ENVIRONMENTAL ENGINEERING

Role of Env. Eng.

1. Protecting the env. from harmful effects of human activities
2. Protecting human fob from the adverse env. factors
3. Improving env. quality & Human Health.

Introduction to Environmental Engineering

1. Environment and Ecosystem
   - → Components
   - → Biogeo Chemical Cycles
   - → Urban network Services - Water supply, Sewerage
2. Environmental Pollution
   - → Soil, air, water, ... Sources, effects, Solution
   - → Water / waste waters / Air quality ~~.....~~ Standards
3. Global env. issues
   - → Climate Change, acid rain, Ozone depletion

ECOLOGY

Study of inter relationships between the organism and their environment

- Two components — ① Non living (abiotic) / non-organic → Physical
② Living (Biotic)
- Interdependent - Sometimes difficult to seperate

ECOSYSTEM

"Basic fundamental unit of ~~ecosystem~~ ecology which include both the organisms and the non living env., each influencing properties of the other and each is necessary for the maintenance of life" (interact with each other)
Ex - Pond, Forest.

PRINCIPAL STEPS AND COMPONENTS

1 Reception of energy (Plants) ← fix solar radiation
2 Production of organic food by producers
3 Consumption of organic materials by consumers
4 Decomposition into inorganic compound
5 Transformation of these into suitable compounds for nutrition of producers.

FROM PURELY FUNKTIONAL POINT OF VIEW

1 Autotrophic Components (produce their own food)
- Green plants - fix solar energy → Synthesise organic compounds from simple inorganic compounds

2 Hetrotrophic Components (cannot produce their own food).
Decomposers - (bacteria/algae) - utilise/rearrange/degrade complex food substances.

Components

1 Abiotic Substances
- Inorganic substances

2 Producers
- Autotrophs
Ex - Plants, algae, phytoplankton

(conversion of inorganic to organic using radiant energy by sun)

Food/organic

$$CO_2 + H_2O \xrightarrow[\text{Energy}]{\text{(Plants)}} C_6H_{12}O_6 + O_2$$

3 Consumers

Herbivore - Primary consumers
Carnivore - Secondary consumers
↓
Tertiary consumer (Secondary carnivores)

Plant → insects → bird → man
Producer — Primary consumer — Secondary consumer — Tertiary consumer
(Primary carnivore)

Deconsumers
Bacteria, fungus

Feed upon dead or decaying organism (plant/organism) Feed upon ~~dead or decaying organism~~ and break them into simple compound released into soil/water/air for ~~ground by~~ Autotrophs.

$O_2 + C_6H_{12}O_6 \xrightarrow{\text{bacteria}} CO_2 + H_2O + \text{Energy}$

Example of pond - abiotic component - water (all dissolved inorganic nutrients)
autotrophic - phytoplankton, some algae
consumers - zooplanktons
Decomposers - fungi, bacteria

Ecosystem

- Natural
  - Terrestrial (Forest, desert, grassland.)
  - Aquatic
    - static (pond, lake)
    - flowing (river)
- Man made (Aquarium, crop field, biological waste treatment plant).

Pond

1) Abiotic - water, soil (sediments)
2) autotroph - Phytoplankton, algae, floating plants
3) Consumers - Zooplankton, Fishes
4) Decomposers - Bacteria (Sediments).

Functions of an eco system

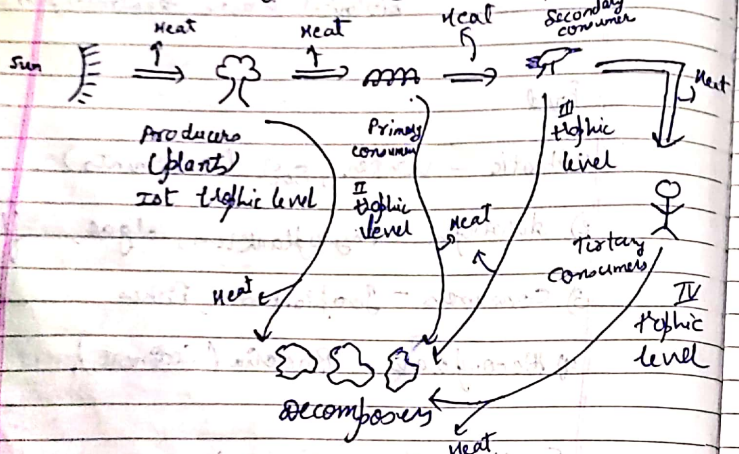
1. Food chain/Food web
2. Ecological Pyramids.

Food Chain

An ecosystem is characterised by the energy flow & circulation of materials through its members.

Different organisms are linked together by their nutritional requirements - Individuals related by this manner is a food Chain.

Defined as a group of organisms in which there is transfer of food energy through a series of repeated eating & being eaten.



Biomagnification.

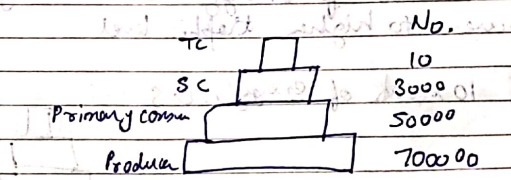
Plant → Insect → birds → ~~man~~ mans

The process in which tissue conc. of chemicals at one trophic level exceed tissue conc. in organisms at the next trophic level in a food chain

Ecological Pyramid

Graphical representation of different trophic levels in an ES where producers occupy the base and the top consumers the apex (top) of the pyramid.

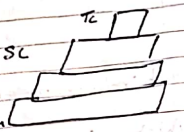
1. Pyramid of Numbers



2. Pyramid of Biomass

Total dry organic matter of organism at each trophic level in an ES is known as Total biomass of individuals in each trophic level.

Biomass gm/m²



75
190
700
2500

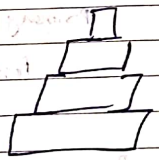
(iii) Ecological Pyramid of Energy

- Shows the amount of energy transfered between trophic level
- Best rep. of all

Thermodynamics - No energy transfer is 100% effecient.

Always loss of energy while moving from lower to higher trophic level

10% rule of energy is E.S



10 J
100 J
1000 J
10000 J

Productivity

- Constant input of solar energy is basic req. of an E.S.

Primary Production - The amount of biomass (organic matter) produced per unit area/unit time by plant by photosynthesis
g/m²/year
Kcal/m²/year (weight or energy)

NPP = GPP - Loss

Respiration.

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

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

$\frac{NPP}{GPP} = 0.52$

→ Primary productivity depends on plant species inhabiting in a particular area.

→ Depends on a variety of env. factors.
- Availability of nutrients
- Photosynthesis capacity of plants

Animal Productivity of whole biosphere 170×10^9 t
Ocean - 55 billion ton/year
Land - 15 B ton/year

Ecological Succession

- Gradual process by which ecosystem change & develop over time
- Env. Changes with time. (Climate, physical change)
- Activities of species of communities also change
- The gradual & predictable change in species composition of an ecosystem
- During ecol. succession some species colonise & their population become numerous & other decreases.

Large rock → weeds → grass → Shrubs → Small trees → Large trees

Biogeo Chemical cycles (Nutrient cycles)

Nutrients < Macro: C, H, N, P, O
Micro: Fe, Mg, Ca, ...

