Sustainable Engineering

Module 2

Naveen Jacob

Associate Professor
Dept. of ECE
VJCET

Introduction

- ❖ Pollution is derived from the Latin word "Polluere" – meaning "make dirty"

- ❖ Pollution – Undesirable changes in the environment which not only adversely affect humans and other living things, but also our development activities and socio-cultural life.

- ❖ Pollutants – Materials in any form that causes pollution

Air Pollution

❖ Indian Standards (IS) define air pollution as :- Presence of foreign matter in the ambient atmosphere, generally resulting from the activity of man, in sufficient concentration, present for a sufficient time and under circumstances which interfere significantly with the comfort, health or wealth of a person or with the full use or enjoyment of property. (Indian Standards (IS-4167) – 1966).

❖ Table shows the estimated composition of dry air, called **background concentration.** When the concentration of any component exceeds this limit due to pollution, then it is harmful.

Component	Concentration (ppm)
Nitrogen	780840
Oxygen	209460
Argon	9340
CO_2	330
Neon	18
Helium	5.2
Methane	2.0
Krypton	1.2
Hydrogen	0.5
Nitrous Oxide	0.5
Ozone	0.1

(ppm = parts per million)

❖ Air pollution gets aggravated during winter season since most of the windows and doors are closed which traps polluted air. But in summer season, pollution reduces due to increased buoyancy through ventilation.

Sources of Air Pollution

Types of air pollution

I. **Natural air pollution and Anthropogenic (man-made) air pollution**,

❖ **Natural air pollution :**

   a) Volcanoes :- produces smoke, ash CO2, sulphur dioxide etc.

   b) Dust :- wind blown dust from desert areas

   c) Forest Fires :- releases smoke, ash, dust, CO2, nitrogen oxides etc.

❖ **Anthropogenic air pollution :**

   a) Stationary point sources :- emission from industry gas chimney/stack

   b) Mobile sources :- Exhaust emissions from vehicles

   c) Evaporative sources :- Evaporation of volatile liquids like paints, perfumes hair sprays etc., due to the improper closing of caps/lids.

II. Outdoor air pollution and indoor air pollution – primarily due to automobile exhaust. Major outdoor air pollutants are known as **"Big Six Criteria air pollutants",** as given below:

i. **NO_x (Oxides of Nitrogen) :**

➢ Discharged from automobile exhaust.

➢ Cause "acid rain", which may corrode metals, buildings, monuments etc.

➢ At high concentration it causes cough and nasal congestion

ii. **SO_x (Oxides of Sulphur) :**

➢ Discharged from combustion of coal, other fossil fuels, automobile exhaust, sulphuric acid manufacturing industry etc.

➢ Cause "acid rain", which may corrode metals, buildings, monuments etc.

➢ At high concentration it causes cough and nasal congestion

iii. **Ground Level Ozone (GL O_3) :**

➢ Created by chemical reaction between NO_x and VOCs (Volatile Organic Compounds, eg; benzene, acetone etc) in the presence of sunlight.

➢ Causes nose, throat and even lung infections.

➢ In plants, it causes premature ageing and suppressed growth

iv. **Particulate Matter (PM)**

➢ Solid particles and liquid droplets found suspended in air, which includes dust, smoke, fumes, mist, fog, fly ash etc.

➢ PM_x :– x is maximum size of particle in micrometres. Size less than 10 micrometre in size are of major concern. Lesser the value of "x", higher the difficult for removal from lungs. Eg. $PM_{2.5}$

v. **Carbon Monoxide (CO)**

➢ Highly toxic fuel from exhaust of vehicles and cigarette smoking

➢ Blood circulation reduces, causing headaches, drowsiness and at high levels even deaths.

vi. **Lead Vapour (Pb) :**

- ➢ Toxic material emitted to atmosphere by leaded gasoline, leaded paint, leaded smelters (extracting metals from their ores) etc.

- ➢ Affects brain, causes mental retardation, liver and kidney damage

III. **Primary air pollution and Secondary air pollution :**

- ✓ Primary pollutants are substances like CO, CO_2, SO_2, H_2S etc.), which that are directly emitted into air and remains there in the same form.

- ✓ Secondary air pollutants are formed by the interaction of two or more primary pollutants. Eg., Ground level Ozone, formaldehyde, Peroxy Acetyl Nitrate (PAN) etc.

IV. Air pollution caused by hazardous air pollutants

- ✓ Toxic air pollutants contained in some heavy metals, asbestos, formaldehyde (in paints), vinyl chloride (in plastics) etc.

V. Particulate Matter pollution and Gaseous air pollution

- ✓ Particles with size between PM_{10} and PM_5 can be removed by physical process. $PM_{2.5}$ will go deep into lungs and cannot be removed and may even cause "cancer".
- ✓ Major gaseous pollutants are CO, CO_2, SO_2, H_2S, Ground Level O_3

VI. Air pollution caused by Volatile Organic Compounds (VOCs)

- ✓ VOCs are organic compounds which easily evaporate (at room temperature) and enter the atmosphere. Eg., Acetone, Benzene, Formaldehyde, Toluene, Xylene etc.

