29/7/11

ECOLOGY AND ECOSYSTEM

Study of Environment is Ecology

Ecology:- Echos + logus.

Ecosystem:- interaction between biotic & abiotic components

Biotic :- Any living organisms
plants,
Animals,
micro-organisms

Abiotic :- Temp, Air, water, soil, p^H, minerals.

Tropic Levels of Ecosystem:- Producers
Consumers ← Primary, Secondary, tertiary ....
Decomposers

Tropic Levels

Producers:- Mostly produce their own food. plants & some microorganisms.

Producers are known as Autotrophes. ~~Those~~ producers prepare food by photosynthesis so they are called phototrophes so they are called autophototrophes.

Microorganisms → Chemotrophes but are also autotrophs
→ autochemotrophes.

Consumers:- Depend on producers for food

Herbivores - depend on plants (1st order)

Carnivores - depend on herbivores (1st & 2nd & 3rd order)

Omnivores - depend on herbivores or producers for food (1st, 2nd, 3rd order).

plants in ponds → phytoplankton

↑

Zoo plankton (primary consumer) (herbivores)

↑

small fish (Secondary consumers)

↑

large fish (Tertiary consumers)

All waste produced by them will be decomposed by decomposers (bacteria)

production of food per unit area per unit time in an ecosystem is called productivity.

They are of 3 types:-

primary productivity < Gross :- Total amount of food produced by producers
Net :- The food available after being consumed by producers

secondary < Gross
Net

Tertiary — Net :- The total energy remaining unutilized by any organism

Organisms :- living things

Population :- several organisms

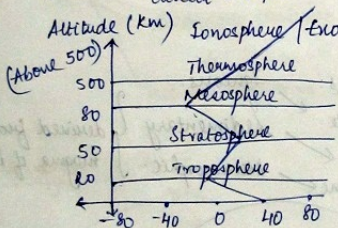
Community / Habitat :- co existence of several biotic creatures

Ecosystem :- community + Abiotic system

Biosphere :- No of ecosystems

Various components of ecosystem :-

1. Atmosphere :- Layer of Air above earth surface
2. Hydrosphere :- Any water comes under hydrosphere
3. Lithosphere :- Land, the ~~planet~~ earth come under lithosphere
4. Biosphere :- The coexistence of several ecosystems is called biosphere.



Variation of temperature.

Water Cycle :-

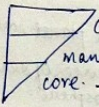
1. Evaporation
2. Condensation
3. Precipitation

of 100%. water in world, 97%. is saline (97.41%.)
rest 3% is potable, of that 2% is present in (1.981%).
polar caps as glaciers
rest 1% (0.604%.) is available in ground, rivers,
human body. Only 0.08% is readily available as
potable water 0.58%. is ground water.

22%. precipitation is over land, 78% of precipitation is on oceans & seas.

~~0.22%. that too~~

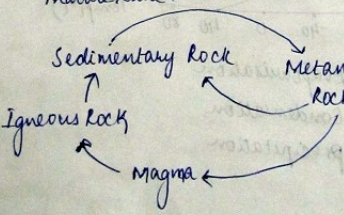
Lithosphere:-



Various types of Rocks:-

- Igneous — Basalt, Granite
- Sedimentary — Sandstone, Slate, Limestone
- Metamorphic — Marble, Stone

} derived from magma of Lava

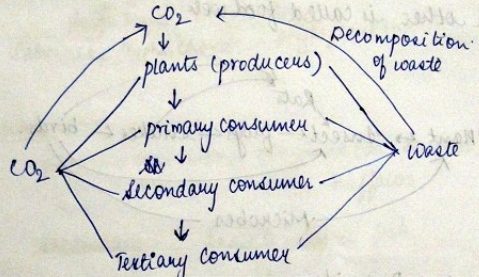


Biosphere :- Combination of atmosphere, hydrosphere and lithosphere.

Elements required for ecosystem are

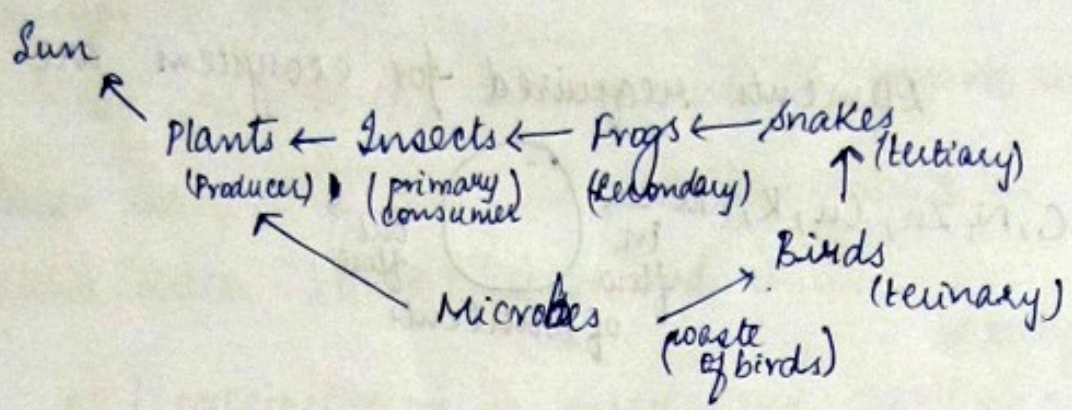
C, N, Zn, Cu, K, Na → In flow of Nutrients → out flow