Nutrient Cycles (Biogeochemical Cycles)

- Organisms - constant supply of nutrition varies in different kinds of ecosystems / seasonal
- Nutrients - Never lost - Recycled in definitely
- Movement of nutrient element through various components
- Chemical interaction between four phases - Atmosphere, Hydrosphere, Lithosphere & Biosphere
- Gaseous Nutrients → Reservoir mainly atmosphere
- Sedementary Nutrients → Reservoir mainly earth's crust

What is common in BiogeoChemical cycles

- Each component exists (typically) in all parts of the earth system
- Biologically Useful part is low
- Chemical / Biochemical transformations
- Can lead to +ve or -ve consequences

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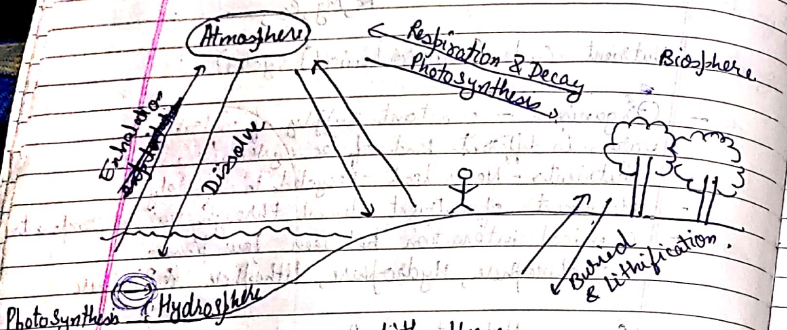
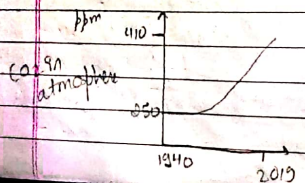
Carbon cycle

Biomass - Living organism - 49% is carbon
Global C - 71% - Dissolved in Ocean
Atm - 1%



- Carbon cycle occours through atm, ocean, living & dead organisms
- Respiration → Return to atmosphere
- Decomposers → Return to atmosphere
- Some Carbon → lost to sediments & removed from circulations (Lithification)
- Burning of wood, forest fire, combustion of fuel
- Release of CO_2 in atmosphere



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- Fast processes in Carbon cycle photosynthesis

Photosynthesis

$$CO_2 + H_2O + Energy \longrightarrow CH_2O + O_2$$

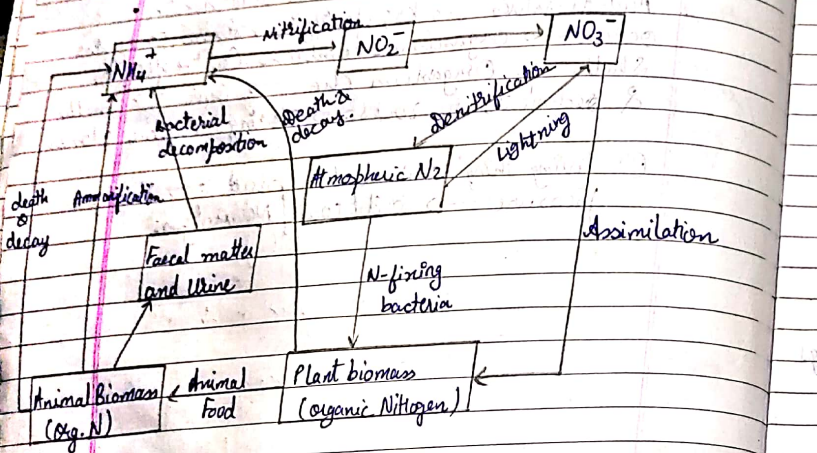
- Slow process in Carbon cycle

① Atm $CO_2 + H_2O \longrightarrow$ Carbonic acid in rain. Acid dissolves rocks releasing ions rivers carry to ocean → organisms combines $Ca^{+2} + HCO_3$ to Shells → Organism die → Sink → Shells & sediments to rocks → storing carbon stones

② Living thing embedded in mud → Heat or pressure → oil / coal / Natural gas.

Nitrogen Cycle

- Most imp. nutrient cycle in terrestrial ecosystem
- Used by organisms to produce complex organic molecule. (nucleic acids, proteins, amino acids)



Nitrogen Cycle

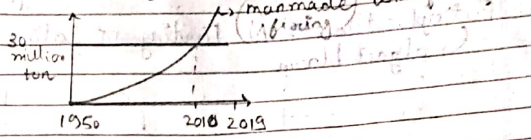
- Nitrogen, cannot be used by plants.

Forms of N
- N_2
- Organic Nitrogen
- NO_2^- / NO_3^-
- NH_4^+

Nitrogen Fixation

converting atmospheric Nitrogen to NH_4^+ / NO_3^- (useful form)

- Bacteria → Only few (legumes) (3 million ton per year)
  eg - roots of ground nuts
- Lightning



Ammonification
converting organic N to NH_4^+

Nitrification

$NH_4^+ \longrightarrow NO_2^- \longrightarrow NO_3^-$

bacteria - Nitrifying bacteria

- Defn Denitrification

$NO_3^- \longrightarrow N_2$

Denitrifying bacteria

Human impact on Nitrogen Cycle

Burning fossil fuels → NO_2 → acid rain

Farming activities → N_2O → global warming
ozone depletion

Fertilizers → contaminate groundwater & surface water with NO_3^- → toxic.

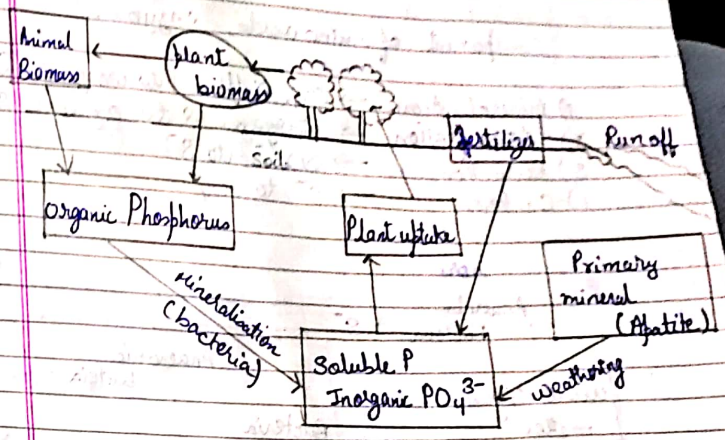
Eutrophication → N limiting in saline water.
(algael bloom)

Phosphorus Cycle

P- macronutrient - necessary for all living things
(ATP, nucleic acid, cell membrane)

Limiting nutrient with respect to algae growth in lakes

No role of atm.



Phosphorus Cycle

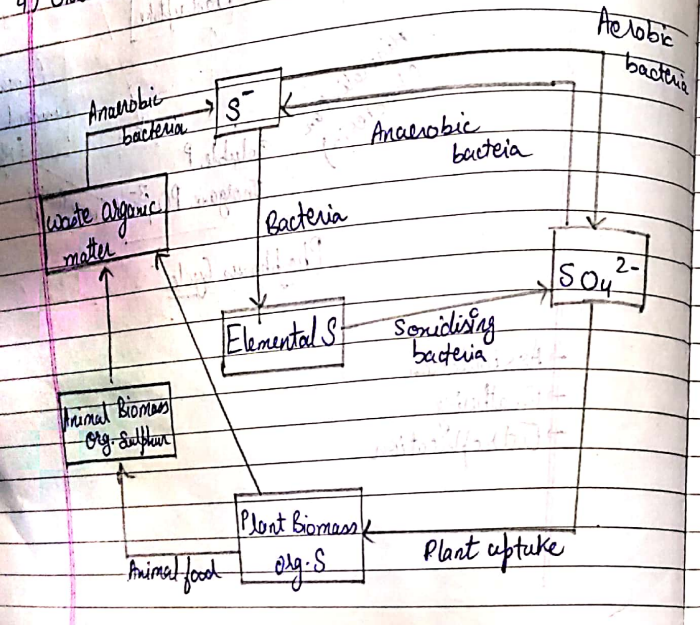
→ Assimilation
→ Weathering
→ Eutrophication

Sulphur Cycle

- Abdt Abundant in the environment, (Sea water - largest source) FeS_2, $CuFeS_2$ fossil fuel

component of amino acids, enzymes.

1) Mineralisation → Org. Sulphur to inorganic Sulphur
2) Assimilation → inorganic S to organic S
3) Reduction → SO_4^{2-} to S^-
4) Oxidation → S^- to SO_4^-

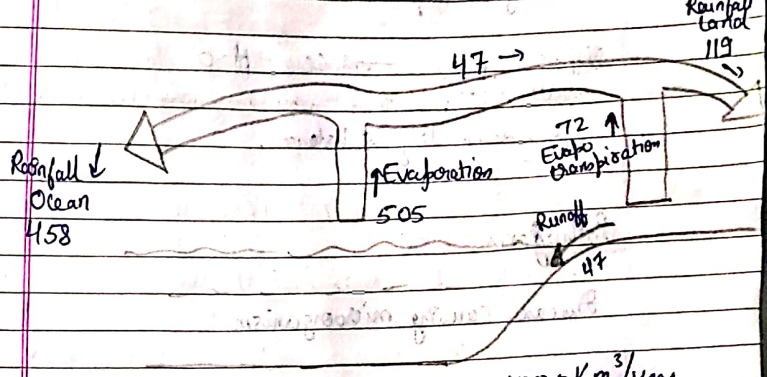


Hychologic Cycle

97% ocean, 0.007% fresh water lakes/rivers
Ground water 1.7%

Evaporation, evapotranspiration, runoff, rainfall (precipitation)

India	
Domestic	9%
Industries	8%
Energy production	8%
Agricultural	85%



Pollutants

- Water
- Air
- Soil
- Noise
- Radioactive

Water Pollutant

- Pathogens
- organic matter
- VOCs (Volatile organic compounds)
- Nutrients
- Heavy (toxic) metals
- Temperature
- Pesticides
- Trace organic pollutants

Organic matter + O_2 → $CO_2 + H_2O$

oxygen demanding substances.