Effects of Air Pollution

I. Effect of air pollution on human health

- ✓ Eye, nose & throat irritation.
- ✓ Chronic Obstructive Pulmonary Disease (COPD) – bronchitis and asthma
- ✓ Cancer caused by carcinogenic agents
- ✓ CO combines with haemoglobin in blood and replaces oxygen

II. Effects of air pollution on plants

- ✓ Suppressed growth and premature ageing in plants
- ✓ Causing leaf bleaching which results in "Chlorosis" (Photosynthesis is affected by loss of chlorophyll)
- ✓ Premature falling of leaves (called abscission)
- ✓ Causes "Necrosis" (dead spot on the leaf structure)

III. Effects of air pollution on animals and birds

- ✓ Affects the mucus lining of the respiratory track
- ✓ Cause bronchitis and asthma
- ✓ Lack of appetite in pet animals
- ✓ Acid deposition causes, aquatic life damage.
- ✓ Migration of "seasonal birds" are obstructed due to severe air pollution.

IV. Effects of air pollution on material and property

- ✓ Acid deposition can corrode metals, eat away stone on statues and monuments
- ✓ Discolouration of buildings and cloth fabrics.

V. Effects of air pollution on environment

- ✓ Reduces visibility due to formation of "smog" (smoke + fog)
- ✓ "Transboundary" pollution (pollutants at one place are carried away to very distant places by wind causing global pollution).

Most common air pollutants, their sources and effects

Pollutant	Possible sources		Effects	
	Natural	Anthropogenic	Human/ flora / fauna	Environment and property
Nitrogen dioxide (NO_2) (Reddish brown toxic gas)	Lightning Forest fires Bacterial activity of soil	Automobile exhaust, HNO_3 Manufacturing industries	Cough & nasal congestions Reduces visibility	Acid rain Brown photochemical smog formation
Sulphur dioxide (SO_2) (Colourless and easily dissolves in water)	Volcanoes	Coal and fossil fuel combustion, Automobile exhaust, H_2SO_4 manufacturing industries.	Respiratory illness (sulphur particles are capable of penetrating deep into the lungs	Acid rain Gray industrial smog formation
Ground level Ozone (GL O_3) (Pale blue gas soluble in water)	Ozone layer present in the stratosphere	Sunlight aided photochemical reaction between VOCs and NOx	Respiratory illness (they penetrate much deep into the lungs), premature ageing and supresses plant growth	Ozone present in the toposphere absorbs infra red energy emitted from the earth
Particulate Matter PM_{10} (coarser particles) size is > 2.5 μm ≤ 10 μm	Dust blown by winds	Automobile exhaust especially from diesel vehicles Road dust	Asthma Bronchitis Reduces visibility Reduces photosynthesis	soils surfaces of buildings and vehicles
Particulate matter PM_{25} size ≤ 2.5 μm	Fine and ultrafine particles in gases	Automobile exhaust especially from diesel vehicles	Aggravates Asthma, Chronic Bronchitis, Reduces visibilty, Reduces photosynthesis	soils surfaces of buildings and vehicles
Carbon monoxide (CO) colourless, odourless toxic gas	Volcanic activity Forest fires	Motor vehicle exhaust Cigarette smoking	Reduces ability of blood to carry oxygen	
Lead vapour (Pb) silvery bluish-white metal (cumulative poison)	Food (Pb is absorbed by plants)	Leaded petrol Leaded paint Leaded smelters	Pb is rapidly absorbed into the blood stream, Affects brain, causes mental retardation	
Ammonia (NH_3) colourless gas with pungent odour	Anaerobic decomposition of nitrogenous matter	Agricultural fields (Fertilisers)	Irritates skin eyes Throat, lungs	Odour problem

Control Measures to Reduce Air Pollution

❖ Build tall chimneys (polluted air gets diluted and dispersed at high altitude and hence ground level pollution reduces)

❖ Promotion of public transport, cycling and walking for local travel

❖ Involve the public in "air quality management activities" & periodic air quality monitoring

❖ Afforestation programmes

❖ Adoption of strict pollution control measures

❖ Reduction in the use of "conventional fuels"

❖ Promotion of use of renewable energy sources

❖ Use of Diesel Particulate Filters (DPF) in vehicles to avoid the emission of $PM_{2.5}$ into environment. (In 2014 WHO compiled the average annual Particulate Matter ($PM_{2.5}$) concentration for over 1600 cities in the world, and found that Delhi is the most air polluted city in the world. Recent study carried out in 2018, (out of 4300 cities in 108 countries) found that Kanpur is the most polluted city in the world)

❖ Usage of "catalytic converters" in vehicles

❖ Adoption of low sulphur fuels in vehicles

❖ Use of electrostatic precipitators, fabric filters and scrubbers (to remove Particulate Matter from waste gas streams)

❖ Use of "sorption" technique (either absorption or adsorption of impurity into a liquid/solid substance)

Central Pollution Control Board (CPCB) introduced "National Air Quality Monitoring Programme (NAMP)

Water Pollution

❖ Water is very important for purifying and detoxifying our body.

❖ Although 70% of earth's surface is filled with water, still less than 1% is useful for direct human consumption.

