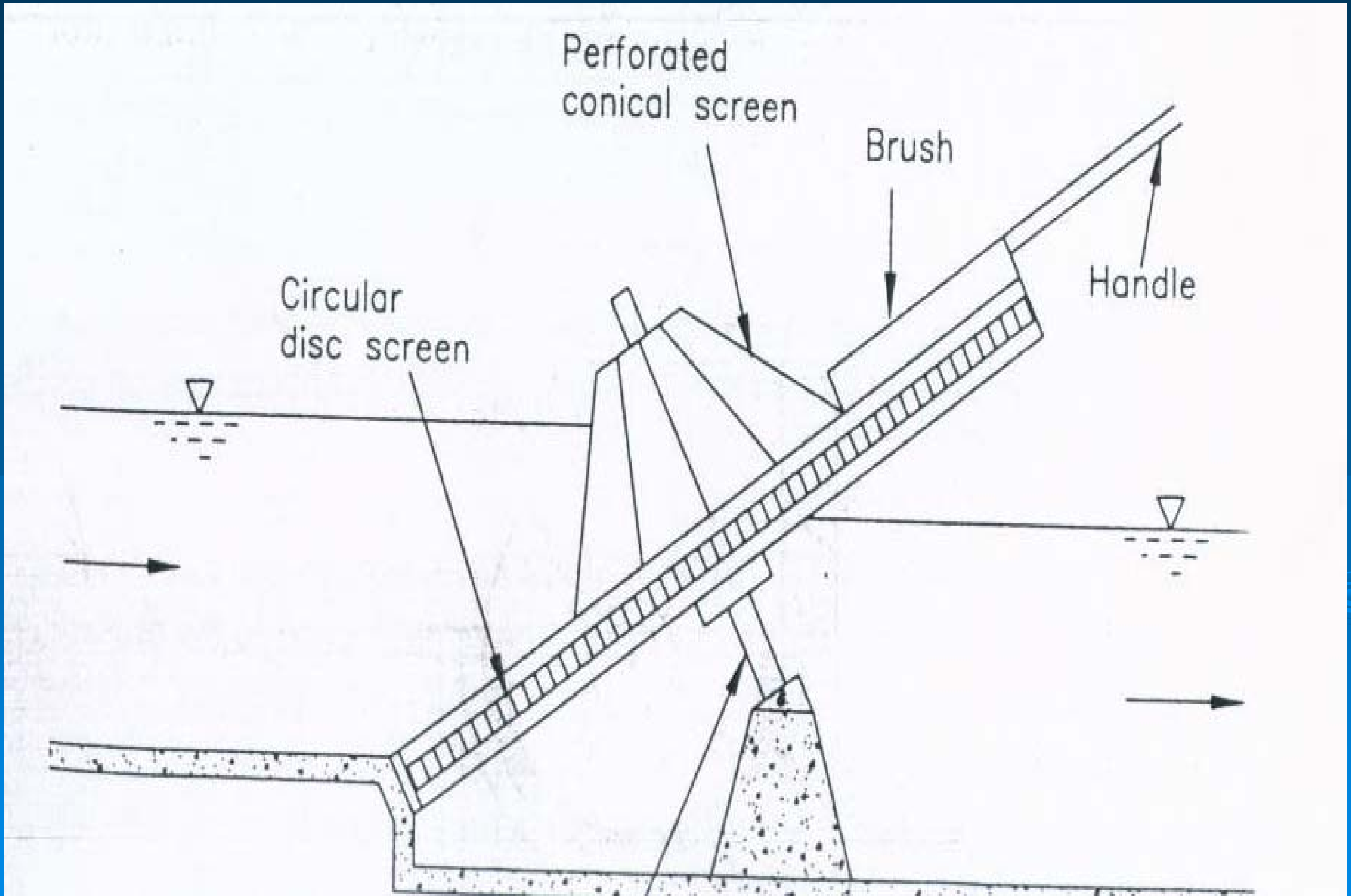
L-31 Preliminary and primary water treatments



L-31 Preliminary and primary water treatments

(ii) Grit Chamber:

Removes heavier inorganic materials,

- specific gravity
- 2.4 to 2.65 like

no

- ash, sand,
- clinkers, egg shells,
- bone chips, grit.

L-31 Preliminary and primary water treatments

Grit Chamber:

These sandy and heavy materials can pose problems like

- **reduce fuel value of manure,**
- **can block the chamber.**

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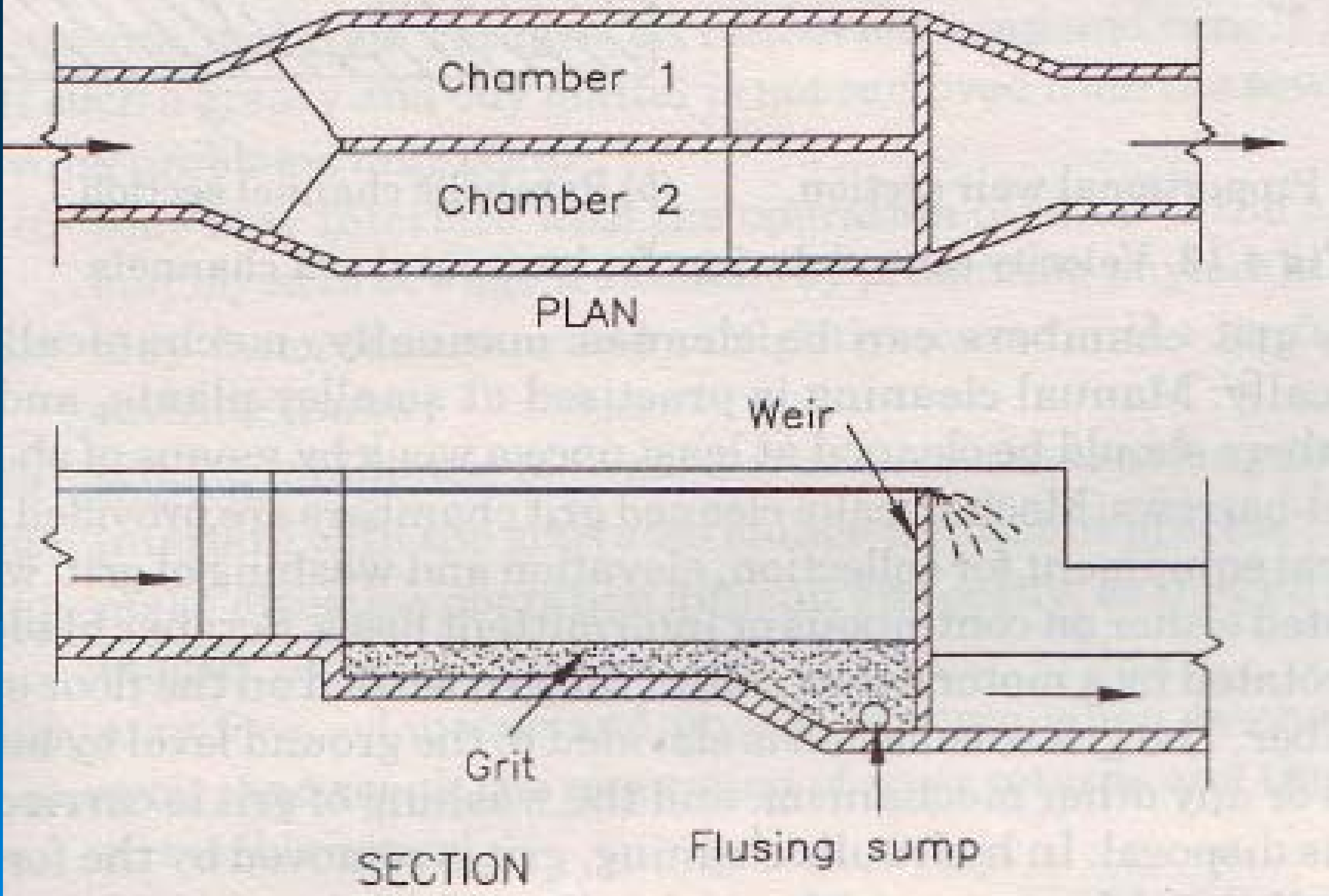

Fig. 4.12. Grit Chamber.

L-31 Preliminary and primary water treatments

- There is a narrow opening to reduce the velocity of sewage.
- These are present after the screeners.

L-31 Preliminary and primary water treatments

Skimming Tanks:

- Greases and oils in sewage includes
- fats, fatty acids, minerals etc.
- from kitchens and restaurants and from garages.

