

Solid and Hazardous Waste pollution

SOLID WASTE

- arises from various human activities and is normally discarded as useless or unwanted.
- discarded ~~urban~~ material from urban community, accumulation of agriculture, industrial and mining wastes.
- 300 to 600 g solid waste per person.

SOLID WASTE

1. Garbage

- 70% moisture content
- $6 \times 10^6 \text{ J}$ heating value
- produce during preparation of storage of meat, fruit, vegetables etc.
- contains minerals and nutrients

2. Rubbish

- 25% moisture
- $15 \times 10^6 \text{ J/kg}$ heating value
- non biodegradable solid waste
- paper, wood, rubber, metals, glass, ceramics.

3. Pathological Waste

- moisture content: 85%
- $2.5 \times 10^6 \text{ J/kg}$: heating value
- dead animals, humans; hospital waste: syringes, bandages, swabs, body fluids

6. Ashes

- residues of the combustion of solid fuels

↓ - 2 kg per person

5. Agriculture Waste

- agriculture waste include animal manure, crop residues, herbicides, fungicides etc.

4. Industrial waste

- waste from industries.
- coal or ore, mines, electroplating works, textile industry, paper industry, dairies, chemical industry, oil refineries.

1. COMBUSTIBLE

2. NON COMB^T

1. ORGANIC

2. INORGANIC POLLUTANTS

- Principle sources of solid wastes are domestic, commercial, industrial and agricultural activities
- Urban wastes: domestic and commercial waste.
 - ↳ 0.3 to 0.5 kg per person per day
 - ↳ amt. generated, density and ratio of constituents vary widely from place to place.

TREATMENT AND DISPOSAL METHODS (SOLID WASTE)

composition : RURAL - agriculture waste food waste
 URBAN - plastic, glass, metal, chemical,

SOLID WASTE DISPOSAL METHODS

Dumping	sanitary land fill	Incineration (Thermal process)	composting	Recycling & Reuse
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1. Dumping

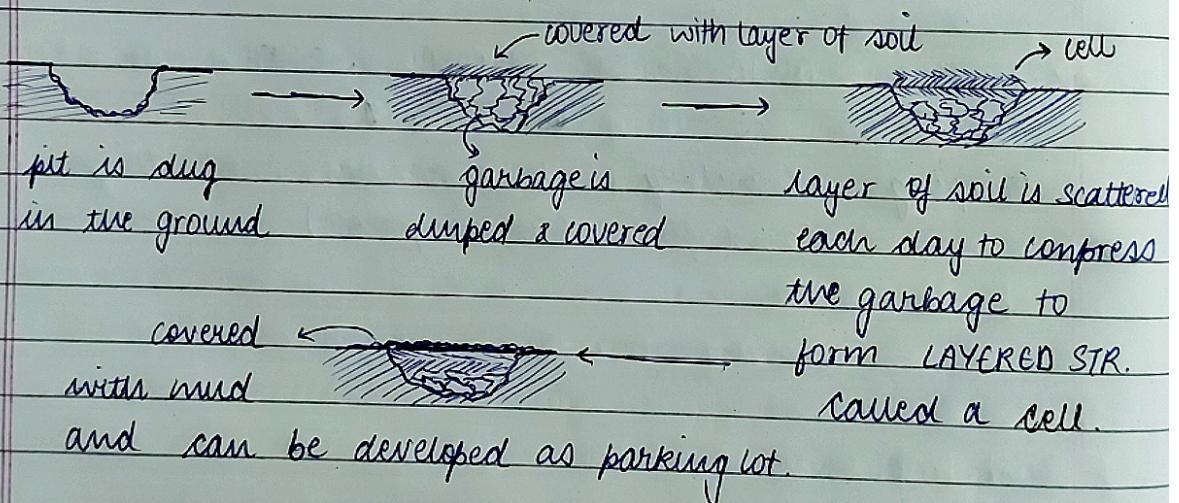
- practiced extensively in India as it reqd. no planning and is cheap.
- OPEN DUMPS: uncovered areas that are used to dump solid wastes that is not segregated.
- breeding ground for flies, rats and insects.
- rain-water run-off contaminates land and water, spreading disease.
- no more used in countries of some countries.