❖ Water pollution can be defined as the presence of some foreign substances or impurities in water in such a quantity, so as to constitute health hazard and make water unfit for use.

❖ **Surface water :-** Water contained in water bodies like lake, rivers and oceans

❖ **Sub-surface water (underground water) :-** Water stored on "aquifers" (underground rock structure)

Sources of water pollution

Water pollution source type can be :

a) **Point source** :- Source from single location (discharge from industrial waste and domestic waste)

b) **Non-point source or diffused** :- Source of origin is diffused over large area and hence cannot be traced (run off from agriculture land, mining area etc.)

Types of water pollution :

I. **Natural sources of water pollution :**
   a) Volcanoes
   b) Rain water
   c) Atmosphere
   d) Underground

II. Anthropogenic water pollution :

a) Domestic waste water :-

  ✓ Domestic sewage is the waste water generated from household activities.

  ✓ Classified into two parts :

    i. Black water (water contain human excreta and urine)

    ii. Grey water (water from bathroom, sink and kitchen)

b) Agricultural waste water :-

  ✓ Run off from agricultural fields and animal farms, are rich in nutrients like Nitrogen and Phosphates, which induce rapid growth of "algae", in surface waters resulting in reduction of oxygen content, popularly known as **"Eutrophication"**

c) Industrial waste water :-

  ✓ Result of industrial operations discharged in to water bodies

d) Ground water pollution ;-

  ✓ Pesticides, metals etc. present in solid waste get dissolved or leached into water, during rain and contaminates the ground water.

Water Pollutants and its Effects

Some of the commonly found pollutants in water are listed below:

i. **Inorganic substances**

   ✓ Nitrates, phosphates, carbonates, chlorides, sulphates of Ca, Mg, Fe etc. These salts make water "hard", which increases soap consumption and deposits scales on pipelines, stains on white fabrics, and eutrophication.

ii. **Acids/Alkalis**

   ✓ High concentration of acid causes eye irritation to swimmers, corrosion to ship's hull, deterioration of fisherman's nets and also detrimental to aquatic life.

iii. **Organic matter**

   ✓ Minimum dissolved oxygen (DO) required in water for aquatic life is 3 to 4 mg/L. Decomposition of organic matter by microorganisms, depletes the DO content in water which is detrimental to aquatic life.

iv. **Suspended solids**

- ✓ Suspended solids settle to the bottom and increases the turbidity of water

v. **Floating matter**

- ✓ These includes oils greases and other materials which float on the surface, not only makes river unsightly, but also obstructs passage of water through water.

vi. **Thermal discharges**

- ✓ Discharges from nuclear power plant boilers will increase temperature of water, which causes harm to aquatic life

vii. **Colouring materials**

- ✓ Effluents from textile industries and paper mills, slaughter house etc., will colour the water and obstructs passage of sunlight, thereby reduces natural disinfection mechanism

viii. Toxic Chemicals

✓ Organic and inorganic toxic compounds produced by various chemical industries have proved extremely toxic to aquatic life. These includes cyanides, sulphides, acetylene, alcohol etc.

ix. Microorganisms

✓ Effluents from food processing industries and slaughter house contain microorganisms which badly affects aquatic life.

x. Radioactive materials

✓ Radioactive waste comprises of a number of radio isotopes (which are unstable) emitting ionizing radiation which may cause mutation and cancer.

xi. Foam producing matter

✓ Presence of foam producing matter discharged from textile mills, pulp and paper mills etc., leads to an undesirable appearance of water bodies.

Effects of Water Pollutants to Humans and Living Organisms

❖ Consumption of contaminated water leads to water-borne diseases like Cholera, Typhoid, Jaundice etc.

❖ Excess amount of metals (fluoride, lead, copper etc.) in drinking water can general body weakness, mental retardation, failure of internal organs, cancer and even death.

❖ Pollutants in water leads to widespread destruction of aquatic life.

❖ Nutrient rich (nitrogen and phosphate) waste water leads to abundant growth of algae which results in eutrophication.

❖ Toxic pollutants from water may enter "food chain". The concentration of pollutants will increase from one link to another and is called **"Bio-Magnification"**

Control of Water Pollutants

❖ Appropriate wastewater treatment has to be provided

❖ Eutrophication can be controlled by using phosphate free detergents and reducing the use of fertilizers.

❖ Organize, public awareness programmes.

❖ Legislative measures have to be made strict and PPP (Polluter Pays Principle) has to be implemented.

Sustainable Waste Water Treatment

❖ Conventional wastewater management system is **"disposal-based linear system"** (ie; waste water is treated and thereafter disposed off)

❖ Conventional system has to be converted to sustainable, closed loop wastewater management system in which waste water can be reused and recycled with less energy and resources.

I. **Conventional wastewater treatment system**

    a) **Preliminary treatment :-** Large floating matters are removed
    b) **Primary Treatment :-** Those impurities which settle in the bottom are removed
    c) **Secondary/Biological Treatment :-** Dissolved and finely divided impurities are degraded biologically using microorganisms
    d) **Tertiary/Advanced Treatment :-** Tertiary treatment is used to remove impurities which remain after secondary treatment.

    After all the above treatments, the water is disposed to near by water body or onto nearby land.