Pathogens

Disease causing microorganism

Pollutants - Sources

Point Sources
- Industry
- Thermal Power Plant
- Municipal Waste Water T.P.

Non Point Sources (diffused sources)
- Agricultural discharge
- Motorised vehicles.

Water Pollutants

1) Pathogens
   → Disease causing organisms that give grow and multiply within the host - infection
   → Germ theory - Late 19th century
   People knew contaminated water & diseases
   → London - 1850 - Cholera - Scientific evidence.

2) Viruses
   - Hepatitis A Virus - hepatitis (Jaundice)
   - Rotav - diarrhoea
   - Polio Virus - polio

Bacteria
- Salmonella Typhi - Typhoid
- Vibrio Cholerae - Cholera
- Shigella - dysentery

Protozoa Entamoeba histolitica - diarrhoea.

2) Oxygen Demanding Substances (organic matter)

Organic matter + O_2 $\xrightarrow{\text{microbe}}$ $CO_2 + H_2O + NH_4^+ + H_2S$ + - - - -

Saturation value of DO - 7.1 - 14.0 mg/L

min do required is 4-5 mg/L

Measuring Oxygen Demand in a Waste Water.

BOD - Biochemical oxygen demand.

COD - Chemical Oxygen demand.

BOD : The amount of O required by microorganisms to degrade waste biologically

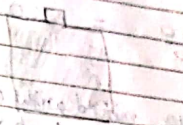
COD : The amount of O required to oxidise waste Chemically.

BOD < COD

Some microorganisms can not degrade every type of chemicals & COD would be always greater than BOD & As chemicals can oxidise organic matters also.

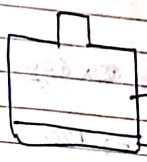
BOD test - Std

BOD - 5 days time at 20°C



Municipal water requires 200 mg/L

So we dilute the sample



$\left(8.0 - 3.4\right) \times \frac{300}{10}$

BOD = (DO initial - DO final) × Dilution

Q. A 10 mL Sample of MWW is mixed with enough Dilution water to fill a BOD Bottle. which had initial DO of 9 mg/L after 5 days of incubation DO was reduced to 5 mg/L what is BOD of waste water

$\Rightarrow (9-5) \times \frac{300}{10} = 120 \ mg/L$

Q. 5 mL sample of waste water mixed with enough dilution water to fill a 300 mL BOD Bottle had initial DO of 9 mg/L In order to assure accurate results it is desirable to have at least 2 mg/L drop in DO during the 5 day period & the final DO should be at least 1 mg/L what range of BOD would this dilution produce

$(9-7) \times \left(\frac{300}{5}\right) = 2 \times \frac{600}{5}$

$\Rightarrow 120$

$(9-1) \times \frac{300}{5} \Rightarrow 480$

480 DO to 120 DO.

Q. Industrial waste water Has an expected BOD of 2500 mg/L Suggest 2 dilutions that can be used for determining BOD.

$2500 = D\left(\frac{9}{}-1\right)$

$\frac{2500}{8}$ $\frac{2500}{5}$

$D = 50$

(6mL)

$2500 = D(9-x)$

$\frac{300}{x} = 50$

$D = 41.25$

2500

$50 = \frac{300}{x}$

$41.25 = \frac{300}{x}$

$25 \times \frac{100}{4} = D$

$625 = \frac{300}{x}$

$x = 0.48$

$2500 = \frac{300}{x}$

$x = \frac{300 \times 4}{25 \times 4}$

0.12 – 7.2727 range.

3 Nutrients

- Chemicals essential for growth of living things

- C, N, P, S, Ca, Fe, ...

- In water quality → N & P considered pollutants when their conc. is high enough to cause excessive algae growth → drinking water quality reduced.

Nutrient enrichment → algae bloom → die and decompose → O_2 level ↓ ← removes O_2

Algae decay → taste, Odour, colour components - not easy to remove

- N & P → limiting nutrient in aquatic environment.

In freshwater P is limiting nutrient
In marine water env. N is limiting nutrient.

Growth of algae can be controlled by identifying the limiting nutrients.

Sources of N: Municipal waste water Agricultural discharge. Some industrial discharge or waste water.

N → Org. NH_3, NH_4^+, NO_2^-, NO_3^-

In fresh water Org. N & NH_3/NH_4^+

NH_3 toxic to aquatic organisms,

NO_3^- in drinking water - Health issues in small babies → O_2 replaced by NO_3^- in blood → blue colouration → (Methaemoglobinemia) blue baby disease
Suffocation death

Babies < 6 month old.

Not enough P in nature, So limiting nutrient in water.

Sources: Agricultural discharge, Man made waste water detergents.

In developed countries → No P in detergents.

4) Heavy Metals

Not precisely defined Metals

Sp. gr > 4-5 and toxic at low conc.

Al, As, Bi, Cu, Co, Ti, Sn, Zn, Cd, Cr.

- Non biodegradable
- Some metals are nutrients Cr, Zn but higher Concentration is toxic.
- Tumour, Kidney damage, nervous system carcinogens.
- Inhaled or ingested (Pb, Hg)

How they are absorbed in the body depend on the metal & form.

Liquid Hg not that toxic, Hg vapour highly toxic.

Pb not a threat as vapour, but dissolved Pb is toxic.
- Kidney, brain affected.

Kidney - millions of nephrons - Chemicals toxic to kidneys - nephrotoxins Pd, Cd, Hg.

5) Pesticides
- Chemicals that kill organisms that humans consider undesirable

- Insecticides, Herbicides, Fungicides

3 main Groups:-

(i) Organs chlorines (Chlorinated HC)

- DDT, endosulfone, aldrin
- Persistent → banned : less toxic
- Easy accummulated in body soluble in fats.

(ii) Organo phosphates
- Parathion, malathion
less persistent but more toxic

(iii) Carbamates - Not persistent, Derive from carbamic a.

Air Pollution

History

1950s - USA
1952 - London Episode - 4000 extra death because of air pollution.

1960s

Air pollutants

Gaseous	Particulates	Primary	Secondary
CO NO_x SO_x	Suspended Particulate Matter (SPM)	Emitted directly to atmosphere	Formed from primary Air Pollutant by various Chemical or Physical processes/reactants in the atmosphere O_3.

Sources

Combustion
Fuel CH_4
Combustion → $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$
Complete combustion

Incomplete combustion
- When O_2 is not enough
- When temp is not enough
- When not enough time is given for reaction.

$CH_4 + O_2 \longrightarrow$ mostly $(CO_2 + H_2O)$ + traces $(CO + HC)$

- Most combustion takes place in air $(N_2 + O_2)$
- When temp is higher → Thermal NO_x
  air $(N_2 + O_2) \longrightarrow$ Thermal NO_x

$N \longrightarrow NO_x$
$S \longrightarrow SO_x$

Ash
- Fly ash
- Suspended Particulate Matter.

particular Matter.

Power plant → SPM, SO_x

Automobile → SPM, ~~SO_x~~, NO_x, CO_x, HC.
fule generally does not contain S.

Secondary Air Pollutants

Ozone and other constituents of ~~photo~~ photochemical smog

HC and other organic component that vaporise — VOC

VOC react with NOx in presence of sunlight

$VOCs + NOx \xrightarrow{\text{Sunlight}}$ Photochemical Smog. (CO_3 + other)

Conversion of Units

1 ppm = $\frac{1 \text{ vol of gaseous pollutants}}{10^6 \text{ volume of air.}}$ earlier

latest Standared

$$\frac{mg}{m^3} = \frac{ppm \times mol.wt}{22.46}$$

Effects of air pollutants

Environmental

Health

Environments

$SO_2 \rightarrow$

$H_2O + SO_{2(g)} \longrightarrow H_2SO_3$ (Sulphurous acid)

$2H_2O + O_2 + 2SO_{2(g)} \longrightarrow 2H_2SO_4$ (Sulphuric acid)

The SO_2 react with water vapour present in the atmosphere forming sulphurous acid, when SO_2 react with water molecules & Oxygen forming Sulphuric acid which causes acid rain during precipitation. It causes deterioration to monuments made up of Marbal Ex - Taj Mahal.