Carbon Cycle :-

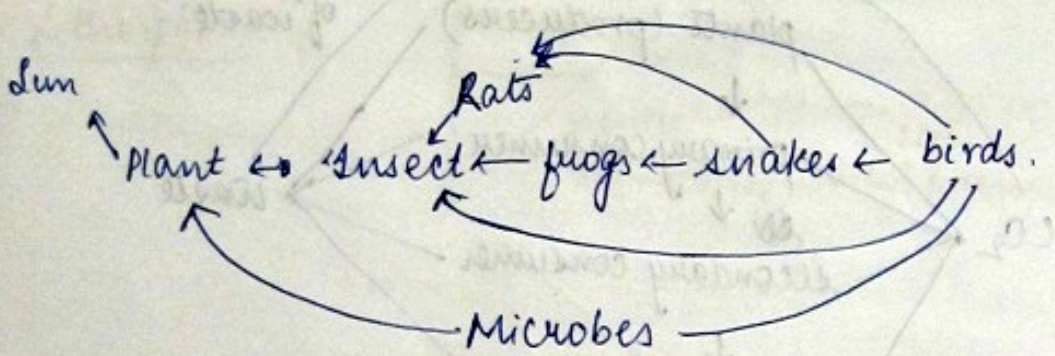


Nitrogen Cycle :-

Food chain :- Indicates the pattern of transfer of food from one level of ecosystem to other level.

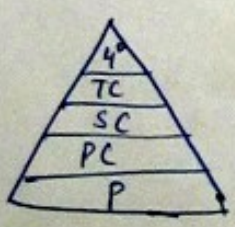


Food Web :- Number of food chains interrelated with each other is called food web



Ecological Pyramid :-

1. Grazing :- starts from plants
2. Detritus :- starts from decomposers



:- pyramid of Numbers

Biomass pyramid

Energy pyramid

Various Ecosystems :- (go through text book)

1. Natural
2. Manmade

} Terrestrial
Aquatic

Pond Ecosystem :-

Abiotic → Heat, light, p^H, CO_2, O_2, calcium, Nitrogen, phosphorus, aminoacids

Biotic :-

producers → Macrophytes :- Rooted plants
Microphytes :- plants with no roots

~~eg :- phytoplankton~~

~~phyto~~ Trapa,
Salvinia, Typha, Chara

phytoplankton

Consumers :-

primary consumer :- Zooplankton, Benthos, cows, buffalos.

secondary :- Insects, small fish

tertiary :- large fish.

Decomposers :- Aspergillus, Clostospodium.

30/4/11

AIR POLLUTION

Natural air pollution → volcanos eruption, Radioactive decay
→ forest fire
→ cyclone

Manmade air pollution :- Combustion
Agricultural management
Land filling / solid waste management
Military Activities
Nuclear Energy production

Pollutants :-

Natural :- Pollen grains, Micro organisms

Gases :- CO, CO_2, NO_x, SO_x, CFC, O_3, Aldehydes, Ketones, ~~Aerosols~~ → Volatile organic compounds (V.O.C), Organic compounds

Assignment :-

Name of pollutant	Source of pollutant	Effect of pollutant on humans, structures, animals etc.

Aerosols :- Dust — (3 μm - 100 μm) allergic effect
Smoke — (0.01 μm - 0.2 μm)
Mist — (40 μm - 100 μm)
Fog — (1 μm - 40 μm) reduce visibility
Fumes :- vapours emitted from volatile compounds (< 1 μm)
Soot — carbon particles combined with dust & water

Primary pollutant :- direct effect on environment, emitted from source

Ex:- dust particles.

Secondary pollutant :- Smog — photochemical smog
Industrial smog

Acid rain

PAN (Peroxy Acetyl nitrate)

Aldehydes

Ozone

Photochemical smog :- In presence of sunlight if carbon particles react with Hydrocarbons, PAN, Ketones, aldehydes, organic acid - photochemical smog occurs

Silicosis :- a disease caused by silica particles.

Factors for self purification -

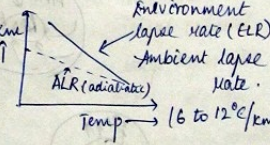
Temperature

wind

Mixing Height

Humidity

precipitation



Adiabatic lapse rate :- It varies from 6°C/km 9.8°C/km decrease in temperature of pollutant with increase in height

If ALR > ELR the condition is known as stable condition or subadiabatic condition.

If ALR < ELR then that condition is called unstable condition or super adiabatic condition.

Neutral condition, temperature is constant with rise in height

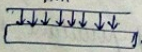
~~Negative~~ Inversion condition, temperature increases with rise in height. It may be radiation or subsidence inverse condition.

(room ht) (cool season, in hilly areas) (3 - 24 hrs)

(1600 ~~1000~~ ht) (coastal area/plane areas hot season) (7 days - several months)

cyclone :-

Anticyclone condition :-



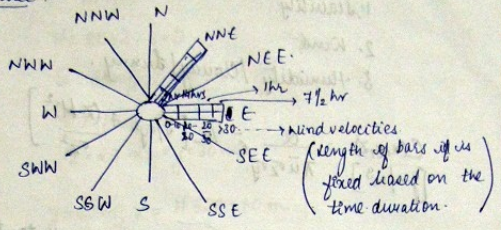
→ Inversion layer (subsidence inversion condition)

Wind :-

Speed

Direction

Wind rose :-



Anemometer :- measures direction & speed of wind for every time interval.

