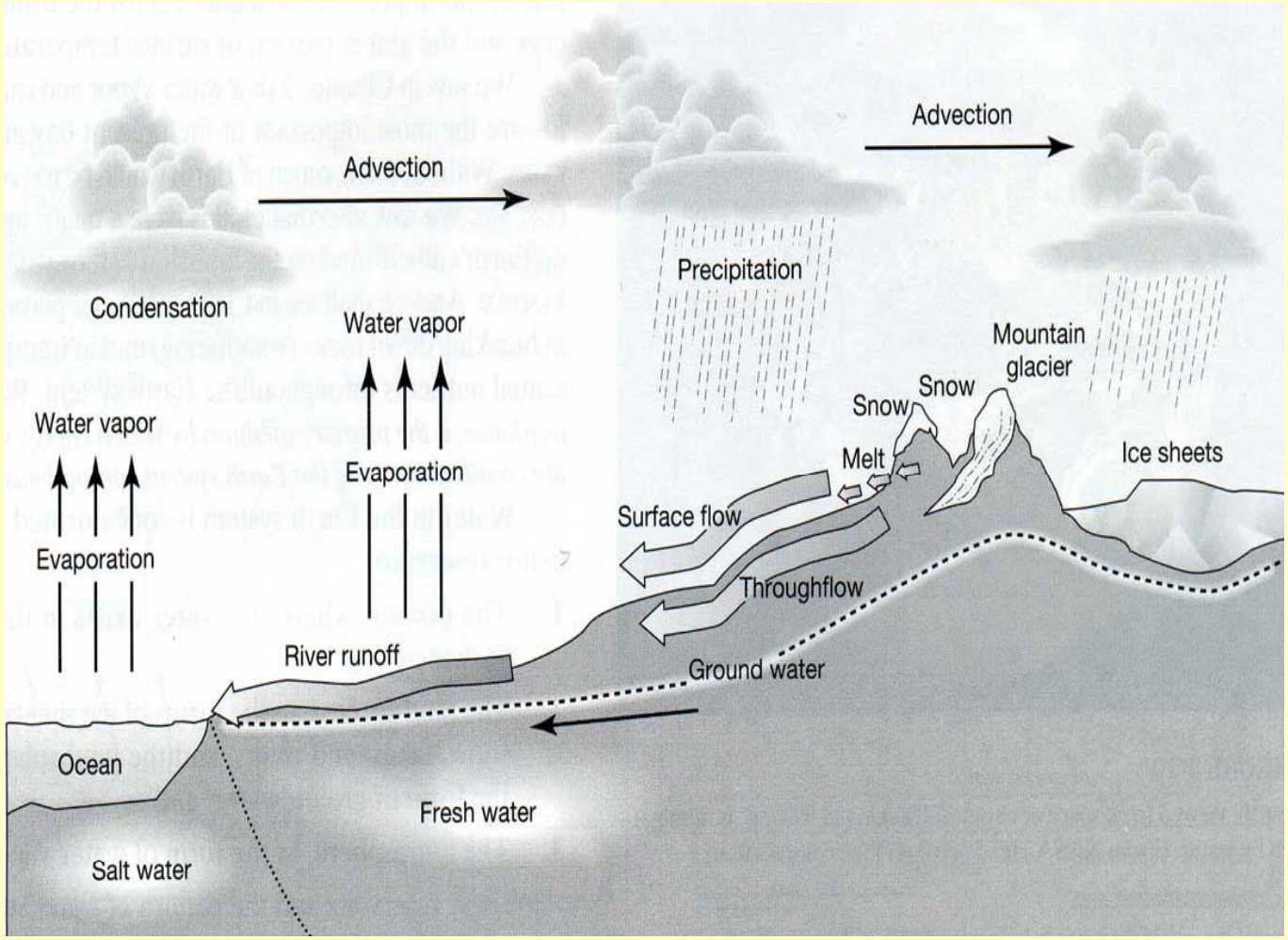
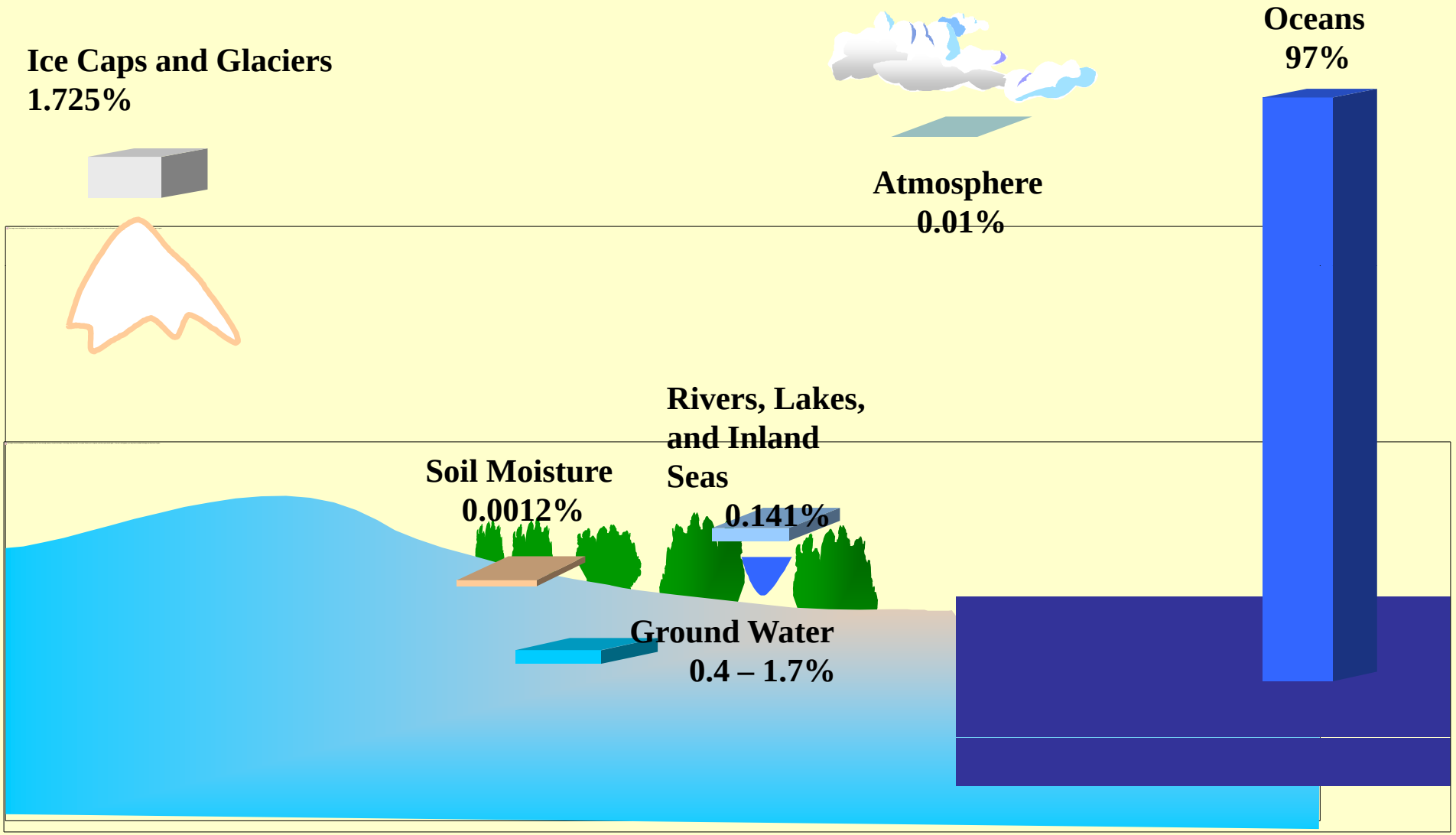
Water Cycle