It causes reduced visibility when the concentration of SO_2 exceeds a particular limit.

It also cause damage to terrestial organisms as well as aquatic organisms because of Acid Rai

Health

It causes respiratory diseases such as bronch Chronic disea asthma (~~asthma~~)

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NO_x (Nitrous Oxide) Oxides of Nitrogen

Environmental

It causes acid rain; when the oxides of the Nitrogen react with the water molecule in the atmosphere leads to the formation of nitric acid and when the precipitation will occur the nitric acid dissolve in the water molecules & reach the earth surface.

Because of the formation of the nitric acid it helps in the productions of photochemical smog.

When oxides of nitrogen contributes to the formation of photochemical smog producing a brown haze over the cities in the Summer season. It also contributes to global warming.

Health

It causes respiratory problems such as damages to the delecate tissues of lungs. Long time exposure causes asthma and also causes bronchitis & emphisima.

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CO

Environmental

It is a green house gas and leads to global warming, ozone depletion.

Health

CO affect the human health beacuse CO has more affinity towards the haemoglobin & it form Carboxyhaemoglobin causin insufficient Oxygen transfer to the cells. There by it leads to different types of respiratory diseases. An increased concentration of CO leading to the brain cell damage & even death

CO_2

It is a green house gas & leads to global warming CO_2 traps radiation in the ground level prevents the cooling of the atmosphere resulting in heating of land & ocean. & finally leads to the global warming

Health

Exposure to CO_2 produces various health issues including Headache, dizziness, difficulty in breathing, etc.

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PM

Particulate Matter is a general term used for a mixture of solid particles & liquid droplets in air

PM can classified based on the diameter

a) PM_{10} Diameter $\leq$ 10 micro meter
PM_5 " $\leq$ 5 "
$PM_{2.5}$ " $\leq$ 2.5 "

Environmental

- Depending upon the chemical composition of PM it may make streams, ponds, lakes acidic
- It causes change in the nutrient balance and it also contributes to the acid rain

Health

Exposure to PM causes various respiratory diseases ex- bronchitis, Amphesima, Asthma, etc.

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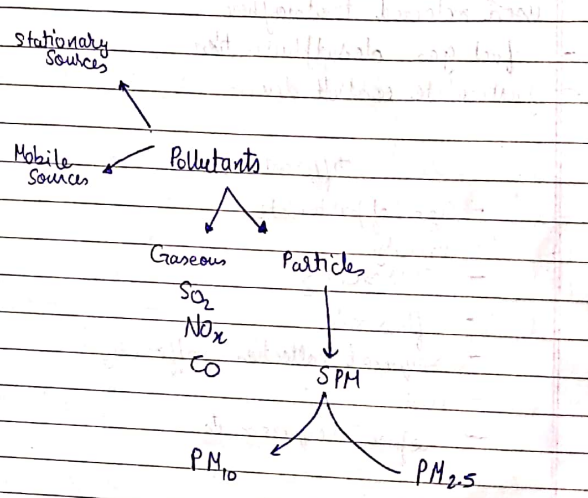
e The ambient concentration of NO_2 in air is 480 micrograms per m^3 at 25°

Find the equivalent concentration in ppm

$$\frac{1\ mg}{m^3} = \frac{1\ part.pm \times mwt}{22.4\ell}$$

$$\frac{480 \times 10^{-6} \times 22.4\ell \times 1000}{46} = ppm.$$

Control of Air Pollutants



Stationary Sources

(i) Pre combustion control
- Reduce emission potential of the fuel itself
- Use fuel with less S, N (fuel switching)
- Physically and Chemically treat fuel to reduce S & N

(ii) Combustion control
- Reduce the emmission by imploring combustion
- New burners (to reduce NO_x), fluidised bed boilers to reduce SO_2, NO_x

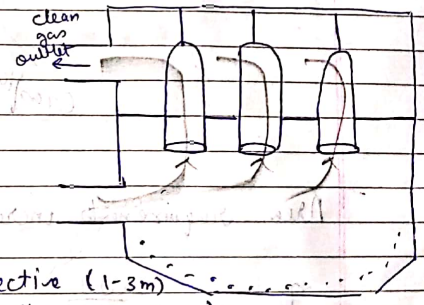
(iii) Post Control Combustion
- Remove pollutants after they are formed but before it is used released to atmosphere
- fuel gas desulphurisation
- particulate control devices

Different Devices
- Size of particulate
- toxicity
- corrosivity
- flow rate
- required collection effeciency
- cost
- space requirements

1. Cyclones (Centrifugal collectors
- only for bigger particulates (> 5 μm
90 %.

2) Bag houses (fabric filters)

Dust laden gases pass through fabric bag, filters, suspended upside down in large chambers



1 μm ~ 100% effective (1-3m)
0.01 μm ~ 90% effective (1 micrometer) Dust
large, expensive, not sufficient for corrosive gases.

Control of Particulate Matter

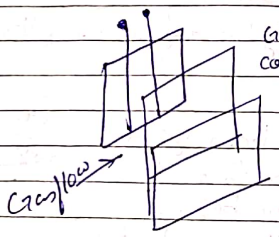
Electrostatic Precipitator (ESP)

- Vertical wires placed between parallel collector plates - plates are grounded & wires are charged upto 100 KV voltage → ionise gas molecule & electrons formed

→ attached to particulate → moved to grounded plate → removed from collection plates by gravity / mechanically

99% eff for < 1 μm

low operation & maintainence cost



Area requirements increases with efficiency

$$\eta_{\text{eff.}} = 1 - e^{-\frac{\omega A}{Q}}$$

A - area of collector plates (m^2)
Q - flow rate (m^3/s)
ω = drift velocity (m/s)

Q In a 6000 m^2 collector plate Area is 97% efficient in 200 m^3/s flow gas from a power plant how larger would the plate area have to be increased to increase the efficiency to 99%

$$\frac{97}{100} = 1 - e^{-\frac{\omega \times 6000}{200}}$$

$$e^{-\omega 30} = \frac{3}{100}$$

$$\frac{99}{100} = 1 - e^{-\frac{\omega (A)}{200}}$$

$$\frac{100}{3} = e^{\omega 20}$$

$$\frac{\ln\left(\frac{100}{3}\right)}{20} = \omega$$

$$\frac{97}{99} = \frac{1 - e^{-\omega 30}}{1 - e^{-\frac{\omega A}{200}}}$$

$$\frac{99}{100} = 1 - e^{-\frac{\ln\left(\frac{100}{3}\right)}{30} \frac{A}{(200)}}$$

$$\frac{1}{100} \ln 100 = \ln \frac{1}{6000} \left(\frac{100}{3}\right) A$$

$$\frac{6000 \ln(100)}{\ln(100/3)} = A$$

$$\frac{6000 \times 2}{2 - \log 3} = A$$

$$A = 7879.81\ m^2$$

Noise pollution

Noise — unwanted sound – Env. pollutant – waste product associated with human activities.

Pollutants → Material → water & air pollutants
Energy residuals
- Thermal pollution → increase in temp of rivers
- Noise pollutants → sound energy.

Sound Measurement (Level and Decibel)

- Faintest sound one can hear 0.00002 pascal
- High intensity (rocket) 200 pascal
- large variation
- A scale based in log of ratios is used
- Measurement on this scale is called level
  Unit is bel $L = \log \frac{\phi}{\phi_0}$

ϕ = measured quantity, ϕ_0 = ref. quantity

Bel is large unit → divided into ten parts.