From 4m ground level (measuring ht for wind speed, generally)

$$\bar{u} = \left(\frac{\bar{z}}{z_1}\right)^k u_1$$

u_1 → measured velocity at z_1

$\bar{z}$ → the proposed ht

z_1 → the measuring ht

k → empirical constant

$k = \frac{1}{9}$ for large lapse rate ELR 10°C/Km

$= 1/3$ for inversion condition

$= 1/7$ general value (if no data is present)

Mixing height :- ~~upto which~~ height, mixing of upto which pollutants ~~are~~ ~~equal~~ takes place.

Mixing ht in summer :- 450 m

" " in winter :- 2100 m.

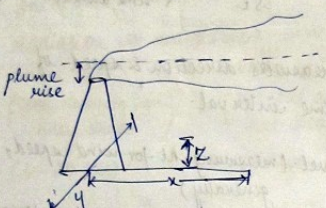
Pollution Concentration Model:-

Gaussian dispersion model:-

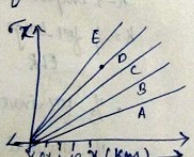
1. stability
2. Wind
3. Humidity / Cloudy / Sunny.

$$C(x,y,z) = \frac{Q}{\pi \bar{u} \sigma_z \sigma_y} e^{-1/2\left[\frac{y^2}{\sigma_y^2} + \frac{(z-H)^2}{\sigma_z^2}\right]}$$

$[gm/m^3]$



ground is assumed to be uniform



Q → pollutant emission rate
Q – gm/sec
$\bar{u}$ – wind velocity at the emission point
$z=0$ at ground level
x – down wind distance
y → cross wind distance
z → height from ground
h → height of chimney
$H = h + \Delta h$.
Δh – plume rise.

$$\Delta h = \left(\frac{D v_s}{u}\right)\left[1.5 + 2.68 \times 10^{-3} P \cdot D \left(\frac{T_s - T_a}{T_s}\right)\right]$$

T_a → Ambient temp^{o}K

D → diameter of stack (m), P → atmospheric pressure (millibars)
v_s → velocity of emission ; T_s → stack gas temp (K)
u → velocity of wind at emission point of stack (m/s)

Q1. $C = \frac{Q}{\pi(20)(30)} e^{1/2}$

a.) $Q = 20\ g/s$

$H = 80m,\ y = 0$

$\bar{u} = 30 m/s,\ z = H$

$x = 1 km$

$\sigma_z = 20\ m;\ \sigma_y = 30 m$

b.) $y = 60m;\ z = H - 20 = 60\ m$

Q2. $Q = 163.19\ g/s$

$h = 77$

$\bar{u} = 8 m/s$

$x = 2 km$

$y = 0.5 km$

$\sigma_z = 130 m$

$\sigma_y = 220 m$

$D = 0.95 m$

$T_a = 293 K$

$P = 1000 millibars$

$V_s = 11.12$

$T_s = 433\ K$

$z = 0$

Q3. $Q = 150 g/s$; $h = 80m$; $\bar{u} = 8 m/s$; $x = 2 km$; $y = 0.5 km$.

$z = 5m$; $D = 0.95 m$; $T_a = 293K$; $P = 1000 millibars$;

$V_s = 11.12 m/s$; $T_s = 433K$

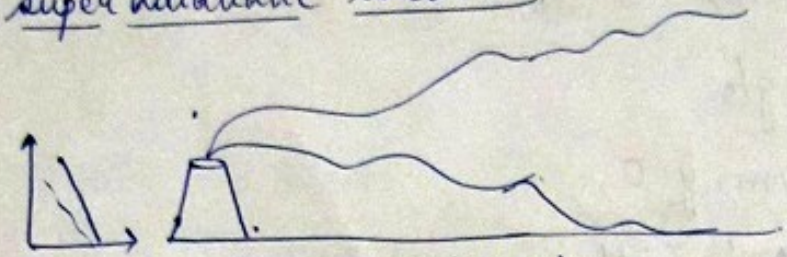
Condition B :— determine σ_y, σ_z

" "

280 220

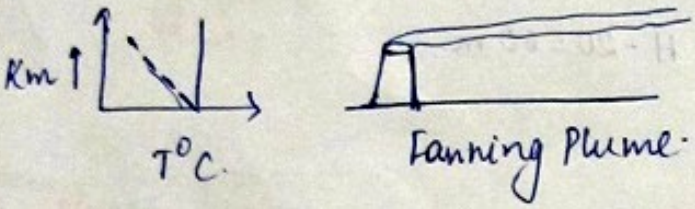
Plume Behaviour:-

In Superadiabatic condition:-



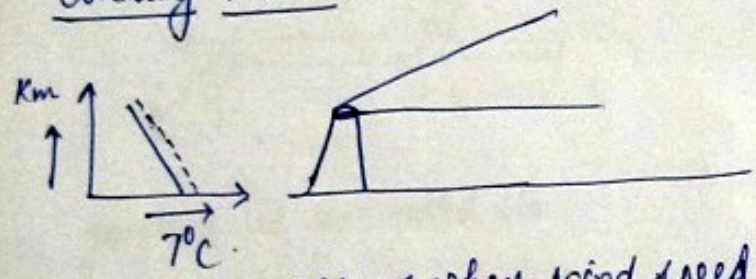
looping plume

Subadiabatic condition:-



Fanning Plume.

