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Link:- https://groups.google.com/forum/#!forum/evsbio2017-ii/new

Importance of Atmosphere

↳ (i) acts as protective blanket

Ozone layer → Stratosphere

Wavelength of U.V. radiation → around 200nm

Lower wavelength → High energy

(ii) CO_2 → Natural component of atm.

But now, fossil fuel burning lots of CO_2 emission

excess CO_2 → green house effect

(iii) N_2, O_2 → is provided by atm.

N_2 → Amino acid → protein

Q. Why N_2 is most abudent gas in atmosphere?

Ans. N_2 → inert gas (triple bond)

↳ does not react with other metals/compounds easily.

Troposphere } ← Characteristic (temp. ...)
Stratosphere }

Meso } not required

Troposphere → with increasing Altitude temp. decreases
(-15°C to -56°C)

↳ U.V. rays → fall on surface of earth (not absorbed by N_2, O_2)

↓

with radiation/convection atm heated up

Teacher's Signature

Stratosphere → with Altitude temp ↑

↳ Because of O_3 presence (which absorbs U.V. radia

$$O_{3(g)} \xrightarrow{U.V.} O_{2(g)} + O_{(g)}$$ (exothermic)

In Volcano emission (eruption)

↳ H_2O, CO_2, SO_2 (major comp.)

↳ CO, HCl, H_2S, HF (minor)

H_2, N_2

$$CO_2 + H_2O \rightarrow H_2CO_3$$ (sediment rock)

↳ CO_2 soluble in water

Cynobacteria → produced O_2 first time

not source of O_2

but in ocean → Saline Water (metals...

O_2 → reacts with metal

Q Where did the O_2 come from?

$$H_2O + \text{U.V. light} \rightarrow H + OH$$

$$CO_2 + \text{UV light} \rightarrow CO + O$$

$$O + OH \rightarrow O_2 + H$$

not source of O_2 we have today

Formation of Ozone (Photodissociation)

$$O_2 + \text{U.V light} \rightarrow O + O$$

$$O + O_2 \rightarrow O_3$$

Q Original source of present day oxygen?
↳ plants started to growth
↳ Photosynthesis → O_2 emission

Calculation of the mean molecular weight of air

C × mol wt

% of gas in air ↙ ↘ corresponding molecular weight of gas

$$M_a = \sum_i C_i M_i$$

$= 0.78 \times 28 + 0.21 \times 32 + 0.934 \times 40 \ g\,mol^{-1}$

$\simeq 28.96 \times 10^{-3} \ kg\ mol^{-1}$ (in S.I. unit)

(M.W. → Ar) = 40 gm/mol

★ Air Pollution :-

Stationary Sources → Volcano, Factory Chimney
Mobile sources → Vehicle exhaust

Natural Sources → Volcanoes, dust, fires, pollen, salt, VOC(s)

Primary Pollutants ↓ coming direct from the source

e.g. CO, CO_2, NO, NO_2

Secondary Pollutations ↓ these come from reactions of primary .. (or elements of atm)

e.g. SO_3, HNO_3, H_2SO_4 (or other components which cause acid rain)
↳ Ozone (O_3)

Major Pollutants
↳ CO, CO_2, SO_2, O_3, NO_2, SPM

(i) Carbon Monoxide (CO):-

Q Why, during combustion of fossil fuels, oxides like CO, CO_2, SO_2 etc. are formed?

Ans Composition of fossil fuels → C, H, O, S, N elements ↓ Burning (Combustion)

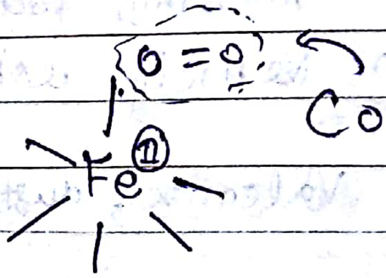
over years

Dead biomasses

$$CHOSN \xrightarrow{O_2} CO \text{ or } CO_2 + SO_2 + NO_x$$

CO → Highly toxic → Why?

Haemoglobin → Coordination compound ↓ 'Fe' central atom



CO has greater affinity towards Fe than O_2.
↓
replaces O_2
↓
no carrying of O_2 to various parts of body.

Air quality index (AQI):-

Toxic > 100%

> 300 } ~~Hig~~ Hazardous
> 400

50 - 60% ⟹ Normal

$$AQI = \frac{\text{Actual Measured Concentration}}{\text{Acceptable Concentration of that pollutant}} \times 100$$

(ii) Carbon dioxide (CO_2)

Q. Atmospheric CO_2 concentration have increased from 280 ppm in pre-industrial times to 365 ppm today. What is the corresponding increase in the mass of atmospheric carbon? Assume CO_2 to be well mixed in the atmosphere.

[Mass of atm $m_a = 5.2 \times 10^{18}$ kg
Mean molecular mass of air $M_a = 29 \times 10^{-3}$ kg/mol]

Ans. Increased CO_2 = 365 - 280 = 85 ppm

Concentration of CO_2 $[C_{CO_2}] = \frac{n_{CO_2}}{n_a}$ → No. of moles $[\because n_{CO_2} = n_C]$

$$= \frac{n_C}{n_a}$$

$$= \frac{M_a}{M_C} \cdot \frac{m_C}{m_a}$$

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

g-mole or No. of moles ✓

$$= 5.2 \times 10^{18} \times \frac{12 \times 10^{-3}}{29 \times 10^{-3}} (365 \times 10^{-6} - 280 \times 10^{-6})$$

$$= 1.8 \times 10^{14}\ Kg$$

$$= 180 \text{ billion tons}$$

Q Calculate the concentration of CO_2 in the room after the fire extinguisher is emptied. Amount of CO_2 is measured to be 10 lb. The dimension of the room is 10 ft x 10 ft x 10 ft. Temp. in the room is increased to 30° (room temp. was 20 °C before fire) and that the ambient pressure is 1 atm.

