Chlorophyll → Mg^{2+}

- Resource depletion : One of major threats
- solid waste
- Loss of biodiversity
- Each & every creature is connected to each other.

Environmental Science : study of interactions among the physical, chemical & biological components of the environment, more often refers to how humans impact on environment

Eg. Photosynthesis

- We are dependent on env. for
  - Air
  - Water
  - Food
  - Shelter

Degradation (Env)

- Pop^n
- Poll^n
- Exploitation of Natural Resources
- Disturbance in Ecosystem
- Waste generation & disposal

- No other source of O_2 in nature other than photosynthesis.

↳ Human activities affects :

Deforestation

- Water cycle : ground water less available (land is almost covered) → water we can drink.

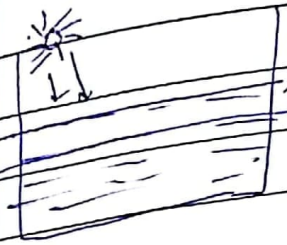
- There is more ~~precipitation~~ evapor^n than precipitation & over land, more precipitation than evapor^n.

Scanned by CamScanner

- About 4×10^{13} m^3 more water falls on land as precipitation than evap^n from it (the diff. b/w evap^n & ") & this is water that is returned to oceans through stream flow

The characteristics of Bodies of Water :-

A. Thermal stratification : (segregation of layers)



↕ gets heated up

Upper atmosphere gets heated (summer) ↓ here, water due to solar radiation Thermal expansion occur. Vol ↑ → Density ↓

At lowest layer : normal density, less temp. than outside

Hence, upper layer will be floating on bottom layer.

Occur due to temp - density relationship.

B. ~~Physical Properties~~ Upper layer → produce more algae (temp ↑) ⇒ rich in O_2

Bottom layer → normal amount of O_2

If we talk about Fe,

Upper layer → Al^{+3} (Oxidation state)

Bottom layer → Al^{+2}

B. Physical Properties :

- Temp :-

low temp. → slow biological process

high → slow metabolism.

Temp.	O_2 conc^n in ~~pure~~ water
0 °C	14.74 mg/l
20 °C	9.1 mg/l
25 °C	8.32 mg/l
35 °C	7.03 mg/l

Scanned by CamScanner

Clausius - Clapeyron eq^n :

$$\log \frac{C_2}{C_1} = \frac{\Delta H}{2.303 R} \left[\frac{1}{T_1} - \frac{1}{T_2} \right]$$

C_1 & C_2 : gas conc^n in water at absolute temp. T_1 & T_2

ΔH : Heat of sol^n → unit kJ/mol

R : Value of gas constant.

1.987 cal deg^{-1}

Q. O_2 conc^n of water saturated with air at 10°c ?

at 25°C, $C_1 = 2.60 \times 10^{-4}$ mol/L $\times$ 32.0 g/mol

$= 8.32 \times 10^{-3}$ g/L $= 8.32$ mg/L

& $\Delta H = 40.65$ kJ/mol

Sol^n :

$$\log \frac{C_2}{8.32} = \frac{40.65 \times 1000}{1.987 \times 4.2 \times 2.303} \left[\frac{1}{298} - \frac{1}{283} \right]$$

273/25

$$\log \frac{C_2}{8.32} = -0.3761$$

$$\frac{8.32}{C_2} = 1.45$$

$C_2 = 5.73$ mg/L $\boxed{11.4 \text{ mg/L}}$

→ $$\log \frac{C_2}{8.32} = \frac{-3500}{(2.303)(1.99)} \left[\frac{1}{298} - \frac{1}{283} \right]$$

Scanned by CamScanner

Date 3 / 8 / 17

Autotrophs : able to produce their own food by :

1) Photosynthesis or → source of energy : sun (light)

2) Chemosynthesis → source of energy : inorganic compounds (no light)

Heterotrophs : not able to produce their own food

Photosynthesis $6CO_2 + 6H_2O \xrightarrow{h\nu} C_6H_{12}O_6 + 6O_2$

Decomposers (CH_2O)

Decomposition rx^n :- (Aerobic & Anaerobic)

→ with air → without air

Aerobic → $\{CH_2O\} + O_2 \longrightarrow CO_2 + H_2O + NO_3^- + PO_4^{3-} + SO_4^{2-}$ + new cells (if +nt in air, get oxidized)

Anaerobic → $\{CH_2O\} \xrightarrow{\text{without oxygen}} CO_2 + H_2O + NH_3 + PH_3 + H_2S$ + new cells (in absence of oxygen)

– microorganisms are heterotrophs, so they feed on the biomass

Productivity :-

It is the ability of a body of water to produce living organisms.

Basic elements required : C, H, O_2, P_4, N_2

CO_2, NO_3^- → compounds

~~CO_2~~

Eutrophication :-

eu → ~~Abandon~~ Abundance trophic → nutrients

Mostly, human activities cause eutrophic cond^{n}s.

1) Untreated municipal sewage water

P N

detergents : polyphosphates agricultural runoff + animal waste

binders → Ca^{2+}

Consequences :

Algae will grow at faster rate

- Eutrophication also means "well nourished" condition
- Enhanced growth of algae is called as "algal bloom"

Even in absence of O_2, decomposition rx^n can takes place (anaerobic)

- p^H of water : 5.6

(CO_2 dissolves in water, forms carbonic acid)

$$CO_2 + H_2O \rightleftharpoons H_2CO_3$$

$$\begin{cases} H_2CO_3 \rightleftharpoons HCO_3^- + H^+ & K_{a_1} = 4.45 \times 10^{-7} \\ HCO_3^- \rightleftharpoons H^+ + CO_3^{2-} & K_{a_2} = 4.69 \times 10^{-11} \end{cases}$$

- HCO_3^- will be formed
- If p^H ↑es, rx^n will shift right side.

$$CaCO_3 + H_2O + CO_2 \longrightarrow Ca^{2+} + 2\,HCO_3^-$$

Henry's law :

solubility

Inference : As

1. The Atmosphere & Air Poln

Date 03 / 10 / 17

→ Like ocean of air, protective blanket layer : Atmosphere
↓
absorbs some magnetic radiation from sun
absorbs harmful gas from outer space.

UV radⁿ → 200 nm
↓
highly destructive, Ozone layer absorbs it
↓
it gas broken down in O_2 & it is exothermic rxⁿ

→ provides imp. gaseous molecules

CO_2 → not " " : in-house gas
↓
natural component of air.

→ Atmosphere provides O_2, N_2 → amino acid → proteins

→ We are composed of non-living thing

→ Human's body → complicated chemical factory.

→ Causes more precipitation ~~of~~ on land : transport b/w water & land

→ learn %.

Major Constituents

N_2	78.08%	(by vol)
O_2	20.95%	
Water vapor	0 - 3 or 4 %	
Ar	0.934 %	
CO_2	0.035%	

→ Why N_2 is in abundance ?
N_2 is an inert gas (O_2 is very reactive).

→ Water vapor → invisible but clouds → visible. why ?
Clouds are made of crystals of light.

→ Memorise range for Troposphere & Stratosphere
0 - 11 11 - 50

Avg. surface temp : 15°C

Camlin Page
Date / /

→ In troposphere, as ~~Temp~~ altitude ↑, temp. ↓ es. Why?
N_2, O_2, H_2O only absorb less solar radiation, so our surface gets heated up & radiates back the heat by conduction & convection process.

Imp. of tropopause :

① Temp = -56°c, water vapor is not able to escape the troposphere. Thus, form^n of light molecules is possible

② In stratosphere, as altitude ↑, temp also ↑ es. Why?
BCOZ Ozone layer breaks down in SO_2 & exothermic in nature. (absorves UV radiation)

$$O_3(g) \xrightarrow{\text{UV light}} O_2(g) + O(g) \quad : \text{Ex othermic})$$

Evolution of Atmosphere

→ Earlier : Only H_2 & He

→ Current : thought to have come from volcano erruptions

Volcanic erruption
- Major comp. → H_2O, CO_2, SO_2
- Minor comp. → H_2S, CO, HCl, HF, N_2, H_2

– Earlier, earth was hot. Then, as temp ↓, water vapour condensed to form oceans

→ CO_2 dissolved in water & was slowly turned into rock.
(soluble)

– After this, first life molecule was formed in ocean (not on land because outer atmosphere had toxic molecules) which were able to produce their own food.
(cyanobacteria)

Scanned by CamScanner

→ O_2 is thought to have 1st come from photodissociation of water vapor & CO_2 by UV light.

$$H_2O + \underset{\text{light}}{UV} \longrightarrow H + OH$$

$$CO_2 + \underset{\text{light}}{UV} \longrightarrow CO + O$$

$$\underset{\text{high energy UV light}}{} \quad O + OH \longrightarrow O_2 + H$$

Formⁿ of Ozone (Unless not formed, no living mat- is possible on land due to UV light)

$$O_2 + \underset{\text{light}}{UV} \longrightarrow O + O$$

$$O + O_2 \longrightarrow O_3$$

Ozone formⁿ.

→ Plants started growing on land after O_2 formⁿ & photosynthe is only source of O_2 in current atmosphere.