$L = 10 \log \frac{\phi}{\phi_0}$ $\phi_0 = 10^{-12}$ watts

6 What sound power level results from combining the effects from 3 sound levels 68 dB, 79 dB, 75 dB.

$68 = 10 \log \frac{\phi_1}{\phi_0}$

$79 = 10 \log \frac{\phi_2}{\phi_0}$

$75 = 10 \log \frac{\phi_3}{\phi_0}$

$\frac{68-12}{10} = \phi_1 = 0.00055165$

$\frac{79-12}{10} = \phi_2 = 0.016572675$

$\frac{75-12}{10} = \phi_3 = 0.011089995$

$10 \log \left(10^{\frac{68}{10}} + 10^{\frac{79}{10}} + 10^{\frac{75}{10}}\right) = 80.79 \text{ Db} = 81 \text{ db}$

$\phi \; 10 \log \left(\frac{68}{10} + \frac{82}{10} - \frac{76}{10} \; \frac{68}{10} \; \frac{81}{10} \; \frac{74}{10} \right)$
$10 \quad 10 \quad + 10 \quad + 10 \quad + 10 \quad + 10$

$= 85.586 \text{ dB}.$

Effect of noise on People

(i) Auditory effect – hearing loss, speech interference

(ii) Psychological / Sociological effects
- An
- Sleep interference
- effect on performance

Noise Control
Path – Receiver Concept

Drinking Water Quality Characteristics
- water used for different purposes (household, industrial, irrigation, recreational)
- Quality requirements different for different uses.

Drinking Water Quality
- Physical
- Chemical
- Microbiological

BIS 10500 = ⊙Acceptable (Desirable) & ⊙Permissible (when no sources available)

Physical Water Quality Parameter
Suspended Solids, turbidity, Colour, Odour

Solids
- Dissolved
- Suspended.

1) Suspended Solid (not in ground water)
- common in surface water
- Clay, Silt, Organic materials (Plant fibers, algae cell)
- Aesthetically displeasing

Measurement : filter, 104°C, drive off liquid.

2) Turbidity
- Direct measure of S.S.
- Measure of the extent to which light is scattered by suspended matter in water
- Clay, silt, veg, microorganisms
- Aesthetically displeasing
- Measured photometrically: by detec directly detecting the % of light of a given intensity that is scattered
- Turbidity
Turbidimeter - Nephelometric
turbidity Unit (NTU)

BIS → 1NTU / 5NTU
Desirable / Permissible

3) Colour

colour due to S.S → apparent Colour

colour due to D.S → True Colour
(difficult to remove

Measurement : Colour comparision method

5 Hazen / 15 Hazen

Chemical WQ Parameter

1) Total D.S. (ground water have more DS generally)
- Results from solvent action of water
- measurement - evaporation to dryness

500 mg/L — 2000 mg/L

2) pH
$pH = -\log(H^+)$
$(H^+)(OH^-) = 10^{-14}$
- corrosive, taste
- Acid rain, ind - discharge

6.5 to 8.5

3) Hardness
- conc. of multivalent metallic cations in water

Ca^{2+}, Mg^{2+}, Fe^{2+}, Fe^{3+}, Al^{3+} .....

- Soap consumption is more
- precipitates formed adhere to tubs, sinks, dishwashers, dishes

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- Boiler Scale
- Health point of view – no problem

Measurement : Titrating with EDTI using Eriochrom Black T (Indicator)

EBT + Ca^{2+} ⟶ Complex (Red)

Complex + EDTA ⟶ EBT + complex (Blue)

	Desirable	Permissible.
Hardness	200	600 mg/L as $CaCO_3$
Ca	75	200 mg/L "
Mg	30	100 mg/L "

4. Alkalinity

Quantity of ions in water that will neutralise H^+

- In natural water OH^-, CO_3^{2-}, HCO_3^-
- Bitter taste
- Titrating with 0.02 N H_2SO_4

200 mg/L (Desirable)

600 mg/L as $CaCO_3$. Permissible,

5. Fluorides (Mostly in ground water)

- In ground water
- Small conc. beneficial as it prevent dental cavities
- if conc. is low than (Fluoridation) should be done
- Excess F – decolouration of teeth
  bone fluorosis, skeletal fluorosis

Stg. 1.0 – 1.5 mg/L

If conc. is greater than we use the defluoridation process.

Defluoridation – difficult – reverse osmosis
ion exchange.

6) Nitrate

Nitrate poisoning in babies
- blue baby disease

4.5mg/L Desirable & Permissible 45mg/L
45mg/L (same).

7) Arsenic

Skin cancer, skin pigmentation

0.01 – 0.05mg/L

Treatment difficult – adsorption and reverse osmosis should be used for removal

MICROBIOLOGICAL QUALITY

- Indicator organisms
  → Total coliforms, faecal coliforms, Escherichia coli

Ex of indicator organisms

- Two techniques
  - Membrane filtration method – Direct count
  - Most probable number method – Indirect count
  - MNP

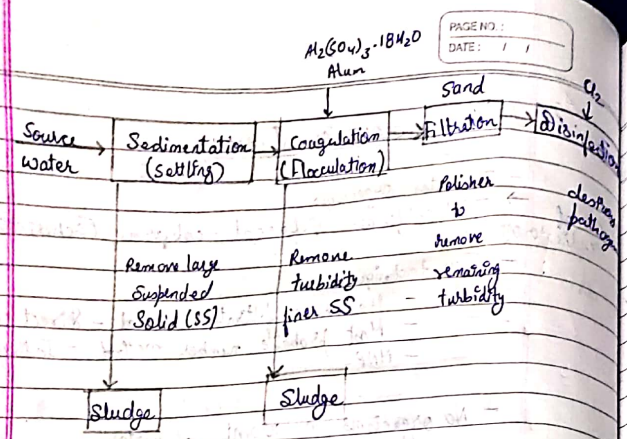
- No organisms in 100mL of water

WATER TREATMENT SYSTEMS

- Source Water to drinking Water

Ground Water – High D.S., low turbidity (SS)
↓
Difficult to remove

Surface Water – High turbidity, high microbial contamination
– low D.S.



Coagulation/Flocculation : Bring together particles.

bigger size → Settle

↓ $(Al(OH)_3)$

: Rapid mixing → Slow mixing → Settling

Disinfection: Killing all pathogenic organism remaining
chlorination, Ozone, bleaching powder
$[Ca(OCl)_2]$

India = 135 L/person/Day is supplied

① Determine a treatment plant capacity for a community of 25,000 person.
If the alum dose for coagulation was found to be 12 mg/l determine the monthly alum requirement for the plant

MLD = million liter per day

25000×135

$= 3375000$ L per day

$= 3.375$ MLD

total alum = 1215 Kg per month.

Waste water treatment plant

Flow diagram

Waste Water Quality

Collection Sump → Inlet chamber → Grit Chamber (Grit basin)

Coarse floating matter screening

Skimming tank → PST (30% BOD is removed) → Primary Sludge

FOG (Fat, oil & grease)

Secondary Treatment process

a) Physico chemical process
b) biological process
* ASP
* TF

SST (Secondary Sedimentation Tank) → Secondary Sludge

Disinfection unit → Discharge (Creek) (Waste water Quality Parameters)

Primary Sludge (PST) ⟷ Secondary Sludge (SST)

Sludge treatment

Sludge thickning → reducing vol. of Sludge
* Gravity Sludge Thickner

Sludge digestion → microbes → OM → H_2O + Energy + CO_2 → volume reducing

Sludge Dewatering (Separating the water)

Sludge drying → Sludge Disposal

elevation

Plan

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Waste Water Treatment

Biological Treatment

Suspended Growth process System
Attached Growth process System

Combined Suspended & Attached Growth process System

Aerobic Process - presence of air
Anaerobic Process absence of air.

ASP (Activated Sludge Process)

Activated Sludge - It will react. It is not inert. It contain living microbes which is ready to react with sludge.