- Atm. - Ocean - Land
- Evap. - PPT - Runoff

Distribution of Water Reservoirs



World Water Supply

97.200% salt water in the oceans

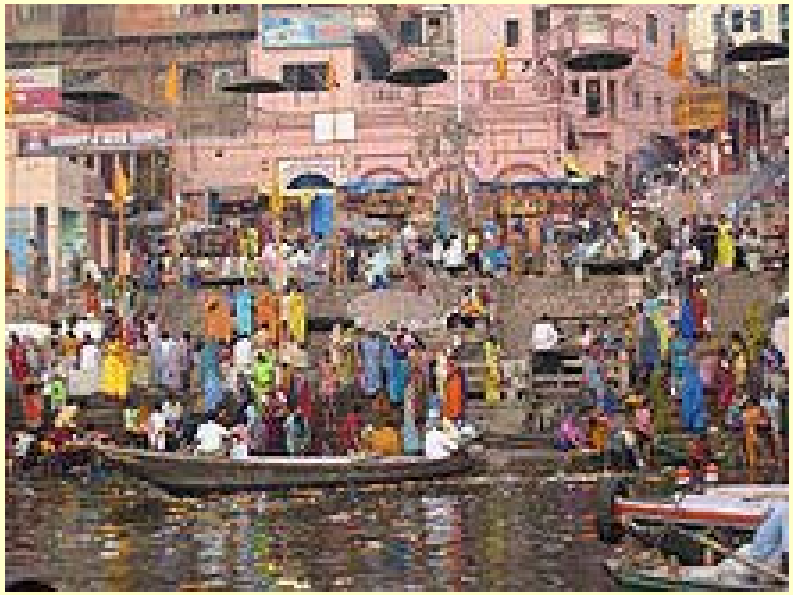
02.014% ice caps and glaciers

00.600% groundwater

00.009% surface water

00.005% soil moisture

00.001% atmospheric moisture



Examples of Polluted Waters

Cardboard – Takes 2 weeks to degrade.

Newspaper – Takes 6 weeks to degrade.

Photodegradable packaging – Takes 6 weeks to degrade.

Foam – Takes 50 years to degrade.

Styrofoam – Takes 80 years to degrade.

Aluminium – Takes 200 years to degrade.

Plastic packaging – Takes 400 years to degrade.

Glass – It takes so long to degrade that we don't know the exact time.

Water Pollution

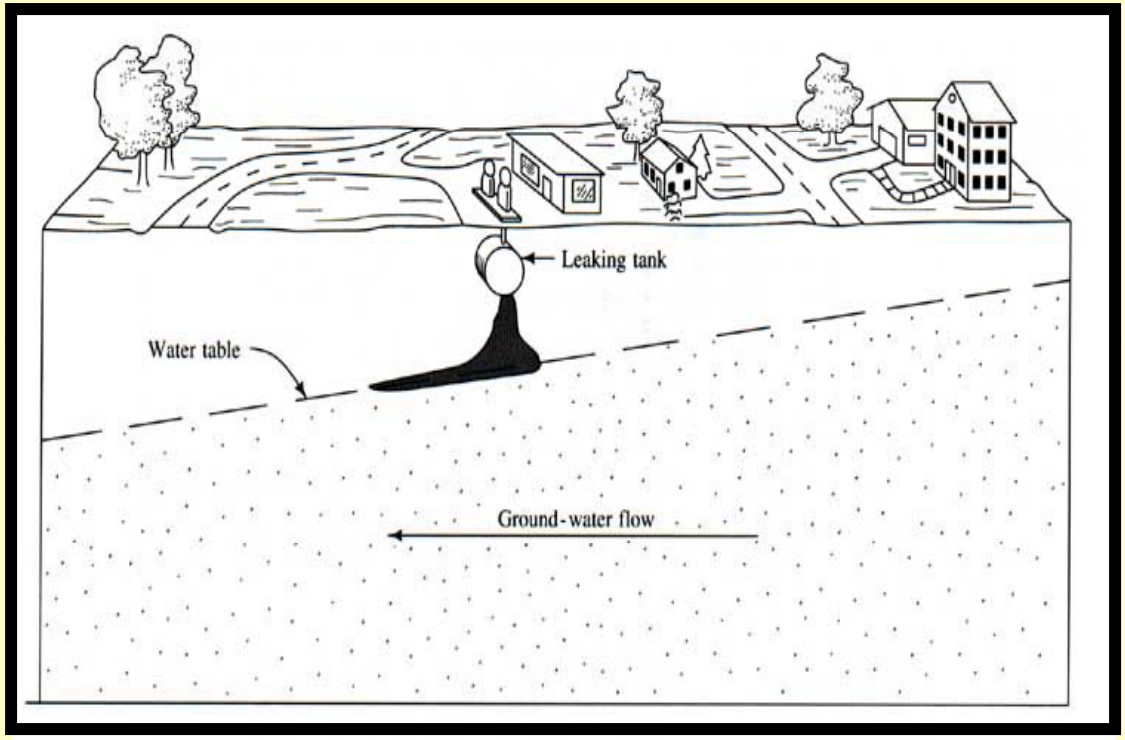
Two major classifications

- Point Source
- Non-point Source

Point Sources

- Single large source
- Can localize it to one spot
  - Sewage pipes
  - Industrial Plants
  - Waste heat: from industrial discharge, power plant, nuclear plant
  - Detergents