2. Sanitary Landfills

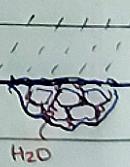
LANDFILLS

- Landfills: main method of disposal

→ convenience → low maintenance cost



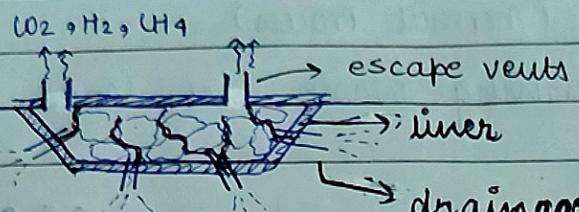
PROBLEMS: 1. When water seeps through the landfill, waste gets contaminated and pollutes the surrounding area.



2. Leaching: contamination of groundwater and soil through landfills.

SANITARY LANDFILLS

- alternative to landfills
- more hygienic
- lined with IMPERMEABLE MATERIALS (liners)
- such as plastic and clay, also built over impermeable soil
- built in methodical manner



drainage system around & beneath the liner to collect liquid leaching from garbage and waste

→ collected lgs are treated to make them environmentally safe?

PHASE 1: ~~aerobic~~ aerobic bacteria deplete available O₂ (respiration)

PHASE 2: anaerobic (~~respiration~~) prevail, H₂ and CO₂ are evolved.

PHASE 3, 4: methane forming bacteria decompose the matter to CH₄ and CO₂ ~~are~~ evolved & passed through vents

PHASE 5: methanogenic (anaerobic breakdown of C) activities decreases,

⇒ system returns to aerobic conditions

PROBLEMS: 1. costly

2. Plastic liner develops cracks

(as it reacts with various chemical solvents in waste).

3. RATE OF DECOMPOSITION is extremely variable.

(less O₂ available in garbage is compact)



4. some ~~biodegradable~~ materials do not decompose.

5. CH₄ gas development (less O₂ present)

→ some countries CH₄ is tapped & used as fuel.

~~ADVANTAGES:~~

1. infections diseases minimized (pests are unable to breed in covered / sealed pits.)

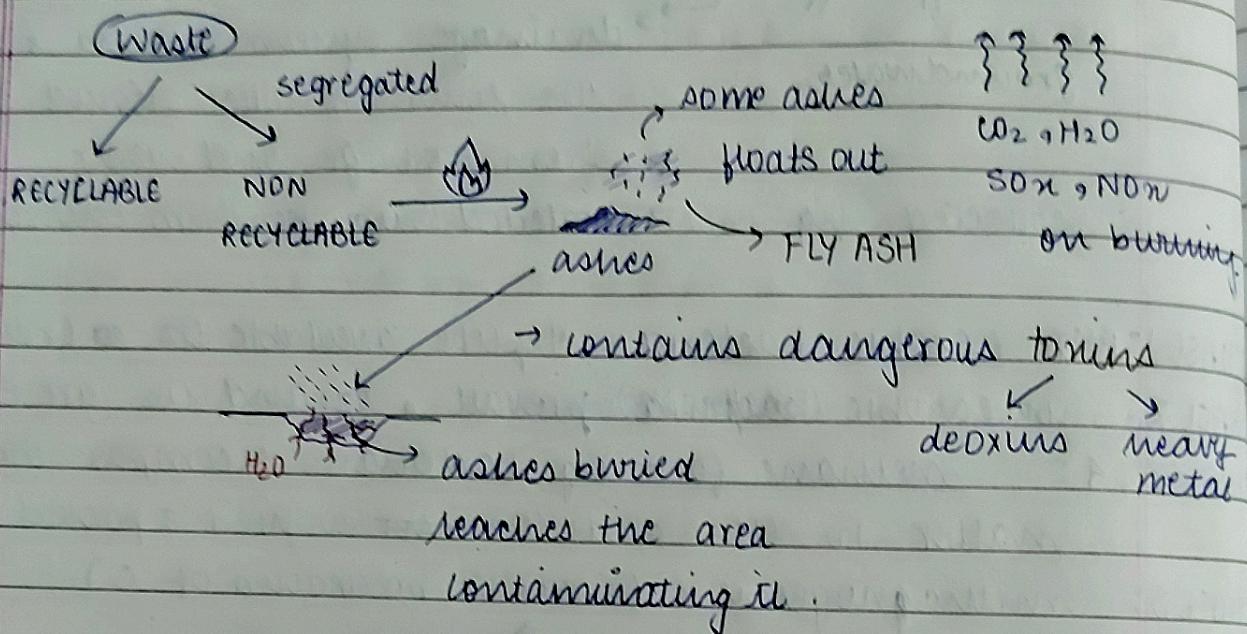
2. NO air pollution from burning.