Ans

$$C_{CO_2} = \frac{\text{No. of moles of } CO_2}{\text{No. of moles of air in the atm}}$$

$$n_{CO_2} = \frac{10 \times 454}{44} \quad [1 lb = 454 gm]$$

$$= 103$$

No. of moles of air → $n_a = \frac{PV}{RT}$

$$V = 10^3 ft^3$$

$$= 10^3 \times 28.3\ L$$

$$= 28,300 \text{ litres}$$

$$\therefore n_a = \frac{1 \times 28300\ L}{\left(0.08206 \frac{atm \cdot L}{gmol\ K}\right)(303)} = 1138$$

green house gases have less absorbing capacity of radiations

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$$\therefore \; x_{CO_2} = C_{CO_2} = \frac{103}{1138}$$

* Green house gases & its effects :-

Minor amount of green house gas is required to maintain aver. temp. after sun goes down.

H_2O, CO_2, CH_4 → green house gases (IR active species)
↓
are able to absorb in IR region

Why not N_2, O_2 ?
↳ both have same atoms forming them
↳ IR inactive species &

24th Oct, 17

Q Estimate the amount of total waste generation for a community of 4000 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.

Ans

Total waste generated per day

= (PCGR) × (No. of people)

= 2.5 × 4000 = 10,000 pounds per day

lb to ton (1 ton = 2000 lb)

∴ = $\frac{10000}{2000}$ = 5 tons per day

Recycling rate → 28%

Total material recovered from recycling = 0.28 × 5 = 1.4 tons per day

Total material recovered for disposal

= 5 − 1.4 = 3.6 tons per day

* Treatment of Solid Waste →

(i) Open dumping →

Build up of landfill gas (Methane) → Can cause fire

Formation of Methane (CH_4) in landfill area $C_6H_{12}O_6$

(a) aerobic biodecomposition reaction

$$\{CH_2O\} + O_2 \xrightarrow[\text{organism}]{\text{Micro}} CO_2 + H_2O + \ldots$$

MSW → Material Solid waste

And plant ---- utilize the formed products:

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

→ Recycling

(6) Anaerobic biodecomposition reaction

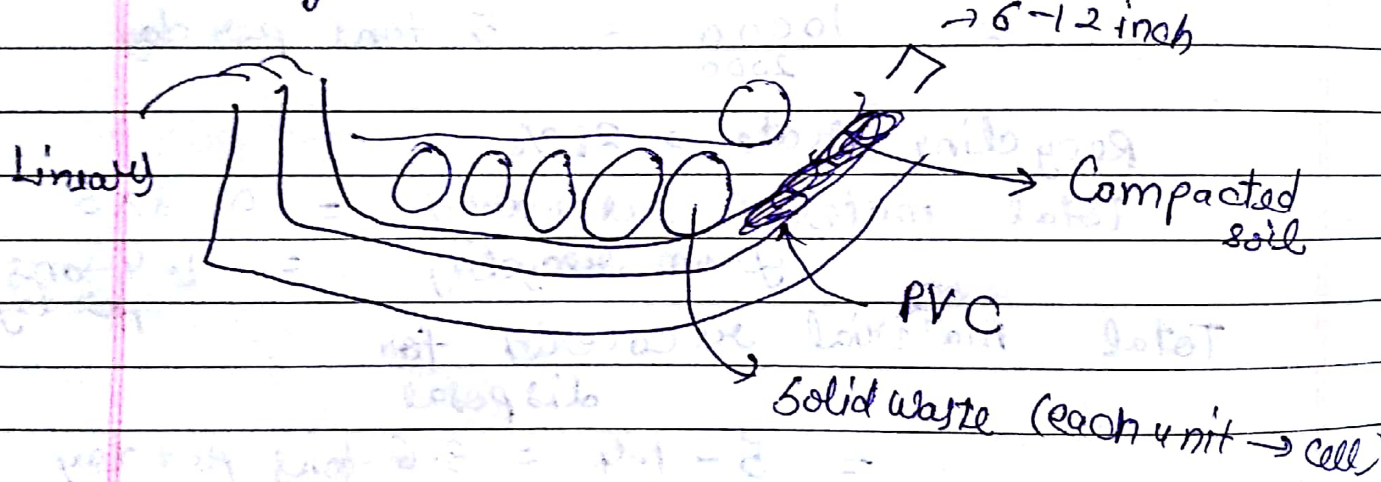
$$\{CH_2O\} \xrightarrow[\text{organisms}]{\text{Micro}} CO_2 + H_2O + CH_4$$

formation of methane

Micro-organisms decompose dead bio mass

Note :- Appropriate proportion of $CO_2 + CH_4$ → Biogas

(ii) Landfills



Q For a population of 50,000, estimate the annual area requirements for a normally landfill having a refuse depth of 4m. Assuming that per capita waste generation rate is 4.0 kg/d and that the density of a normally compacted landfill is 450 kg/m³.

Ans Area required = $\dfrac{50000 \times 4\ kg/d \times 365\ d/year}{450\ kg/m^3 \times 4m}$

$= 40555.55\ m^2/year$

Recycling, dumping etc. → Least preferred options for waste management

Most preferred options
(i) Least ~~con~~generation of waste
(ii) Waste exchange

$$A + B \rightarrow \text{Desirable product} + \text{By product (BP)} \rightarrow \text{Not useful}$$

In waste exchange, By products of one industry can be used ~~to~~ as raw material of other

Important

(iii) Composting :-

Q why do micro-organisms decompose elements in dead bio masses, not alive?