→ Calculate mean molecular weight of air

$$M_a = \sum_i C_i M_i$$

C = % of individual gases, M = respective mol wt.
(N_2, O_2, Ar)

$$= \left(\frac{78.08}{100} \times 28 + \frac{20.95}{100} \times 32 + \frac{0.934}{100} \times 40\right) \times 10^{-3} \text{ kg/mol}$$

$$= 2186.24 + 670.4 + 37.36 \times 10^{-5}$$

$$= 28.94 \times 10^{-3} \text{ kg/mol}$$

Scanned by CamScanner

Camlin Page
Date / /

Air Pollution

Major source of Air poll^n :

Volcanic eruption : (natural, uncontrollable)

Manmade source → Stationary : factory
→ Mobile : vehicle

Primary pollutants : directly coming from sources
(MO, NO, NO_2, SO_2)

Secondary pollutants : combine with other elements in atmosphere
(SO_3, HNO_3, H_2SO_4, O_3)

O_3 → secondary pollutant in Troposphere
→ natural component in stratosphere.

05/10/17

Carbon Monoxide

→ formed as a result of incomplete combustion

fossil fuel $\xrightarrow[\text{(insufficient amount of } O_2)]{\text{incomplete combustion}}$ CO

fuels : derived from bio origin (hydrocarbons)

fuel $\xrightarrow{O_2}$ CO_2

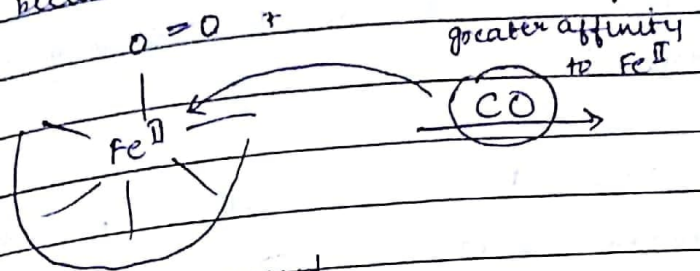
formation : [CHOSNP]
↓ combustion
[CO_2 + H_2O + NO_x + SO_x
CO]

Scanned by CamScanner

→ Odorless, colourless

→ Most abundant of all poll^n gases

→ CO is very much toxic. (especially to those who have haemoglobin) because hb contains Fe^{2+}



Hb won't be able to carry O_2 in our body & lack of O_2 may be fatal

These 5 are covered by protein

• CO has greater affinity to Fe^{II} in haemoglobin.

Air Quality Index (AQI)

→ It is parameter to check cond^n of air at a particular loc^n in terms of air poll^n.

Q. Avg. CO conc^n in Jaipur air = 3ppm. Is air quality ok? Acceptable conc^n level for CO = 9ppm

$$AQI \text{ here} = \frac{3ppm}{9ppm} \times 100 = 33.3\%$$

Air becomes unhealthy when AQI ≥ 100%

AQI	Cond^n of Air
0 - 50	Good
51 - 100	Moderate
101 - 150	Unhealthy for sensitive Groups
151 - 200	Unhealthy
201 - 300	Very
301 - 400	Hazardous

Scanned by CamScanner

Camlin Page
Date / /

CARBON DIOXIDE

→ formed through complete combustion of fossil fuels.
CO_2 is not pollutant. It is a natural component
Only for last 200 yrs, amnt of CO_2 ↑ drastically due to combustion of fossil fuels.

Ex. Atmospheric CO_2 conc^n have ↑ from 280 ppm in pre-industrial times to 365 ppm today. What is corresponding ↑ in mass of atmospheric C ? Assume CO_2 to be well mixed in atmosphere.

Given:
Sol^n: Mass of atmosphere $m_a = 5.2 \times 10^{18}$ kg
Mean Molecular weight of air $M_a = 29 \times 10^{-3}$ kg/mol

Sol^n: we will start with conc^n of CO_2 in air
↳ no. of moles here

$$n = \frac{m}{M} \quad \frac{\text{(given mass)}}{\text{(Molecular mass)}}$$

$$C_{CO_2} = \frac{n_{CO_2}}{n_a} \quad \frac{\rightarrow \text{no. of moles of } CO_2}{\text{no. of moles of air}}$$

conc^n of CO_2 in air

$$n_a = \frac{5.2 \times 10^{18}}{29 \times 10^{-3}} = \qquad \{\because n_{CO_2} = n_a\}$$

$$C_{CO_2} = \frac{M_a}{M_C} \times \frac{m_C}{m_a}$$

$$\begin{array}{r} 365 \\ -280 \\ \hline 85 \end{array}$$

Or $$\Delta m_C = \frac{M_C}{M_a} \cdot m_a \, \Delta C_{CO_2}$$

$$= \frac{12 \times 10^{-3}}{29 \times 10^{-3}} \times 5.2 \times 10^{18} \times 85 \times 10^{-6}$$

$$= \cancel{5.304 \times 10^{12} \text{ kg}}$$

$$= \cancel{5.304 \times 10^{15} \text{ kg}}$$

$$= \cancel{5.304 \times 10^{15} \text{ kg}}$$

$$= \boxed{1.8 \times 10^{14} \text{ kg}}$$

Que. Calculate conc^n of CO_2 in room ... emptied. Amount of CO_2 ... dim^n of room is 10 × 10 × 10 ... to 30°C (room temp was 25°C ... ambient pressure is 1 atm.

Sol^n $x_{CO_2} = \frac{\text{gmol } CO_2}{\text{gmol gas}} \equiv C_{CO_2}$

$$n_{CO_2} = \frac{10 \text{ lb}}{44 \text{ g/mol}} \times$$

$$= 103 \text{ g mol}$$

$$n_a = \frac{1 \times 10^{3} \text{ lit} \times 10}{(30}$$

$$= 1138$$

$$x_{CO_2} = \frac{103}{1138} \times 1$$

Greenhouse g

- Greenhouse gases :
- In absence of green ... would be −18°C.
- (Currently ...

Greenhouse effect
back the heat
The greenhouse
earth, atm.
occur

Scanned by CamScanner

Que: Calculate conc^n of CO_2 in room after fire extinguisher is emptied. Amount of CO_2 is measured to be 10 lb. The dim^n of room is 10 × 10 × 10 feet. Temp. in room is ↑ed to 30°C (room temp. was 20°C before fire), & that the ambient pressure is 1 atm.

Sol^n $x_{CO_2} = \frac{\text{gmol } CO_2}{\text{gmol gas}} \equiv C_{CO_2} = \frac{n_{CO_2}}{n_a}$

using $PV = nRT$

$n_{CO_2} = \frac{10 \text{ lb}}{44 \text{ g/mol}} \times 454 \text{ g/lb}$ ↳ conversion

$= 103$ g mol of CO_2

$n_a = \frac{1 \times 10 \text{ feet} \times 10 \text{ feet} \times 10 \text{ feet} \times 28.3 \text{ L/ft}^3}{(303 \text{ K})\left(0.08206 \frac{\text{atm.L}}{\text{gmol.K}}\right)}$ conv

$= 1138$

$x_{CO_2} = \frac{103}{1138} \times 100 = 9.05\%$

Greenhouse gases and its effects

- Greenhouse gases : water vapor, CO_2, CH_4
- In absence of greenhouse gases, the avg. temp. of earth would be −18°C. (eventhough they are minor component of air) small quantity
- (Currently, it is 15°C)

Greenhouse effect : Sunlight hits the land first. It radiate back the heat & by convection, condn, temp. in atm ↑es. The greenhouses gases trap this radn and reflects it back to earth atm. Due to this, drastic change in temp. doesn't occur

→ larger quantity of greenhouse gases, larger will be surface temp (like venus)

→ Mars → very low quantity of greenhouse gases

* N_2, O_2 → not greenhouse gases
H_2O, CO_2, CH_4 → greenhouse gases

→ homoatomic → covalent bonds are very strong : IR inactive
→ heteroatomic → covalent bonds are ~~too~~ weak
IR ~~acting~~ active molecules (when earth radiates back, it does so in form of IR radiation) & these molecules trap them.

10/10/17 Is the greenhouse effect real?