Conning Plume:-

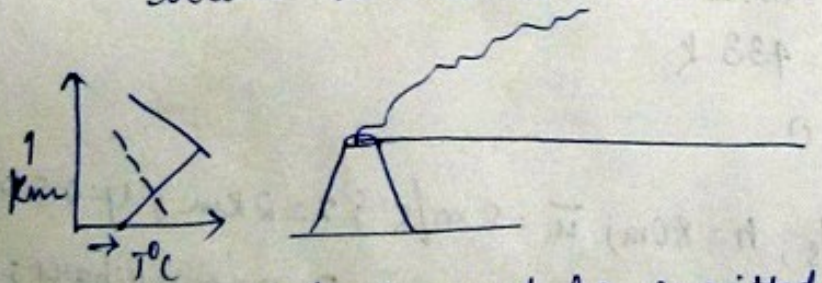


occurs when wind speed > 32 Kmph

occurs just after completion of radiation inversion

Lofting Plume:-

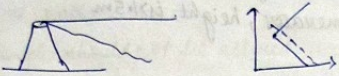
occurs in radiation inversion condition



pollutants must be emmitted above inversion layer.

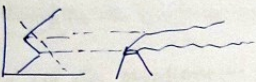
Fumigation plume :-

Subsidense inversion condition



Trapping plume

Both radiation and subsidense inversion condition.



→ Design of stack depends on :-

1. Maximum concentration of pollutant
2. Velocity of emission
3. Metrological condition
4. Geographical condition

as per CPCB the height of stack must be atleast 2 to 2.5 times the height of tallest building in that area and the minimum height is 30m.

$$h = 74(Q_p)^{0.27}$$

Q_p – particle emission rate in ton/hour.

$$h = 14(Q_s)^{1/3}$$ Q_s – SO_2 emission rate in Kg/hour

In thermal power plant

if capacity is 200MW-500 MW, stack height is >220m.

and ●p > 500MW, height is ≥275 m

In steam usage plants, height is ≥9.5 m

In diesel generator, height is ≥1.5 m

→ To measure pollution concentration, the following should be known:-

1. Source
2. Nature
3. Extent
4. Effects

→ To monitor the pollution in an area. we need to know

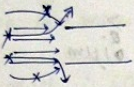
1. Sources
2. topography
3. Climatology
4. vegetation
5. Population distribution
6. Exotic pollution
7. Area map.

Types Instruments of sample collection :-

1. High volume samplers.
2. Gravitational settling chambers
3. Pollution monitoring unit.

Points to take care while collecting samples:-

1. Volume
2. Time, place.
3. Samples should not be altered.
4. Frequency, duration.
5. Isokinetic condition.



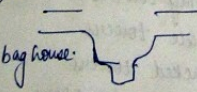
Control of Air pollution:-

1. Naturally → Dispersion → Washout
   → Gravitational setting → Adsorption
   → Absorption
2. Artificially

→ To control particulate matter emitting from source:-

1. Gravitational setting chamber
2. Centrifugal collectors
3. Electrostatic precipitation
4. Wet scrubbers
5. Fabric filters.

For gravitational setting chamber method Stroke's law is used. Its applicable for particles of size >50μm.



2. centrifugal collectors

used in ceramic, food, wood, pharmaceutical Industries

5-25 μm (particle size)

50-90% efficiency

3 Electrostatic precipitation :-

can remove particles of size ≥ 1 μm.

efficiency 95 to 99%

used in thermal power plants

can resist 300-450°C

4 Wet Scrubbers :-

	size	efficiency
Spray towers	>10 μm	<80%
wet cyclonic	>25 μm	<80%
Venturi scrubber	>0.5 μm	<99%

5. In case of filtration heat loss is more

>99% efficiency.

< 1 μm

100-450°C

Gaseous pollutant control :-

1. Absorption unit :- Spray towers
Plate towers
Packed towers
Venturi scrubbers

2. Adsorption unit :-

Packed weights (adsorbants may be activated carbon, activated alumina, dehydrated zeolite, silica gel)

3. Combustion :- Stoichiometric combustion :-

Air : fuel ratio is 14.7 : 1

i.e 14.7 moles of O_2 is required to burn 1 mole of fuel

product is CO_2

In petrol engines O_2 : fuel → 12 : 1 ⟶ CO, HC

In Diesel engines O_2 : fuel → 16 : 1 ⟶ NO_x, smoke, PM (particulate matter)

For complete combustion,

Catalytic convertors

Catalytic oxidisers

Thermal oxidisers. may be used in vehicles.

platinum, palladium are used as catalysts.

one way catalytic conversion

$$2CO + O_2 \rightarrow 2CO_2$$

$$H_xC_y + O_2 \rightarrow CO_2 + H_2O$$

$$NO_x \rightarrow O_2 + N_2$$

Metals used for catalytic oxidisers are rhodium, palladium

for thermal oxidisers the temperature must be around 500-700°C.

19/8/11

WATER POLLUTION

Surface water source:-

Ponds, lakes
Rivers
Ocean

Subsurface water:-

Aquifer
- wells, tubewell
- springs.
- Infiltration gallery.
- Infiltration wells.

Various types of precipitation:-

Cyclonic.
Convective
Orographic

→ Storage capacity of source
→ Permeability
→ Runoff characteristics
→ Timing of precipitation

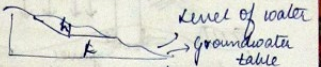
$$\text{porosity} = \frac{\text{Total vol. of voids}}{\text{Total vol. of soil}}$$

permeability is the capability of soil to allow water to flow through it.