Diesel

- It is a narrow rectangular tank

30/10

L-31 Preliminary and primary water treatments

Skimming Tanks:

- The disposals can be converted into
  - soaps,
  - lubricants,
  - candles and
  - non edible products.

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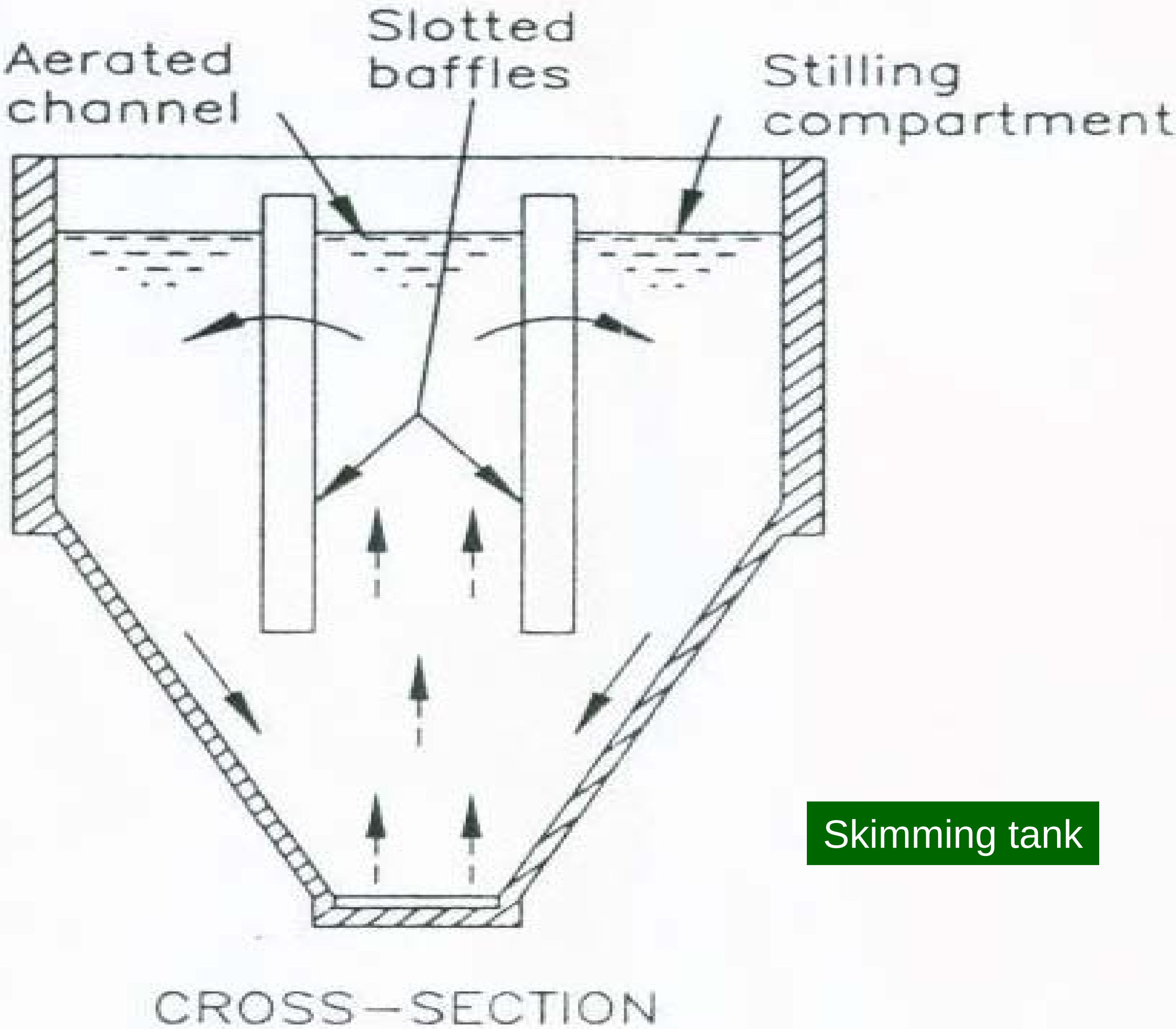

Skimming tank

L-31 Preliminary and primary water treatments

DISADVANTAGES :

Oily matter can pose these problems

- **clogging.**
- **create odour.**
- **Interfere the activated sludge process.**
- **Digestion will be harder.**

difficult
30/10

L-31 Preliminary and primary water treatments

Advantages:

- The sewage is freshened
- H_2S and other gases are removed.
- Flocculation of the colloidal matter takes place.

L-31 Preliminary and primary water treatments

Primary Treatment:

- After the removal of heavy solid particles,
- the removal of small bits of solid particles are done by

  - Sedimentation
  - Flotation
  - Neutralization

L-31 Preliminary and primary water treatments

Sedimentation:

The solids are removed by gravitational settling

Principle:

If the specific gravity of solids present in waste water is greater than that of water.

L-31 Preliminary and primary water treatments

- Then the solid particles
- settle down by gravity.

- in the sedimentation tank.

[storage tank].

- The time period for waste water detention is known as
- **Detention time.**

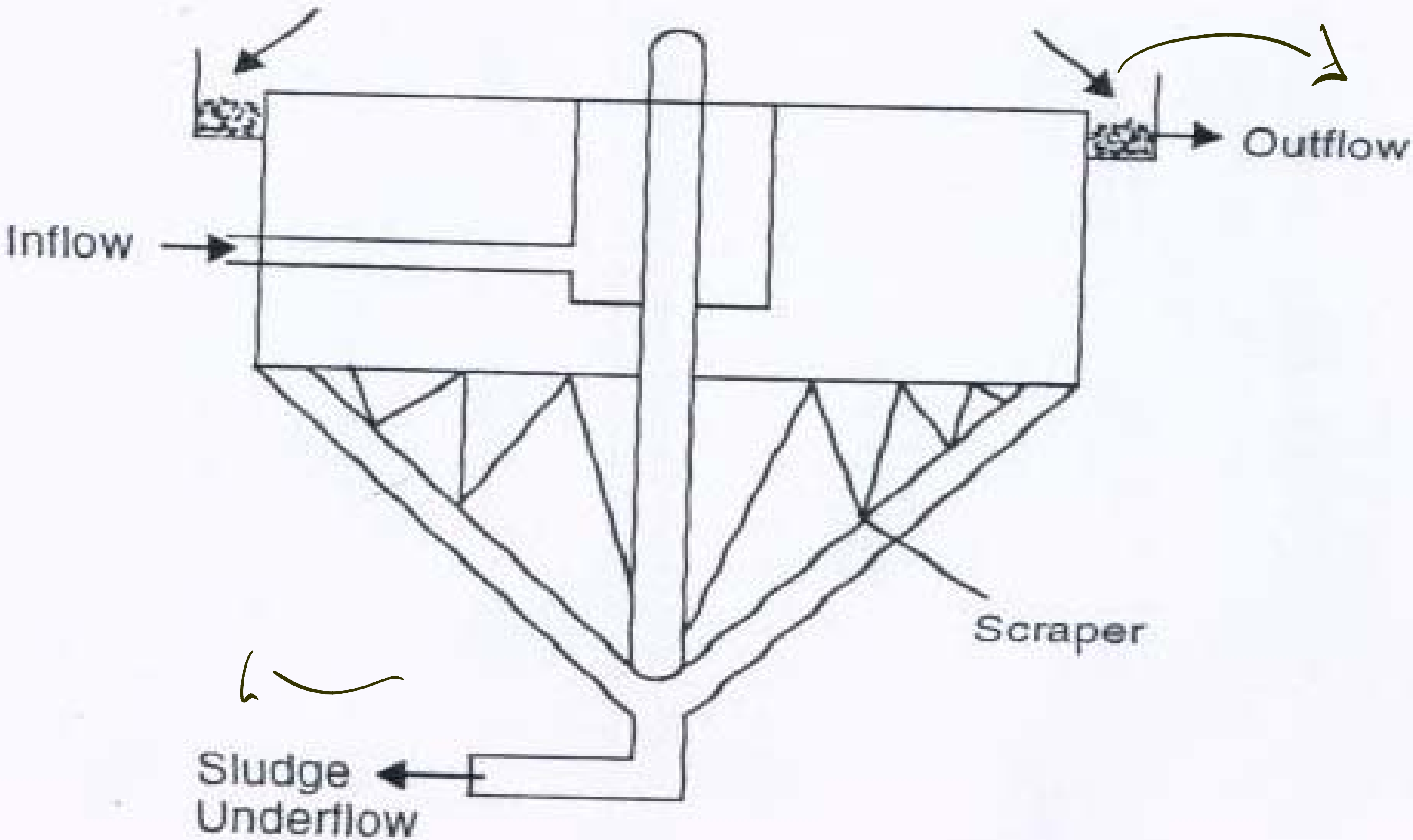

Fig. Circular Radial Flow.