→ polar ice is disappearing → sea level ↑ → low line fields will be submerged

→ since CO_2 dissolved in water, the oceans are largest carbon sink in th

$$CO_2 + H_2O \rightleftharpoons H_2CO_3$$

as amount of acid ↑es, pH ~~of Bos~~ ↓es (not good)

OZONE (O_3) (pollutant in Troposphere)

→ O_3 : secondary pollutant

→ cause respiratory illness (ENT system will get affected)
O_3 (Los Angeles smog)

• leads to form photochemical smog
↓
presence of sunlight

$h\nu + O_3 \rightarrow O_2 + O$

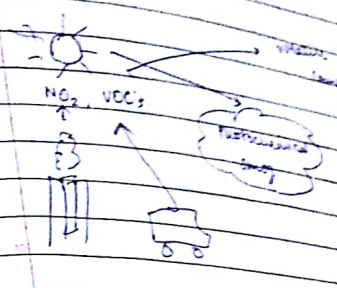
Oxidising smog ↳ highly reactive

SO_2 (London smog - first observed in London)

• leads to form classical smog
↳ Reducing smog

Sources of NO_2 : fossil fuels

Photochemical smog
- visible as brown haze



How ozone is formed in Tro

$N_2 + O_2 + \text{high temp}$

$2NO + O_2 \rightarrow 2NO$

$NO_2 + h\nu \rightarrow N$

$O + O_2 \rightarrow$

How Photochemical Smog

Plants

VOC's → (

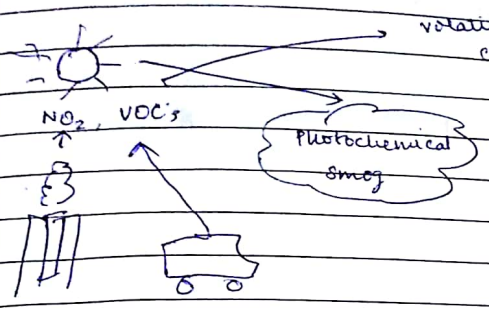
Ozone + Hy

Scanned by CamScanner

Sources of NO_2 : factories, VOC's

Photochemical Smog :

- visible as brown haze



How ozone is formed in Troposphere (Remember)

$N_2 + O_2 + \text{high temp} \longrightarrow 2NO$ (reacⁿ in engines)

$2NO + O_2 \longrightarrow 2NO_2$ (gas in the air)

$NO_2 + h\nu \longrightarrow NO + O$ (Photodissociation by sunlight)

$O + O_2 \longrightarrow O_3$

How Photochemical Smog is formed :

plants → VOC's → Isoprene (eg. of VOC's) → Hydrocarbon

Ozone + Hydrocarbon → product gas → condenses → visible cloud → photochemical smog

* The pollutants are not confined in a city due to atmosphere (wind) it will be dispersed everywhere (CO_2 gets dissolved in oceans)

→ During the daytime, late in evening we can witness photo chemical smog because O_3 is formed in series of reac^n which will take some time and after that only, smog will be formed (3 - 5 pm)

→ O_3 + lemon peel (HC) → photochemical smog
lab

Nitrogen Oxide & Nitric Acid

fuel
N, S → NO_x . SO_x
↓ H_2O
HNO_3 ⇒ component of acid rain

- Prolonged exposure harm lungs.

SO_2 & sulfuric acid

- causes classical smog

pollutants dispersed due to : windflow → observed in daytime (as temp^r it becomes denser & moves up)
⇓
unstable condition
(up & down movement in the atmosphere)

→ Earlier in morning / late in night : No windflow ⇒ stable condition
↓
won't disperse the pollutants

London Smog

SO_2 + stable condition

CO, CO_2, O_3, SO_2, NO_x, etc

① since there is no up-down movement stuck to the surface
Once inhaled, it more deep, more ... person pneumonia
→ doesn't have any particular ...

Role of SO_2 in London Smog
i) Early in the morning during ... sun rises
ii) winds are calm
iii) clear sky
iv) ①

→ learn 2-3 discoveries

Acid Rain

SO_2 → SO_3 H_2O

→ pH of water bodies ↓
→ leaves have wrinkles ...
acid rain destroys it
→ Dissolves & carries ...

Ques: 100 × 12 + 85 + 2 ...

12/10/17 Major Air Po...
Suspended ...

→ Suspended in ...
tiny particles ...

Scanned by CamScanner

CO, CO_2, O_3, SO_2, NO_x, SPM

Camlin Page
Date / /

(1) since there is no up-down movement, SO_2 once formed will stuck to the surface.
Once inhaled, it make people prone to bacterial infection like penor pneumonia.
→ doesn't have any particular colour

Role of SO_2 in London Smog
i) Early in the morning during winter after longer nights, before sun rises
ii) winds are calm
iii) clear sky
iv) (1)

→ learn 2-3 diseases

Acid Rain

$$SO_2 \longrightarrow SO_3 \xrightarrow{H_2O} H_2SO_4$$

→ pH of water bodies ↓ : not good for aquatic life
→ leaves have waxing coating to protect from UV radⁿ, acid rain destroys it
→ Dissolves & carries away minerals from soil.

Ques. $100 \times 12 + 85 + 2.1 \times 32 + 1.5 \times 74 + 9.5 \times 16$

12/10/17 Major Air Pollutant -
Suspended particulate Matter (SPM)

→ Suspended in atmosphere bcoz they're very light & tiny particles - float in atm.

Scanned by CamScanner

Forest fire

Eg. Volcanic eruption - ash produced → Natural

Flour, Talcum powder → Manmade

Represented as PM 2.5 ⇓ diameter ≤ 2.5 μm

PM 10 ↳ diameter ≤ 10 μm

characterised by their diameter

* diameter of hair ≃ 50 μm

diameter of sand particle ≃ 90 μm

Cause Health Effects (Not to Remember)

→ Lung irritation

~~Fig A.~~

Q. A powerplant generates 2.76×10^5 megawatt hours of electricity per year by burning 1.66×10^5 tons of a low-grade coal containing 3.2% sulfur & 15.4% ash. The ratio of fly ash to bottom ash is 0.65 & plant's efficiency is 85%. Determine the amount of each particulates emitted per year. (learn the formula)

Soln

** learn.

$$\boxed{e_p = (a)(b)(c)\left[1 - \left(\frac{p}{100}\right)\right] \times 10^{-2}}$$: Particulates

e = emissions in tons / year

a = mass % ash content of coal burned

b = ratio of fly ash to bottom ash

c = coal consumption in tons / year

p = % particulate coll^n efficiency

→ lesser percent of ash [illegible]

$e_p = (15.4)(0.65)(1.66 \times$

$= 2492$ tons

$= 4.98 \times$

Converting

~~as stated~~ $e_p = \frac{4.98 \times 10^6}{2760}$ tons

$= 1.80$ lb

$= 0.01$

Sulfur Dioxide,

$e_{SO_2} = (1.90)$

$e_{NO_x} = (15)$

$e_{SO_2} = (1.90)(1.66$

$= 10,100$

$= 20.2$

Converting :

$e_{SO_2} =$

Nitrogen oxide

$e_{NO_x} =$

Converting

e_{NO_x}

Scanned by CamScanner

→ lighter portion of ash that flies : fly ash
heavier . . . . remains on surface : ~~bottom~~ bottom ash

$$e_p = (15.4)(0.65)(1.66 \times 10^5)\left[1 - \frac{85}{100}\right] \times 10^{-2}$$

$$= 2492 \text{ tons / year}$$

$$= 4.98 \times 10^6 \text{ lb / yr}$$

converting :

~~we have~~ $e_p = \dfrac{4.98 \times 10^6 \text{ lb / yr}}{276\,000 \text{ MWh / year}}$

$$= 18.0 \text{ lb / MWh}$$

$$= 0.0180 \text{ lb / kWh}$$

sulfur Dioxide :

$$\boxed{\begin{aligned} e_{SO_2} &= (1.90)(c)(s) \times 10^{-2} \\ e_{NO_x} &= (15)(c) \times 10^{-3} \end{aligned}}$$

$$e_{SO_2} = (1.90)(1.66 \times 10^5)(3.2) \times 10^{-2}$$

$$= 10,100 \text{ tons / year}$$

$$= 20.2 \times 10^6 \text{ lb / yr}$$

converting :

$$e_{SO_2} = \frac{20.2 \times 10^6 \text{ lb/yr}}{276,000 \text{ MWh / yr}} = 73.1 \text{ lb / MWh}$$

Nitrogen oxide :

$$e_{NO_x} = (15)(1.66 \times 10^5) \times 10^{-3}$$

$$= 2490 \text{ tons / year}$$

$$= 4.98 \times 10^6 \text{ lb / yr}$$

Converting :

$$e_{NO_x} = \frac{4.98 \times 10^6}{276,000} = 18.0 \text{ lb / MWh}$$

Scanned by CamScanner

→ developed countries produce more waste than developing

2. SOLID WASTE MANAGEMENT

Solid waste:
- solid materials that are of no use.
- we ~~are~~ dump them into bins.

Types of Wastes

1. Municipal Solid Waste : mostly, biodegradable waste (less in concern)

small quantities of hazardous waste
discarded medicine → because ~~are~~ man made, not natural

2. Agricultural Solid Waste

Exam. 3. Hazardous Waste : that poses substantial or potential threats to public health or environment

4 factors that determine

→ ignitability
→ reactivity
→ corrosivity
→ toxicity

Eg: Bio-Medical are not dumped with municipal waste
Heavy metal

4. Electronic Waste
Boxes are made of plastic } Hazardous
ICs, chips : metals

→ Online shopping : cross wave to cross from ...
plastic → ...
Plastic tape contains PVC ...

Plastic Pollution

→ Plastic is used in abundance because it ...
- inexpensive &
- raw materials are easily available
- useful.

→ HCs : generated as by product of ...
(Polyethene)
→ Biologically inert

Disadvantages:
→ non-biodegradable
→ Hard to Reuse Recycle
→ made from non-renewable ...

→ Threat to Animals
- Pacific Ocean is one of the ...
- Discarded Plastic usually ends ...

Pollutants from Plastic :

Ques. Estimate the amount of to... community of 4,000 p... generation rate is 2.5 pou... recycling rate is 28%. A... material that are rent...