As per darcy's law,

$v \propto i$

$v = Ki$



i - hydraulic gradient $= \frac{h}{L}$

K - permeability coefficient

$$K = \frac{cd^2\gamma}{\mu} = \frac{cd^2\rho g}{\mu} = \frac{cd^2 g}{\nu}$$

$c \rightarrow$ constant, depends on size of pores, soil it is called shape factor

$d \rightarrow$ diameter of soil particle.

$\rho \rightarrow$ bulk density

$\gamma \rightarrow$ unit weight of soil

$g \rightarrow$ acceleration due to gravity

$\gamma = \rho g$

$\mu \Rightarrow$ dynamic viscosity of water.

Specific yield :-

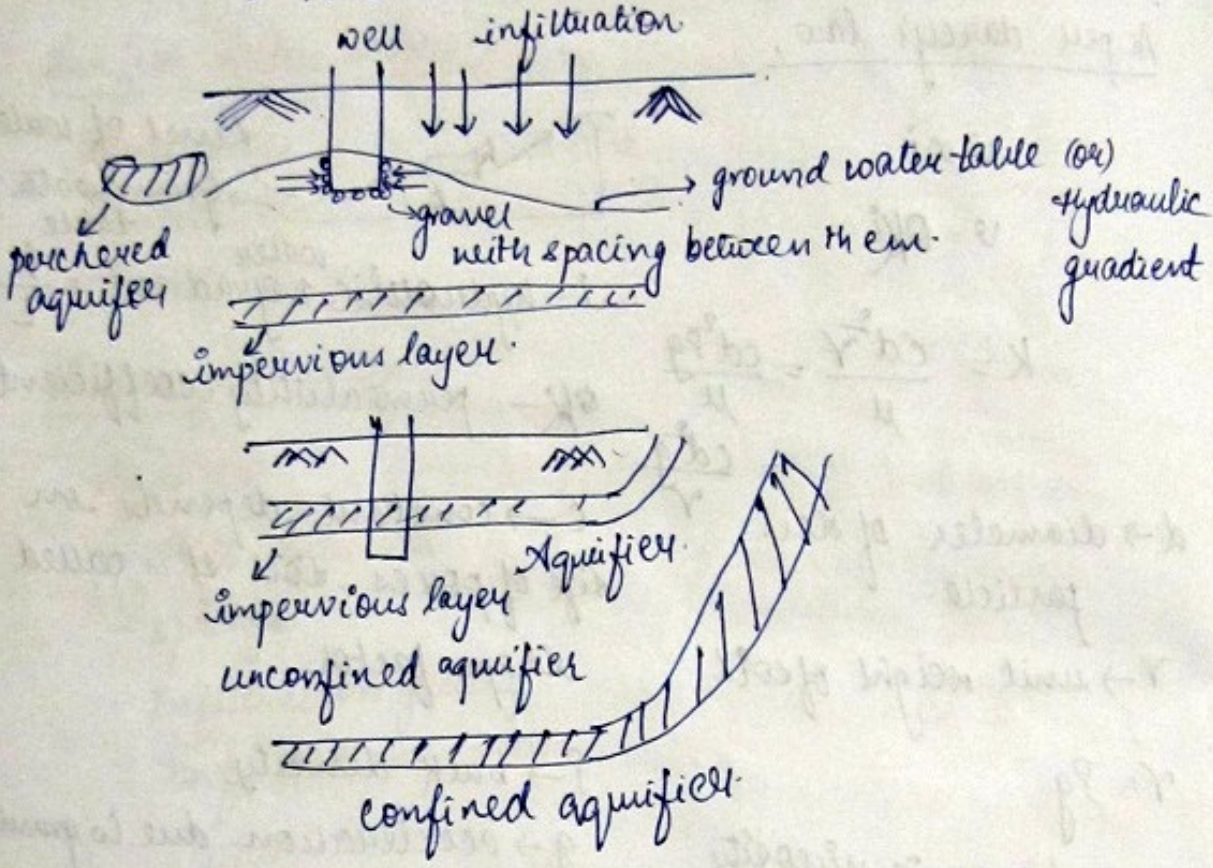
$$\text{specific yield} = \frac{\text{vol. of water obtained due to gravity drainage}}{\text{total vol of material drained}} \times 100$$

field capacity / specific retention $= \frac{\text{vol. of water held against gravity drainge}}{\text{total vol of material drained}} \times 100$

porousity = specific yield + field capacity.

Aquifier:- Soil strata where underground water is stored

Types:- 1. Confined
2. unconfined
3. Perchered



water level/amount → confined > unconfined

→ Ways of water pollution :-

Natural forces/factors:-

1. Geological pattern of area
2. Topological ~~pattern~~ graphical
3. Meteorological pattern
4. Hydrological pattern
5. Biological

During precipitation pollutants are:-

- Gases
- Dust
- Bacteria / virus
- Acid fumes.

Runoff:-

- Salt.
- Suspended.
- Microorganisms
- Vegetation cover
- Sulphur.

Infiltration:-

- Flouride, Chloride, Calcium
- ~~Chloride~~ Iron, Manganese, Arsenic, Cadmium.

Man-Made:-

- Domestic Sewage
- Industrial wastes.
- Agricultural wastes.
- Dams.