L-31 Preliminary and primary water treatments

- In a well designed And efficient sedimentation tank within
- 2 hrs detention time.

- about 50% of a suspended solid
- 90% of the suspended solids and
- 40% organic matter

- Are removed.

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L-31 Preliminary and primary water treatments

- In rectangular tanks feed is introduced at one end along with the width of the tank and
- the overflow is collected at the surface either across the other end or at different points.

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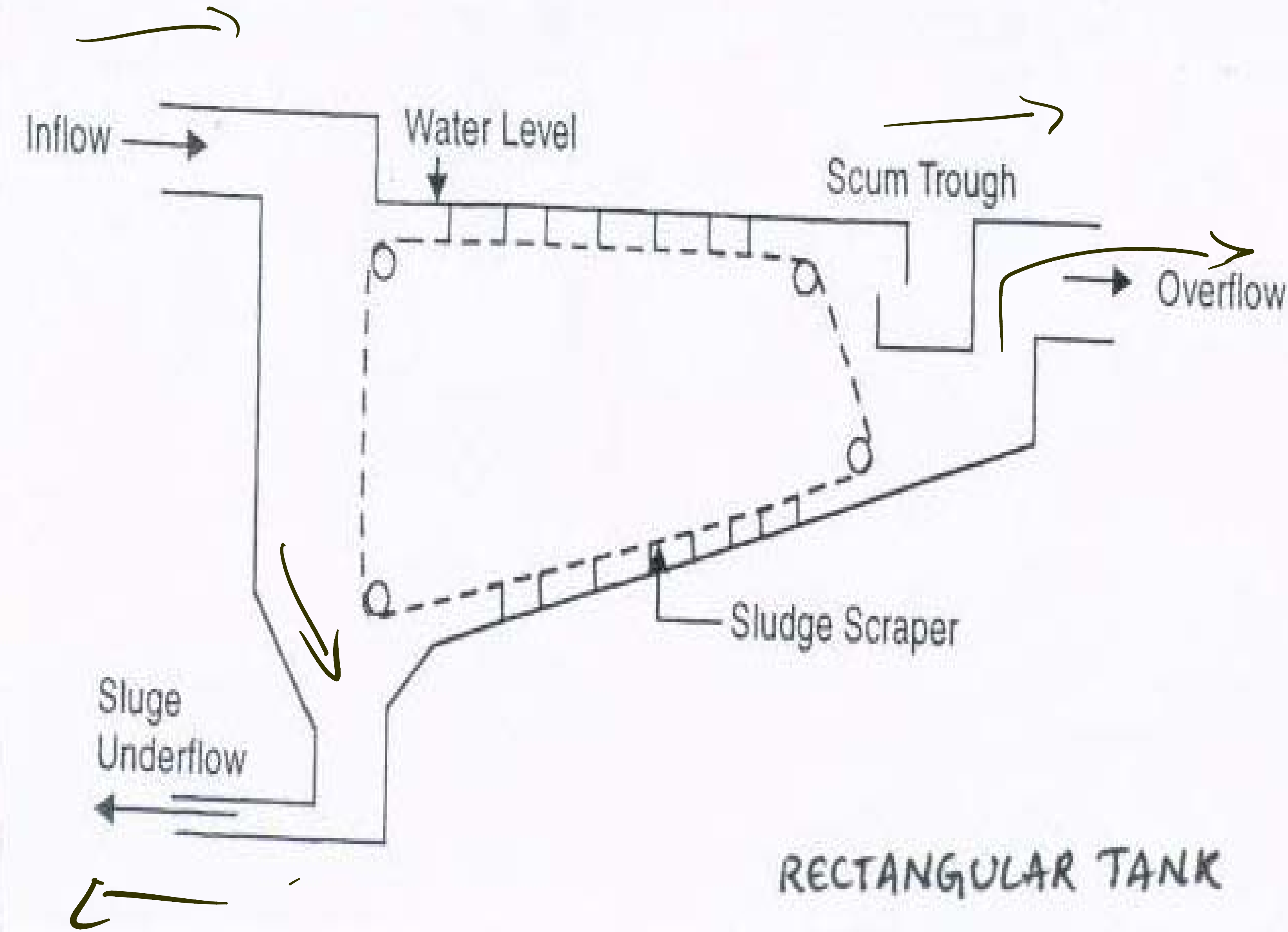

Inflow
Water Level
Scum Trough
Overflow
Sludge Scraper
Sluge
Underflow
RECTANGULAR TANK

L-31 Preliminary and primary water treatments

FLOTATION:

- It is used after sedimentation

for

- finely divided suspended solids and
- oily matter.
- Flotation technique is used

- in paper industries

to recover fine fibres

from the screeners.

L-31 Preliminary and primary water treatments

Than water

- **Particles of low density are**
- **very difficult to settle and**

- **The particles float to surface**
- **these can be easily removed.**

- **chemical coagulants such as**
- **Al & Fe salts can also be added.**

L-31 Preliminary and primary water treatments

The floated particles can easily be entrapped in the air bubbles.

Types:

(i) Dispersed - air flotation.

(ii) Dissolved - air flotation.

L-31 Preliminary and primary water treatments

Dispersed Air Flotation:

- The air bubbles generated
- are about 1 mm in diameter.
- Th not favourable for municipal waste water,
- wastes like oil, grease and face powders Can be separated.

L-31 Preliminary and primary water treatments

Dissolved Air Flotation:

In this air is dissolved in water at one atmospheric pressure.

- The flotation time in tank is
- half an hour.

L-31 Preliminary and primary water treatments

Neutralization:

- When pH of the industrial waste is too high or too low then it should be
- neutralized by alkali or
- Lime-soda treatment.
- Caustic-soda treatment.

30/10

L-31 Preliminary and primary water treatments

Neutralization:

- In acidic effluent Lime is added.
- In alkaline effluent H_2SO_4 or CO_2 is added.

L-32 Secondary and Tertiary water treatments

Secondary Treatment or Biological Treatment:

- It is a biological process that uses
- aerobic bacteria to remove
- biodegradable organic wastes.

L-32 Secondary and Tertiary water treatments

Secondary Treatment or Biological Treatment:

- It removes 90% of O_2-demanding wastes.
- Anaerobic bacteria converts 95% biodegradable carbon into biogas.

Secondary treatment

- **Aerobic treatment**
  - **Oxidation pond**
  - **Aerated lagoons**
  - **Trickling filter**
  - **Activated sludge**
- **Anaerobic treatment**
  - **Sludge digester**
  - **Septic Tank**

L-32 Secondary and Tertiary water treatments

Aerobic treatment:

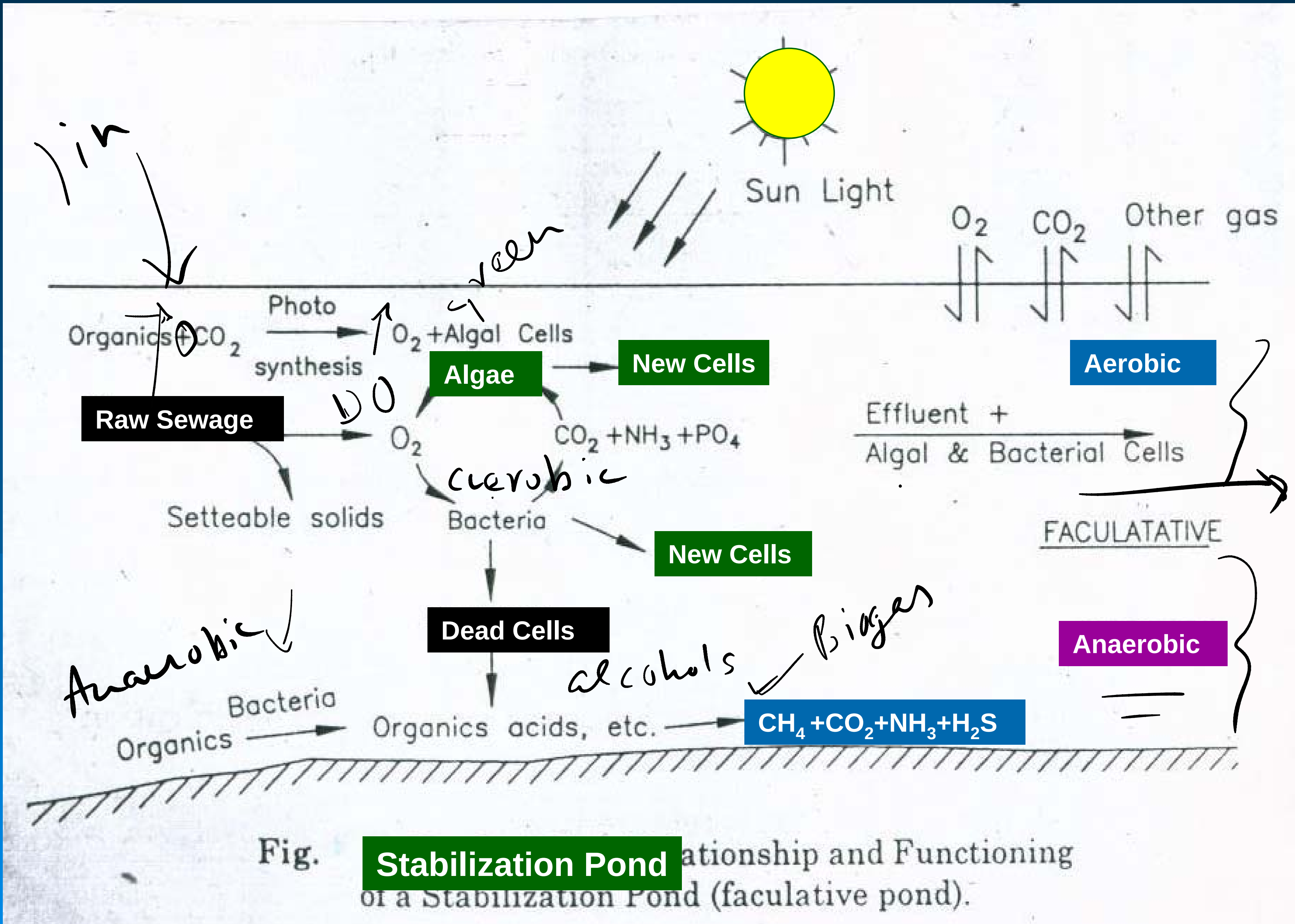
- Oxidation pond.
- Aerated lagoons.
- Trickling filters.
- Activated sludge.

L-32 Secondary and Tertiary water treatments

1. Oxidation pond or stabilization pond:

- Waste water is purified with the
- help of algae and aerobic bacteria in the pond.
- Which decompose organic food.

Oxidation pond or stabilization pond:



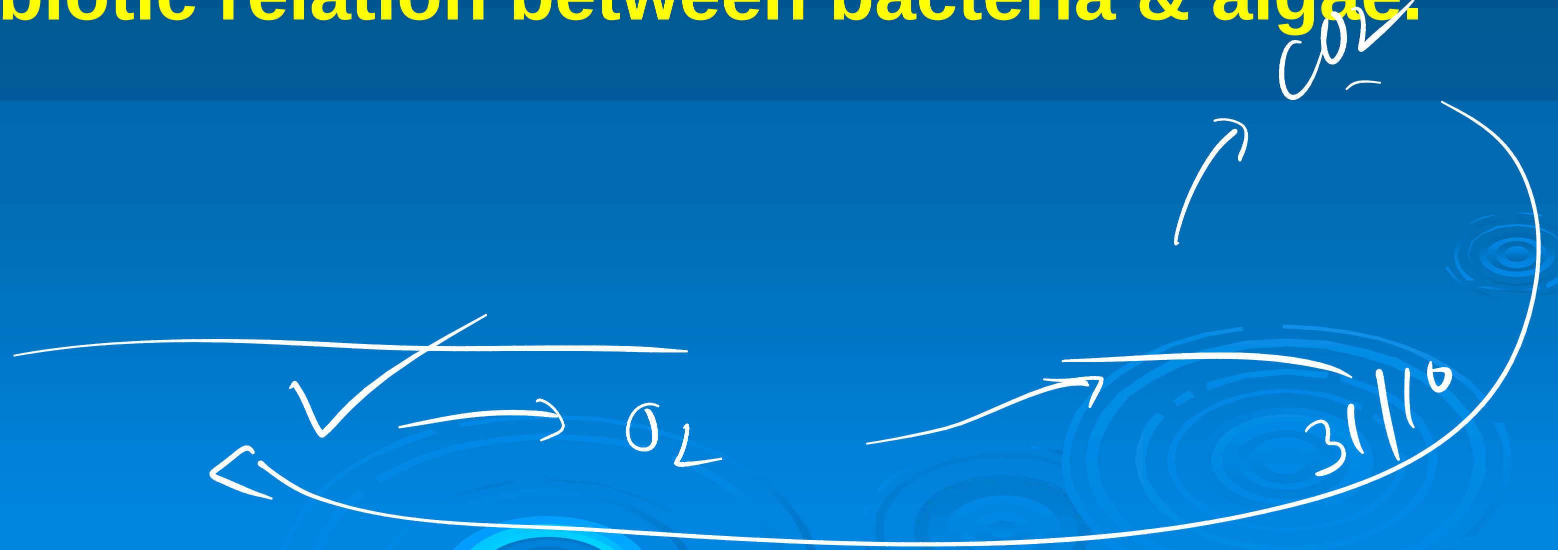
L-32 Secondary and Tertiary water treatments

- **They are used for treating--**

sewage & biodegradable industrial waste water.

This ponds shows –

symbiotic relation between bacteria & algae.



L-32 Secondary and Tertiary water treatments

- The organic matter give food to the **aerobic bacteria.**
- Aerobic bacteria convert (oxidize) **the waste in to CO_2 and nitrates.**

31/10

L-32 Secondary and Tertiary water treatments

[Oxidation pond]

- **The ponds can be of any shape and size.**
- **and 1.0m to 1.8m deep**
- **to avoid aquatic weeds**

31/10

L-32 Secondary and Tertiary water treatments

[Oxidation pond]

- **Stabilization ponds are open flow thorough earthen (clay) basins,**
- **specially designed and constructed to**
- **treat sewage and**
- **biodegradable industrial waste waters.**

3/16

L-32 Secondary and Tertiary water treatments

[Oxidation pond]

- provide long detention periods from
- few hours to several days.

- the aerobic bacteria eat up the organic matters [waste] and
- convert (oxidize) them in to CO_2 and nitrates.

- The algae utilizes these products for its growth.

L-32 Secondary and Tertiary water treatments

[Oxidation pond]

- **Algae produces O_2 by the process of photo synthesis**
- **which is utilized by aerobic bacteria and so on.**
- **Sewage organisms are stabilized by**
- **both aerobic and anaerobic reactions.**

L-32 Secondary and Tertiary water treatments

[Oxidation pond]

- **In the top aerobic layer where O_2 is supplied through**

atmosphere

- **algae photosynthesis**

organics + $CO_2 \longrightarrow O_2 \uparrow$ + Algae cells.

- **Few alcohols and organic acids are also oxidized along.**

L-32 Secondary and Tertiary water treatments

[Oxidation pond]

Bottom

- **The sludge and organic matter in Anaerobic layer are converted into**
- **CH_4, CO_2, NH_3 and H_2S.**

can be collects as Biogas

- **These gases escape the pond as bubbles.**

L-32 Secondary and Tertiary water treatments

[Oxidation pond]

Advantages:

- Can be redesigned easily on requirement

Disadvantages:

- More land area requirement .
- mosquito breeding and
- bad odour

L-32 Secondary and Tertiary water treatments

2. Aerated lagoons:

- These are large holding tanks or ponds having a
- depth of 3-5 m and
- lined with cement, polythene or rubber.
- These are treated for about
- 2-6 days.