3. Minimal fire hazards.

(rats, flies etc.)

3. Incineration (Thermal Process)

- process of burning waste in large furnaces



• Incineration is taken as the last resort as burning garbage produces tonnes of toxic ash, it is mainly used for treating INFECTIOUS WASTE.

SOLUTIONS:

- ① - govt. or private operators can
 - installing properly equipped incinrators which
 - convert water → steam energy
 - generate electricity.
 - reducing waste by 90% in vol
75% in wt.
- scrubbers : device that uses liq. to spray to neutralise acid gases in smokes
- filters : remove tiny ash particles
- burning at HIGH TEMP destroys harmful chemical compds & disease causing bacteria
- regular testing ensures residual ash is non hazardous & fit for landfilling.

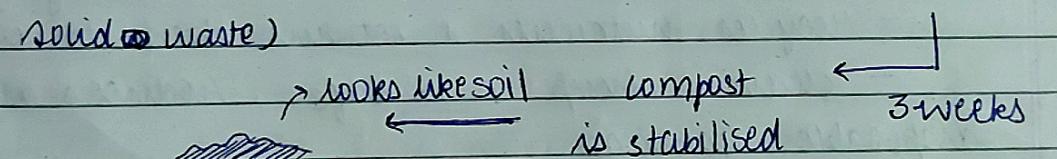
ADVANTAGES

- useful material and energy can be recovered
- solid wastes load converted to small ashes (easy to handle)

4. composting

- anaerobic method of decomposition
- natural process of organic waste that yields manure or compost, rich in nutrients
- microorganisms (fungi & bacteria) convert degradable waste into humus like substance.

Organic waste $\xrightarrow[\text{CO}_2]{\text{Oxidn}}$ $\text{CO}_2 + \text{heat}$: ~~to~~ thermophilic bacteria
(35% - 40% of $T = 45^\circ\text{C}$ continues decomposition
solid waste)



- rich in carbon, (earthy smell, dark brown color)

Nitrogen: excellent
for growing plants

OPTIMUM CONDITIONS

temp: $40 - 50^\circ\text{C}$

→ above this biological activity is reduced. N_2 is lost as NH_3 .