Common type of pollutants in water bodies:-

Organic, Radioactive, Inorganic, Suspended, Thermal pollutant

Effects of water pollution:-

Physical, Oxidation, Toxic, Nutrient / Eutrophication, Micro Organisms

Potable H_2O :- tasty, safe

Palatable H_2O :- tasty, not safe

Crystalline H_2O :- pure, not conductor of electricity.

PHYSICAL	CHEMICAL	BACTERIALOGICAL
Turbudity	Solids	Occurence
Colour	Hardness	Density
Taste/Odour	Salts	Toxicity
Conductivity	Metals	Enzyme Activity
Temperature	pH	Bacteria
Particle size	Nitrogen	Viruses
Flow velocity	Dissolved gases	Protozoa
Hydrological balance	Organic matter (BOD, COD)	Worms
Dimension of water body	Plants, vegetation	Fungii
		Algae

Turbudity

→ Silt

→ Organic

→ Microorganisms

Turbuditymeter / Turbudity rod] Jar (N.T.U meter)

(units are measured in terms of silica scale. mg/l)

generally units are J.T.U (jackson turbudity unit)
N.T.U

~~Soil~~

→ ~~pond~~ Range of turbudity for household is 5-10 N.T.U

Colour :-

→ Vegetation
→ Organic
→ Microorganism
→ Chemical
→ Iron, Manganese

Water colour is measured in comparision with standard (i.e platinum is dissolved in 1mg/lit of H2O - cobalt)

Instrument used for this purpose is Tintometer.

→ ~~Odour~~ Max. colour limit is 20 ppm

Taste / Odour :-

→ Microorganisms.
→ Gases
→ Organic / Inorganic compounds
→ Chemicals
→ Threshold order number = number of time dilution required to make the H_2O potable.

It should be less than 1 and not more than 3.

Conductivity meter :-

concentration of salts (dissolved molecules) = conductivity × coefficient. (0.45 to 0.8). (mostly 0.65) ppm

Temperature :- Use thermometer.

Chemicals :-

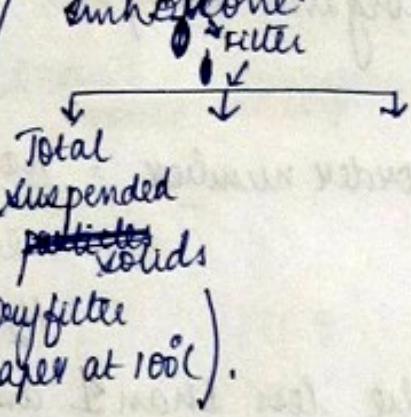
Solids :- Suspended :- small detectable by naked eye (soil)
dissolved :- can't be seen (salts, minerals)
Colloidal :- very small particles (micro organisms)
Floatable :- float over water

How to measure particles :-

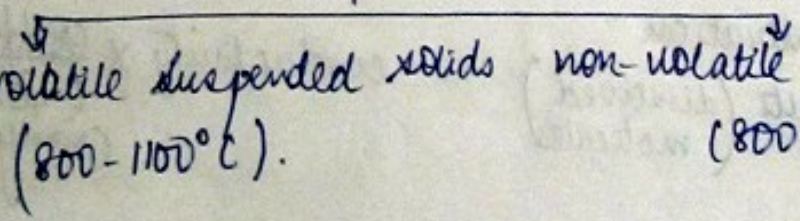
2. Remove suspended / settlable particles

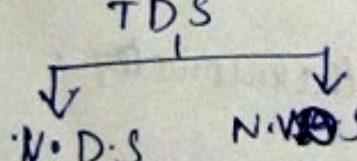
~~3. Remove floatable~~
1. Remove floatable particles by screens.

→ using  ~~sample~~ one.



Total Suspended Solids.

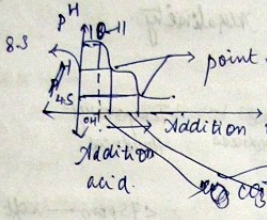




pH value :- $pH = -\log[H^+]$.

< 7 - Acidic.

> 7 - Alkaline (caused by OH^-, CO_3^{--}, HCO_3^-)



> 11 — OH^- ions

8.3 to 11 — carbonate ion.

4.5 to 8.3 CO_3^{--}, HCO_3^-

~~4.5 to 8.3~~ < 4.5 HCO_3^-.

Hardness :- caused by Ca^{2+}, Mg^{2+}, SO_4^{2-}, Cl^- of.

Hardness is ~~caused~~ caused by Ca^{2+}, Mg^{2+}

Temporary hardness

Permanent hardness

units: mg/L as $CaCO_3$.

$$T.H = Ca^{++} \times \frac{\text{combining wt of } CaCO_3}{\text{combining wt of } Ca^{2+}}$$

$$+ Mg^{++} \text{ mg/L} \times \frac{\text{combining wt of } CaCO_3}{\text{combining wt of } Mg^{2+}}.$$

combining wt = equivalent weight.

Temporary & Hardness :- CO_3^{-}, HCO_3^{-} of Ca^{2+}, Mg^{2+}

Permanent hardness :- ~~SO_4^{-}~~ SO_4^{-}, NO_3^{-} of Ca^{2+}, Mg^{+2}.

Temporary = Alkalinity.

permanent hardness = Total hardness − Temporary Hardness.

(75 - 115ppm)

< 75ppm — soft water

> 200ppm — hard water

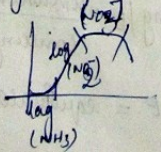
Chlorides:-

If chloride concentration > 400 mg/l not consumable water ; < 250 mg/l potable.