Effluent from PST → Aeration tank

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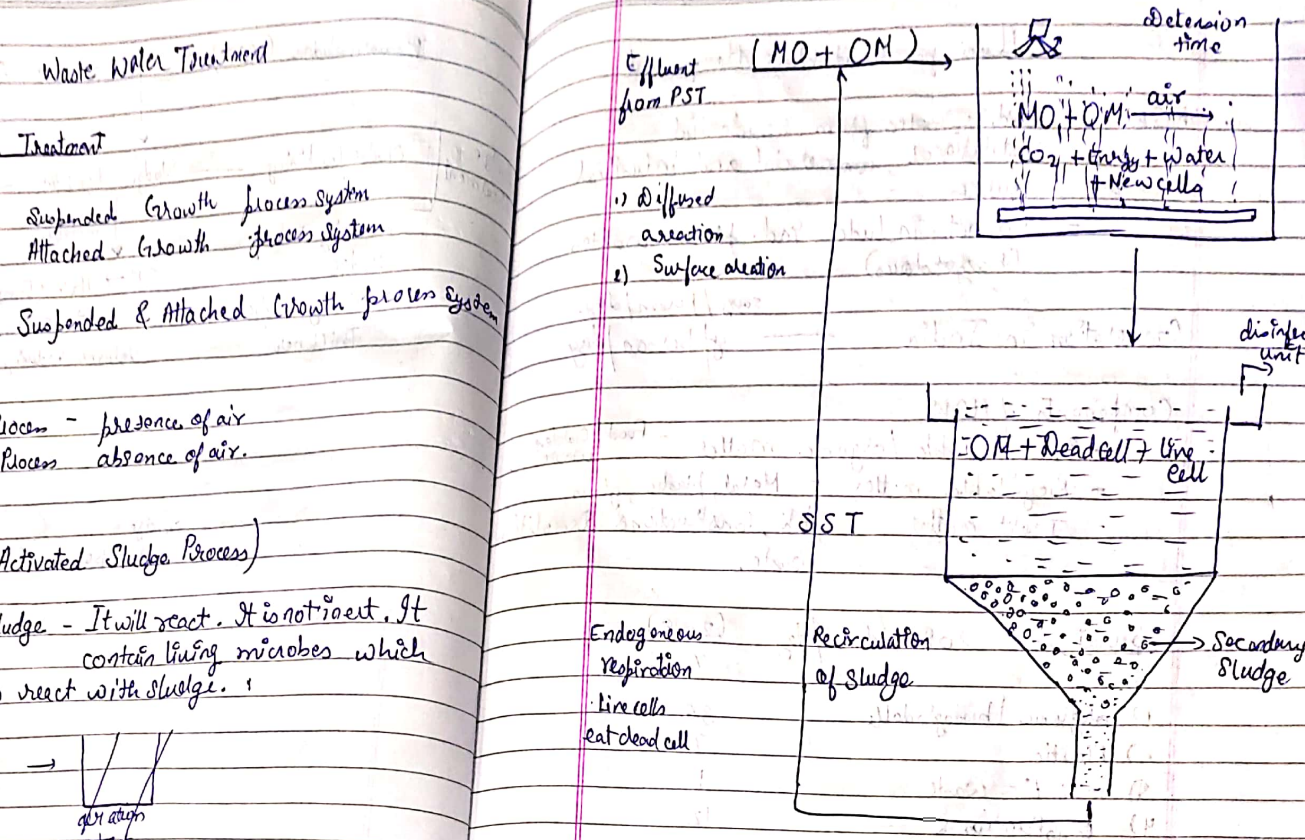
OM - Organic matter
MO - Microbes



1) Diffused aeration
2) Surface aeration

1) F/M ration — Food/Microbes

2) Volume/Aeration

Municipal Solid Waste Management

MSW - Solid wastes from residential, institutional, commercial and industrial sources
- Do not includes ind. process wastes (hazardous)

Generation in India — 500g/person/day. — g/person/day

Components of MSW
- Biodegradable / organic matter - Food / Garden waste
- Recyclable matter - Metal, plastic, glass
- Inert matter - Ash, Construction & Demolition waste.

Surat 2080 ton/day (2018)	%
1) organic / biodegradable	36
2) Plastic	7
3) E-waste	1
4) Construction &	12
5) Textile	11
6) Paper	8
7) Glass, metal, rubber	11
8) Inert / other	13
	100%

Characteristics of MSW

Particle size, density, moisture content, heat, value.
- Moisture Content - Weigh loss at 105°C for 2h
- Volatile fraction - weigh loss at 900°C for 2h.
- Ash - Weight of residue after combustion
- Ultimate analysis - determining C, N, O, H, S
  - Chemical Composition - C/N ratio
- Energy content - Heat value (calorific value)
  - Depends on mix of materials of moisture content.

Q Residential solid waste has the following components

	% by mass	Moisture content (%)	food dry weight	wet
Paper	50%	6	47g	8g
Glass	20%	2	19.6g	0.4g
Food	20%	70	6g	14g
Vegetation	10%	60	4g	6g.

Find the moisture components of total waste.

$$\frac{50 \times 6}{100} + \frac{20 \times 2}{100} + \frac{20 \times 70}{100} + \frac{10 \times 60}{100}$$

$$= 3 + 0.4 + 14 + 6$$

$$23.4 \text{ gm}$$

9.

Material	% by mass	Heat Value KJ/Kg
Paper	31.7	15800
Vegetation	16.2	6300
Plastic	11.5	32800
Food waste	8.5	5500
Wood	7.6	16000
metals	7.4	0
Glass	6.6	0
Rubber	3.6	22300
Textile	3.3	18700
Other inert	3.6	0

Find the calorific value of waste

$$\frac{31.7 \times 15800}{100} + \frac{16.2 \times 6300}{100} + \frac{11.5 \times 32800}{100}$$

$$+ \frac{5500 \times 8.5}{100} + \frac{7.6 \times 16000}{100} + 3.6 \times 23 \cdot$$

$$+ 3.3 \times 187$$

$$5008.6 + 1020.6 + 3772 + 467.5 + 1216$$

$$+ 802.8$$

$$+ 617.1$$

$$= 12904.6$$

$$\approx 12900 \text{ KJ/kg}$$

$\frac{1}{2}$ coal

Processing / Treatment / Disposal of MSW

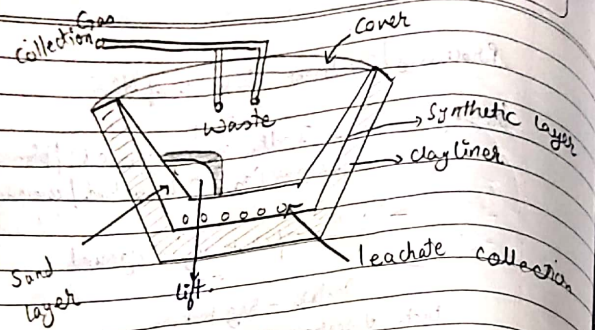
Segregation - In India - no organised / planned segregation at household / community level

- Sorting of waste by unorganised Sector - rag pickers

Lack of segregation - Deprive proper scientific disposal.

1. Segregation
2. Recycling
   - Highest priority in MSW management
   - Reused as raw materials for new products

   Paper - reprocessed as newsprint, paper board
   Glass - Construction materials, bottles
   Org. waste - Used as fertilizer (compost)
   Construction waste - construction of roads
   Al cans - reprocessed as Al sheets
   Plastic bottles - reprocessed as auto parts, fiberfill
3. Engineered landfilling
   - Open dumping - not allowed
   - Engineered method for disposal of MSW within land fill → phys, chem, biol. processes occur, degradation of waste results in ↓ & leachate (polluted water from the base of landfill and gases. In cities - land cost high.



Q Determine the area needed to handel 1 year municipal SW for a town of 1 lakh people assume average generation of 500 g/person per day land fill density 600 kg/m³ & 6 lifts of 8 m height assume 20% of land fill volume is soil used for cover.

$$\text{Mass} = 100000 \times \frac{500}{1000} \times 365$$

$$\frac{V \times 80}{100} = \left(\frac{100000 \times .5 \times 365}{600}\right) \times$$

$$V = 38020.8333$$

$$A = \frac{38020.8333}{18}$$

$$A = 2112.2685 \ m^2$$

4 Biological Treatment

In India - more organic fraction - 50%
- segregation is imp.

(i) Composting
- Bacteria & Fungus
- Biological conversion of organic matter - aerobic.
- End product is compost, rich in nutrients - fertiliser

(ii) Vermicomposting
composting of earthworms - vermicompost.

(iii) Anaerobic digestion (Biomethanation)
Stabilisation of waste occurs, biogas generated
Biogas - 65% CH_4, rest CO_2
large no of plants in towns

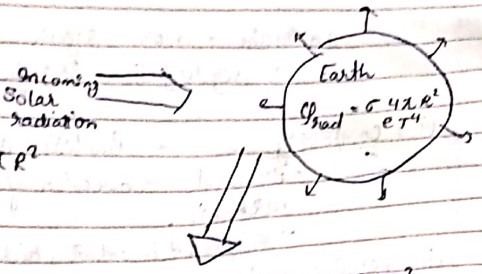
5 Thermal Treatment (Waste to Energy Technique)

Req: Low moisture content & inert content
high heat value

- Incineration
- Consists of combustion Chambers, heat recovery system, air pollution control system, ash handling system

Adv. Volume reduction, less land area, recovery of heat
Disadv. Air pollutants, toxic ~~dioxins~~. dioxins.