II. Sustainable wastewater treatment methods

i. Wastewater ponds

- ✓ Water bodies having depth of around 1 to 4 meters, with embankment around them and are designed to receive, hold and treat wastewater.

- ✓ Impurities in wastewater is oxidized naturally, using the principle **"algal-bacterial symbiosis"**, in the presence of sunlight.(Fig.1)

- ✓ Disadvantage is that the pond requires large area and also the treatment process is slow.

- ✓ More number of wastewater ponds can also be connected in series (Fig.2) to improve the efficiency. First pond remove inorganic impurities. Second pond removes nutrients (Nitrogen, phosphorous etc;) and pathogens (harmful microorganisms).
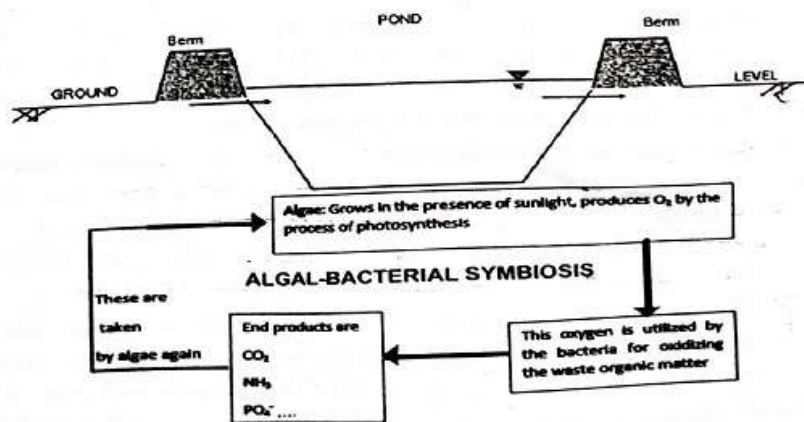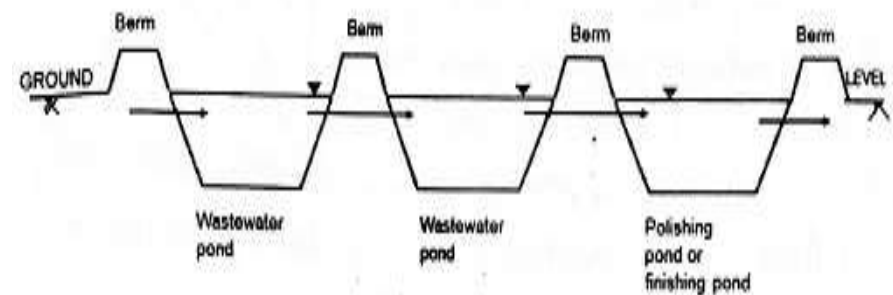

Fig. 1 : Wastewater pond

Fig. 2 : Wastewater ponds connected in series

ii. **Constructed Wetlands :-** In this, the pollutant removal mechanism are microbial decomposition and plant uptake of nutrients from soil. The effluent are used for irrigation, water gardens and flushing toilets. Constructed wetlands consists of :

a) **Impermeable liner** – prevent wastewater inside the constructed wetland system to come in contact with ground water.

b) **Distribution Media** – Use crushed gravels which spreads the wastewater on the surface of the constructed wetland.

c) **Macrophyte Plants** – Aquatic plants that can provide appropriate environment for microbial decomposition of impurities.

d) **Filter bed (Soil Layer)** – Water gets purified when it get filtered through the soil layer.

e) **Under drain system** – This will take away the treated affluent out of the wet land.

Schematic cross section of a typical constructed wetland
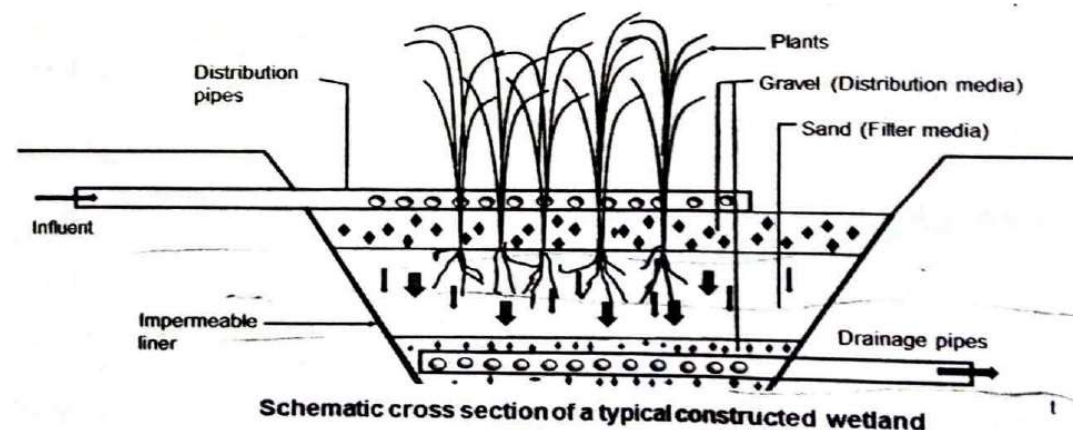
iii. Upflow Anaerobic Sludge Blanket (UASB) :-

- ✓ In this method, anaerobic bacteria degrade organic materials in the absence of oxygen and produce methane and carbon dioxide.