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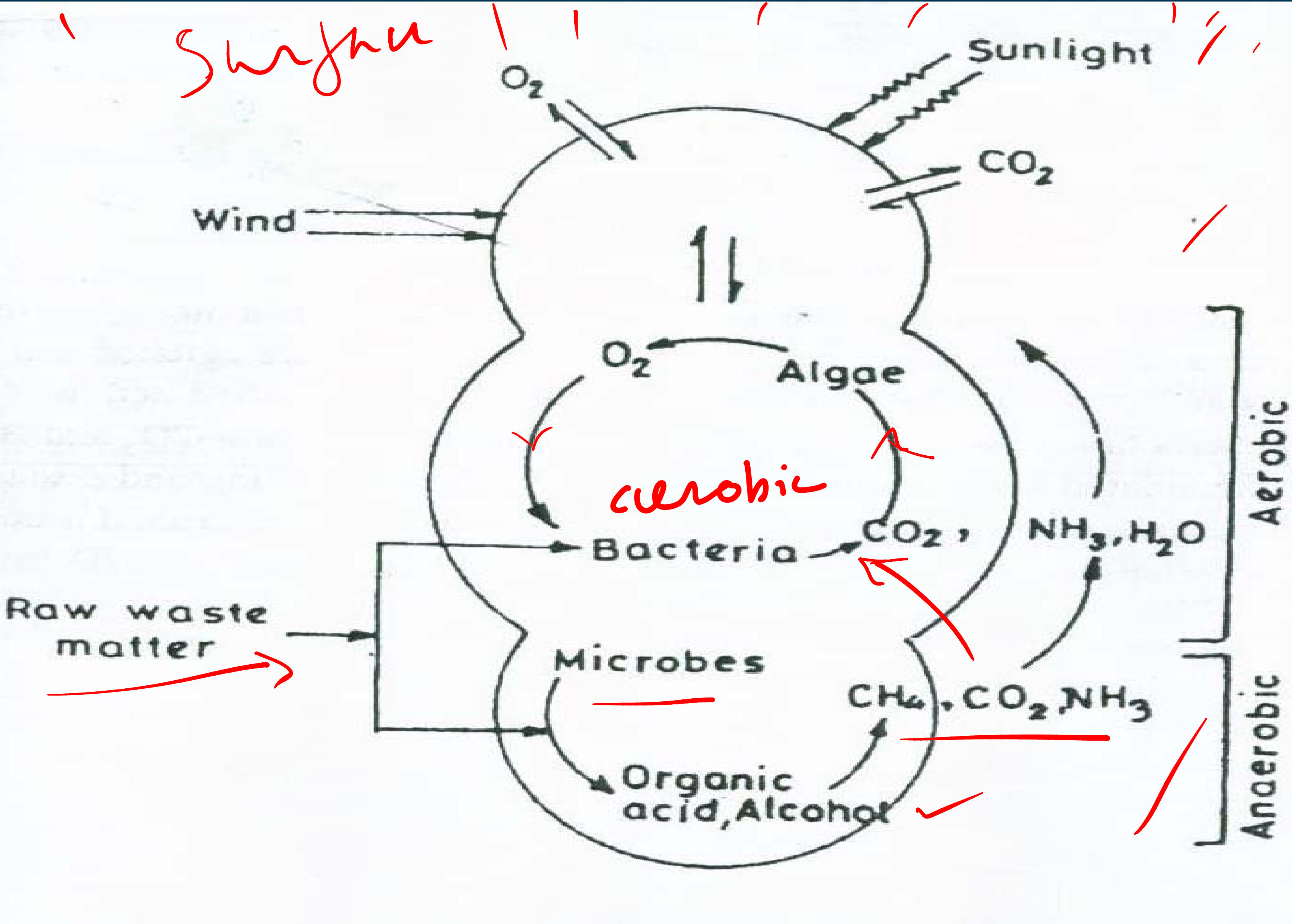


Fig. Aerated lagoon

L-32 Secondary and Tertiary water treatments

[Aerated lagoons:]

- During this time,
- a healthy sludge is formed

- BOD removal is up to 90%.
- Floating aerator maintains
- aerobic environment and

- prevent settling of the biomass.

31/10

L-32 Secondary and Tertiary water treatments

3. Trickling filter:

- It consists of circular or rectangular beds,
- 1m to 3m deep, made of PVC,

stones & chips

- Coal, Coke of size 40 to 150 mm.

31/10

- On this bed, the waste water is sprinkled from the top.

L-32 Secondary and Tertiary water treatments

- **used in treatment of-**

  Domestic Sewage.

- **also known as –**

  Sprinkling Filters.

  Used for treatment of-

- **Dairy**
- **Distillery**
- **Slaughter house**

31/10

L-32 Secondary and Tertiary water treatments

(Trickling filter)

- On this bed, the waste water is sprinkled from the top.

- air can enter from bottom.
- A gelatinous film made of
- bacteria and aerobic micro organisms known as
- ZOOGLEA.

3 | 10

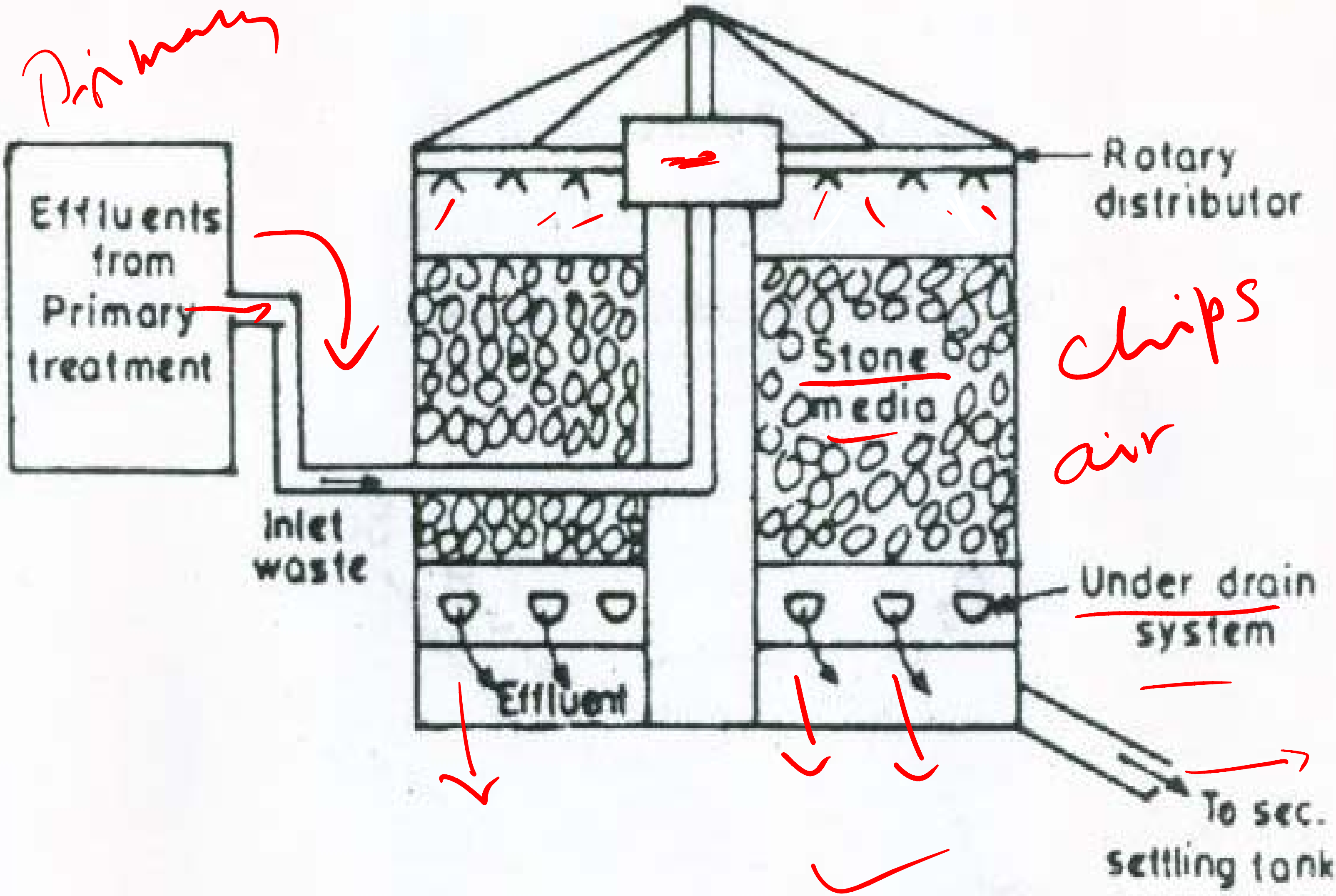


Fig. Trickling filter.