Ans → In dead bio-masses,

$$\{CH_2O\} + O_2 \xrightarrow{\text{micro-organism}} CO_2 + H_2O + \text{New-cell}$$

Aerobic decomposition

Thus micro-organisms, get energy & multiply their numbers

→ In alive bio-masses

$$\{CH_2O\} + O_2 \xrightarrow{\text{Micro-organism}} CO_2 + H_2O + \text{New Cell}$$

+ P, N, S are found

PO_4^{3-}, NO_3^-, SO_4^{2-} → Important nutrients for living bio masses

Anaerobic decomposition

$$\{CH_2O\} \rightarrow CO_2 + H_2O + \text{New Cells} + CH_4$$

In dead bio-masses

$$\{CH_2O\} \rightarrow CO_2 + H_2O + \text{New Cells} + CH_4$$

P, N, S → PH_3, H_2S, NH_3 are formed too

★ Production of Bio-fuel from agricultural waste

Coal or Crude Oil
(C, N, O, P, S etc.)

Fermentation

$C_6H_{12}O_6 \xrightarrow{\text{yeast}} 2C_2H_5OH + 2CO_2$ (Same reaction is used in Baking)

↓

~~Bio-fuel~~
(ethanol)

No need to remember structures →

Oil/ fat + Alcohol → Biodiesel + Glycerin (By product which is used to make soaps)

★ Organic pollutants in Industrial Waste Water:-

★ Pulp & paper Industry:-

↳ Polluntants →
(i) Suspended solid
(ii) Chlorinated Compounds

Tanneries
↓
Chlorinated phenols (3, 5- dichlorophenol)

~~Dye~~ Textile industry
↳ Heavy metals, benzene, formaldehyde

Azo dyes, PCBs, Pesticides

★ Sugarcane based Industry :-

★ Cosmetic Industry :-

Name of pigment	Composition	Colour
(I) Zinc Oxide (ZnO)	ZnO (100%)	White
Titatinum oxide	TiO_2 (100%)	~~Blue~~
(II) ~~Cobalt blues~~	Co_3O_4 - 30-35% & Al_2O_3 - 65-70%	Blue
(III) Read lead	$PbO_3 + PbO$	Red
Synthetic iron	Fe_3O_4	~~B~~
(IV) Chrome green	Co_2O_3	Green
(V) Ochre	Naturally occuring Fe_2O_3 (30-35%)	Yellow

★ Water Pollution (Types) :-

(i) Ground Water Pollution

$$C_6H_6 + \frac{15}{2}O_2 \longrightarrow 6CO_2 + 3H_2O$$

$$C_6H_6 + NO_3^- + H_3O^+ \longrightarrow 6CO_2 + 3N_2 + 6H_2O$$

[Cool & dark] → very slow

Reasons of Ground water Pollution → leaky landfills
Agricultural runoff
Mine spills

★ Inorganic species as Pollutants:-

(i) ~~Cyani~~ Cyanide

$$2Na[Au(CN)_2] + Zn \rightarrow Na_2[Zn(CN)_4] + 2Au$$

Zn → greater affinity to cynaide

Q Why cyanide is deady poisonous substance?
↓
exists in water as HCN
↓
Replaces oxygen from haemoglobin to form stable cynaide compound

(ii) Ammonia

Polyurethans foam is used in cushion, furniture, carpets

(iii) H_2S (Hydrogen Sulfide)

(iv) Nitrites → causes
Blue baby Syndrome

*VOCs

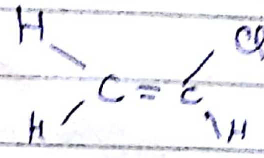
Q why plant produces VOCs like isoprene etc?

(i) to attract (air... maybe? not sure)

(ii) to repel insects

VOCs

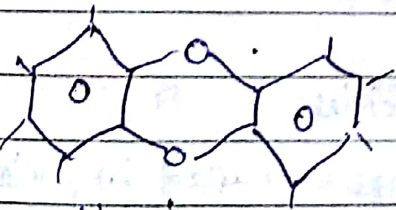
↳ Most toxic → Vinyl chloride, Benzene



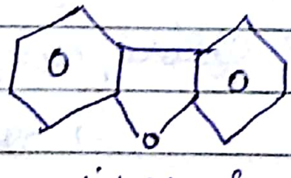
* PoPs

↳ PAHs PCBs DDT → Intentionally produced

Polychlorinated dioxins
Polychlorinated dibenzofurans (PCDF) } Unintentionally produced



dioxin

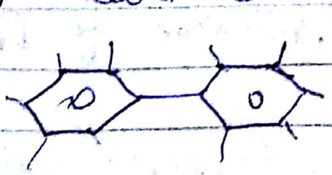


dibenzofuran

(i) Polynuclear Aromatic Hydrocarbons

Alizarin → coordinating agent

(ii) Poly Chlorinated Biphenyls (PCB)



$C_{10}H_{1-x}Cl_x$ → general formula

x → No. of Chlorine atoms

Use of PCB → insulating materials (to coat over metal wires
Coolant in transformers

(iii) DDTs

used to kill malaria (1940-60)

↳ synthesis → easy
↳ So, very cheap → Hence, popular

☆ Examples of Organophosphates insecticides
↳ Parathion, Malathion, Paraxon

Harmful to Insects Mammals

pest?