- ✓ Methane can be reused as biogas (alternative energy source)

- ✓ The sludge deposited can be used as fertilizer.

Schematic diagram of a typical UASB reactor
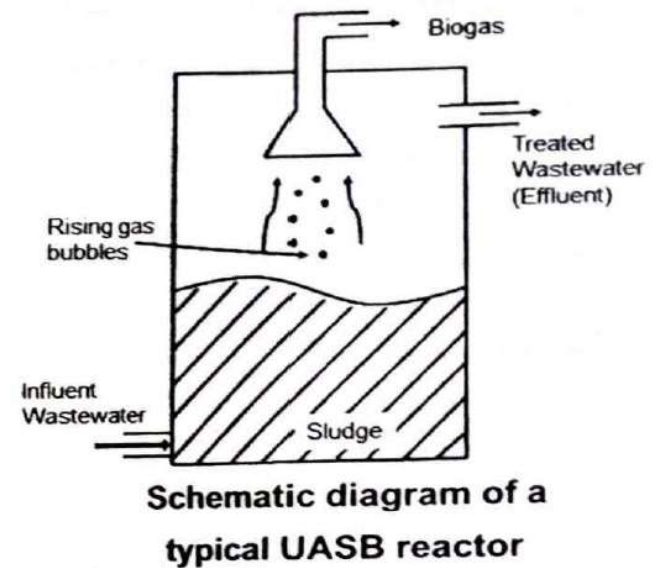
iv. Soil Aquifer Treatment (SAT) :-

- ✓ It is a geo-purification system where partially treated wastewater effluent is introduced into the ground water through various soil layers, thereby various stages of filtration takes place before it gets mixed with ground water.

Reuse : The effluents from all the above water treatment methods can be used for irrigation of crops, parks, gardens, play grounds etc. It can also be used for boating in recreation centers, creation of artificial wetlands, cooling system in industry, toilet flushing in residential area etc., Moreover, sludge can be used as fertilizers

Solid Waste

❖ Waste arising from various human activities that are normally solid and that are discarded or useless. Solid waste can be classified into :

a) **Rubbish :-** Solid waste that will not decompose and that are either combustible (paper, plastic, rubber etc.) or non-combustible (glass, metals, ceramics etc.)

b) **Garbage :-** Solid waste components that will decompose (fruits, fish, meat, vegetables etc.)

I. **Sources of solid waste**

   i. **Municipal solid waste (MSW)**

   ✓ Solid waste generated from residential areas , commercial sector (hotels), institutional buildings (office and educational institutions) and municipal sector (landscape, street sweepings etc.)

   ✓ **Plastic waste :**
   ➢ Microplastics, formed by the degradation of plastic material, enters our body and are small enough to move through our membranes causing health issues.

   ➢ Burning of plastics release poisonous chemicals to air.

➢ Plastic waste clogs the drain and results in flooding.

➢ Marine and wild animals consume plastics, mistaking as food

✓ **E-Waste :**

➢ Solid waste comprises of electronic circuits and electrical components. As and when an upgraded version of electronic gadgets come into market the old items will be dumped as e-waste. Eg; computer, mobile phone, television air conditioner etc.

➢ Burning of e-waste produces toxic chemicals like mercury, lead, cadmium, arsenic etc.

➢ India is the 5th largest producer of e-waste in the world.

iii. Biomedical/Hospital/Infectious solid wastes

- ✓ Solid waste in the form of disposable syringes, needles bandages, body fluids etc. which are highly infectious.

- ✓ Kerala's one and only biomedical waste treatment plant operated by Indian Medical Association is situated at Manthuruthy in Palakkad district.

iv. Hazardous solid waste

- ✓ Solid waste that generate danger immediately or after a long period of time, like paints, radioactive wastes, pesticides, pathology waste (human body parts and excretions during surgery) from hospitals etc.

v. Agricultural solid waste
- ✓ Solid waste generated from farms, dairies, vineyards, fields etc. and mainly consists of spoiled food grains, vegetable wastes and animal wastes.

- ✓ The sludge deposited can be used as fertilizer.

II. Impacts of solid waste

i. Impacts on land environment

- ✓ Deteriorating soil quality and decrease in vegetation abundance leading to breeding of rats, flies, birds and other organisms that serve as disease vectors
- ✓ Land value of nearest places will reduce than market price

ii. Impacts on water environment

- ✓ Contaminates nearby surface water and ground water resources

iii. Impacts on air environment

- ✓ Generation of greenhouse gases leads to climate change
- ✓ Causes stinking (suffocation due to foul smell)
- ✓ Burning of solid waste cause smoke contains carbon monoxide and other oxides which are toxic to living organisms

iv. Impacts on health

- ✓ Spread of water borne disease
- ✓ Prolonged exposure causes bronchitis, pneumonia etc.
- ✓ Heavy metal deposits causes poison through inhalation and skin absorption

Solid Waste Management

II. Solid waste disposal methods

i. Open dumping

- ✓ Municipal solid waste is disposed in low lying city outskirts. But this method is never a solution since it contaminates air, water and land.