L-32 Secondary and Tertiary water treatments

ZOOGLEA

The organic impurities in the waste water are

- absorbed on the gelatinous film and
- oxidized by bacteria and micro organism.

L-32 Secondary and Tertiary water treatments

- ❖ When the film of impurities attached becomes
- ❖ thick and detaches is settled down.
- ❖ This helps in removing 60-85% BOD.

31/10

L-32 Secondary and Tertiary water treatments

Advantages:

- Effective for industrial wastes. Lesser land area required.
- BOD removal is 60 to 75 %.
- Simple in working. Effluent is sufficiently nitrified & stabilised.
- Less filter media required.

31|10

L-32 Secondary and Tertiary water treatments

Disadvantages:

- Cost of construction is high.
- Efficiency decreases with load.
- Filters are sensitive.

31/10

L-32 Secondary and Tertiary water treatments

4. Activated Sludge Process:

- **This is the final biological treatment.**
- It is a example of **aerobic suspended growth system.**

L-32 Secondary and Tertiary water treatments

4. Activated Sludge Process:

- In this process, the sewage or industrial waste water is
- aerated in a reaction tank in which microbial flock is suspended.

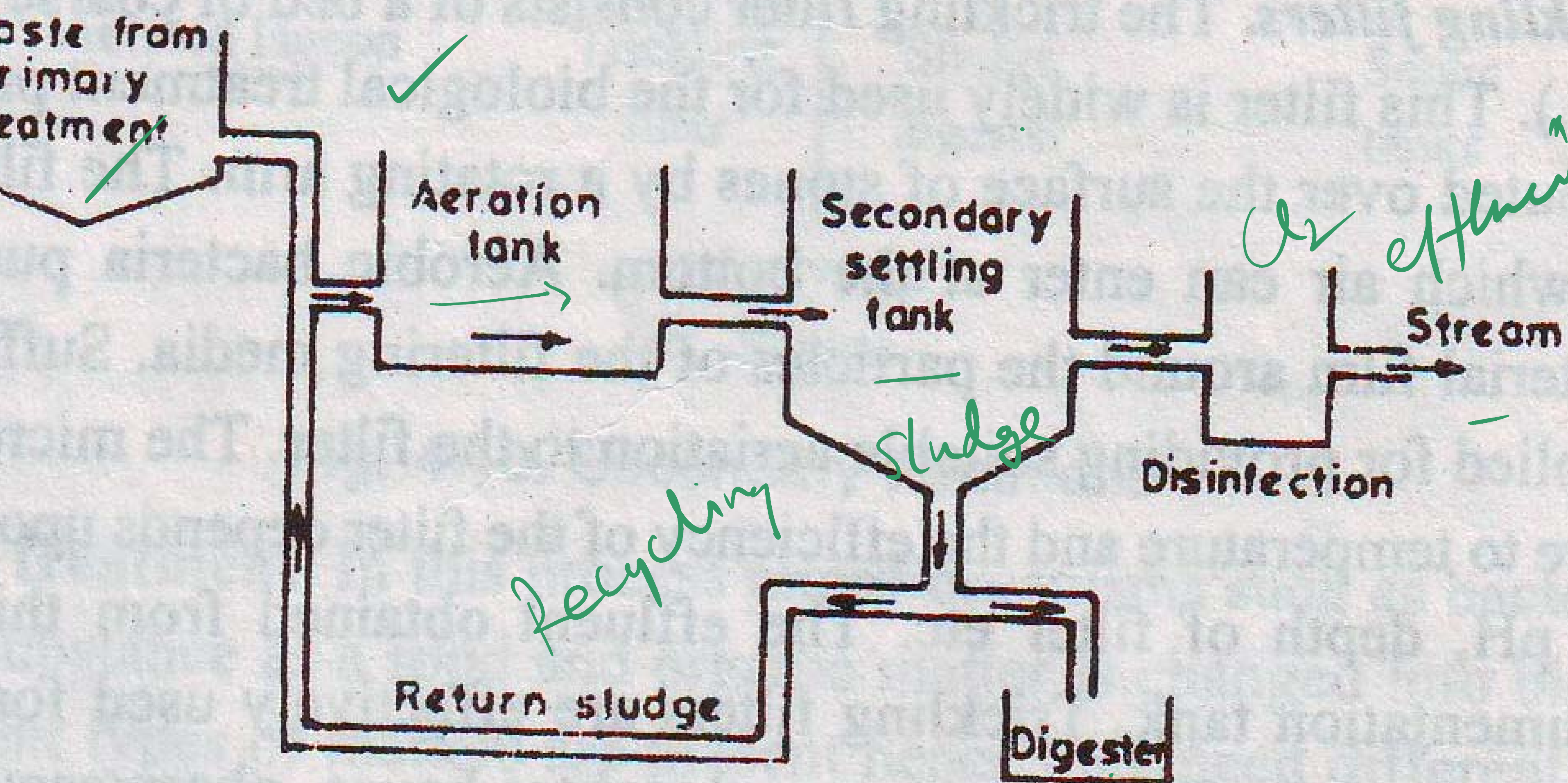


Fig. 4.13. Activated sludge plant.

L-32 Secondary and Tertiary water treatments

- Mixture of waste water & micro organism is Aerated in aeration tank.

- In this tank micro organism metabolizes the soluble & suspended organic matter, by taking DO .
- Active mass of microbes are called as-

  Activated sludge.

- The aerobic bacteria bring about biological digestion of the waste into CO_2 & H_2O.

L-32 Secondary and Tertiary water treatments

- The aerobic bacteria convert the waste into CO_2 and H_2O by biological degradation.
- Some organic compounds are sent for recycling also.
- The remaining suspended solid is called activated sludge.
- This can be discharged from chamber.

L-32 Secondary and Tertiary water treatments

Anaerobic Treatment:

i) Sludge digester

ii) Septic tank

L-32 Secondary and Tertiary water treatments

Sludge Digester:

The main purpose is

- to reduce its pathogenic contents and
- to improve its de watering characters.

Sludge is stabilized by

- decomposing the organic matter under controlled anaerobic conditions.

breakers.