[Why? → Mammals have enzyme which cause hydrolysis]

☆ Herbicides

(a) Chlorophenoxy Herbicides
↳ Agent Orange → used in Vietnam War
↓
Caused genetic defects in ~~..~~ upcoming generation

(b) Triazines Herbicides

(c) Dalapon

☆ Eco-friendly way to deal with pests
↳ A. ~~....~~ Natural Chemical defenders → Application of Pheromones
↓
synthesis

★ Waste Water :- Used water with various ~~contaminants~~ Contaminants

Water treatment

(i) To reuse

(ii) We can't let flow contaminated water into water bodies to pollute nature

Sewage treatment

↳ Preliminary, Primary, Secondary, Tertiary

method ~~steps~~
equipment
Aim

In secondary treatment

↳ biodegradable contaminants are removed.

(i) Preliminary method

↳ (a) Screening

equipment → bar screen or grid like screen

Aim → separate large bulky floating object

(b) Comminution

equipment → Comminutor

Aim → Rotating action to break down large size particles

(c) Grit removal process

equipment → Grit chamber

Aim → removes the particles that settle down

(ii) Secondary ~~treat~~treatment

(a) Primary treatment

↳ primary sedimentation tank

↳ remove suspended solids

$$\underset{\text{Alum}}{Al_2(SO_4)_3} + Ca(OH)_2 \rightarrow CaSO_4 + \underset{[ppt.]}{Al(OH)_3}$$

Q Why ~~CaSO~~ $CaSO_4$ is used?
↳ to raise pH of waste water.

$Al(OH)_3$ is used to remove suspended solids.
(thus formed)

Q Design a screen chamber with max. flow (Q) of $0.15\ m^3/s$ of domenstic water
width to depth ratio → 1.5 : 1
Velocity of waster water (V_h) = 0.75 m/s
The clear opening of the chamber = 25 mm &
diameter of each bar = 10 mm

Calculate:
(a) The No. of bars
(b) Exact area through which water can pass
(c) Effective cross sectional area of channel

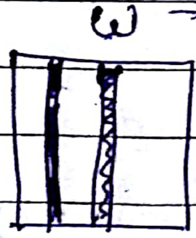
Ans (a) If No. of bars = n
Then clear opening ⇒ n+1

W → width

$$W = n \times 10 + (n+1)25$$

$$D = \frac{1}{1.5} W$$

D ↓ depth



Area = WD.

$$\text{Also, Area } (A_2) = \frac{Q}{V_h} = \frac{0.15}{0.75} = 0.2\ m^2$$

$$A_2 = D(1.5D)$$

$$\Rightarrow \frac{0.2}{1.5} = D^2 \Rightarrow D = 0.4\ m$$

$$\therefore W = 0.6\ m$$

$[n \times 10 + (n+1) 25] = 600$

$\Rightarrow 10n + 25n + 25 = 600$

$\Rightarrow 35n = 575 \quad \simeq 16$

(b) Exact ~~Area~~ = ~~Area Total~~ − ~~Area of bars~~

Effective width = Total width − width of bar

$= 0.6\ m - (0.01 \times 16)\ m$

$= 0.44\ m$

Hence, effective area $= 0.44 \times 0.4$

$= 0.176\ m^2$

Particle settling velocity → Velocity with which particles settle in a certain fluid.

↳ can be calculated by Stoke's law.

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 & time of a 3 m deep horizontal flow grit chamber which removes grit with specific gravity = 1.9, size of 0.2 mm, temp 22 °C, viscosity of water = 1.002×10^{-3} kg(ms^{-1})

Ans

$$v_h = \frac{g(\rho_p - \rho_w) \times d^2}{18 \mu}$$

$\mu \rightarrow$ Viscosity of fluid

$d \rightarrow$ diameter of particle

v_h

Specific gravity $= \dfrac{\text{density of particle}}{\text{density of water}}$

$\Rightarrow \rho_p = 1.9 \times 1000\ kg/m^3 = 1900\ kg/m^3$

Retention time
↓
time required to settle particles

Settling Velocity $(V_s) = \frac{Q}{A}$

$V_s = 0.02$ m/s
↳ (m/d) conversion

$$Area = \frac{35000}{1728} \frac{m^3/d}{m/d} = 20.25\ m^2$$

Volume = Area × depth

$$\text{Retention time } (t) = \frac{\text{Volume of grit chamber}}{\text{flow rate}}$$

$$= \frac{\text{Depth of the tank}}{\text{Settling Velocity}}$$

$$= \frac{60.75\ m^3}{35000\ m^3/d} = 0.0017 d$$

$= 2.5$ min.

Sludges → produced at the end of preliminary step
↳ useful to produce biogas?

Q Determine quantity and volume of sludge produced in 10 days in the treatment of 10 MLD of domestic wastewater with following condition:
(i) Suspended solid in wastewater = 250 g/m³
(ii) SS removal efficiency of primary tank = 60%
(iii) Concentration of solids in sludge = 6%
(iv) Density of water = 1000 kg/m³
(v) Solids contribution per capita = 75 g
(vi) Specific gravity of sludge = 1.03
Also calculate volume of sedimentation tank & no. of people residing in that locality.