ii. Sanitary land fill

- ✓ Solid waste is dumped onto a scientifically designed land, especially low lying land. Thereafter a soil cover is applied to reduce odors and keep out pests.
- ✓ The bottom and sides of landfills are lined with clay or plastic liners to prevent the escape of liquid waste.
- ✓ Natural decomposition will results in production of CH_4, CO_2, H_2S, NH_3 etc.
- ✓ Establishment is costly

iii. Incineration

- ✓ It is the thermal process of direct burning of solid waste at a temperature around 600^0C
- ✓ Relatively costly and causes air pollution

iv. **Pulverisation**

- ✓ Solid waste is pulverized in grinding machines to reduce its volume.

iv. **Composting**

- ✓ Biological process of converting biodegradable organic waste into "compost" using micro-organisms.

- ✓ Used as fertilizers

v. **Pyrolysis**

- ✓ This is the process of thermal decomposition of solid waste at a temperature of around 900^0C.

vi. **Disposal into sea**

- ✓ Method used in coastal areas having deep sea water level (>30 m) at a reasonable distance from shore (16 to 20 km).

- ✓ Disadvantage is that lighter components of solid waste, float and return to the shore during high tides.

Solid waste management in Kerala

❖ According to Kerala State Pollution Control Board (KSPCB), generation of municipal solid waste is about 8500 tonnes per day and only 51% of it, is treated

❖ Solid waste is dumped at a spot which is some distance away from urban area. As a result clean state become garbage mounds.

❖ Some of these places are Vilappilsala in Trivandum, Kureeppuzha in Kollam, Kozhenchery in Pathanamthitta, Vadavathur in Kottayam, Brahmapuram in Ernakulam, Lalur in Thrissur, Njeliyanparampu in Kozhikode, Pettippalam and Chelora in Kannur, Seethangoil and Kollangara in Kasargod.

❖ Inspite of all these, there are successful models of implementations of municipal solid waste in our state such as Attingal Municipality, Alappuzha municipality, Adat panchayath in Thrissur and Sreekrishnapuram in Palakkad.

❖ According to Swatch Sarvekshan 2020 report, carried out in 4200 towns and cities, Indore in Madhyapradesh ranked 1st, Surat in Gujarat ranked 2nd and Navi Mumbai in Maharashtra ranked 3rd.

Zero Waste Concept

❖ Concept of Zero waste focuses on

    i. Maximizing Recycling
   ii. Minimizing Waste
  iii. Reducing Resource consumption
  iv. Ensuring, products can be reused, repaired or recycled back to nature.
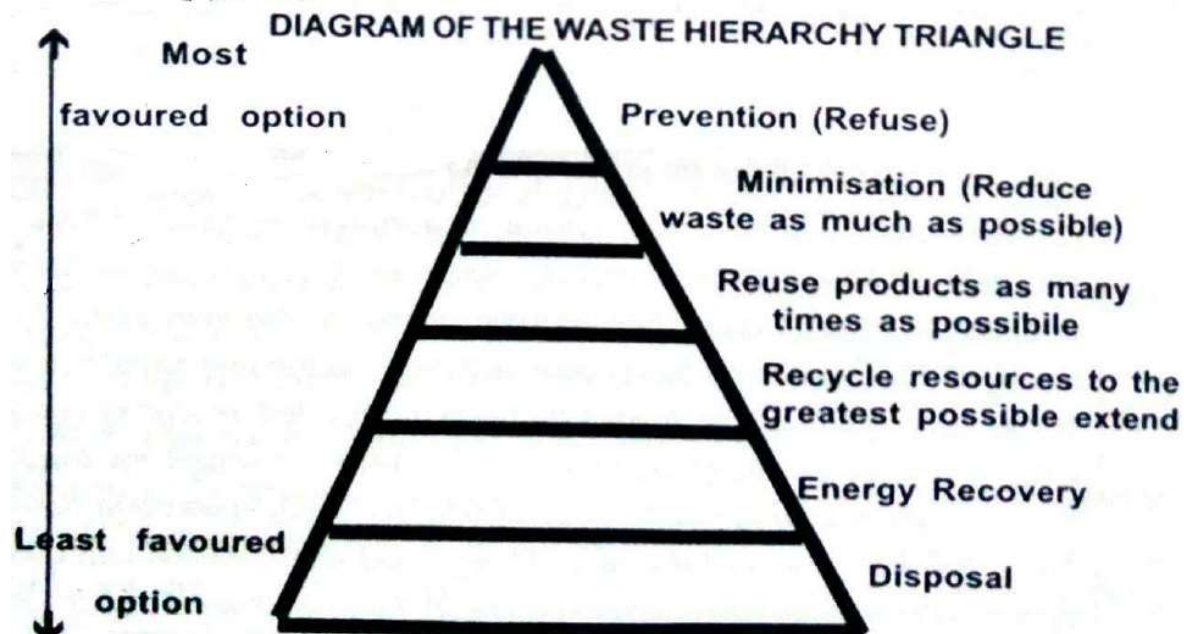
Principles of Zero waste concept

❖ Waste for one species is food for another, hence the waste are continually recycled in nature.