Nitrogen & its Compounds:-

→ Organic nitrogen
→ Free nitrogen/Ammonia } Kjeldahl nitrogen (Organic + Inorganic)
→ Nitrite (toxic). → It should be nil in H_2O supply
→ Nitrate ~~>~~ 45 mg/l (ppm) in H_2O supply

growth of nitrogen



NO_2^- consumption leads to blue baby disease in kids. (Body turns blue & kid may die).

↓ methaemoglobinemia

Flourides :-

< 0.8 to 1 ppm

dental cavity / dental cavities.

> 1.5 ppm

decolourisation of teeth.

deformation of bones.

Iron & Manganese

→ Imapart colour to water

Iron - red

Manganese - Brown

Iron concentration in water < 0.3 ppm

Manganese concentration in water < 0.05 ppm

→ textile

→ utensils

→ plumbing fixtures

→ Iron bacteria

Other metals in water :- Lead, Barium, Arsenic (skin cancer), Boron, Chromium, cyanide. (Radical)

↓ Toxic effect, Heart attacks

Gaseous compounds :- H_2S, CH_4, CO_2, O_2

bad odour.
taste
Anaerobic bacteria
Corrosive (to pipe line)

Bacteria perform aerobic decomposition (Helpful gas but in limited concentration)

Max. saturation of O_2 = 9.1 mg/L at 20°C

In sea water O_2 must be more than 4 mg/L at 20°C and for fresh drinking water O_2 must be more than 7 mg/L at 20°C

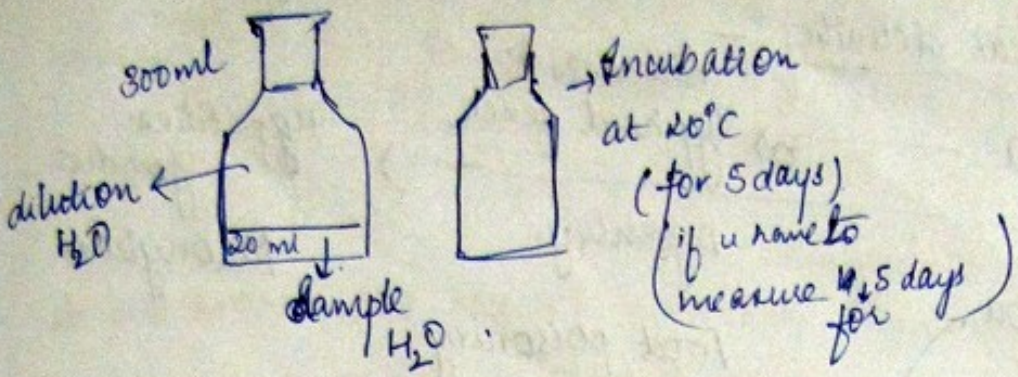
Decrease of O_2 ∝ rate of decrease of organic substances

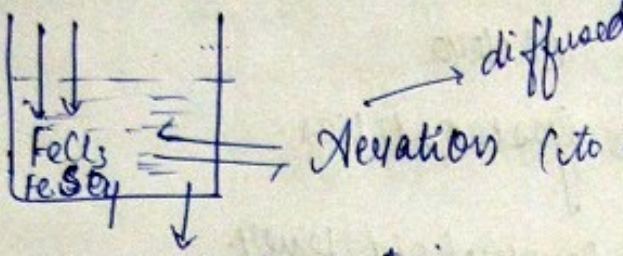
Indicator of O_2 in water is $Na_2SO_4 + K_2$

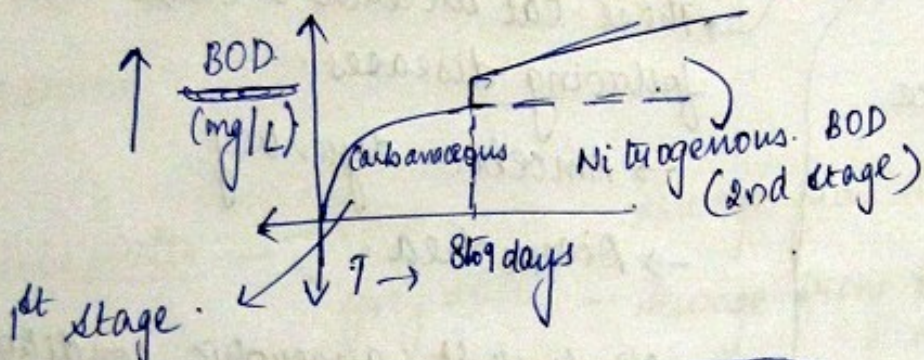
BOD → biochemical oxygen demand → organic matter oxidation
COD → chemical oxygen demand → Inorganic & Organic matter oxidation.

$$BOD = \left(\begin{array}{l}\text{Initial dissolved} \\ O_2 \text{ in water}\end{array} - \begin{array}{l}\text{Final dissolved} \\ O_2 \text{ in water}\end{array}\right) \times \frac{\text{Total vol. of bottle}}{\text{Vol. of sample}}$$

(generally it is measured for 5 days).







$$BOD_t = [DO_i - DO_f] \times \text{dilution ratio}$$

If $t = \infty$

BOD_t = BOD (ultimate) [BOD (ultimate) = BOD_u]

$BOD_5 = 65\% \, BOD_u$.