Use $d = \frac{M}{V}$ → A×H

Scanned by CamScanner

→ Online shopping : solid waste ~~to~~ comes from packaging plastic ~~— cause of~~

Plastic tape contains PVC takes 100 yrs to degrade

Plastic Pollution

→ Plastic is used in abundance because it is
- inexpensive &
- raw materials are easily available
- useful.

→ HCs : generated as by product of petroleum refinary (Polyethene)

→ Biologically inert

Disadvantages :

→ non-biodegradable } Write in exam

→ Hard to Reuse, Recycle

→ made from non-renewable sources

→ Threat to Animals
- Pacific Ocean is one of the largest dumping ground for plastics
- Discarded Plastic usually ends up with marine sources.

Pollutants from Plastic : Biosphenyl - A

Ques. Estimate the amount of total waste generation for a community of 4,000 people if the per capita waste generation rate is 2.5 pounds per person per day & the recycling rate is 28%. Also calculate total amount of material that are sent to landfill.

Use $d = \frac{M}{V}$ → $A \times H$

Scanned by CamScanner

M = total no. of people × rate of generation of solid waste

total amount of SW generated each day = M = 4000 × 2.5

(If asked annually, multiply by 365)

Recycled : 28 % of M

other 72 % → go to landfill

Sol^n Total generation Rate (waste generated per day)

= 2.5 × 4000

= 10,000 pounds per day.

$\boxed{1 \text{ ton} = 2000 \text{ lb}}$

→ M = 5 tons per day

Recycling rate = 28 %

amount of material recovered for Recycling -

= 0.28 × 5 = 1.4 tons per day

→ amount of material recovered for Disposal.

5 − 1.4 = 3.6 tons per day

Treatment of solid waste

Disposal methods for Municipal Waste :

1.) Open dumping
2.) land filling
3.) Composting
4.) Incineration : Burning of solid waste (we can't burn all kinds of solid waste)
5.) Anaerobic digestion
6.) Gasification
7.) Waste

1) Open Dumping
- Open burning of waste

Drawbacks
→ build-up of landfill
of fire.

micro organism are a

→ Biode

Eg $C_6H_{12}O_6$

Photosynthesis

Reverse of Ph

Anaerobic :

Hence, CH_4

Appropriate

→ has adverse

2) Landfills
→ planned
→ we don't

Preventive
4) top leve

Scanned by CamScanner

1) Open Dumping

- Open burning of waste is practised at dumpsites

Drawbacks

→ build-up of landfill gas which can lead to ~~as~~ outbreaks of fire.

} micro organism are able to break down these compounds

biodegradable }

Biodecomposition Rxn → aerobic

Eg. $C_6H_{12}O_6$: $\{CH_2O\} + O_2 \xrightarrow{\text{microorganism}} CO_2 + H_2O$

Photosynthesis : $CO_2 + H_2O \xrightarrow{h\nu} \{CH_2O\}$

Reverse of Photosynthesis rxn.

Anaerobic : $\{CH_2O\} \longrightarrow CO_2 + H_2O + CH_4$

Hence, CH_4 is produced here

Appropriate proportion of CO_2 & CH_4 ⇒ Biogas.

→ has adverse health ~~ofs~~ effects

2) Landfills

→ planned method, more ~~spec~~ scientific than Open dumping.

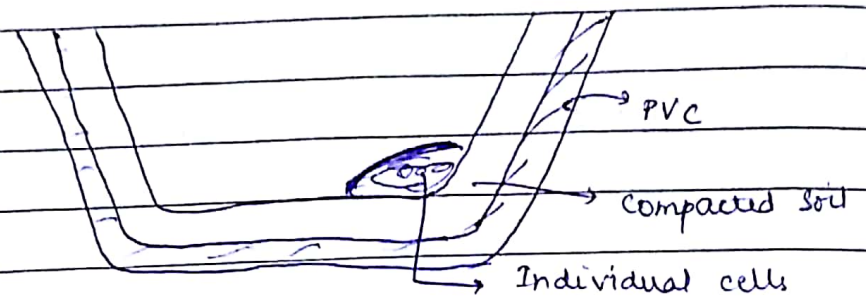
→ we don't include hazardous waste.

Preventive measure

↳ top level of aquif - bottom level of landfill = 20 feet.

Scanned by CamScanner

→ We make double layer because CH_4 can sink into ground



→ After dumping, we will again cover waste by compacted soil.

→ To close the landfill, we again have to cover it with compacted soil (1-2 ft thick)
Can't build ~~to~~ tall buildings on it.

→ Why CH_4 is generated in landfill ?

Ques For a population of 50,000 estimate the annual area requirements for a normally landfill having a refuse depth of 4 m. Assuming that per capita waste generation rate is 4 kg/d and that the density of a normally compacted landfill is 450 kg/m³.

$$d = \frac{M}{V} = \frac{M}{A \times h}$$

$$A = \frac{M}{d \times h}$$

$$= \frac{50000 \times 4\ kg/d \times 365\ d/yr}{450\ kg/m^3 \times 4\ m}$$

$$= 40555.55\ m^2$$

Scanned by CamScanner

1. Waste reduction and Reuse
2. Recovery, Reuse and Recycling

→ Waste Hierarchy

1. Waste reduction and reuse :

Waste minimisation
Waste exchange

26/10/17

Waste Exchange

→ Production of BIOFUEL from agricultural waste

→ Main reason behind this thinking :

Composition of : Coal → degradable biomasses (from our body)

→ BIOFUEL : derived from dead biomasses (dead body $\xrightarrow{\text{combⁿ}}$ $CO_2 + H_2O$ vapor)
& compose of O_2, N_2, C, ...

→ agricultural waste : biomaterial

→ sugar $\xrightarrow[\text{yeast}]{\text{adding}}$ ethanol
↳ replacement of natural occuring gasoline (internal combustion is reduces)

Scanned by CamScanner

The main rx^n is fermentation : → presence of O_2 is not desirable

$$C_6H_{12}O_6 \xrightarrow{\text{yeast}} 2\,C_2H_5OH + 2\,CO_2$$

sugar (eg → glucose) — ethanol — carbon dioxide

Also from (sucrose, fructose)

Use of by-products of oil refining industry to produce biodiesel.

- can also extract oil from seeds

Oil of fat + Alcohol $\xrightarrow[65^\circ C]{\text{catalyst}}$ Biodiesel (ester) + Glycerin By product.

Learn. Examples :

→ Fly ash → used in cement making from coal based thermal power stations.

Composting :

- In last of rx^n, manure produced is called compost → can be used as fertilizer.
- large amount of kitchen waste which are biodegradable except egg shell, meat shell, fish bone

$$\text{Biomass} + O_2\ (\text{Aerobic / bacteria}) \longrightarrow CO_2 + H_2O + \text{Organic Manure}$$

- Micro organisms feed on dead biomasses because they get nutrients from it. So, they decompose the dead biomasses

Aerobic $\{CH_2O\} + O_2 \xrightarrow{\text{microorganisms}}$ Org. manure (compost) + Hence, it releases the

$\{PNB\}$ phosphorous

Anaerobic $\{CH_2O\} \xrightarrow{\text{microorganism}}$

- Benefits (learn 2-3)
- In composting a proper ... required

Source of C : brown ...

Source of N : green ...

- Moisture content :
- high C/N ratio — low —

⇒ Reuse : Donate ... avoid plastic

This is how, nutrients are being recycled in nature

Aerobic $\{CH_2O\} + O_2 \xrightarrow{\text{microorganism}} CO_2 + H_2O$ + new cells
$+ PO_4^{3-} + NO_3^- + SO_4^{2-}$

{PNS}
phosphorus

Org manure (compost) : presence of & C. & moisture

Hence, it enhances the fertility of the soil.

Anaerobic $\{CH_2O\} \xrightarrow{\text{microorganism}} CO_2 + H_2O$ + new cells
$+ CH_4 + PH_3, NH_3, H_2S$

Biogas

bad odour producing gases

- Benefits (Learn 2-3)
- In composting a proper ratio of C : N = 35 : 50 is required

Source of C : brown ~~root~~
Source of N : green
- Moisture content : 40 to 60%.

- high C/N ratio → corrected by dehydration
  low -- → -- -- adding cellulose

⇒ Reuse : Donate / Exchange
avoid plastic

Scanned by CamScanner

WATER POLLUTION

→ How water gets polluted. ?
industrial waste (produce chemicals, used to produce new stuffs)

Chemical Rxn carried out in industries.
→ generally, toxic in nature (Benzene, Toluene etc)

A + B $\xrightarrow{\text{solvent}}$ DP + By Product
raw material — desired product — needs to be discarded (fatty molecules)

→ Only 0.6 % of water is fresh & not for directly use

Sources of liquid waste:
① Municipal sewage effluents
② Industrial wastewater
③ Agricultural runoff

Inorganic industrial waste water

- large proportion of toxic chemicals

- Coal Washing

- Side effect of Thermal Power Plants:
Acid Mine Drainage

- Pyrite $Fe^{2+} \longrightarrow Fe^{3+}$
Iron.