❖ Copying nature's successful strategies for waste management.

Benefits of Zero waste concept

❖ Saves money, improves sustainability and improves material flow by reuse and recycling.

Waste Management Hierarchy

❖ Waste management hierarchy generally refers to **"3Rs"** – Reduce Reuse, Recycle. This is expanded today to **"4Rs"** – Refuse, Reduce Reuse, Recycle and **"5Rs"** – Refuse, Reduce Reuse, Recycle, Recover.

❖ The hierarchy followed in waste management is shown below:

DIAGRAM OF THE WASTE HIERARCHY TRIANGLE

Most favoured option

Least favoured option

Prevention (Refuse)

Minimisation (Reduce waste as much as possible)

Reuse products as many times as possibile

Recycle resources to the greatest possible extend

Energy Recovery

Disposal

"3R" Concept of Waste Management

I.   Reduce
- ❖ Reduce waste generation at source, ie; purchase minimum number of products and avoid buying unnecessary products. But this depend upon attitude and lifestyle of consumer.

II. Reuse
- ❖ Long lasting goods should be repaired/reused over and over. Eg: bottles, cans, cartons etc. Electronic gadgets can be reused after minor repairs.

III. Recycle
- ❖ Discarded material that cannot be reused should be sent to industry so that industry can use this as a resource for new product. Two types of recycling :- **Upcycle** (converting low value material into high value products) **and Downcycle** (converting high value products into low value raw materials). Upcycle is more desirable.

What we can do to reduce solid waste
- ❖ Carry your own cloth or jute bag while shopping
- ❖ Segregate waste to biodegradable and non-biodegradable and dispose separately
- ❖ Dig compost pit in garden and put all biodegradable into it.
- ❖ Small units can be set up to make bags, cloths, dolls, home decoration materials etc; from discarded materials.
- ❖ Set up a platform for exchanging our old items with the old items that are dropped by others
- ❖ Try to sell the recyclable items to Rag pickers.

Greenhouse Effect

❖ Assignment-1

Global Warming & Climate Change

❖ Assignment-1

Ozone Layer Depletion

❖ Assignment-1

Carbon Credits & Carbon Trading

Carbon Cycle

❖ Carbon compounds exists in solid state (Coal, lime stone etc.) liquid state (petroleum products) and gaseous state (CO_2).

❖ When carbon containing fuels are burnt for energy, carbon is released in the form CO_2.

❖ Trees and plants convert CO_2 into carbohydrates during photosynthesis and releases O_2 to the atmosphere. Humans and animals takes O_2 during respiration and releases CO_2.

❖ When plants decay and animals die, microorganisms break down the carbon content in their body to CO_2 and the same is taken by plants. This cycle flow of carbon is called **Carbon Cycle.**

Global Warming Potential (GWP)

❖ **Green House Gases (GHG)** released by fossil fuels, vehicles and industries, in right proportion are necessary for human survival on earth. But excessive release will result in global warming.

❖ Each GHG has a different **Global Warming Potential (GWP)**. It is the relative measure of the amount of heat trapped by a GHG in the atmosphere.

❖ GWP of each GHG is expressed in terms of CO_2 equivalent **(CO_2e).**

❖ GWP of CO_2 has be assigned the value "1" and GWP of other GHGs are used to convert the non-CO_2 gases to equivalent CO_2.

❖ ie; if the GWP of methane is 21, this means that the heat trapped by 1 tonne of methane is equal to the heat trapped by 21 tonnes of CO_2 over a period of 100 years.

Top ten per capita GHG emitters in the world

	Country	Per capita GHG emission in tonnes of CO_2 e/year
1	Canada	24
2	United States	19
3	Russia	16
4	Japan	9
5	European Union	8
6	Indonesia	8
7	China	7.5
8	Brazil	7
	World average	6.5
9	Mexico	6
10	India	2

Global Warming Potential of the main Green House Gases

Gas	Global Warming Potential (CO$_2$ equivalents) (CO$_2$e)	Atmospheric Life (years)
CO$_2$	1	5 to 200
CH$_4$	21	12
N$_2$O	310	114
HFCs	140 to 11700	1.4 to 260
PFCs	6500 to 9200	10000 to 50000
SF$_6$	23900	3200

Example :

➤ Calculate CO$_2$ equivalent for 10 kg methane, if the GWP for methane (CH$_4$) is 21, for a time interval of 100 years.

Solution :

- GWP of methane is 21. This means 1 kg of CH$_4$ traps heat equivalent to that heat trapped by 21 kg of CO$_2$.