Point Source - Example

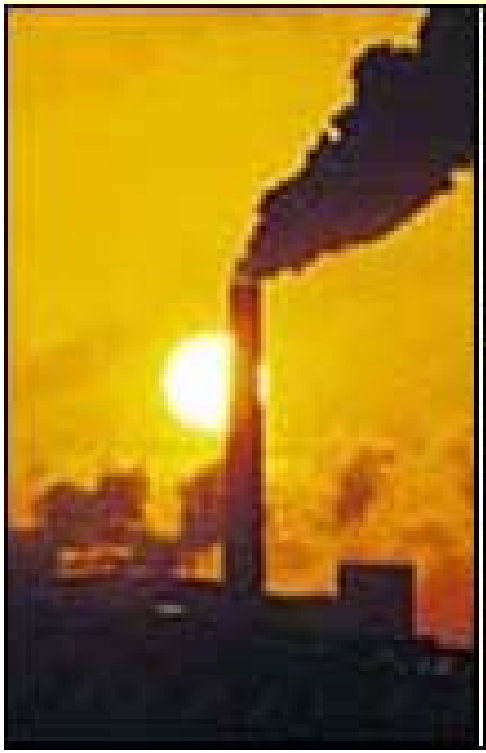


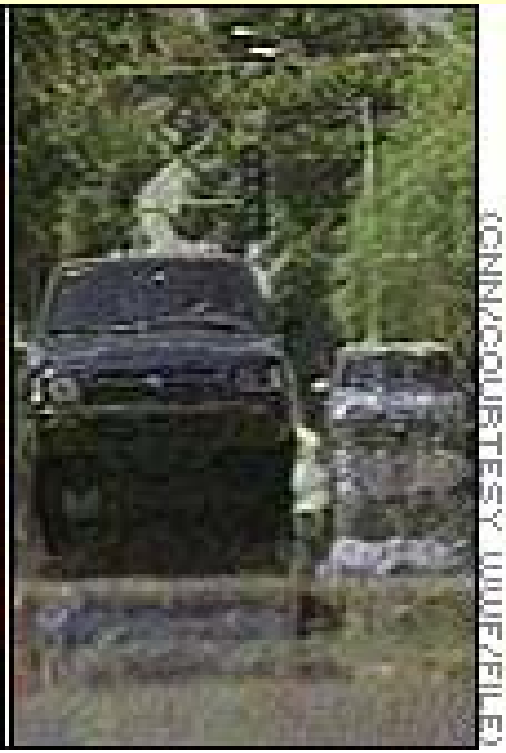
- LUST - Leaky Underground Storage Tanks
- 22% of the 1.2 million UST are LUST

- Non-point Sources

Diffuse source or many smaller point sources

- Automobiles
- Fertilizer on fields





Water Pollution: Many Forms

- Synthetic *Organic Compounds*
- **Inorganic Compounds & Mineral** Substances such as Acids, etc.
- **Radioactive** substances
- **Oxygen-demanding** wastes
- Plant Nutrients
- Sediments
- **Thermal Discharges**

How do spills happen?

Oil spills into rivers, bays, and the ocean are caused by **accidents** involving ***tankers, barges, pipelines, refineries, and storage facilities***, usually while the oil is being transported to us, its users (as in the photo at right, which shows a supertanker, the *Amoco Cadiz*, sinking off the coast of France in 1978).

Spills can be caused by:

People making mistakes or being careless.

Equipment breaking down.

Natural disasters such as hurricanes.

Deliberate acts *by terrorists, countries at war, vandals, or illegal dumpers*.

What constitutes quality drinking water?

- Free of pollutants
- Tastes good
  - Want Sodium Bicarbonate and Calcium Sulfate in same concentrations as found in saliva
  - 10 ^{o}C
  - As little chlorination as possible
- Calcium & magnesium account for most water hardness, death rates (cardiovascular disease) higher in soft water areas than in hard water areas
- Copper needed to absorb & metabolism iron, but >1mg/liter makes water unpalatable

Forms of Pollution – Details

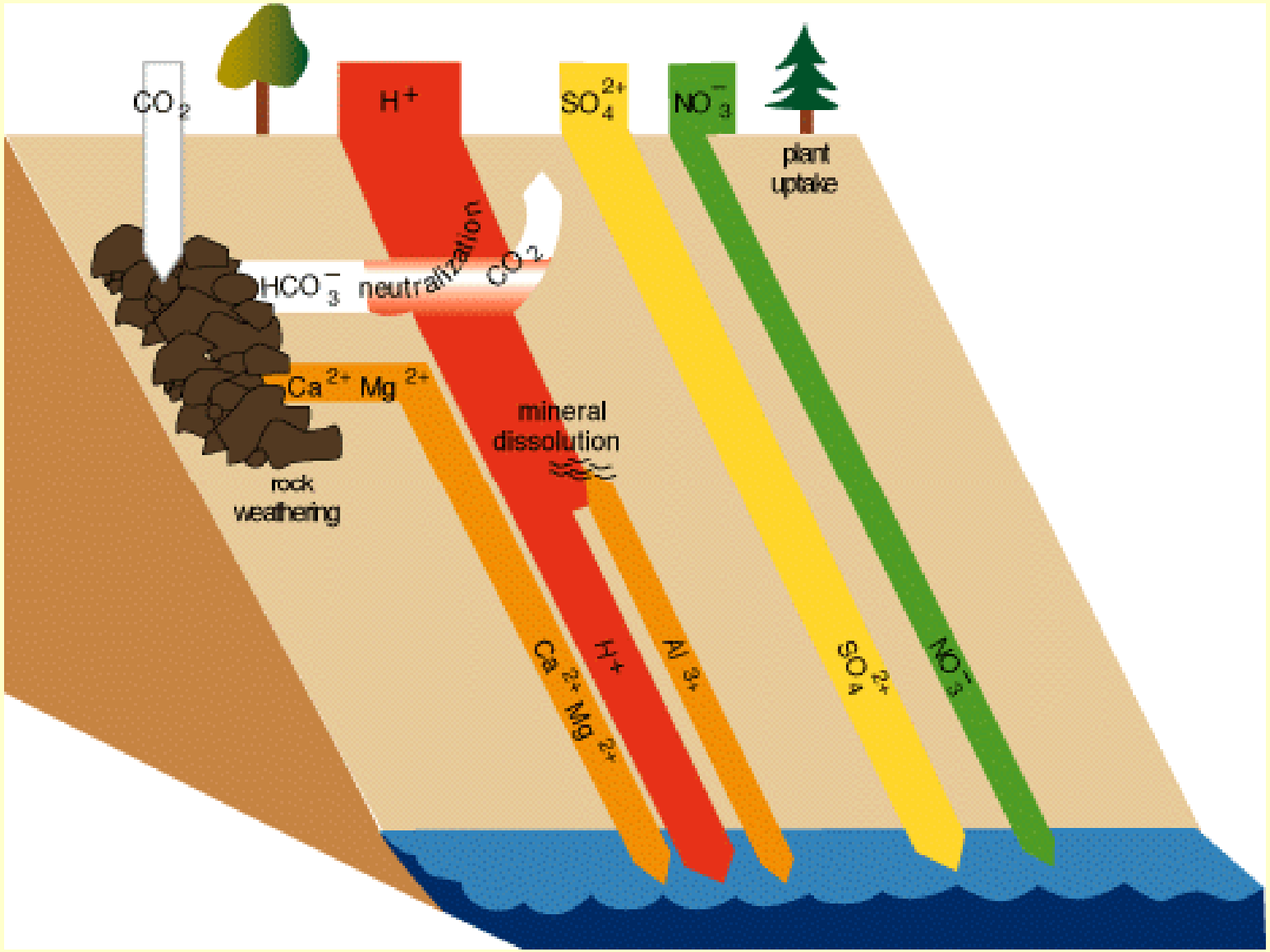
- Inorganic – acids, metal salts, toxic metals