Products $\boxed{Fe(OH)_3 + H_2SO_4}$

$FeS_2 + O_2 +$

31/10/13

Organic waste

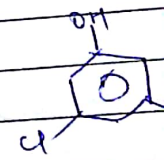
Sources:
→ Industrial waste wat
→ Agricultural ..

Paper & pulp ind
- Chlorinated orga
- Acidic compou

Organic ... c

Tanneries
- most pollutin
contains w

- chlorinated



Sugarca

Pharma
→ We dis

Scanned by CamScanner

$FeS_2 + O_2 + H_2O \rightleftharpoons Fe(OH)_3 + H^+ + HSO_4^-$ (not to learn)

31/10/17

Organic Water Pollutants

Sources:

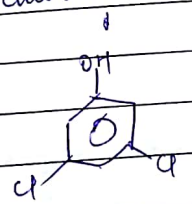
→ Industrial waste water

→ Agricultural " " : need to use fertilizers & pesticides
↓
organic compound
Their residue flow into water bodies

Paper & pulp industry
- Chlorinated organics → to bleach
- Acidic compounds

Organic comp. + Chlorinated comp. : very harmful

Tanneries
- most polluting industries
- contains hairs
- chlorinated phenol : used for tanning : highly toxic (high solubility)



Sugarcane based Industries:

Pharmaceutical Industries:

→ We discard medicines after expiry
↓
organic comp
⇓
easily dissolve in water

- Food processing plants

- Cosmetic Industry

learn (not %)

Name of pigment	Composition	Colour
Zinc oxide	i.) ZnO (100%)	White
Titanium Oxide	ii.) TiO_2 (100%)	
Cobalt blues	i.) Co_3O_4 - 30-35% Al_2O_3 - 65-70%	Blue
Red lead	i.) $Pb_3O_4 + PbO$	Red
Synthetic Iron	ii.) Fe_3O_4	
Chrome Green	i.) Cr_2O_3	Green
Ochre	i.) Naturally occuring Fe_2O_3 (30-35%)	Yellow

→ Fertilizers : Nitrogen & Phosphates

Sources of water pollution

a.) Point sources

b.) Non-point / diffuse sources

Water pollution

- Ground water poll^n (toxic chemicals gets soaked in water)
- Surface water poll^n

→ Biodegradable solid wa
animals decompos

→ Biodecomposition

1.) lack of O_2 (

biodegradable

$C_6H_6 + O_2$

comes from petroleum industr

Groundwater

$+ NO_3^- +$

learn → once grou
due to
a) anaerobic
b) cool and

1.) cyanide
→ used

→ H
↳ CN^-
SO

Scanned by CamScanner

→ Biodegradable solid waste are less harm for water bodies as animals decompose them. ⇒ exposed to high level of O_2

→ Biodecomposition process is slower in groundwater as

1) lack of O_2 (Anaerobic rxn) ⇒ 50 times slower than Aerobic decomposition rxn.

biodegradable organic comp.

$$C_6H_6 + O_2 \xrightarrow[\text{(surface water)}]{\text{microorganism}} 6\,CO_2 + 3\,H_2O$$ → learn this

comes from petroleum industry

$$\xrightarrow[+\ NO_3^- + H^+]{\text{Groundwater}} 6\,CO_{2\,(aq)} + 3\,N_{2\,(g)} + 6\,H_2O_{(l)}$$

learn : presence of H^+ & NO_3^- is necessary

learn → Once groundwater is polluted, it is very hard to degenerate due to

1) anaerobic atmosphere
2) cool and dark ⇒ (temp ↓)

Inorganic Species as Pollutants

1) cyanide : naturally occuring
→ used in electroplating

→ HCN : very deadly poisonous. Reason :
↳ CN^- has greater affinity for Fe^{2+} than O_2 (same as CO).
So, Hb won't be containing O_2

Scanned by CamScanner

2.) Ammonia : natural source of
NH_3, H_2S, PH_3 → anaerobic decomposition rxn

→ To used in producing foam (cushioning material)

3.) H_2S :
→ Industrial use : to produce S & H_2SO_4

4.) Nitrites :
→ If drinked, may cause Blue baby syndrome

2/11/17

Organic Compounds

1. Volatile Organic Compounds (VOCs) :
2. Persistent Organic Pollutants (POPs) : persist in nature

1. VOCs → volatile in nature

1. are of low molecular wt., high vapor press. → can smell them easily
Eg. ~~the~~ methanol, chloroform, ethanol, hexane, benzene, acetic acid (learn)

2. used as paint thinner
3. are used ~~in~~ as solvent in typical organic synthesis

Isoprene : produced & reduced by plants
to reduce insects
to attract polynator

Uses of VOCs
- cleansing of glass
- cosmetics
- Permanent mark

Toxic effect
- most toxic
(benzen
- causes irri

→ not nat

learn : charact
1.) There
2.) They
poor
3) They

→ POP

↳ wi
Ex

→ U

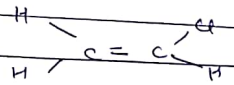
Scanned by CamScanner

Uses of VOC's

- cleaning of glasses
- cosmetics
- Permanent marker

Toxic effect

- Most toxic : vinyl chlorine



known human carcinogen
(benzene, toluene, also)

- causes irritation to eyes, nose & throat.

2. POPs (10 + 2) → {10 comp. are intentionally produced POPs
+2 : not intentionally, produced as byproduct}

→ not naturally occurring - Produced by Industrin
(Now, millions are POPs in world)

learn characteristics of POPs :

1.) These are chlorinated aromatic organic compound.
2.) They are very stable (very persistent in nature) because poorly degradable (don't break down into simpler comp.)
3.) They have very high fat solubility

→ POPs can be transferred by wind & water

↳ Why do Industries produce these ?
Because they're stable, long lasting. so, more ~~efficient~~ cost - effective.

→ Use plastic containers : more attractive

Scanned by CamScanner

learn 10 unintentionally

i) DDT
ii) PCBs (Poly-chlorinated Biphenyls
iii) Hexachlorobenzene
iv) PAHs (polynuclear Aromatics HCs)

learn 2 unintentionally
i) Polychlorinated dioxins → two O
ii) " dibenzofurans (PCDF)

Toxic Effects
→ hormone disruptors (Imp.)
→ mimic estrogen

- most are banned in developed countries
- still residues are found in water
- still used in developing countries

→ To get popular, a product should be
i) cheap (easily synthesised)

PAHs

sources

Manmade	Natural
vehicle exhaustion	volcano
burning of fuels	

Uses

- Napthalene : to kill moths, cockroach repeller

→ Alizarin

→ used a
→ Coolan

learn Toxi
i) inter
ii) dis
iii) Bio

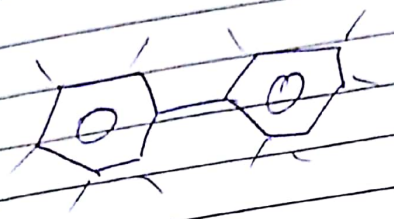
2 → Us

C_2H_5O
C_2H_5O

Scanned by CamScanner

→ Alizarin – made from phenanthrene

PCB's



x : 1 to 10

$C_{12}H_{10-x}Cl_x$

→ Used as insulating materials

→ Coolants in electrical equipment

learn. Toxic Effects

i) interferes with endocrine system (interferes harmonal syste

ii) disrupt reproduction & fetal development

iii) Birds : make egg shell thin (interfers calcium – metabolism)

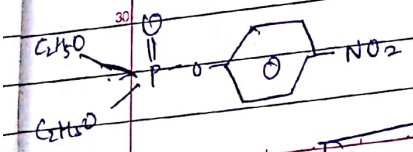
DDT

→ Used as pesticides : kill pests ⇓ biological organism that spread diseases, & damages food

{ cheap to produce
{ effective as pesticide

Less persistent Insecticides

(a) Organophosphates



learn

Ex. : Parathion , Malathion , Paraoxon

→ Mammals possess an enzyme that accomplish malathion hydrolysis, but not insects.
⇒ We won't get affected by malathion

b) Carbamate

learn
eg. Carbary

Herbicides

↳ to control weeds
↳ As : Non - bio degradable

a) Chlorophenoxy Herbicides
Mixture of 2,4-D & 2,4,5-T : Agent Orange

Toxic effect
↳ genetic damage

b) Triazine herbicids :

eg Atrazine, Metribuzin (learn)

→ inhibits phosynthesis in case of crops, but not in case of weeds

c) dalapon

DIOXINS : Polychlorinated dibenzo-p-dioxins

most toxic : 2,3,7,8 - tetrachlorodibenzo-para-dioxin (TCDD)

→ in dumping sites (produced)

Alternative approach to control pests :
Environmentally attractive approach to control the pests

→ More costly, so not much popular.

1) Appⁿ of PHEROMONES :
↓
produced & released by insects

→ Particular insects release particular pheromones for many purpose

→ We will take big blocks (bottles) & cover inside surface with sticky material. Insect will smell & get attracted & get trapped & eventually, die.

→ Not commercial to synthesize. → very costly.

Camlin Page
Date 07 / 11 / 17

WASTEWATER TREATMENT

→ We should not discard wastewater directly without treatment

Wastewater:
used water which can't be used without treatment again.