Global Warming & Climate Change



Reflected = $\alpha\ S\pi R^2$

α = albedo
0.31

$S\pi R^2 (1-\alpha) = \sigma 4\pi R^2 T^4 e$

(S) Solar Constant = 1370 w/m²

(σ) Stefan Boltzman Constant = 1370 w/m²

Av. global tem = 254 K (−15°C)

Actual global tem = 288K (15°C) 34° increase

Sun Black Body 5800 K

→ Spectrum peaks at 0.5 μm
→ Short wavelength.

Earth black Body 288 K
→ peak 10.1 μm → long wavelength rad. (thermal rad.)

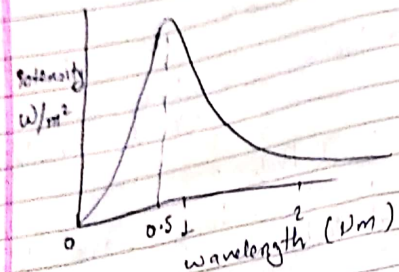
As radiation energy pass through the atm.

i) Rad. energy
ii) Scattering
iii) Stop by absorption

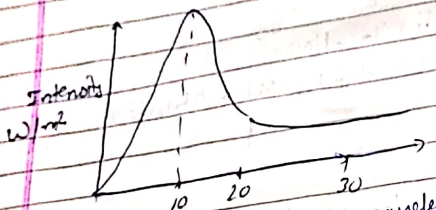
Most of the long wavelength energy radiated by the Earth is absorbed different gas

CO_2, CH_4, N_2O hal

Incoming Solar rad.



Outgoing rad from Earth



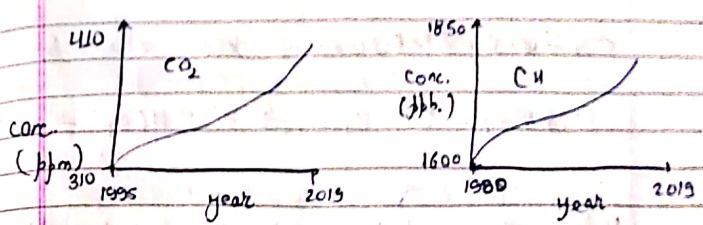
- H_2O vapour absorbs wavelength < 8 μm & > 18 μm
- CO_2 - ~ 15 μm
- ~~Radioactivity~~ Radioactivly active gases that absorb wavelength > 4 μm are called GHG
  Green House Gases

This heats the atm. → radiates back to earth

Global Warming Potential

A weighting factor that enables comparisons to be made between 1 kg of CO_2

CO_2 - 1
CH_4 - 86
N_2O ~~NH_4~~ - 280



Carbon emission from fossil fuel - 80% of CO_2
25% of CH_4
25% of N_2O

Impact of Climate Change

(i) Rising Sea level

Water expands as it warms, density decreases, volume increases
→ Sea level rise.
Melting glaciers and ice caps → increase water volume and rising sea level.

In the last 100 years, ocean level risen by 10-20 cm

→ Increasing shoreline erosion, coastal flooding, flooding coastal wetland, ground water salinity.

(ii) Ocean Acidification

Ocean Stores 50 times more CO_2 as atm.

CO_2 dissolved in Ocean

$CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^- \rightleftharpoons 2H^+ + CO_3^{2-}$

Natural Ocean pH → 8 - 8.3 (alkaline)

pH drop of 0.1 in 50 years

Expected to be 0.3 by ~~2010~~ 2100

→ Reduces CO_3^{2-} — affects plantation - food for fish.

Global Action on Climate Change

- United Nations framework convention on Climate Change (UNFCCC) - 1992 - "Activities stabilization of GHG conc. in the atm. at a level that would permit dangerous intervene with climate System".

- Led to Kyoto Protocol - 1997

- Set target for 37 industrialised nations to reduce their emission by 5% below 1990 level of 2008-2012

- Target achieved - 10% reduction
- But total global emission increased by developin nations.

- Paris Agreement (2015) - 160 countries - To reduce emission upto 2030 "To hold the increase in temp below 2°C

Carbon Credit

A permit / certificate allowing the holder such as a company to emit CO_2 or other GHG

One CC = 1 ton of CO_2 or CO_2 equivalent gases.

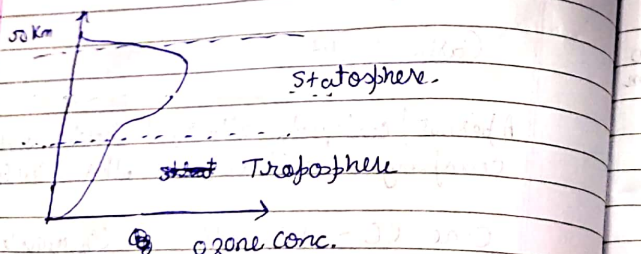
Ozone depletion

- Stratospheric O_3 depletion
- Ozone - unusual characteristic
  - Beneficial in stratosphere (UV atmosphere)
  - Harmful at ground level

- 90% Ozone in stratosphere - ozone layer
- In stratosphere - O_3 is ~~cond~~ continuously created and removed by various photochemical methods

Many gases involved in G.H effect also cause Ozone depletion

- CH_4 reduce Ozone depletion
- Many causes Ozone depletion



UV-A penetrates deeply into skin, DNA damage, photoaging

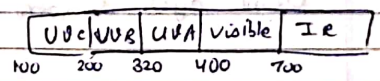
Some UV-A beneficial - Vitamin D

UV-B poses greatest threat to health
- Reddening of skin

reduction in Vit D, Skin Cancer, suppression of immune system, Cataracts

UV-C destroy DNA

- Helpful => destroy microorganism - Disinfectant
- ~~Disinfectant~~ • Ozone shields us from UV radiation



Ozone as a protective shell

O_3 formation in Stratosphere

(i) Atomic O_3 is formed by photolytic decomposition of mol. O_2

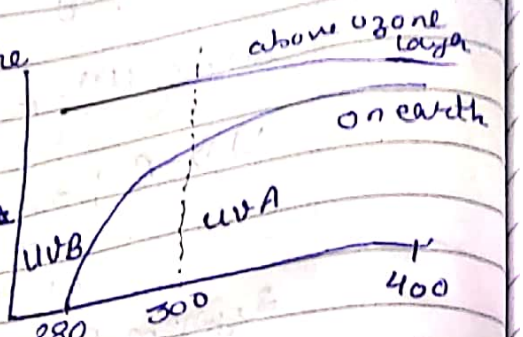
$$O_2 + h\nu \longrightarrow O + O$$

(wavelength < 242 nm)

(ii) The at. O_2 formed reacts with mole O_2 to form O_3

$$O + O_2 + M \longrightarrow O_3 + M$$

M → third body (N_2) to carry heat generated



Ozone Removal

photodissociation

$$O_3 + h\nu \longrightarrow O_2 + O \quad (200 - 320 nm)$$

Ozone layer removes almost all UV with < 290 nm

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Ask sir for notes.

Sources of Energy (4)

Wave	Electricity	Kerosene
Tidal	Steam	CNG
Hydro	Nuclear	Firewood
Solar	Hydrogen	man & animals
Wind	Coal	
Biomass	Petrol	
Geothermal	Diesel	

Classification of Energy (4)

1. Renewable & Fossil Source
2. Primary & Secondary
3. Commercial & Non Commercial Source.
   - (Fix price) (Petrol & Diesel)
   - (No fix price) (Man & Animals)

(Properties)

Fuels

(4-6) Mcal/kg

Solid	Liquid	Gaseous
	9.5-10 Mcal/kg	9500 Kcal/kg
	(Low Sulphur Heavy stock) LSHS	1 Kcal (30000)
coal	Petrol (Gasoline)	Hydrogen (
White coal	Diesel (10-10.5 Mcal/kg)	Methane (10000 Kcal
Pet coke	Kerosene (11700 Kcal/kg)	
	Ethanol	
	Biodiesel	
	Light Diesel Oil	
	Furnace Oil	

Coal Calorific Value (4000 - 6000) Kcal/kg
→ Indian Coal (3500 - 4500) Kcal/kg
have low value due to presence of ash & moisture.