- **One gram of lead in 20,000 liters** of water makes it unfit for drinking. Lead is often found in the pipes of older homes

Forms of Pollution – Details

- Organic: sewage, pesticides, plastics, etc.
- One drop of oil can render up to 25 liters of water unfit for drinking
- One gram of 2,4 D can contaminate 10 million liters of drinking water!
- One gram of (**Polychlorinated Biphenyls**) PCBs can make 1 billion liters of water unsuitable for freshwater aquatic life!

Acid Precipitation:
When Air Pollution Becomes Water Pollution



How does acid kill the fish? One way is mobilizing metals

- When all base cations are striped from soils
- Acid now reacts with metals e.g. aluminum
  - Normally aluminum is immobile
  - below pH 5 - mobile aluminum
- Fish breath in the water
  - Aluminum comes out of solution
  - Clogs gills – suffocate
  - Aluminum causes problems with fish

  by interfering with the ability of gills to take oxygen from water

Effect of water pollution

1. **Oxygen Demanding Wastes:**

- Organic matters (plants or animal etc.,) reaches water bodies it get decomposed by **micro-organisms** in water.

- Dissolved oxygen (DO) is used for this purpose.

- ***DO is the amount of oxygen dissolved in water.***

- The amount of DO is depends on ***aeration, photosynthetic activity in water,***
- ***Respiration of animals and plants, and ambient temperature***.

- Lower DO level may be harmful to animals especially fish population

- Oxygen depletion (deoxygenation) helps in release of phosphates from bottom sediments and causes ***eutrophication***.

- The ***saturated value of DO varies from 8-15 mg/L.***

- For ***active fish species (trout and Salmon) 5-8 mg/L*** of DO is required

- whereas ***less desirable species like carp can survive at 3.0 mg/L of DO***.

2. Nitrogen and Phosphorous compound:

Addition of these compounds to the water helps in the **growth of algae** and other plants.

These plants die and decay, which again makes the ***consumption of oxygen*** for the degradation.

Excess growth and decomposition of plants ***changes the concentration of CO_2***, which will **change the pH of water**.

3. Pathogens:

Waste water especially sewage contains many pathogenic and non-pathogenic micro-organisms and many viruses.

Hence, the waste water causes water borne diseases like ***cholera, dysentery, typhoid, jaundice etc***. are spread by water contaminated with sewage.

4. Toxic compounds:

Pollutants such as heavy metals, pesticides, cyanides and many other organic and inorganic compounds are harmful to aquatic organisms.

They increases the **bio-accumulation** and It leads to **bio-magnification**.

Eg DDT (dichlorodiphenyltrichloroethane)

Water → Zooplankton → Minnows → Needle fish → Birds

0.00001 → 0.01 → 0.1 → 1.0 → 10.0 (ppm) DDT concentration

Hg causes Minamata disease

Hg dumped into water and it transformed into water soluble ***Methyl mercury*** accumulation in fish

Methyl mercury contaminated fish caught from *Minamata bay* in Japan.

Itai-itai disease due to Cd contamination.
Blue baby syndrome due to Nitrate contamination in water
Fluorosis – fluoride contamination causes defects in teeth and bones.

Waste water treatment

Primary treatment:

1. It is physical process for removal of **debris, large particles by screening**.
2. The wastewater after screening is passed through **grit chamber containing sand**.
3. Then the water is passed through the **sedimentation tank** or clarifier where most Of the **suspended solids settle down** due to gravity.
4. For better removal of suspended solids, sometimes **chemically treated polymers** are used.
5. By this way 35% of BOD and 60% of suspended solids are removed during Primary treatment.

BOD : DO required to aerobic decompose for 5 days at 20deg.

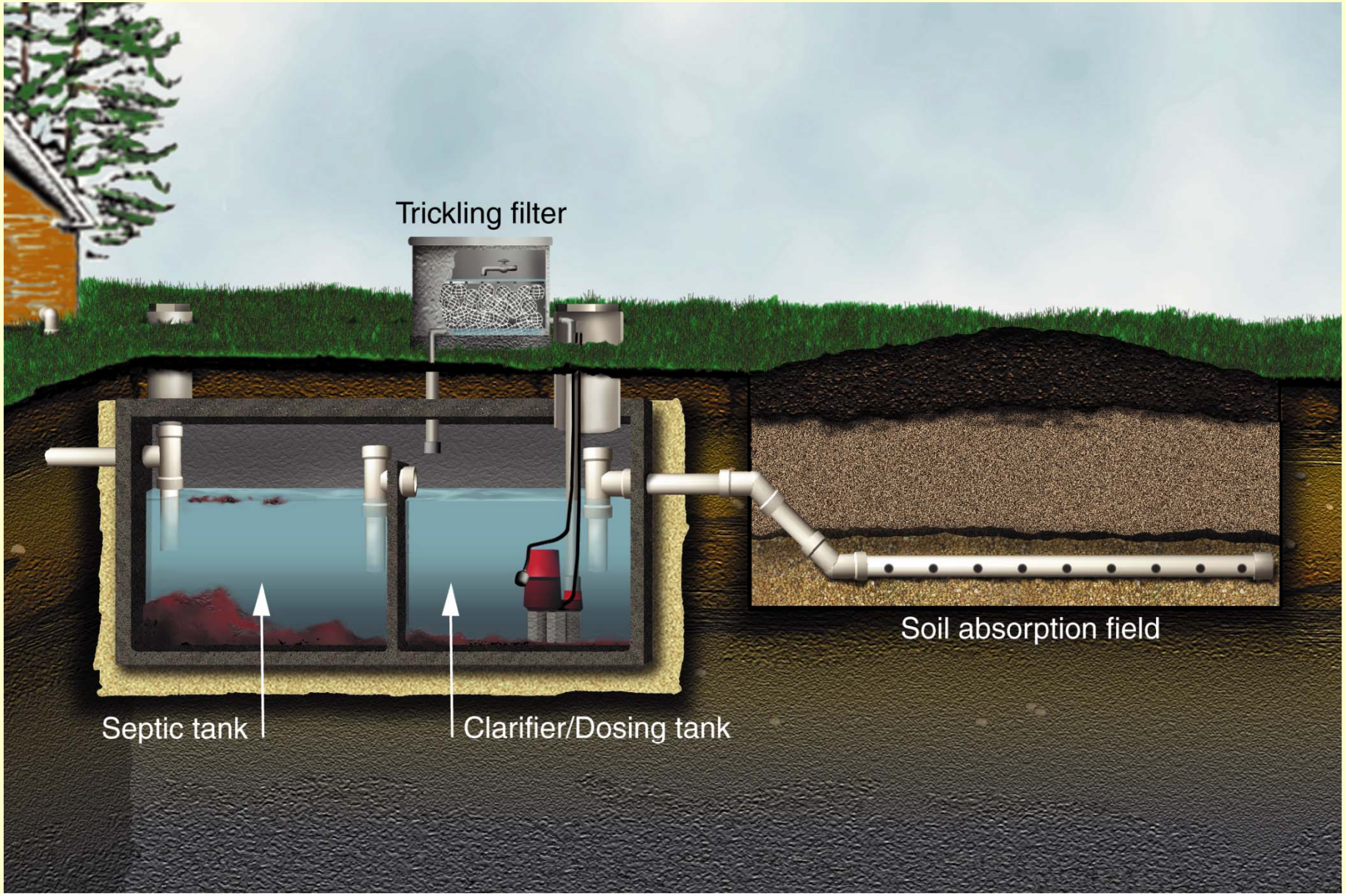
Secondary treatment:

1. It is a ***biological process***
2. **Microorganisms** used to degrade the pollutants
3. It removes up **90% of the BOD and 90% of suspended solids**.

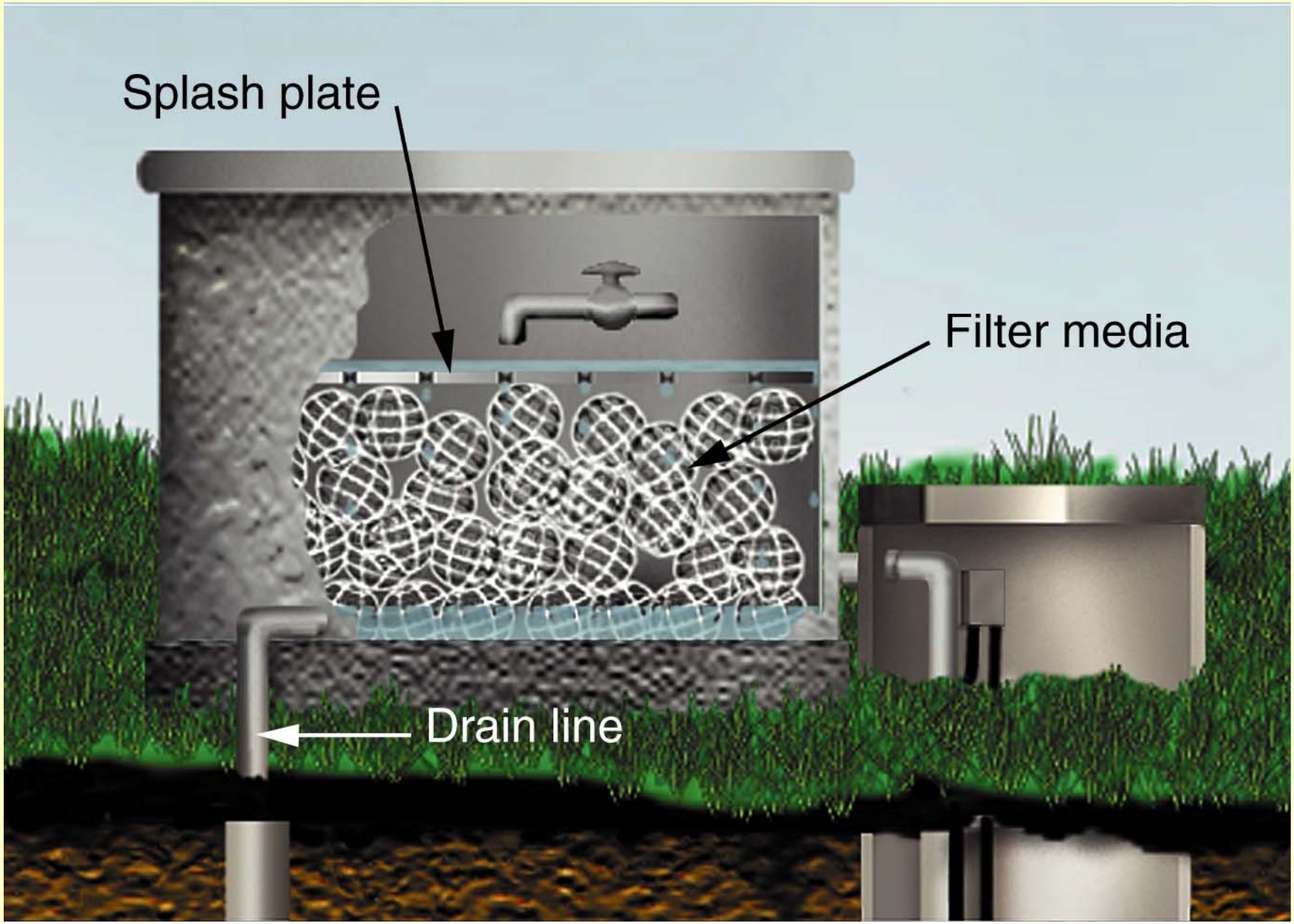
Design of Trickling Filter System

- Each trickling filter has several components:
  - Septic tank.
  - Clarifier/dosing tank.
  - Trickling filter.
  - Land application system.

Trickling Filter System



Trickling Filter

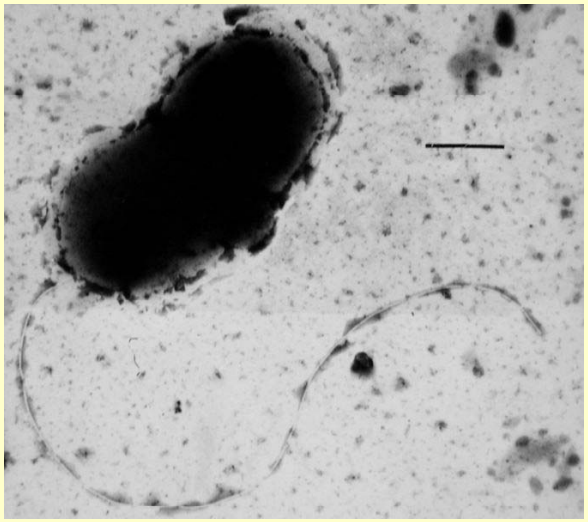


Trickling Filter Design- Clarifier/Dosing Tank

- It is a concrete or fiberglass tank that allows biological materials to settle out of the water.
- It also houses a pump to dose water over the top of the filter.
- Return water from the filter, enters the tank.