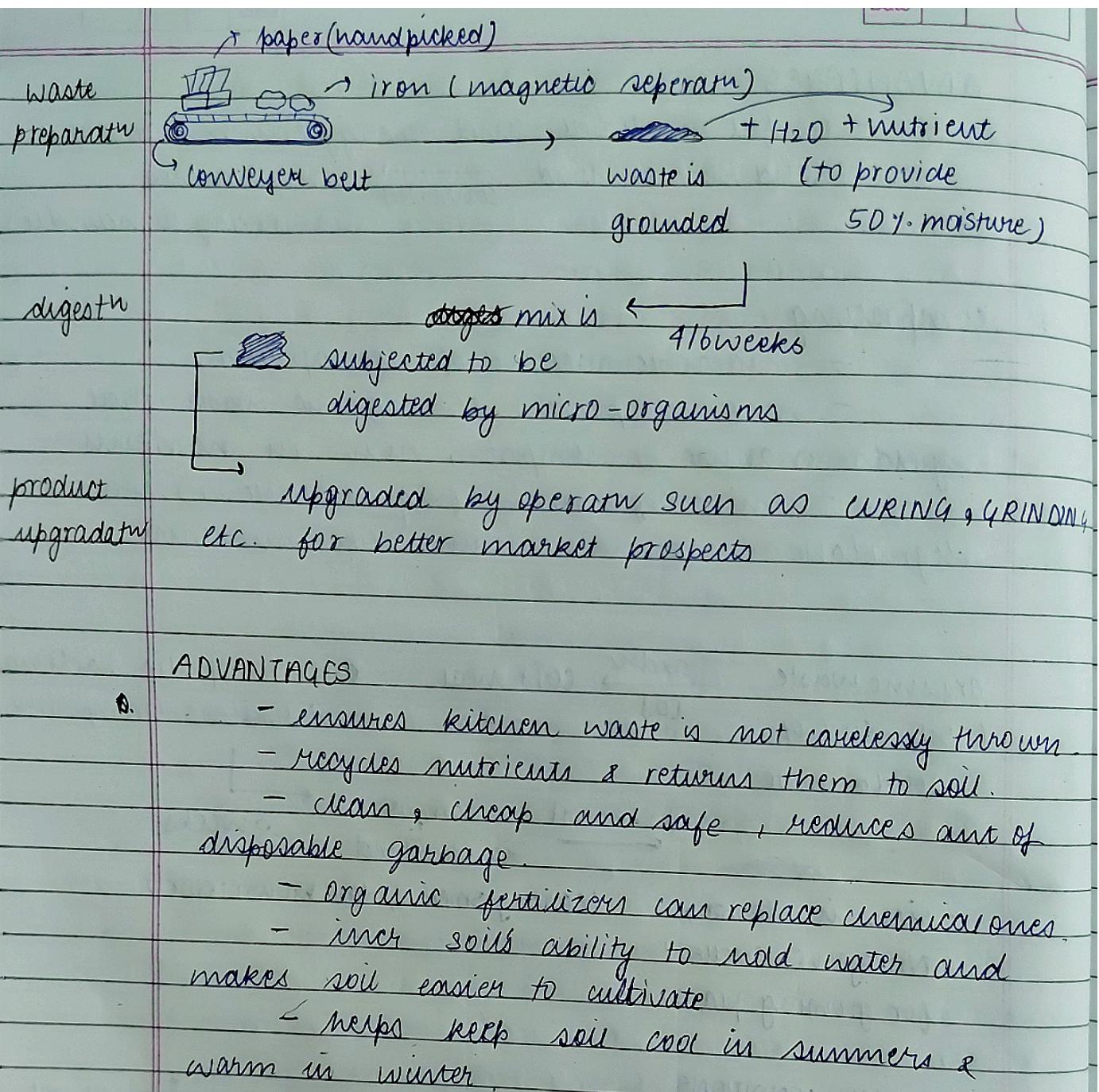
pH = 9.5 to 9.5

air: $40 - 70\text{ l} \cdot (0.5 \text{ to } 0.8 \text{ m}^3 \text{ / day/kg})$

C:N = 35 to 50 : 1

C:P = 100 : 1

Vermicomposting: worms are added to compost
- help to break the waste and add excreta
of the worms makes compost rich in nutrients.



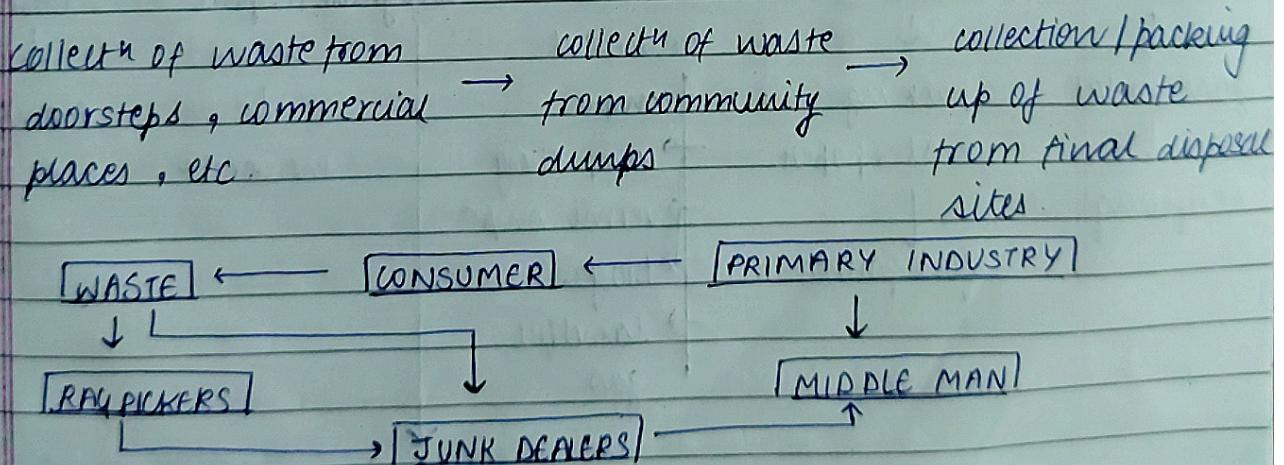
5. Recycling and Reuse

4 R's:

1. REFUSE: refuse to buy new items. use already available stuff.
2. REUSE: reuse stuff / item & don't throw them away
 - used cans, bottles
 - jute shopping bags can be used again & again
3. RECYCLE: segregate waste to make sure that it is collected and taken for recycling
4. REDUCE: reduce unnecessary waste
 - carry your own shopping bags

→ Recycling involves collection of used and discarded materials (steel, Al, Cu in waste), processing these ~~in~~ and making them into new products.