Purpose of Wastewater Treatment:
- We can't dispose them directly in nearby water bodies without treatment (affects acquatic water (have contaminants))
- We can't directly use ocean water directly & it undergoes rigorous procedure to treat it. so, surface water is only source of ~~wast~~ water.

→ Treated Water : won't be used for drinking purposes.

Sewage Treatment — Common for all treatment plants

Multi-stage process : Preliminary, Primary, Secondary, Tertiary ⇓ Advanced Treatment (Finally removed, depend on type of contaminants, treatment is done : Case Specific)

Each stage has :
- name of stage
- type of contaminants
- Treatment for this stage

→ Primary Treatment : Use chemical
→ Biological method : help ~~of~~ from microorganism

Wastewater: Preliminary (physical method) → Primary (physical) → Secondary → Tertiary → Disposal in Water Bodies

Preliminary
① Bar screen : ma
name of step
→ (used to bl
② Wastewater next step . C
(Rotating f
Rotatin
③ Grit Chambe
name of
(maintain
particles
→ remo
Primary
④ T
Removed
A
equi
metho

Scanned by CamScanner

Preliminary Treatment

① Bar screen : made of long, narrowly placed metal bars
name of step : Screening
→ (used to block large floating objects)

② wastewater next flow into Comminutor
step : Comminution
(Rotating blades : break large stone particles into small)
Rotating Cutting Screen

③ Grit Chamber - equipment
name of step : Grit Removal
(maintain flow of water very slow, so that the small particles like sand, clay, etc get settle down)
→ removing the grit.

Primary Treatment

④ Type of contaminant : suspended solid
(solid particles / liquid droplets (oil, ..))
⇓
light wt particle (float on water)

Removed by using Al sulphate & Ca Hydroxide

$$Al_2(SO_4)_3 + Ca(OH)_2 \longrightarrow Al(OH)_3 \downarrow$$

pH ↑ due to this. Due to which, ppt. of $Al(OH)_3 \downarrow$ is formed

gelatanous (settle down in bottom of tank along with suspended solid)

equipment : primary sedimentation tank.

method is both physical & chemical

Scanned by CamScanner

Q. Design a screen chamber with max flow (Q) of 0.15 m^3/s of domestic wastewater.

(Bar screening)

Width to depth ratio is 1.5 : 1, 0.75 m/s

Velocity of waste water (V_h) =

The clear opening of chamber = 25 mm & diameter of each bar = 10 mm. distance b/w 2 bars

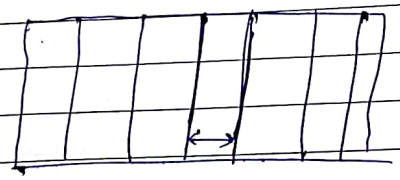
Calculate

i.) no. of bars

ii.) Exact area through which water can pass

iii.) effective cross-sectional area of channel.

i.) Area = $\frac{Q}{V} = \frac{0.15}{0.75} = \frac{1}{5}\ m^2$



if no. of bars = n

⇒ no. of openings = (n+1)

~~wid~~ depth = h

width = $\frac{3}{2}h$

⇒ $\frac{3}{2}h^2 = \frac{1}{5}$ ⇒ $h^2 = \frac{2}{15}$ ⇒ h =

⇒ h = 0.365 m ≃ 0.4 m

⇒ width = 0.547 m ≃ 0.6 m

⇒ ~~No of~~ let no. of bars = x

⇒ $\frac{25}{1000}(x+1) + \frac{10}{1000}x = \frac{6}{10}$

⇒ $25x + 25 + 10x = 600$

⇒ $35x = 575$

⇒ $x = 575/35 = \boxed{115/7}$ = 16.

$\rightarrow \boxed{x = 16}$

(ii) Total width $= 16 \times$ width of 1 bar

$\frac{6}{10} = 16 \times \frac{16}{100}$

$\rightarrow \frac{60 - 16}{100} = \frac{44}{100} = 0.44\ m$

(iii) Effective cross sectional area

$A = 0.44\ m \times 0.4\ m$

$= 0.176\ m^2$

Q. A WW treatment plant receives a flow of $35\,000\ m^3/d$ ($d \rightarrow$ day) Calculate the particle settling velocity (V_s), surface area, volume & retention time of a 3 m deep horizontal flow grit chamber which removes grit with a specific gravity of $\simeq 1.9$ & size of 0.2 mm temp 25°C, viscosity of water $= 1.002 \times 10^{-3}$ kg (ms)$^{-1}$ (Apply Stoke's law)

(grit removal)

density of particle

$$\boxed{V_s = \frac{g \cdot (\rho_p - \rho_w) \cdot d^2}{18\mu}}$$

$d \rightarrow$ diameter of particle

Se $\boxed{1.9 = \frac{\rho_p}{\rho_w}}$ $\rightarrow 1000\ kg/m^3$

$$= \frac{9.8\ (1.9 - 1) \times 0.2 \times 0.2 \times 10^{-6} \times 10^3}{18 \times 1.002 \times 10^{-3}}$$

$= 0.02 \times$ ~~[illegible]~~ $= 0.02$ ~~[illegible]~~ m/s

$= 0.02 \times 60 \times 60 \times 24$ m/d

$\boxed{V_s = 1728\ m/d}$

Surface area $= \frac{Q}{V_s} = \frac{35000}{1728} = 20.25\ m^2$

Scanned by CamScanner

Volume = A × h

= 20.25 × 3

= 60.75 m^3

Retention time : time required for all particles to settle down

$t = \frac{\text{vol. of grit chamber}}{\text{flow rate}} = \frac{\text{depth of tank}}{\text{settling velocity}}$

$= \frac{60.75\ m^3/day}{35000\ m^3}$

$= \frac{60.75 \times 24 \times 60}{35000}$ min

= 2.5 min

9/11/17

Primary Sedimentation Tank

Sludges :

$Al(OH)_3 + CaSO_4$

We need to discard sludges after every cycle.

We'll not directly dispose it, but treat it by performing decomposition rxn (in anaerobic condn)

Q3. Determine the quantity & volume of sludge produced in 10 day in the treatment of 10MLD of domestic wastewater with the following condn.

10 Million-litre / day

⇒ 10^7 litre / day

i) Suspended solid in wastewater = 250 g/m^3

ii) SS removal efficiency of primary tank = 60%

iii) Conc^n of solid in sludge = 6 %

iv) Density of water = 1000 kg/m^3

v) Solid contribution per capita = 75 g

vi) Specific gravity of sludge = 1.03

Scanned by CamScanner

Also calc. volume of sedimentation tank and no. of people residing in that locality

$(1\,L = 10^{-3}\ m^3)$

$10\ MLD = 10^7\ L/day = 10^4\ m^3/day$

Quantity (mass) of sludge produced = SS removal efficiency × SS in water × Volume of ww per day

$= \frac{60}{100} \times 250\,\frac{g}{m^3} \times 10^4\,\frac{m^3}{d}$

$= 150 \times 10^4\ g/d$

~~10 days → $150 \times 10^4 \times 10$ g~~

~~$= 15 \times 10^6$ g~~

~~$= 15000$ kg~~

Volume of sludge produced = $\frac{\text{Quantity of sludge produced}}{\text{Density of water} \times \text{specific gravity of sludge} \times \text{\% of solid in sludge}}$

(100 − amnt. of moisture) %

$= \frac{1500\ kg/d \times 100}{1000\ kg/m^3 \times 1.03 \times 6}$

$= 25\ m^3/day$

Retention Time = $\frac{\text{Vol. of primary tank}}{\text{Vol. of sludge produced per day}}$

$\frac{25\ m^3}{d} * 10\ d$ = Vol. of primary tank

∴ Vol. of primary tank = $250\ m^3$

Scanned by CamScanner

No. of people : $\frac{150 \times 10^4 \, g/d}{75 \, g/capita/day} = 2 \times 10^4 = 20,000$

Total sludge produced per capita solid contribⁿ

SECONDARY TREATMENT

Trickling filter method :

Only able to remove biodegradable organic matter (aerobic decompⁿ rxⁿ)

Equipment : Trickling Filter

large circular concrete field full of stones

We don't want to carry out anaerobic decompⁿ rxⁿ as it produces harmful gases.

$$\{CH_2O\} + O_2 \longrightarrow CO_2 + H_2O + \text{new cell}$$

(Aerobic)

$$+ PO_4^{3-} + SO_4^{2-} + NO_3^-$$

$$\downarrow \quad \downarrow \quad \downarrow$$

Anaerobic $\longrightarrow PH_3 + H_2S + NH_3 + CH_4$ (Bad Odour)

Pipes : water flow through these, have holes ⇒ water sprinkles ⇒ biodegradable waste here are removed.

Q4. A wastewater treatment plant receives a flow of 35,000 m^3/d containing BOD of 250 mg/L. Primary treatment removes 25% of organic matter. → biodegradable organic matter

Calc. no. of trickling filters with diameter of 60 m which would accomodate an organic load (concⁿ of microbes) of 250 $g/m^2/d$

Sol^n Amnt. of BOD present

$= 250 \frac{g}{L} \times$

$= (250$

$= 250 \times$

$= 6$

Total area req =

$= \frac{656}{25}$

$=$

Total no. of

(a) If rate of O_2

(b) at 0°C

(c) O_2 content

Calc. amo

Sol^n

Amount of

$=$

Scanned by CamScanner

Sol^n Amnt. of BOD present entering the trickling filter.