Seeding :- Adding microorganisms. to dilution water

$BOD_u = COD$ (only when non-biodegradables materials are present)

Bacteriological Activities :-

Bacteria → Typhoid fever
Virus → Dysentry.
Protozoa
Worms
Algae
Fungi
Plankton

Diseases
Hepatitis
Jaundice
Poliomyelitis
Food poisoning
Cholera
Gastroenteritis
Paratyphoid fever

Plants which grow on surface of H2O due to sunlight rain

→ These eat bacteria & cause the following diseases.
→ Amoebic dysentry.
→ Diarrhoea.

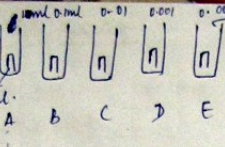
No sunlight, anaerobic condition.

Indicator Microorganism :- Total coliform.
= Fecal Coliform + Vegetation coliform
(96% from human faeces)

E. coli (Escherichia).

→ fecal streptococci
→ Lactobacilli
→ Clostridium perferum

MPN → most probable number
↳ multiple tube fermentation technique



As per MPN the allowed value is 125/100 ml.

Membrane filtration technique :-

5-10μm size of pores.

80% of water is filtered.

This is mixed with distilled H_2O & then put on petri dish & the growth of colony is measured.

Waste water :- — Black water :- Sewage from House
— Grey water :- Sewage from Kitchen & Sinks.

Sewage :- ~~Waste~~ — Grey water :- from sinks, washing machines, kitchens
— Black water :- from bathroom (faeces urine)

These should be collected in a sewerage for treatment. After treatment they are discharged into water bodies.

Water has self purification capacity

Factor affecting self purification process :-

physical :- dilution & Dispersion.
Sedimentation.
Sunlight

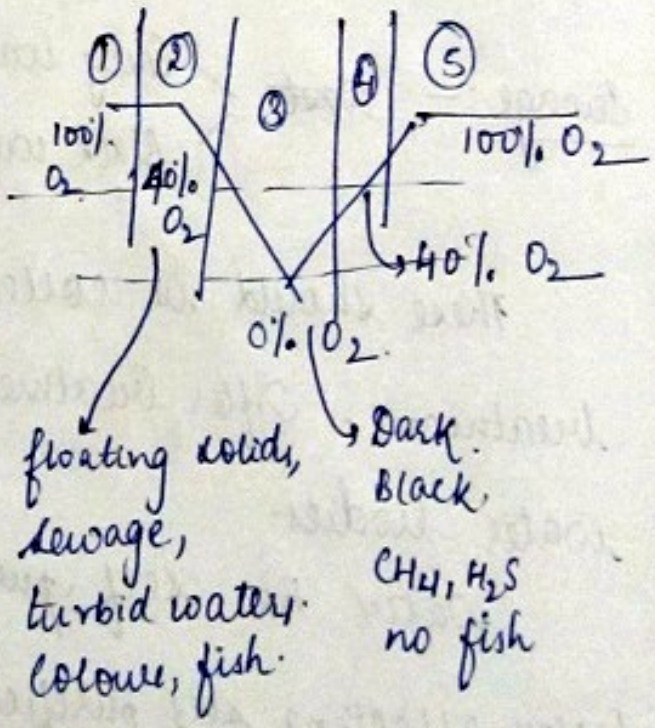
Chemical → Oxidation
Reduction

Factors:- → Temp.
→ Turbulence
→ Hydrography (velocity, surface area)

{ at 35–40°C. microorganisms are very active & absorb more O_2 do less dissolved O_2 in H_2O. } → Available dissolved oxygen
→ Amount & type of organic substances
→ Rate of reaeration.

Zones in water body:-

② Zone of biodegradation :
③ Zone of active decomposition
④ Zone of recovery.
Zone of cleaner water
①, ⑤



Class test Solutions :—

1. $H = 300m$ $x = 4km$

$u = 2.5 m/s$

$z_e = 10m$

$y = 0$

$z = 0$

$$C = \frac{Q}{\pi \bar{u} \sigma_y \sigma_z} \cdot e^{-\frac{1}{2}\left[\frac{y^2}{\sigma_y^2} + \frac{(z-H)^2}{\sigma_z^2}\right]}$$

$$Q = \frac{165\,kg}{10^6} \times \frac{2.5 \times 10^6}{24 \times 60 \times 60} = 4.77\ g/s$$

$$= 477\ mg/s$$

$$\bar{u} = u\left(\frac{\bar{z}}{z_e}\right)^n = 2.5 \cdot \left(\frac{300}{10}\right)^{0.2} = 4.986\ m/s$$

$\sigma_y = 400$

$\sigma_z = 200$

2. $Q_p = 2.9 \frac{tonnes}{year} \times 12 \times 0.3 \times \frac{1}{300 \times 24} = 1.45 \times 10^{-3}$ tonnes/hour

$Q_s = 60 \frac{tonn}{year} \times 12 \times 0.3 \times \frac{1}{300 \times 24} = 30 kg/hr$.

minimum stack height = 30m.

$h_p = 74 (Q_p)^{0.27} = 18m$. $h = 44m$ as it is $> 30m$

$h_s = 44m$

Oxygen deficit = Saturation dissolved oxygen - Actual

$$C = \frac{Q_R C_R + Q_S C_S}{Q_R + Q_S}$$

$Q_R \rightarrow$ rate of flow of H_2O

$C_R \rightarrow$ concentration of dissolved oxygen.

$Q_S \rightarrow$ sewage water flow

C_S — concentration of sewage