$1\ ML = 1$ millilitre $= 10^6\ L$ $[1L = 10^{-3}\ m^3]$

Ans

$10\ MLD = 10 \times 10^3\ m^3/d$

$= 10 \times 10^6\ L/d$

$= 10^7\ L/d$

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

$= 0.60 \times 250\ g/m^3 \times 10 \times 10^3$

$= 1500\ kg/d$

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

[Note :- If moisture content is given to be x than solid % = 100 − x]

$= \dfrac{1500\ kg/d}{1000\ kg/m^3 \times 1.03 \times 0.06} = 25\ m^3/d$

~~Volume of sedim~~ Retention time = $\dfrac{\text{Volume of primary tank}}{\text{Volume of sludge produced per day}}$

[Retention time → ~~to~~ Here '10' days]

∴ Volume of tank = $25 \times 10 = 250\ m^3$

No. of people = $\dfrac{1500 \times 10^3}{75} = 20{,}000$

* Secondary treatment :-

↳ Trickling filter method -
solid stones, pipes with holes to sprinkle

Oxygen is required to carry out biodegradable reaction

$\{CH_2O\} + O_2 \rightarrow CO_2 + H_2O$
$+$ New cells

Q A wastewater treatment plant receives a flow of 35000 m^3/d containing BOD (Biodegradable organic matter) of 250 mg/L. Primary treatment removes 25% of organic matter.
Calculate the no of trickling filters with diameter of 60 m which would accomodate an organic load (conc. of microbes) of 250 $g/m^2/d$

Ans Total amount of organic matter entering the trickling filter $= 250\ mg/L \times 0.75 \times 35000\ m^3/d$

$= 6562500\ g/d$

$[1\ L = 10^{-3}\ m^3]$

Total area required $= \dfrac{\text{Total org. matter in ww}}{\text{Org. load microbes}}$

$= \dfrac{6562500\ g/d}{250\ g/m^2/d} = 26250\ m^2$

• No. of trickling filters $= \dfrac{26250}{\text{Area of each filter}}$

$= \dfrac{26250}{\pi d^2} \approx 10$

Q (a) If rate of O_2 required per kg of organic matter decomposed

*

Digestion → heating of substance

Anaerobic digestion → heating of sludges in complete absense of air

Mesophilic — microorganism growth, 30° to 45°

Thermophilic — 45° to 60°

Anaerobic digester

Sludge cake → end product

V_{sludge} (raw) V_{sludge} (d) → Volume of digested sludge

Q Design an anaerobic sludge digester to treat sludge from the treatment of 10 MLD domestic wastewater flow with following condition:

(i) Quantity of sludge = 500 kg/d

(ii) ~~Quantity~~ Concentration of solids in raw sludge = 4%

~~Conc. of solids in sludge~~

(iii) Density of water = 1000 Kg/m^3

(iv) Specific gravity

(v) Total mass of solids in digested sludge = 290 kg

(vi) Specific gravity of digested sludge = 1.04

(vii) Con. of solids in digested sludge = 10%

(viii) Digestion time = 15 days

Compute the volume of sludge to be digested per day.

Ans

$$\text{Volume of raw sludge} = \frac{\text{Quantity of sludge produced}}{\text{Density of water} \times \text{Specific gravity} \times \text{\% of solids in sludge}}$$

$=$

$= 12.25\ m^3$

$$V_{sludge}(d) = \frac{\text{Total mass of solids in digested sludge}}{\text{density of water} \times \text{Specific grav. of digested sludge} \times \text{Solid con. in digested sludge}}$$

$$= \frac{290}{1000 \times 1.04 \times 0.10} = 2.80\ m^3$$

$$\text{Volume of anaerobic digester} = \left[V_s(r) - \frac{2}{3}\left(V_s(r) - V_s(d)\right)\right] \times \text{digestion time}$$

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

$= 89.25\ m^3$

Q An anaerobic reactor has been employed to treat food processing waste water at 20°C. The flow rate is 2 m^3/day with a mean soluble COD of 7,000 mg/L. Calculate the maximum CH_4 generation rate.

Ans Total amount of organic matter undergoing anaerobic digestion

$\therefore$ Total COD removed $= \frac{(7000 \times 10^{-6})}{10^{-3}} \times (2)$ Kg/d

$= 14$ Kg/d

Complete anaerobic degradation of 1 Kg COD produces 0.35 m^3 CH_4 at STP.

14 kg COD produces ~ $0.35 \times 14 = 4.9$ m^3 CH_4/D at STP.

At 20°C, the CH_4 gas generation $= 4.9 \times (293/273)$

$= 5.3$ m^3/d

↓

Max. CH_4 generation rate

Air Striping method → (Skipped) $\boxed{\text{but read}}$

Imp.

✓ ★ Biological process :-

{ Reactions important }

$2NH_4^+ + 3O_2 \xrightarrow{\text{Nitrosomonas}} 4H^+ + 2NO_2^- + H_2O$

$2NO_2^- + O_2 \xrightarrow{\text{Nitrobacter}} 2NO_3^-$

$$6NO_3^- + 5CH_3OH + 6H^+ \text{ (denitrifying bacteria)} \rightarrow 3N_2(g) + 5CO_2 + 13H_2O$$

$$NH_3 \rightarrow NH_4 \xrightarrow{\text{Nitrosomonas}} NO_2 \xrightarrow{\text{Nitrobacter}} NO_3 \xrightarrow{\text{reducing agent}} N_2$$

★ Chlorination for removing Ammonia

pathogens → kill

$$Cl_2 + H_2O \rightarrow H^+ + Cl^- + HOCl$$ (Hydrochlorous acid)

Important

$$NH_4^+ + HOCl \rightarrow NH_2Cl \text{ (monochloramine)} + H_2O + H^+$$

$$NH_2Cl + HOCl \rightarrow NHCl_2 \text{ (dichloromine)} + H_2O$$ (causes smell of chlorine odour)

$$NHCl_2 + HOCl \rightarrow NCl_3 \text{ (trichloromine)} + H_2O$$

↳ unstable → N_2

$$2NH_3 + 3HOCl \rightarrow N_2 + 3HCl + 3H_2O$$

This is not important reaction (don't remember) → $2NH_3 + 3Cl_2 \rightarrow N_2(g) + 6H^+ + Cl^-$

Q A flow of 850,000 gpd requires a dose of 25 mg/L Chlorine. If sodium hydrochlorite is 15% available chlorine, how many pounds per day are needed?