$= 250 \frac{g}{L} \times \frac{75}{100} \times 35\,000\ m^3/d$ (25% already being removed)

$1 m^3 = 10^3 l$

$= \left(250 \times \frac{3}{4} \times 35\,000 \times 10^3\right) g/d$

$= 250 \times 3 \times 8750\ kg/d$

$= 6\,562\,500\ g/d$

$$\boxed{\text{Total area req} = \frac{\text{Total amnt. matter in ww}}{\text{organic load}}}$$

$= \frac{6\,562\,500\ g/d}{250\ g/m^2/d}$

$= 26250\ m^2$

Total no. of trickling filters $= \frac{26250 \times 7 \times 4}{22 \times 60 \times 60}$

$= \boxed{10}$

(a) If rate of O_2 req per kg of organic matter decomposed = 2 kg O_2

(b) at 0°C & 1atm pressure density of air = 1201 kg/m^3

'c' O_2 content in air = 20.95 % ≈ 21 %

Calc. amnt of oxygen & air required.

Sol^n

Amount of O_2 required

= rate of O_2 required per kg of organic matter decomposed × total organic matter destroyed per day

$= 2 \times 6\,562\,500\ g/d$

Anaerobic : $CO_2 + CH_4$: biogas produced

Camlin Page
Date / /

Sludge Treatment

Anaerobic Digestion

Digestion : any object is subjected to anaerobic decomp^n & heating the substrate

2 types

Mesophilic	Thermophilic
30 – 45°C	45 – 60°C

Upper than 60° ⇒ microorganism will be destroyed

Q6. Design an anaerobic sludge digester to treat sludge from the treatment of 10 MLD domestic WW flow with foll. cond^{n}s

(i) Quantity of sludge produced = 500 kg/d
(ii) Conc^n of solid in raw sludge = 4%
(iii) Density of water = 1000 kg/m^3
(iv) Sp. gravity of raw sludge = 1.02
digestion time = 15 days

We need : V (raw sludge) & vol (digested sludge)
(observe vol ↓ on digestion (heat applied ⇒ moisture reduced))

(a) Volume of sludge to be digested per day :
(earlier formula)

$$= \frac{500 \text{ kg}}{1000 \text{ kg/m}^3 \times 1.02 \times 0.04} = 12.25 \text{ m}^3$$

shrinked

$$= 2.80 \text{ m}^3$$

(b) $$V_{st} = \frac{290 \text{ kg}}{1000 \times 1.04 \times 0.10}$$

(values are given in question)

V_{st} ↙ Vol. of digested sludge

vol. of digester

Scanned by CamScanner

Camlin Page
Date / /

vol. of digester = $\left[V_{st(r)} - \frac{2}{3}\left(V_{st(r)} - V_{st(d)}\right) \right] \times$ digestion time

$= 12.25 - \frac{2}{3}\left(12.25 - 2.8\right) \frac{m^3}{d} \times 15\ d$

$= \left(12.25 - 6.3\right) \times 15\ m^3$

$= 89.25\ m^3$

Scanned by CamScanner

AQUATIC CHEMISTRY

Date 16 / 11 / 17

Characteristics of Bodies of Water :

→ Physical Properties

Normal Temp. is suitable

Conc^n of O_2 also depends on Temp.

$$T \propto \frac{1}{\text{Solubility of } O_2 \text{ (dissolved } O_2)}$$

Source of dissolved O_2 : atm O_2 / photosynthesis by Algae.

(learn) 25°C, ⇒ O_2 conc^n in water : 8.32 mg/lt

clausis - clap eyson eq^n :

$$\log \frac{C_2}{C_1} = \frac{\Delta H}{2.303 R} \left[\frac{1}{T_2} - \frac{1}{T_1} \right]$$

Alkalinity :

capacity of H_2O to accept H^+

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

$$CO_3^{2-} + H^+ \longrightarrow HCO_3^-$$
$$HCO_3^- + H^+ \longrightarrow CO_2 + H_2O$$
$$OH^- + H^+ \longrightarrow H_2O$$

CO_3^-, HCO_3^-, OH^- are able to accept H^+

To calculate Alkalinity,

$$\boxed{\text{alkalinity} = [HCO_3^-] + [CO_3^{2-}] + [OH^-]}$$

Scanned by CamScanner

Ques pH of 10.00, alkalinity of water is found to be 1.00×10^{-3} mol/L. Calc conc^n of bicarbonate ion.

$K_{a_2} = 4.69 \times 10^{-11}$

$H_2CO_3 \rightleftharpoons H^+ + HCO_3^- \rightarrow K_{a_1}$

$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-} \rightarrow K_{a_2}$

$p^H + p^{OH} = 14$

$\Rightarrow \boxed{p^{OH} = 4}$

$\Rightarrow [OH^-] = 10^{-4}$ mol/l

$K_{a_2} = 4.69 \times 10^{-11} = \frac{[H^+][CO_3^{2-}]}{[HCO_3^-]}$

$[CO_3^{2-}] = 2.18 \times 10^{-4}$ mol/lit

& Alkalinity $= [HCO_3^-] + 2[CO_3^{2-}] + [OH^-] = 1.00 \times 10^{-3}$ mol/l

get from 2 eq^{n}s, 2 variables

$[HCO_3^-] = 4.64 \times 10^{-4}$ mol/l

Inference from Henry's law:

$$\frac{C_1}{P_1} = \frac{C_2}{P_2}$$

Q. Conc^n of diss. O_2 = ? If partial pressure for O_2 = 56 mm Hg. Conc^n of DO is 0.44 g/100 ml, PP : 150 mm Hg

$$\frac{56}{x} = \frac{150}{0.44}$$

$\Rightarrow \boxed{x = 0.15 \text{ g } O_2 / 100 \text{ ml}}$

Surface Wat

→ Normal pH for no

→ Turbidity

→ Dissolved O_2 (DO

– Ground water has

– Surface water i

– If conc^n of DO

BOD – BIOC

COD –

★ We are going

indirectly.

– amount of

in gram

O_2 is i

{ CH_2

First of

DO;

Keep i

Scanned by CamScanner

Surface Water Quality

→ ~~Normal~~ p^H for normal water : 5.5
→ Turbidity
→ Dissolved O_2 (DO)

– Ground water has nothing to do with DO (anaerobic rxn)
– Surface water is susceptible to pollⁿ

– If concⁿ of DO is less in surface water ⇒ quality of water is less

BOD – Biochemical O_2 Demand
COD – Chemical " "

* We are going to calc. amount of organic ~~matter~~ pollutant indirectly.

BOD

– amount of O_2 needed to degrade the organic matter biologically (taking help of microorganism) in given volume of water

O_2 is in eqᵐ b/w surface water and atm.

$$\{CH_2O\} + O_2 \longrightarrow CO_2 + H_2O$$

First of all, we will pour sample in BOD bottle & calc. DO_i (initial concⁿ of DO).
Keep it in dark for 5 days & calculate DO_f (final concⁿ)

~~allow~~

$$BOD_5 = DO_i - DO_f$$

↓
5 days

→ Why kept in dark ?
so that photosynthesis doesn't occur by algae because photosynthesis 'll release O_2 which can affect our experiment.

Eg $DO_i = 8\ mg/L$, 5 days, $DO_f = 2\ mg/L$.

$BOD_5 = 8 - 2 = 6\ mg/L$

⇒ ~~Organic~~ Micro organisms have taken 6 mg/L of O_2 to decompose the organic matter. (as pollutant)

How to measure amount of Organic matter in sample of water by BOD test ?

$$\underset{30g}{\{CH_2O\}} + \underset{\downarrow}{O_2} \xrightarrow{\text{microorganism}} \{CO_2\} + H_2O$$

We already know DO_f

Here, O_2 acts as an O.A.

$$O_2 + 4H^+ + 4e^- \longrightarrow 2H_2O$$

★ One mole of O_2 is required to bio-decompose 1 mole of organic matter.

if BOD = 8 mg/L

⇒ $n_{O_2} = \frac{8 \times 10^{-3}}{32 \times 4}\ mol/L = 2.5 \times 10^{-4}\ mol/l$

$= 2.5 \times 10^{-4}\ mol/l$

⇒ $n_{organic\ matter} = 2.5 \times 10^{-4} \times 30\ g/l$ → Organic matter

$= 7.5 \times 10^{-3}\ gm$

COD

→ measures the conc^n of or by acidified dichromate

$3\ CH_2O + 16\ H_3O^+ + 3$

BOD

— Biologically

— Microorganism

— give measure of bio degradable ~~biological~~ ma

— specific

⇓

denotes presence of organic matter

→ Because of

⇒ 6 salts

Tempor

contain

when hea

(Ca / Mg

COD

→ measures the conc^n of organic substances that can be oxidized by acidified dichromate (O.A.) at 100°C

$$3\,CH_2O + 16\,H_3O^+ + 2\,Cr_2O_7^{2-} \xrightarrow[100°C]{} 4\,Cr^{3+} + 3\,CO_2 + 27\,H_2O$$

(OA)

(microorganisms aren't allowed to carry microorg. at 100°C)

BOD	COD
– Biologically	– chemically
– Microorganism + nt	– microorganism – nt
– give measure of only bio degradable ~~biological~~ matter	– give measure all type of matter, both degradable & non-biodegradable
– specific ⇓ denotes presence of biodegradable organic matter	– ~~general~~ less specific ⇓ denotes both biodegradable & non-biodegradable matter

→ $\boxed{COD > BOD}$

Hard Water : (Numerical)

→ Because of Mg^+, Ca^{2+}, HCO_3^-, Cl^-, SO_4^{2-}

→ 6 salts possible.