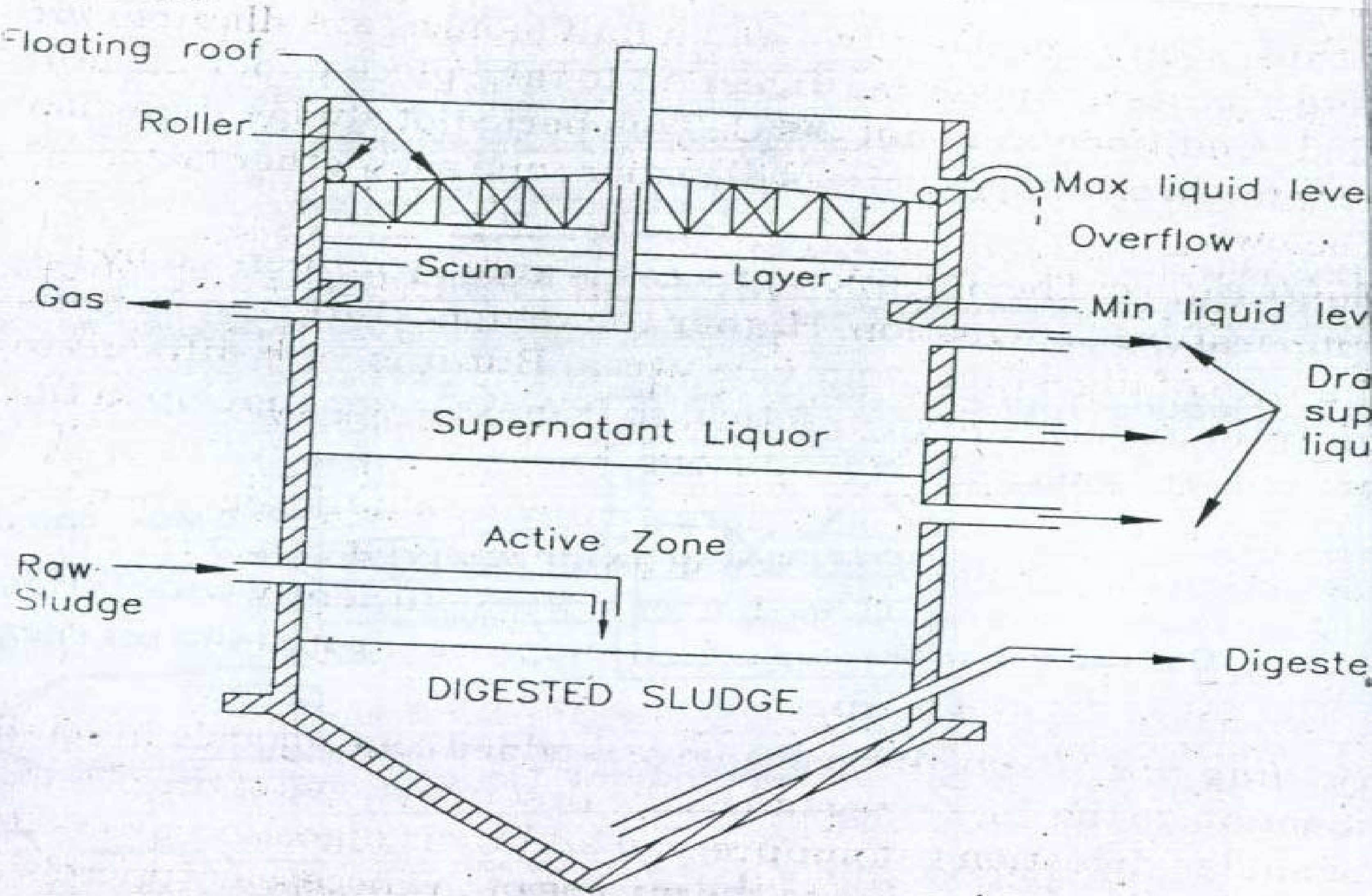


Fig. Anaerobic Sludge Digestion Tank.

L-32 Secondary and Tertiary water treatments

- The process of stabilization is called sludge digestion and is carried out in sludge digestion tank.

- Organic matter is converted into CH_4, CO_2 and H_2O.

  Organic matter $\longrightarrow$ $CH_4 + CO_2 + H_2O$.

- Pathogens will die with non-availability of food.

L-32 Secondary and Tertiary water treatments

Construction: of a sludge digester.

- Consists of a cylindrical RCC tank with hoppered bottom and is

- covered on top by means of either fixed or floating roof.

L-32 Secondary and Tertiary water treatments

Process (Sludge Digester)

- The raw **sludge is pumped** into the centre of the tank.
- **Gases** produced in the process are **collected** by gas dome at the top.
- The **digested sludge settles down** to **the bottom** and is taken out .

L-32 Secondary and Tertiary water treatments

(Sludge Digester)

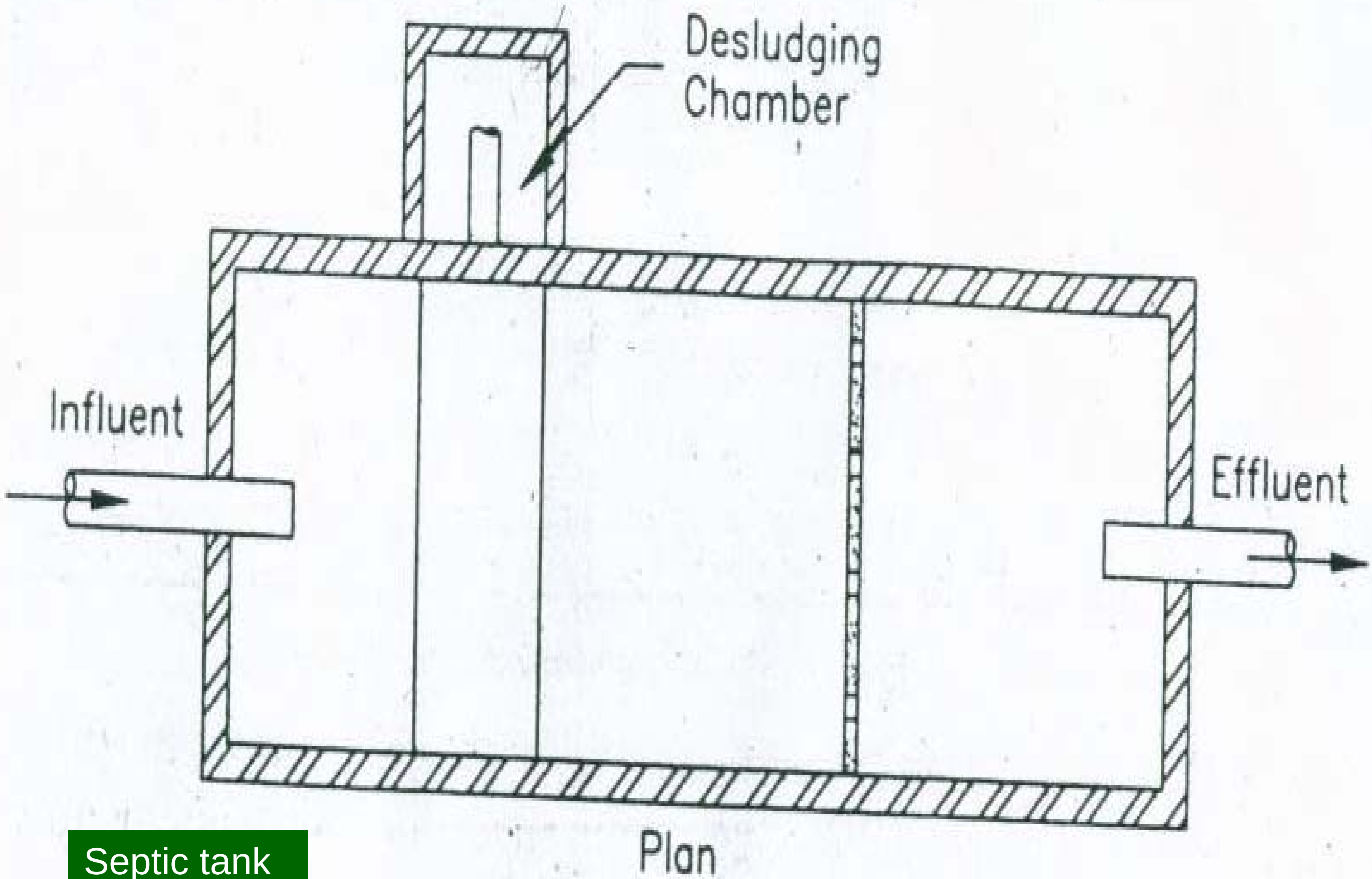
- The supernatant liquor collects in the upper portion of the tank.
- The scum formed at the top is not allowed to harden,
- otherwise it will prevent the gases from wising into the collection.

L-32 Secondary and Tertiary water treatments

SEPTIC TANK:

- It is a combined sedimentation & digestion tank.
- Sewage is allowed to flow slowly through this tank to
- enable the sewage solids to settle to the bottom of the tank.
- Where these are digested anaerobically.

Septic tank



Septic tank

L-32 Secondary and Tertiary water treatments

- Due to anaerobic condition the biodegradable organic matter is converted into gases and liquids.

- A thick crust of scum is formed at the surface of the tank.

- The septic tank is de sludged at regular intervals, generally once in every 1-5 years.