Trickling Filter Design-Trickle Filter

- A trickling filter, which is a tank of media such as gravel of plastic material.
- Wastewater is distributed over the top of the media and flows downward across the media surface in a thin film.
- It then exits the bottom of the tank and flows into the clarifier/dosing tank.



Desulfovibrio vulgaris

$H_2NCONH_2 \rightarrow CO_2 + 2NH_3$

$NH_3 \rightarrow HNO_3, HNO_2$, etc.

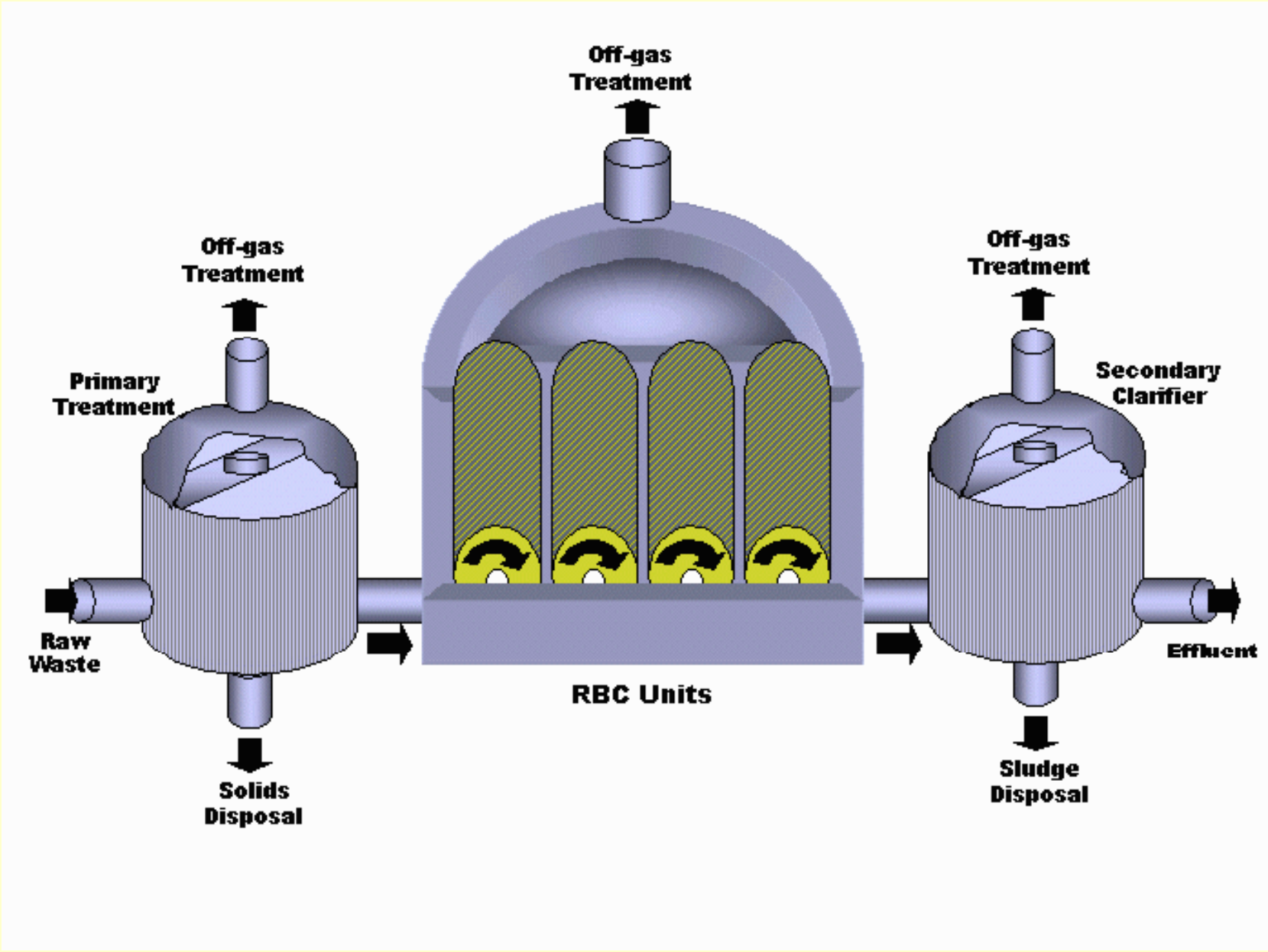
HNO_3, HNO_2 + Base $\rightarrow$ NH4NO_3, NH_4NO_3, NH_4NO_2, $Ca(NO_3)_2$, etc

Activated Sludge Process:

1. The effluent from the primary clarifier goes to aeration tank.
2. Aeration tank also receives ***microorganisms*** from the secondary settling tank known as activated sludge.
3. **O_2 is pumped into aeration tank for maintaining aerobic conditions**.
4. After few hours of agitation, the waste water goes to secondary settling tank, where the solids settle at the bottom.
5. The **sludge is produced, dewatered and disposed off**.
6. This can be used for landfills or disposed off in ocean or used in **croplands, pastures as organic fertilizer.**

Rotating Biological Contactor (RBC)

Rotating Biological Contactor (RBC)



Upflow Anaerobic Sludge Blanket (UASB) Reactor

It consists of 4 stages of **anaerobic digestion**

Hydrolysis, acidogenesis, acetogenesis and methanogenesis.