- Thus 10 kg of CH$_4$ traps heat equivalent to that of heat trapped by 21 x 10 = 210 kg of CO$_2$
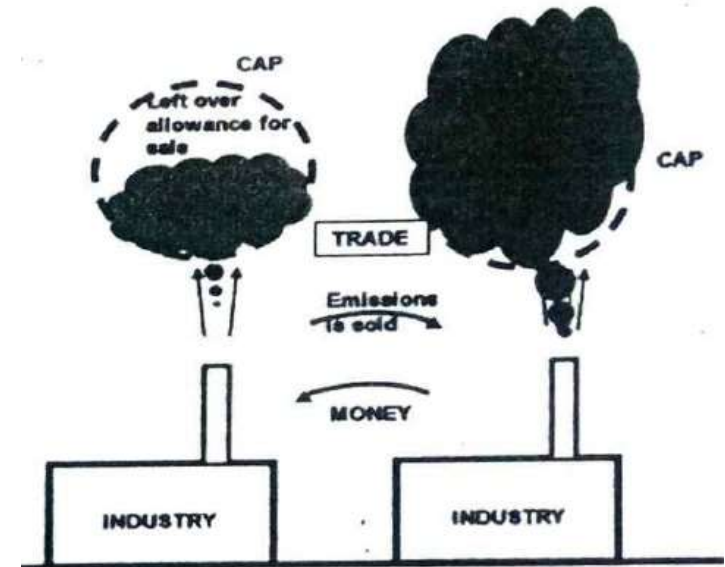
Carbon Credit

- ❖ **Clean Development Mechanism (CDM)** projects are carried out to help Non-Annex-I countries to achieve sustainable development and to assist Annex-I countries in complying their emission reduction commitments.

- ❖ These CDM projects generate **Certified Emission Reduction (CER)** unit or **Carbon Credit**.

- ❖ It is the financial instrument that represents one tonne of CO_2 or equivalent green house gas, removed from the atmosphere due to CHG emission reduction techniques. It is used by developed countries to earn CER unit or Carbon Credit.

- ❖ CDM Executive Board (CDMEB) controls and monitors the implementation of CDM.

- ❖ Afforestation programmes, clean technologies (green/sustainable products), renewable energy sector, sustainable transport, sustainable agriculture are some of the major areas of CDM projects.
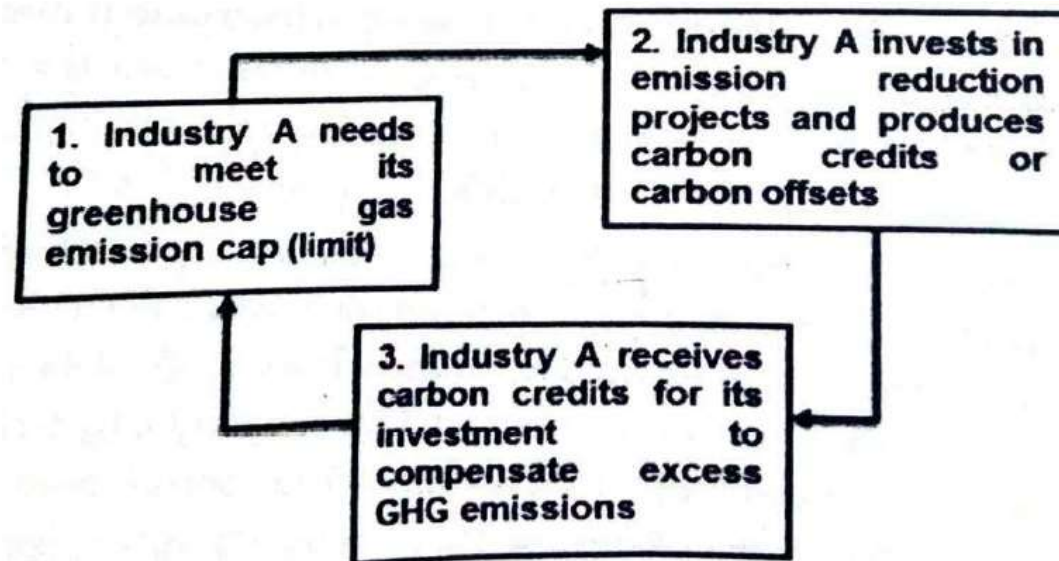
Carbon Trading

❖ Countries can sell and purchase GHG emission units (Carbon Credits). This is referred to as **Carbon Trading.**

❖ Six CHG emissions are included in carbon trading. They are CO_2, CH_4, N_2O, Hydroflurocarbons, Perflurocarbons, and Sulphur Hexafluoride

❖ The trading is carried out in international market known as **"Carbon Market"**. The **European Union Emission Trading Scheme (EUETS)** is the world's largest carbon trading market today.

Trading progrmmes are of two types :

i. **Carbon Cap Trade Programme :** Here government puts a limit or cap on the GHGs emitted. Players/Participants whose actual GHG emissions are less than the limit or cap can sell the unused emission allowances to their participants and vice versa.

ii. **Carbon Offsetting Programme :** Carbon offsetting is the use of carbon credits which enables participants/players to compensate for their excess emissions through investments in greenhouse gas emission reduction projects (such as afforestation programmes, renewable energy etc.). So, here one plays in monetary terms to reduce the GHG emission, instead of actually reducing emission of his/her own.

1. Industry A needs to meet its greenhouse gas emission cap (limit)

2. Industry A invests in emission reduction projects and produces carbon credits or carbon offsets

3. Industry A receives carbon credits for its investment to compensate excess GHG emissions

Legal Provisions for Environmental Protection

❖ Covered this topic towards the end of 1st module – Refer printed notes.

Carbon Footprint & its classification, Carbon Neutrality, Carbon Tax

❖ Assignment-2