→ 7-15% waste is ~~not~~ recycled only.



ADVANTAGES

- less utilisation of raw materials
- reduce environmental impact
- clean & healthy surroundings - saves money
- prevent meant of waste at the source.

SEGREGATION OF WASTE

BIODEGRADABLE

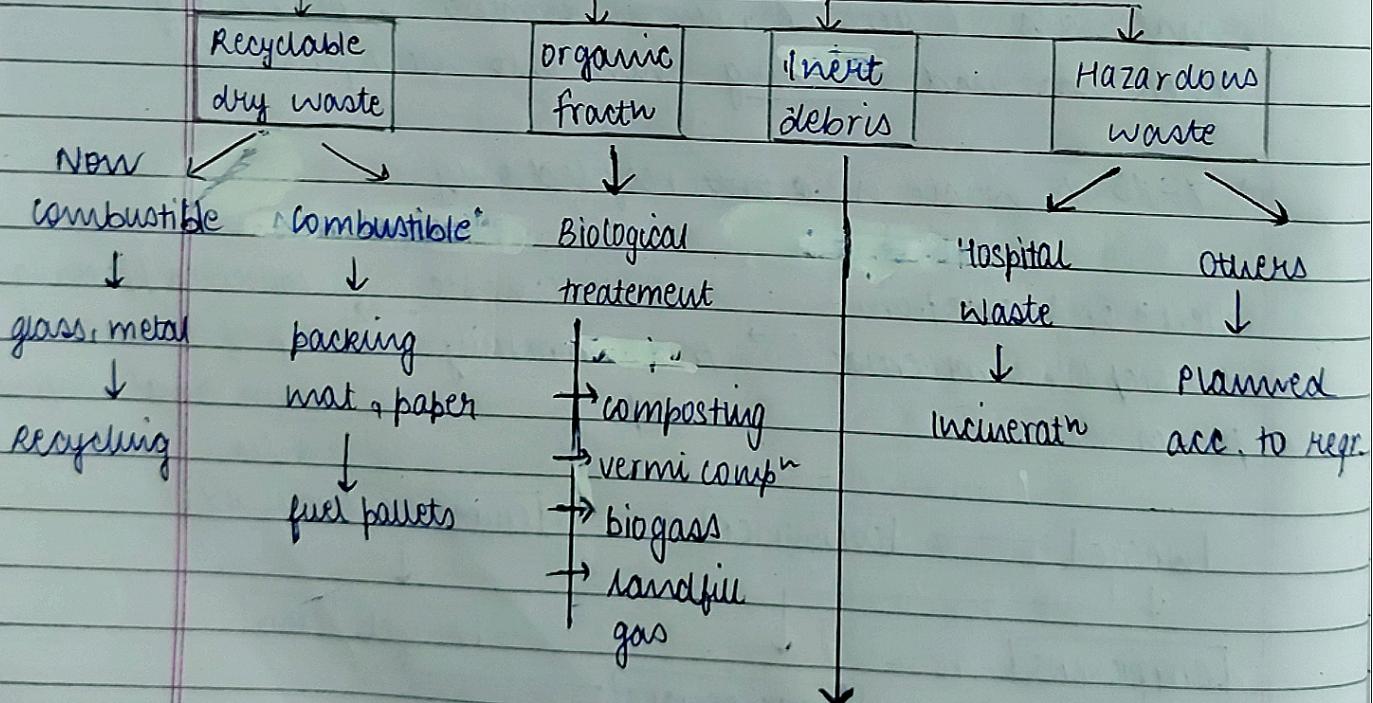
- organic waste
- kitchen waste, fruits, flowers, leaves, paper

NON BIODEGRADABLE

- RECYCLABLE: plastic, metal, glass
- TOXIC: old medicines, paints, chemicals, bulbs, spray cans, fertilizers, pesticides, batteries, shoe polish
- SOILED: hospital waste like cloth soiled with blood & other bodily fluids

MUNICIPAL SOILED WASTE

SEGREGATED AT SOURCE



low grade construction
paving of roads.

HAZARDOUS WASTE → waste that could pose a threat to human health and the environment, if managed improperly.
 → any waste which b/c of its QUANTITY, CONC, or PHYSICAL, CHEMICAL or INFECTIOUS char, may cause significant hazard to human & environment.