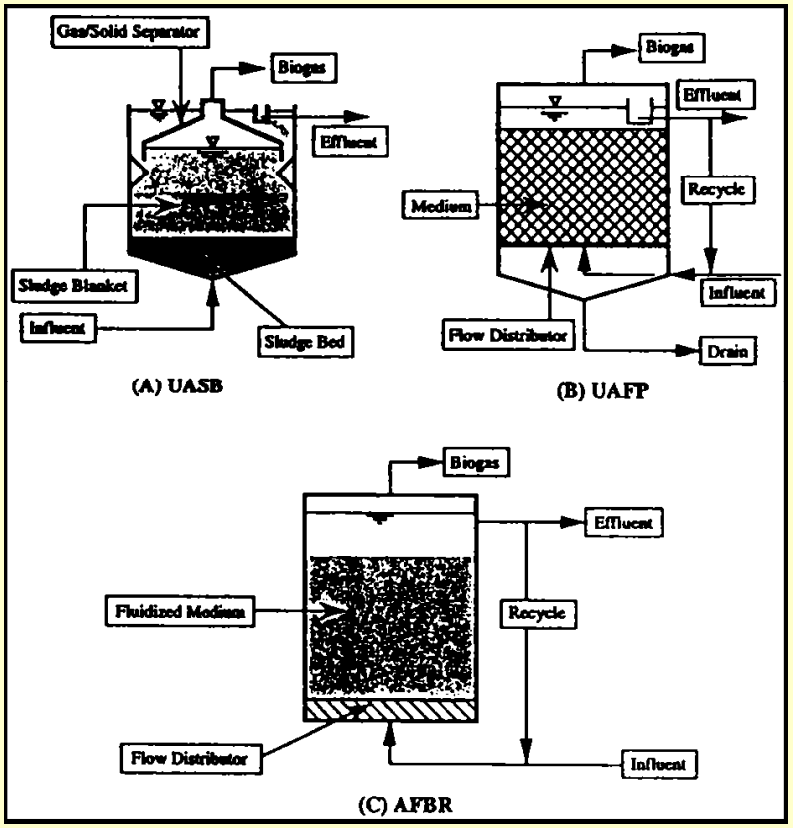
Biogas produced is collected at the top of the reactor.

The wastewater to be treated is fed into the reactor **at the bottom**.

The above mentioned four process occurs one by one

The influent converted into **H_2, CO_2, CH_4, acetate**,

Methane and CO_2 produced and separated from the reactor.



Marine Pollution

Marine Pollution

Marine pollution involves the **pollution of sea water and the coastal zones** by industrial effluent, domestic sewage, oil spills etc.,

Sources:

Few eg.

Toxic Metals : Pb, Cu, Zn, As, Cr Sb, Hg and Sn from mine drainage

Pesticides

Radioactive waste

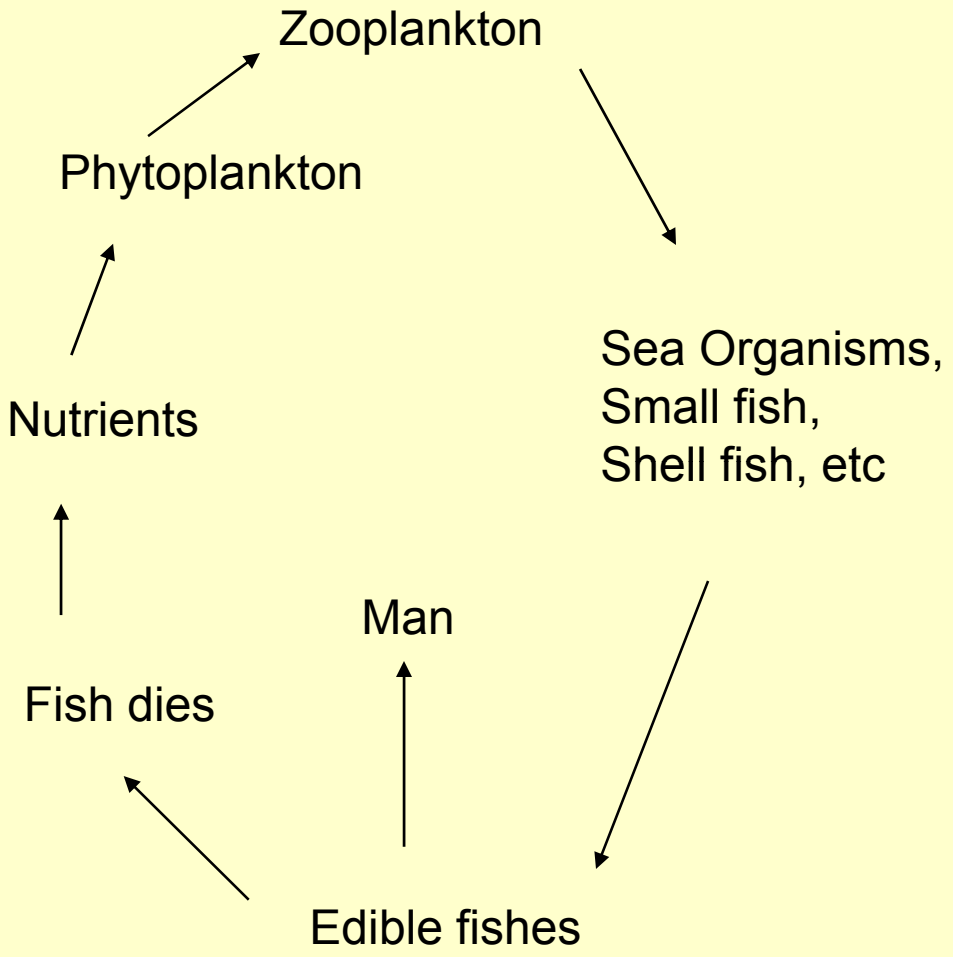
Tannery waste

Effects of Marine pollution

1. *Causing **Bio-accumulation***

2. Causes the **ecological Imbalance** in the marine environments.

3. **Temperature of the coastal sea water changes** due to the pollutants and it affects the other related qualities of water.



Can dam affect the fish by thermal pollution ?

Chemical treatment for the faster degradation

for eg. Surfactants.

By using boats can ***<u>tow a boom</u>*** which collects the oil.

A skimmer at the back of the boom removes the oil from the ocean

Thermal Pollution

- Thermal pollution defined as the presence of **waste heat in the water**, which is undesirable for the natural environment.

- Heat producing sources

Eg.

Thermal power plant

Nuclear power plant

Refineries

Steel plants

Effects of thermal pollution

1. **Dissolved O_2** content is decreased.

2. **O_2 penetration** is decreased at higher temperature.

3. **Toxicity of the pollutants increases** with increase in temperature.

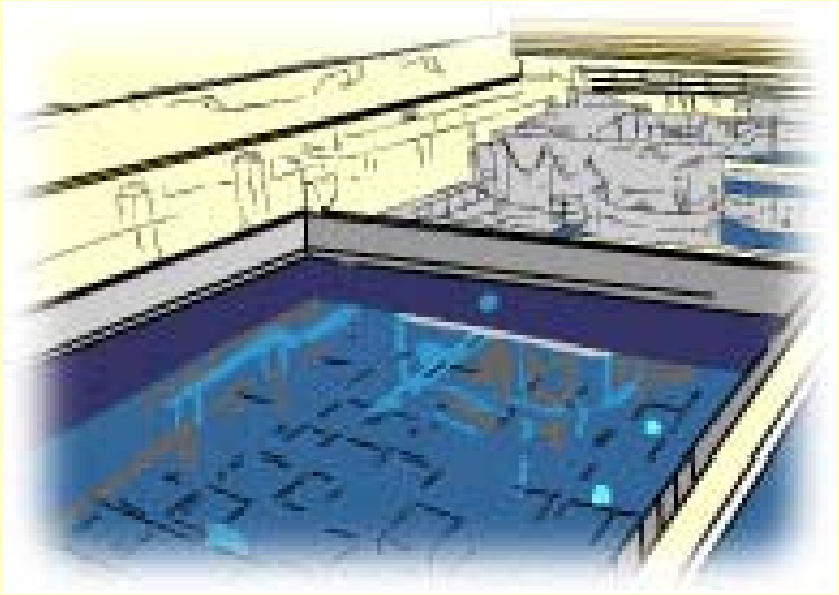
4. **Composition of flora and fauna** changes due to thermal shock.