Septic tank

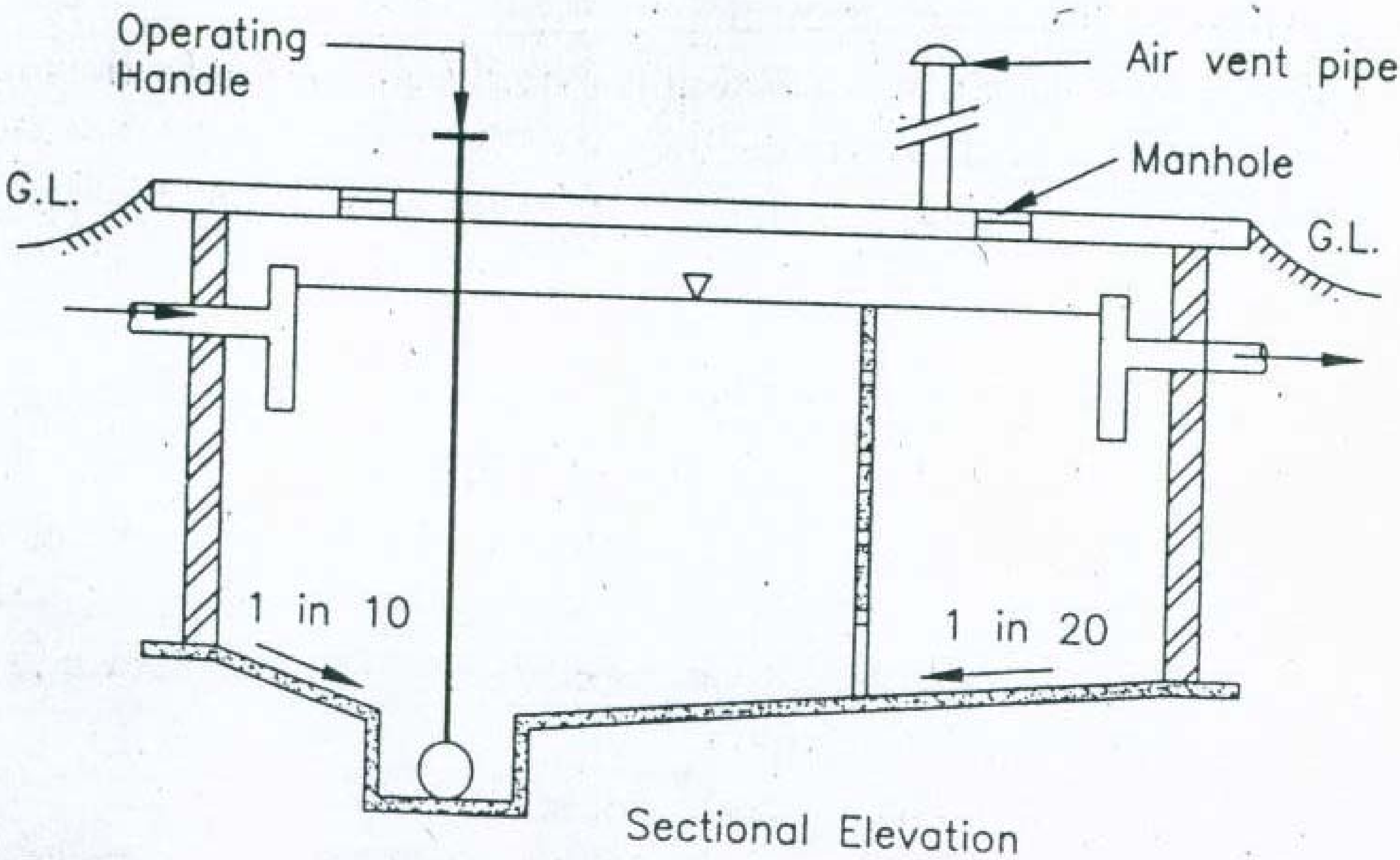


Fig. . Septic Tank.

L-32 Secondary and Tertiary water treatments

- The construction should be made to avoid short circuiting
- to ensure perfect sedimentation.
- In this tank biochemical reaction takes place
- in presence of anaerobic bacteria

L-32 Secondary and Tertiary water treatments

- 60-70% of suspended matter is settled as sludge at the bottom of tank.
- Organic matter is decomposed into gases and liquid.
- Very bad smell spreads out due to digestion process.
- It can remove about 90% of BOD.

L-32 Secondary and Tertiary water treatments

Advantages:

- This process reduces waste volume by 65%.
- Digested sludge can be used as manure.
- Gases produced are used as fuel.
- Less operation & maintenance cost.

L-32 Secondary and Tertiary water treatments

Tertiary Treatment:

Main components are:

- **Fine suspended solid particles should be removed.**
- **Micro organism such as bacteria should be removed.**

L-32 Secondary and Tertiary water treatments

- Removal of inorganic solids and final traces of organics.

Tertiary Treatment

i) Coagulation ii) Chemical oxidation

iii) Ion exchange

L-32 Secondary and Tertiary water treatments

1.Coagulation:

- Coagulants are used to convert the waste particles into solid particles.
- Negatively charged colloidal suspensions removed by co-agulants.
- In co-agulants (certain chemicals) are rapidly dispersed is waste water to change the characters of impurities.

L-32 Secondary and Tertiary water treatments

- Mostly used co-agulants for waste water treatment are

- hydrated lime, alum, ferric chloride and chlorinated coppers.
- At high pH these co-agulants produce
- insoluble $Al(OH)_3$ and $Fe(OH)_3$ flocs.

L-32 Secondary and Tertiary water treatments

$$Al_2(SO_4)_3 + 6H_2O \longrightarrow 2Al(OH)_3 + 3H_2SO_4$$

$$3H_2SO_4 + 3Ca(HCO_3)_2 \longrightarrow 3CaSO_4 + 6H_2CO_3$$

$$6H_2CO_3 \longrightarrow 6CO_2 + 6H_2O$$

$$Al_2(SO_4)_3 + 3Ca(HCO_3)_2 \longrightarrow 2Al(OH)_3 + 3CaSO_4 + 6CO_2$$

L-32 Secondary and Tertiary water treatments

- If the density of precipitation is less or low then
- polymeric agents can be added to make the precipitations bigger in size.
- By filtration flocs can be removed.

L-32 Secondary and Tertiary water treatments

Chemical Oxidation:

In tertiary treatment oxidizing agents such as

- chlorine,
- ozone etc.

are widely used for disinfection, removing organic materials.

- Chlorine destroys bacteria present in the waste water.

L-32 Secondary and Tertiary water treatments

$$Cl_2 + H_2O \longrightarrow HCl + HOCl$$

$$NH_3 + HOCl \longrightarrow NH_2Cl + H_2O$$

$$\text{Bacteria} + HOCl \longrightarrow \text{Killed pathogens}$$

- **Ozone** is another **powerful oxidizing agent** and acts as an
- **efficient disinfectant** and for many complex organic materials such as **pesticides etc.**

L-32 Secondary and Tertiary water treatments

Ion Exchange:

- This method is effectively used in removing hardness and

- Mn, Fe salts from potable water.

- Trace elements Cu, Cr, Pb, Ni, Cd etc.

- present in industrial waste water can be removed by this method.

of exchange material are given under :

Hydrogen-cycle cation exchange :

$$\left.\begin{array}{l}Ca\\ Mg\\ Na\end{array}\right\}\begin{array}{l}SO_4\\ Cl\\ NO_3\\ HCO_3\end{array} + \underset{\substack{\text{Cation}\\ \text{exchange}\\ \text{material}}}{XH} \longrightarrow X\left\{\begin{array}{l}Ca\\ Mg\\ Na\end{array}\right. + \begin{array}{l}H_2SO_4\\ HCl\\ HNO_3\\ H_2CO_3 + CO_2\end{array}$$

Hydroxide-cycle anion exchange :

$$\begin{array}{l}H_2SO_4\\ HCl\\ HNO_3\\ H_2CO_3 + CO_2\end{array} + \underset{\substack{\text{Anion}\\ \text{exchange}\\ \text{material}}}{Y\,OH} \longrightarrow Y\left\{\begin{array}{l}SO_4\\ CO_3\\ Cl\end{array}\right. + H_2O$$

Regeneration of cation-exchange material :

$$X\left\{\begin{array}{l}Ca\\ Mg\\ Na\end{array}\right. + \begin{array}{l}H_2SO_4\\ \text{or}\\ HCl\end{array} \longrightarrow \underset{\substack{\text{Anion}\\ \text{exchange}\\ \text{material}}}{XH} + \left.\begin{array}{l}Ca\\ Mg\\ Na\end{array}\right\}\begin{array}{l}SO_4\\ \text{or}\\ Cl\end{array}$$

Regeneration anion-exchange material :

$$Y\left\{\begin{array}{l}SO_4\\ CO_3\\ Cl\end{array}\right. + NaOH \longrightarrow Y\,OH + \begin{array}{l}Na_2SO_4\\ NaCl\\ Na_2CO_3\end{array}$$

L-32 Secondary and Tertiary water treatments

(Ion Exchange)

- It is economical
- Special ion-exchanger are used for
- retrieval of toxic metal ions
- from industrial waste water.

Assignment-3

Q.1. Write short notes on :

i) Organic water pollutants.

ii) Radioactive water pollutants.

iii) Synthetic water pollutants.

Q.2. Discuss the sources, effects and types of water pollution.

Q.3. Write short notes on:

a) Trace elements in water

Assignment-3

b) Significance & determination of D.O.,B.O.D. and C.O.D.

Q.4. How the oligotrophic lakes are converted into eutrophic lakes? Describe the types, effects and control of Eutrophication.

Q.5. write the techniques to remove water pollution by $1^0, 2^0, 3^0$ treatment methods.

CASE STUDIES

THIS IS FOR YOU TO DO WITH INTEREST AND ENTHUSIASM


THANKS