Ans gpd → gallon per day

Lbs day = Conc. (mg/L) x flow (MGD) x 8.34 lbs/gal

Ans = 25 mg/L x 0.85 mgd x 8.34 / 0.15

= 1.181

* Water disinfection :-

$Cl_2 + H_2O \rightarrow H^+ + Cl^- + HOCl$

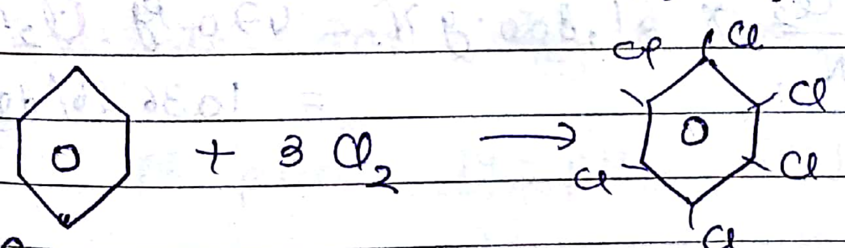
HOCl → weak acid

$HOCl + OCl^-$ → The combination **free available chlorine** | Combined available chlorine & Chloramine

$HOCl \rightleftharpoons H^+ + OCl^-$

In water → Pathogen, Ammonia ↓ Chlorination Removes NH_3 first.

Q. How Chlorine kills pathogens?



C_6H_6 C_6Cl_6 (Hexachlorobenzene)

(Removable H → replaced by Cl)

$\boxed{2NH_3 + 3Cl_2 \rightarrow N_2(g) + 6H^+ + Cl^-}$

Q. Calculate the weight ratio of Cl : N (Molar ratio is 3:2)

Ans. 3 moles of Cl_2 = 3×71 = 213 g

2 moles of N = 2×14 = 28 g

Thus, the stoichiometric weight $213/28$ = 7.6 g Cl_2 per gram of N (as ammonia)

Q. A waste treatment plant handles 1500,000 L/day of sewage that contains an average of 50 mg/L of NH_3-N. How many grams of Cl_2 (aq) must be present daily in the waste water to remove all ammonia?

Ans. One mole of NH_3 contains 14 g of N and 3 g of H

Thus, 50 mg/L of NH_3 contains $\frac{14}{17} \times 50$ mg/L = 41.2 mg/L of N

in 1500,000 L there will be

~~1500,000 L × 41.2 mg/L~~

= 61,800,000 mg N

or 61,800 g N/day

The theoretical amount of Chlorine required is -

$$\frac{7.6 \text{ g } Cl_2}{1 \text{ g N}} \times 61,800 \text{ g N} = 470 \text{ kg } Cl_2/\text{day}$$

$$= 1036 \text{ lb/day}$$

(c) Chlorine dioxide.

$$ClO_2 + 4H^+ + 5e^- \rightarrow Cl^- + 2H_2O$$

$$ClO_2 + e^- \rightarrow ClO_2^-$$

Teacher's Signature

Taste & order producing organic substances

↳ Decamember

* Alkalinity:-

The species, that can attract H^+ ions.
capacity of species

$$CO_2 + H_2O \rightleftharpoons H_2CO_3$$

$$H_2CO_3 \rightleftharpoons HCO_3^- + H^+ \quad Ka_1$$

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

Alkanity → Conc. of all negative ion species

$$= [HCO_3^-] + [OH^-] + 2[CO_3^{2-}]$$

Q. pH of 10.00, alkanity of water found to be 1.00×10^{-3} mol/L. Calculate conc. of bicarbonate ion. $K_{a2} = 4.69 \times 10^{-11}$

Ans

$$pOH = 14 - pH = 14 - 10 = 4$$

$$[H^+] = 10^{-10}$$

$$\therefore [OH^-] = 10^{-4} \text{ mol/L}$$

$$Ka_2 = \frac{[H^+][HCO_3^-]}{[H_2CO_3]}$$

$$[OH^-] = \frac{K_w}{[H^+]}$$

$$Ka_1 = \frac{[H^+][CO_3^{2-}]}{[HCO_3^-]} \Rightarrow [CO_3^{2-}] = \frac{K_{a_2}[HCO_3^-]}{[H^+]}$$

$$= 2.18 \times 10^{-4} \text{ mol/L}$$

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

Q What is the predicted concentration of dissolved oxygen, if the partial pressure for oxygen is 56 mm Hg? The conc. of dissolved oxygen is 0.44 g / 100 ml solution. The partial pressure of oxygen is 150 mm Hg.

Ans

$P_1 = 150$ mm Hg ; $P_2 = 56$ mm Hg

$$\frac{0.44 \text{ g } O_2}{150 \text{ mm Hg}} = \frac{C_2}{56 \text{ mm Hg}}$$ [By Henry's law]

$\Rightarrow C_2 = 0.15 \text{ g } O_2$

★ Surface water Quality :-

pH of water → near about 5.6

To know
↳ Amount of organic matter present

BOD (Biochemical Oxygen Demand)

Experiment → Take water sample & pour it on BOD bottle
↓
Dissolved oxygen initially (DO_i)
↓
Keep bottle in dark
↓ Microorganisms do their job slowly
After 5 days, Measure DO_f

Teacher's Signature

$BOD_5 = DO_i - DO_f$

Q. A sample has an initial DO of 8 mg/L & in five days this drops to 2 mg/L

Ans. ↳ 6 mg/L is the amount of oxygen that has been utilized by micro-organisms during this 5 day experiment.
↳ BOD

Q. Why BOD bottle is kept in dark?

Ans. We can not know what is the amount of oxygen that Algae generated ← which forms oxygen during sunlight ← Photosynthesis ← ~~Alogi~~ Alage → Micro organism is present in H_2O generally

Keep dark ←

Calculation of Organic matter

$$\{CH_2O\} + O_2 \xrightarrow[\text{organism}]{\text{Micro-}} \{CO_2\} + H_2O$$

In BOD, O_2 is acting as oxidizing agent

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

One mole of oxygen is required for the bio-decomposition of one mole of organic matter.