Hardness

- Temporary
  - containing HCO_3^-
  - when heated, gets removed (Ca / Mg) by forming ppt
- Permanent
  - Containing SO_4^{2-}, Cl^-

→ SO_4^{2-} / Cl^- can be removed using soda-lime method, Zeolite, etc

→ Soap molecule :

Organic part : tail

Ionic : head

tail part ~~both~~ binds with oil / greese

head part binds with water molecule (attaches with H^+)

This is how, soap cleans clothes / utensils.

24/11/17

$CaCO_3$ equivalent hardness

Calcium carbonate equivalent	=	Equivalent wt. of $CaCO_3$ / Equivalent wt. of hardness producing substances	× Mass of hardness producing subs.

Multiplication factor

→ In convention, we should give hardness in form of $CaCO_3$ equivalent. (amount of lime & soda needed)

Why $CaCO_3$?

i) MM : 100

equivalent wt. : $\frac{100}{2}$ (Ca^{2+})

ii) most soluble in water

Q. 1. Calculate the calcium carbonate equivalent hardness of a water sample containing only 204 mg of $CaSO_4$ per litre.

Mol. wt. of $CaSO_4$ = 136, $CaCO_3$ = 100

→ $CaCO_3$ equivalent = $\frac{50}{136/2} * 204$ mg/L

$= \frac{50}{68} \times 204$

$= 150$ ~~mg~~ ppm

Q2. Calculate the temporary hardness of water containing:

$Mg(HCO_3)_2$ = 7.3 mg/L

$MgCl_2$ = 9.5 mg/L

(Don't consider salts like

Temporary Hardness :

$= \frac{50}{73} * 7$

$= 5 +$

$= 15$

Permanent Hardness

$\frac{50}{95/2} * 9.$

$= 10$

$= 20$

Total hardness

Q. Calculate

Simply m

Lime S

for removal

Scanned by CamScanner

Q2. Calculate the temporary, permanent & total hardness of a sample of water containing:

$Mg(HCO_3)_2$ = 73 mg/L $Ca(HCO_3)_2$ = 162 mg/L

$MgCl_2$ = 9.5 mg/L $CaSO_4$ = 13.6 mg/L

(Don't consider salts like NaCl, Fe_2O_3, KCl)

Temporary Hardness : {Multiplying factor for $Mg(HCO_3)_2$} * [$Mg(HCO_3)_2$] + {Multiplying factor for $Ca(HCO_3)_2$} * [$Ca(HCO_3)_2$]

$$= \frac{50}{73} * \frac{73}{10} + \frac{100/2}{162/2} * \frac{162}{10}$$

$$= 5 + 10$$

$$= 15 \text{ ppm} \qquad (1 \text{ ppm} = 1 \text{ mg/L})$$

Permanent Hardness :

$$\frac{50}{95/2} * 9.5 + \frac{50}{136} * \frac{136 \times 2}{10}$$

$$= 10 + 10$$

$$= 20 \text{ ppm}$$

Total hardness = 15 + 20 = 35 ppm.

Q. Calculate total hardness of 1000 litre.

Simply multiply (in ppm) by 1000

Lime Soda process

For removal of 1 mole of $CaCl_2$ / $CaSO_4$ → 1 mole of soda is req.

1 mole $MgSO_4$ & $CaSO_4$ → 1 mole of soda & lime excess

1 mole of

Lime requirement for softening:

$$= \frac{74}{100}\left[T.H. \text{ of } Ca^{2+} + 2 * T.H. \text{ of } Mg^{2+} + P.H. \text{ of } Mg^{2+}\right] \times \frac{\text{Vol. of water}}{\text{in } l}$$

Mol. wt. of ~~soda~~ lime

Soda requirement for softening:

$$= \frac{106}{100}\left[P.H. \text{ of } (Ca^{2+} + Mg^{2+})\right] \times \frac{\text{vol. of water}}{\text{in } l}$$

Ques. Calculate amnt. of lime & soda for softening 50,000 l of hard water containing : $Mg(HCO_3)_2$ = 144 ppm
$Ca(HCO_3)_2$ = 81 ppm , $MgCl_2$ = 95 ppm , $CaCl_2$ = 111 ppm
Fe_2O_3 = 25 ppm Na_2SO_4 = 15 ppm

	Quantity	M.F.	$CaCO_3$ equivalent
$Mg(HCO_3)_2$	146	100/84	
$MgCl_2$	95		
$CaCl_2$	111		
$Ca(HCO_3)_2$	81		

Lime required

$$= \frac{74}{100}\left(\{2 \times Mg(HCO_3)_2\} + Ca(HCO_3)_2 + MgCl_2\right) \times$$

$$= \frac{74}{100}\left(2 \times 100 + 100 + 25\right) mg/l \times 50000\, l$$

$$= 16.25 \text{ kg}$$

Soda required

$$= \frac{106}{100}\left(\frac{100}{111} \times 111 + \frac{100}{95} \times 95\right) mg/l \times 50000\, l$$

$$= 10.6 \text{ kg}$$

* If asked for a year, multiply by 365.

Scanned by CamScanner

1 numerical → BOD
1 numerical → Hardness

Eg. (BOD) : A wastewater contains 250 mg/L benzoic acid. What is theoretic BOD of this water? Mol. wt. of benzoic acid is 122 g/mol

$\{CH_2O\} + O_2 \longrightarrow CO_2 + H_2O$

1 mole of organic comp. → 1 mole of O_2

$n_{\text{Benzoic acid}} = \frac{250}{122} \times 10^{-3} = 2.05 \times 10^{-3}$

$\Rightarrow n_{O_2}$ required $= 2.05 \times 10^{-3}$

$m_{O_2} = 65.$

→

$C_6H_5COOH + \left(\frac{15}{2}\right) O_2 \longrightarrow 7CO_2 + 3H_2O$

2.05×10^{-3} $\quad \frac{15}{2} \times 2.05 \times 10^{-3}$

$\Downarrow$

15.36×10^{-3} moles

$\Downarrow$

0.493 g

$\Rightarrow$ $\boxed{\text{BOD} = 0.493 \text{ g/L}}$

→ Rate of decomposition at particular temp:

$K_T = K_{20}\, \theta^{(T-20)}$ → °C

K_{20} = rate const. at std. of 20°c

θ = has value of 1.135 for temp b/w 4°- 20°c &

1.047 for temp b/w 20- 30°c

$BOD_t = L_0 (1 - e^{-kt})$

↳ time

L_0 = ultimate BOD

k : rate of biodecomposition rxn (d^{-1})

t = time required to carry out exp.

Scanned by CamScanner

Eg. A ww sample has an ultimate BOD = 300 mg/L. At 20°C, the 5 day BOD was 200 mg/L & oxⁿ rate const. was 0.22 /d. What would be BOD_5 at 25°C

$$K_T = K_{20}\,\theta^{(T-20)}$$

$$\Rightarrow K_T = 0.22\,(1.047)^5 = 0.277\ d^{-1}$$

$$BOD_5 = L_0\,(1-e^{-kt5})$$

$$= 300\,(1-e^{-0.277\times5})$$

$$= 225\ mg/L$$

$$\Rightarrow BOD\ (25°C) > BOD\ (20°C)$$

Eg. (Alkalinity):

A groundwater sample contains 300 mg/L of bicarbonate at $p^H = 10$. Calculate

i) Carbonate ion concⁿ $[CO_3^{2-}]$

ii) Total carbonate alkalinity in ppm

iii) Total carbonate alkalinity as $CaCO_3$. (won't consider $[OH^-]$)

Given: At p^H 10, total carbonate $(HCO_3^- + CO_3^{2-}) \Rightarrow$ 73% of HCO_3^- + 27% CO_3^{2-}

let x : total carbonate (total alkalinity)

$$\Rightarrow \frac{73x}{100} = 300 \Rightarrow x = 411\ mg/L$$

$$[CO_3^{2-}]\quad \frac{27x}{100} = 411 - 300 = 111\ mg/L$$

Total carbonate alkalinity (as $CaCO_3$) = M.F. for HCO_3^- as $CaCO_3$ × $[HCO_3^-]$ + M.F for CO_3^{2-} × $[CO_3^{2-}]$

$$= \frac{100/2}{61/1}\times300 + \frac{100/2}{60/2}\times111$$

$$= 431\ mg/L$$

Scanned by CamScanner