→ Gaseous & Petrol give around 10000 Kcal/kg Calorific value

→ Kerosene used in aircraft application

For Kerosene the pour point is very low. The point refers to as freezing of liq fuel to solid. It does not freeze in lower temp. above in atmosphere

Pressure in LPG is 15 bar & in pressure cooker is (1.5 - 2) bar. For storing of Hydrogen we need pressure of 600 bars Pressure in tube & tyres of cycle. ~ 1.7 - 2.4

Net Calorific Value And Gross calorific Value
NCV < GCV. when we burn Hydrocarbon we lose energy in conversion of Hydrogen to Water Vapours in form of latent heat so this lost energy is removed from Gross Calorific to give Net Calorific Value.

Cloud Point - when fule just starts to freeze
Pour point - when fule is just completely freezed that point is pour point.

Low Sulfur Heavy Spark
Light Diesel Oil
Petrol
Diesel Kerosene

Density of Petrol 760 Kg/m³
Diesel - 820 - 840 Kg/m³
SCNG - 0.85 Kg/m³
Pressure to Store CNG = 200 bar.
SHydrogen - 0.120 Kg/m³

Energy Conversion

Petrol Engine requires Spark to ignite. So all petrol operated are known as SIE = Spark ignition engine.
A spark is triggering 33 times in 1 second.

Low grade energy to High grade energy is difficult where as we can convert High grade energy to Low grade.

High to Low → Easy
Low to High → Very difficult.

Power plant

Coal → Heat energy → mechanical → Electrical
(Chemical energy)
(61% Lost in process)
(39% is obtained)

→ Frictional losses
→ Transmission & Distribution Losses (12% T&D) in Transmission cables.

→ Theft & Decoit loses (T&D)

Total energy which we obtain is not more than 12%

High (Electricity) ⟶ low (Heat) easy

to heat water

low (Heat from Coal) ⟶ High (Electricity)

to produce electricity in Power Plant

1 min = 2000 cycle = 2000 spark Trigger ⟶ 4000 rpm

60 sec = 2000 cycle

1 cycle = 2 rpm = 4 strokes

2000 cycles = 4000 rpm

1 sec = 33 cycle

$\frac{1}{33}$ sec = 1 cycle

1 cycle = 4 strokes

1 sec = 33 cycle = 132 Strokes

$720^\circ = \frac{1}{33}$ sec

combustion duration $(72^\circ) = \frac{1}{330}$ sec.

combustion duration is approximately 1/10 of cycle time

compression ratio of diesel is more than petrol. No spark plug in diesel engine

Diesel engine hetiogeneous mixture and petrol have homogeneous mixture. Petrol engine is size confined while diesel is not.

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Diesel engine size can be increased where as in Petrol engine Size can be reduced to any extent.

diesel cycle. Diesel engine will have higher efficiency.
Diesel engine will be bulkier than petrol engine

Diesel is hetrogeneous mixture
Petrol is homogenous mixture

efficiency = Output / input

Engine is energy conversion device → power producing device (energy)

input is in Kwatt output is also in Kwatt.

calorific value = KJ/Kg × Kg/Sec = KJ/Sec

Heat pu × amount pr sec

pump, fan, blowers, compressors are energy consuming device.

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Refrigeration & AC.

To cool below atmospheric temperature.

COP - coefficient of performance

COP = What you get / What you pay = cooling effect / Refrigeration effect
work done upon compression

All refrigerators work on Vapour Compression Refrigeration System

Q What do you mean by COP of HVAC System

Heating Ventilation & Air conditioner.

(b) For a domestic air conditioner having COP of 3-5, for each megajoule of heat removed how much of input is required

S.

Nuclear fusion is taking place on the surface of Sun.

Q Give the classification of solar System.

Solar Systems are classified as Solar Photovoltaic System & Solar Thermal Systems.

Solar Photovoltaic Systems are direct energy conversion devices that converts solar energy into electricity whereas solar thermal Systems are mainly useful for process heating. The power produced from solar P.V is DC with conversion effeciency around 10 to 15%.

Solar PV cells are mono crystaline or poly crystaline solar cells.

Discuss the working of flat plate collector for water heating applications.

Solar thermal system — flat plate
                    \ concentrating collector

flat plate - area of absorber = area of collector

Conc collector - area of absorber < area of collector

Conc. ratio = area of collector / area of absorber

Q How much solar energy is available on a surface of unit area

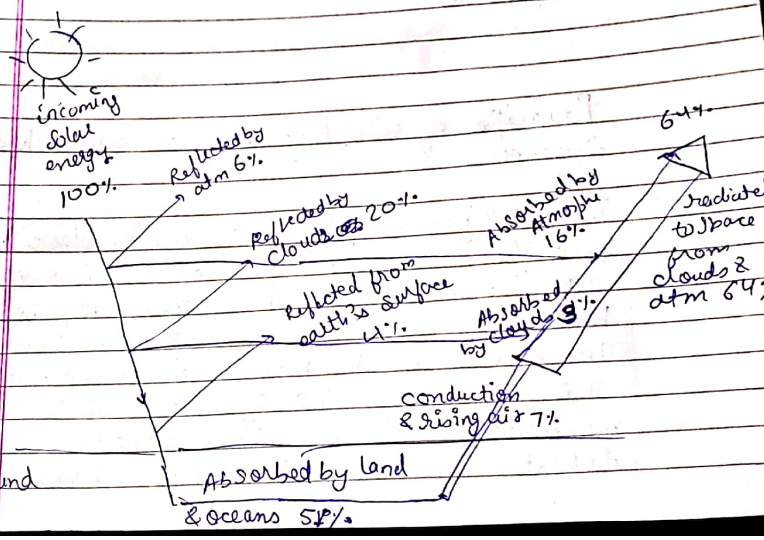
For most of the cities in India the Assumption is 500 w/m² average day hours = 10hrs

1 KWh = 1 unit.

5000 W.Wh/m²

5 KWh/m² average

Earth's Energy Budget



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Beyond the layer of atm the energy available on a surface area of unity perpendicular to the direction of radiation in space at a mean distance from the sun is called the solar constant having the value equals to 1367 watt/m^2.

Q An inventor claims that he has devised a solar pv system that can produce 2 KW of power per m^2 of surface area. State weather whether his claim is valid or not.

- His claim is invalid because solar constant is 1367 watt/m^2 in space so max value could be 1367 if efficiency is 100%. so it is not possible.

Principle of Working of Solar water heating System.

- This comprises of flat plate with black coat and the tubes are mounted onto its surface and the assembly is placed below the glass to achieve green house effect. The system is well insulated & placed inclined. It is connected with storage tank which is also insulated such that the hot water will retain its heat throughout the night & hot water will

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be available in the morning. For a family of 4 a 100L per day system is sufficient (LPD).

DeSalination unit. - Solar thermal System.

Biomass and Bio Energy.

Biogas plant is a system that converts the organic matter into biogas and manure through a process of anaerobic digestion. The biogas has the composition of CH_4 & CO_2. Any organic matter like cow dung kitchen waste, food waste, rice husk can be processed as substrate.

Classification of Biogas Plants
1) Floating Dome BGP
2) Fixed Dome BGP
3)

Advantages & Disadvantages of floating dome & fixed dome Biogas Plant.

Enriched biogas.

Energy from wind

Reasons from formation of wind

$KE = \frac{1}{2} mv^2$

$= \frac{1}{2}(\rho A v) \cdot v^2$

$= \frac{1}{2} \rho \frac{\pi D^2}{4} v^3 = \frac{\pi}{8} \rho D^2 v^3$

1 Comparison between floating and fixed dome

2 Parameter affecting the performance of Biogas plant.
- pH should be maintained

3 factors affecting the site selection of Biogas plant,
- supply & demand, Temp, ~~amount~~ availability of water

Energy Conservation & Management

Energy Act

This act is passed by the parliament and mandatory for all industries. This act is passed in 2001 with the initiative from ministry of power govt. of India.

$$EER = \frac{\text{Heat}}{\text{Work}}$$

Star Label Description Draw.

- More stars more saving
- Efficiency parameters.
- Brand & Model details
- Technical Parameter
- Applicable dates of Stndard
- Manufacturing year
- Unique Code

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