32 gm of O_2 → 1 mole

1 gm of O_2 → $\frac{1}{32}$ mole of O_2

8 mg = 0.008 g of O_2 → $\frac{0.008}{32}$ = 0.00025 mole of O_2

SO_4^{2-} →

1 mole of org. matter = 30 gm

∴ 0.00025 moles of org. matter = 30 × 0.00025 = 7.5 ~~gm~~ mg

Chemical Oxygen Demand (COD)

COD → Chemical method

BOD → Biodecomposition reaction

$$3CH_2O + 16H_3O^+ + 2Cr_2O_7^{2-} \rightarrow 4Cr^{3+} + 3CO_2 + 27H_2O$$

COD → Dichromate iron ($Cr_2O_7^{2-}$) ↓ oxidizing agent

$Cr^{+6} \rightarrow Cr^{+3}$

BOD → O_2 oxidising agent

COD → measures both bio-degradable & non-biodegradable matter ↓ $\boxed{\text{Hence less specific method}}$

BOD → measures Biodegradable matter ↓ $\boxed{\text{Specific method}}$

★ Hard Water :- Ca^{2+}, Mg^{2+} with either SO_4^{2-} or Cl^- or HCO_3^-

Temporary hardness → $Ca(HCO_3)_2$, $Mg(HCO_3)_2$ } → by heating → ppt of $CaCO_3$

Permanent hardness → Cl^- or SO_4^{2-}
↳ Removed by chemical or physical method

Soap → Long organic chain + Anionic Head

★ Thermal Stratification :-

★ $CaCO_3$ equivalent hardness :-

$$\text{Calcium carbonate eq}^n = \underbrace{\frac{\text{Equivalent weight of } CaCO_3}{\text{Eq weight of hardness producing substance}}}_{\text{Multiplication factor (M.F.)}} \times \text{Mass of hardness producing substance}$$

$$\text{Eq}^n \text{ weight of salt} = \frac{\text{Molar mass}}{\text{Ionic charge (?)}}$$

Q. Calculate the $CaCO_3$ eqn hardness of a water sample containing 204 mg of $CaSO_4$ per litre ?

Ans

Mol weight of $CaCO_3 = 100$

" " $CaSO_4 = 136$

$$CaCO_3 \text{ eq}^n \text{ hardness} = \frac{100}{136} \times 204 = 150 \text{ ppm}$$

Q. Calculate the temporary, permanent and total hardness of a sample of water containing

$Mg(HCO_3) = 7.3 \, mg/L$; $Ca(HCO_3)_2 = 16.2 \, mg/L$

$MgCl_2 = 9.5 \, mg/L$; $CaSO_4 = 13.6 \, mg/L$

Ans Since (HCO_3) salts are ~~permanent~~ temporary salts

Temporary hardness

$= [M.F. \text{ for } Mg(HCO_3)_2 \times [Mg(HCO_3)]$

$+ [M.F. \text{ of } Ca(HCO_3)_2 \times [Ca(HCO_3)_2]$

$$= \frac{100/2}{146/2} \times 7.3 + \frac{100/2}{162/2} \times 16.2$$

71
27
98

$= 15 \text{ ppm}$

Permanent Hardness -

$= [M.F. \text{ for } MgCl_2 \times [MgCl_2] + M.F. \text{ of } CaSO_4 \times [CaSO_4]$

$$= \frac{100/2}{95/2} \times 9.5 + \frac{100/2}{136/2} \times 13.6 = 35 \text{ ppm}$$

Teacher's Signature

* Soda lime process

For Ca salts → Only soda required
For Mg salts → both soda & lime

Temp. hardness: Mg → 2L (Only lime)
Ca → L (lime)

Lime req. for softening

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

(74 = Mol. weight of lime)

T.H. → Temporary hardness

P.H. = Permanent hardness

Soda req. for softening

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

(106 = Mol weight of soda)

Q. Calculate the amount of lime & soda eqⁿ for softening 50,000 litres 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.

Ans

Lime required

$$= \frac{74}{100}\left\{[2\times Mg\,HCO_3] + [Ca(HCO_3)_2] + [MgCl_2]\right\} \times \text{vol. of water}$$

$$= \frac{74}{100}\left[2\times100 + 100 + 25\right] mg/L \times 5000\,L$$

$$= \frac{74}{100}\times(325)\,mg \times 50000$$

$$= 16,25,000\ mg$$
$$= 1.625\ kg$$

Soda reqⁿ

$$= \frac{106}{100}\left[CaCl_2 + MgCl_2\right]\times \text{Vol. of water}$$

$$= \frac{106}{100}\left[\frac{100}{111}\times 111 + \frac{100}{95}\times 95\right] mg/L \times 50,000\,L$$

$$= \frac{106}{100}(200)\,mg \times 50000$$

$$= 10.6\ kg$$

Q. A wastewater contains 250 mg/L benzoic acid (Ph COOH). What is the theoretical BOD of this water? The molecular weight of benzoic acid is 122 g/mol.

Ans

$PhCOOH + O_2 \longrightarrow$

$+\frac{15}{2}O_2 \longrightarrow 7CO_2 + 3H_2O$

∴ number of moles of oxygen required to bio decompose the organic matter is 7.5.

∴ 1 mol of benzoic acid = 7.5 mol of

The no. of moles of benzoic acid is litre is as follows

$$n = (250 \times 10^{-3})\, g/122$$

$$= 0.00205$$

$\therefore$ oxygen req. $= 7.5 \times 0.00205$

$= 0.015375$ mol of oxygen req.