5. **Metabolic activities** of the aquatic species changes due to the low O_2 level.

6. **Fish migration** is affected due to the formation of different thermal zones.

Control of Thermal Pollution

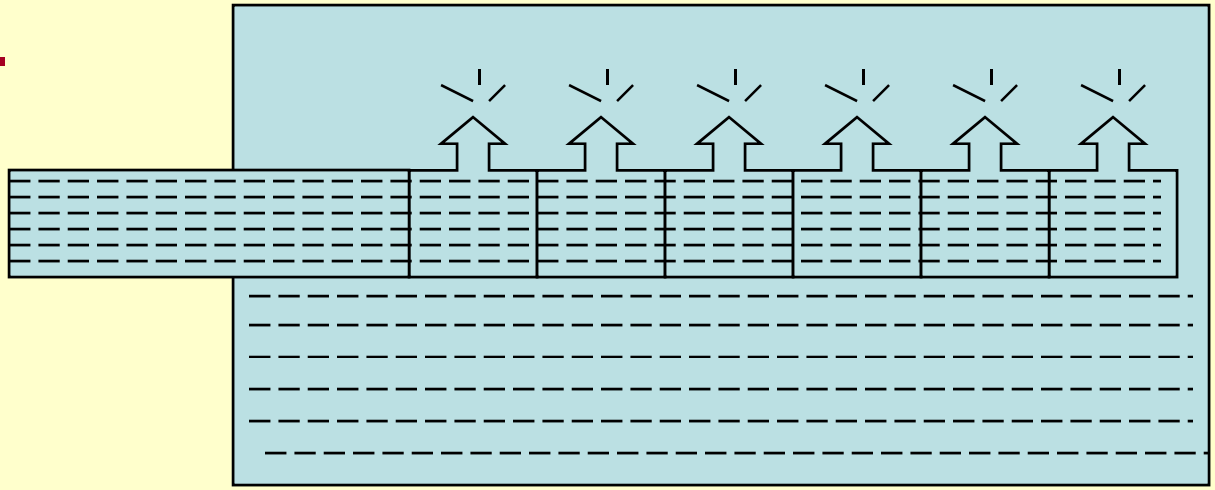
a. Cooling pond



Water from the condensers is Stored in ponds for natural evaporation Cooling.

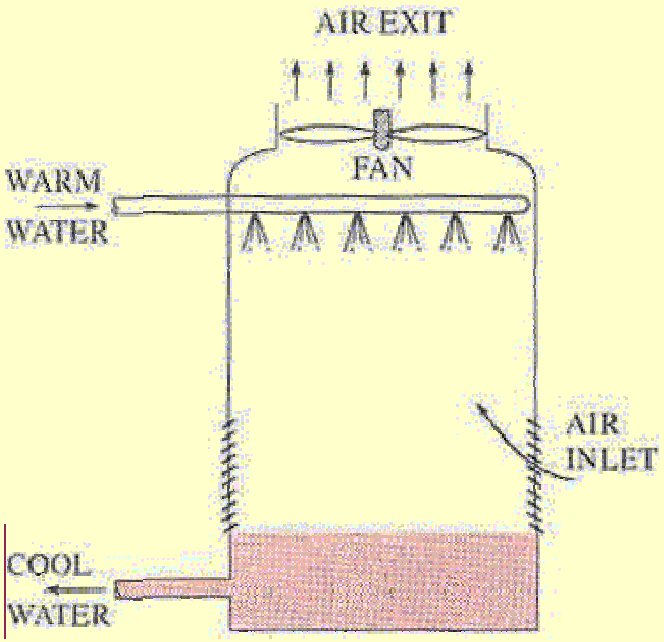
The it is recirculated or discharged to the water body

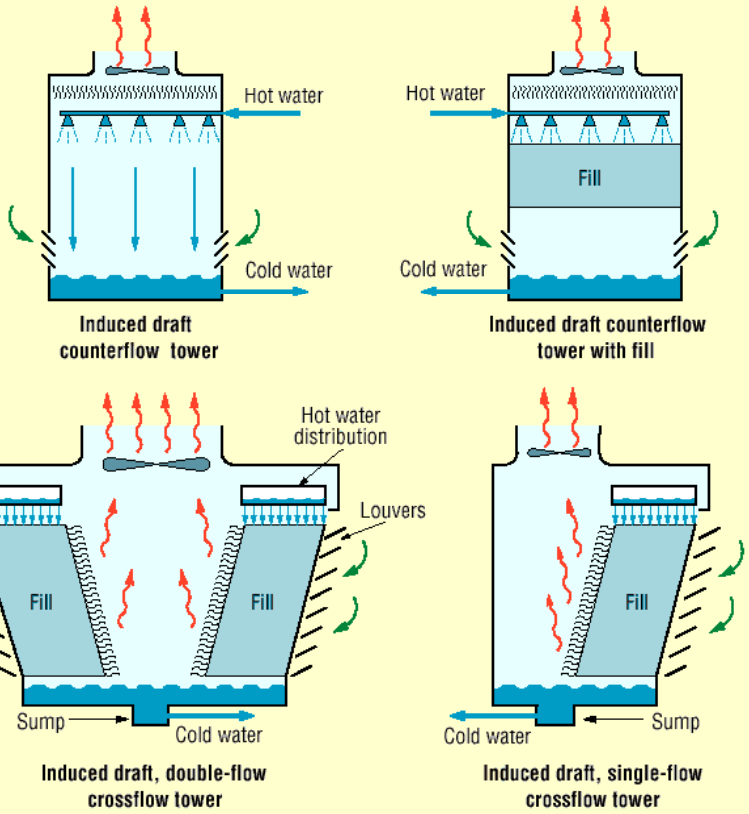
b. Spray pond



c. Cooling Tower

1. Wet Cooling Tower





1. Large amount of **water is lost** by evaporation

2. In the vicinity of the tower extensive **fog** will form ,

3. which is not good for the environment and it causes **damage to the vegetation**.

2. Dry cooling tower

1. Hot water is passed through the spiral column

2. No water loss

3. Installation and operation cost is higher than wet cooling tower