$\therefore$ Demand for oxygen $= 0.015375 \text{ mol} \times 32 \text{ g/mol}$

$= 0.493$ g of oxygen

Rate constant at 'T' $\rightarrow$ $K_T = K_{20}\, \theta^{(T-20)}$

$T \rightarrow$ Temp. (in °c)

K_{20} = rate constant at standard of 20°C

θ has value $\rightarrow$ 1.135 for temp. b/w 4–20°C

$\rightarrow$ 1.047 for temp. 20–30°C.

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

$t \rightarrow$ time required to carry out experiment

K = rate of biodecomposition reaction (d^{-1})

L_0 = Ultimate BOD

Q. A wastewater sample has an ultimate BOD equivalent equal to 300 mg/L. At 20°C, the 5 day BOD value was 200 mg/L & the reaction rate constant was 0.22/day. What would be 5 day BOD of this water at 25°C.

Ans.

$L_0 = 300 \text{ mg/L}$

$BOD_5 = L_0 (1 - e^{-K \times 5})$

$K_{25} = K_{20}\, \theta^{(25-20)} = 0.22 (1.047)^5$

$= 0.277 / \text{day}$

$BOD_5 = 300 (1 - e^{-K \times 5})$

$= 300 (1 - e^{-0.277 \times 5})$

$= 225 \text{ mg/L}$

BOD (25) > BOD (20)

Q. A groundwater sample contains 300 mg/L of bicarbonate at pH = 10.0. Calculate

(i) The carbonate ion conc. $[CO_3]^{2-}$

(ii) Total carbonate alkalinity in ppm &

(iii) Total carbonate alkalinity in as $CaSO_3$

~~Ans~~ Given: At pH 10.0, Total carbonate $(HCO_3^- + CO_3^{2-})$

$\Rightarrow$ 73% HCO_3 + 27% CO_3

Ans. Let 'x' be total alkalinity

∴ 73% of x is 300 mg/L of HCO_3

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

$\therefore$ $[CO_3^{2-}] = 411 - 300 = 111$ mg/L

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

$$= \frac{\text{Eq}^n \text{ weight of } CaCO_3}{\text{Eq}^n \text{ weight of } HCO_3} \times [HCO_3^-] + \frac{\text{Eq}^n \text{ weight of } CaCO_3}{\text{Eq}^n \text{ weight of } CO_3^{2-}} \times [CO_3^{2-}]$$

$$= \frac{100/2}{61/1} \times [HCO_3^-] + \frac{100/2}{60/2} \times [CO_3^{2-}]$$

$$= \frac{50}{61} \times 300 + \frac{50}{30} \times 111 \text{ mg/L}$$

$$= 431 \text{ mg/L}$$

13 DAY 195-171 • WK 29 WEDNESDAY

Major Air Pollutants

Ozone (O_3) ⇒

O_3	SO_2
① Photochemical smog	Classical smog
② $O_3 \rightleftharpoons O_2 + O$ — oxidizing smog	Reducing smog
③ Los Angeles smog	• 1952 → London smog

Que.] The New Jersey power company PSE&G has determined that for every 10,000 kW it generates, it must burn approximately 2000 g of coal. The coal used at this particular facility is a form of bituminous coal with the approximate chemical formula $C_{100}H_{85}S_{2.1}N_{1.5}O_{9.5}$. As an engineer, you have been asked to calculate the amount of CO_2

14 DAY 196-170 • WK 29 THURSDAY

and SO_2 discharged into the atmosphere. 1 tons = 2000 lb

Ans.] molecular weight of coal

$$= \frac{100}{12} + (85)(1.00) + (2.1)(32.06) + (1.5)(14.00)$$

$$+ (9.5)(16.00)$$

$$= 1525 \text{ g/mole}$$

⇒ Assuming complete combustion, the stoichiometric equation for the combustion of the coal can now be written:

$$C_{100}H_{85}S_{2.1}N_{1.5}O_{9.5} + 120.1\,O_2 \longrightarrow 100\,CO_2 + 42.5\,H_2O$$

$$+ 2.1\,SO_2 + 1.5\,NO_2$$

⇒ 1525 g of coal produces → 100 × 44 g of CO_2

1 g of coal produces → (100 × 44) ÷ 1525 g of CO_2

JUNE 2016

M	T	W	T	F	S	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

A Power Plant generates 2.78×10^{5} ~~mg~~ megawatt hours (MWh) of electricity per year by burning 1.66×10^{5} tons of a low-grade coal containing 3.2 % Sulfur and 15.4 % ash. The ratio of fly ash ~~to~~ bottom ash is 0.65 and the plant's ~~participate~~ collection efficiency is 85 %. Determine the amount of each particulates emitted per year.

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

e = emission in tons/year
a = mass percent ash content of coal burned
b = ratio of fly ash to bottom ash
c = Coal consumption in tons/year
P = % particulate collection efficiency of the precipitator

$e_{SO_2} = (1.90)(166,000 \text{ tons/yr})(3.2 \times 10^{-2})$
$= 10,100$ tons/yr
$= 20.2 \times 10^{6}$ lb/yr

Converting again
$e_{SO_2} = \frac{20.2 \times 10^{6} \text{ lb/yr}}{278{,}000 \text{ MWh/yr}}$
$= 73.1$ lb/MWh
$= 0.0731$ lb/KWh

Nitrogen oxides:
$e_{SO_2} = (15)(166,000 \text{ tons/yr}) \times 10^{-3}$
$= 2490$ tons/yr
$= 4.98 \times 10^{6}$ lb/yr