EFFECTS

- increase in mortality
- inc in serious, irreversible or incapacitating reversible illness.
- potential hazard to human health

EFFECTS:

CHARACTERISTICS OF HAZARDOUS WASTE

Reactivity

- unstable at normal cond'n → cause explosive rxn
- cause explosive rxn
- strength of toxic fumes, gases & vapours.

eg: Na, K metal,
 dry picric acid,
 cyanide (CN^-) plating off,
 compd forming explosive peroxides.

Corrosivity

- liquids with $pH < 2$ or $pH > 12.5$
- capable of corroding metal
 eg: H_2SO_4 , HCl , $NaOH$,
 OH^- , lime $Ca(OH)_2$,
 battery acid, drain openers etc.

Tonicity

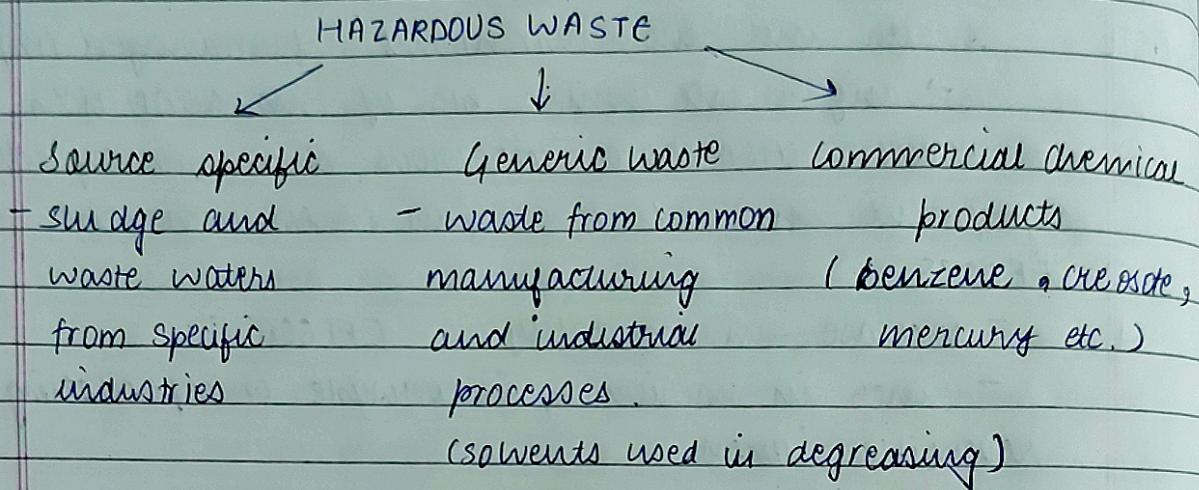
- release toxic materials on leaching in excess
- measured by TCLP:
 Tonicity characteristics

Leaching Procedure

- C_6H_6 (petroleum products),
- Cd (Ni-Cd batteries)
- Pb (Pb batteries, paints)
- Ag (photofixer, silver mercury)
- Cr, Hg (Hg batteries),
- rat poison, antifreeze

eg: volatile liq, solvents (acetone, toluene, CH_3OH , ethers etc), rubber, cement, glue, paint thinners etc.

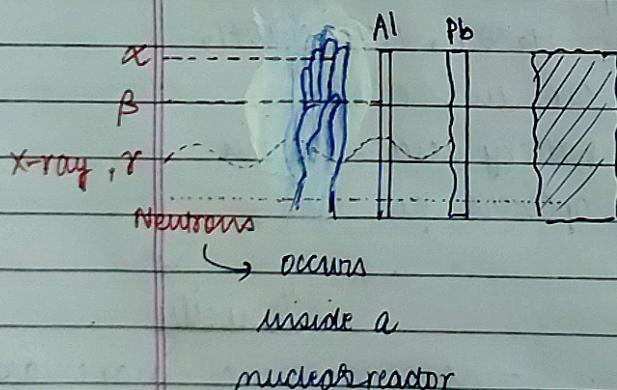
EPA: Environment Protection Agency



INDUSTRIAL PROCESSES

1. Radiochemical waste

- Radioactivity arises naturally from decay of some isotopes.
 - ↳ some are radioactive, some are not.



α : dangerous to lungs, cannot penetrate through skin, paper.

β : blocked out by Al.

γ : blocked by Pb

1. SOURCES

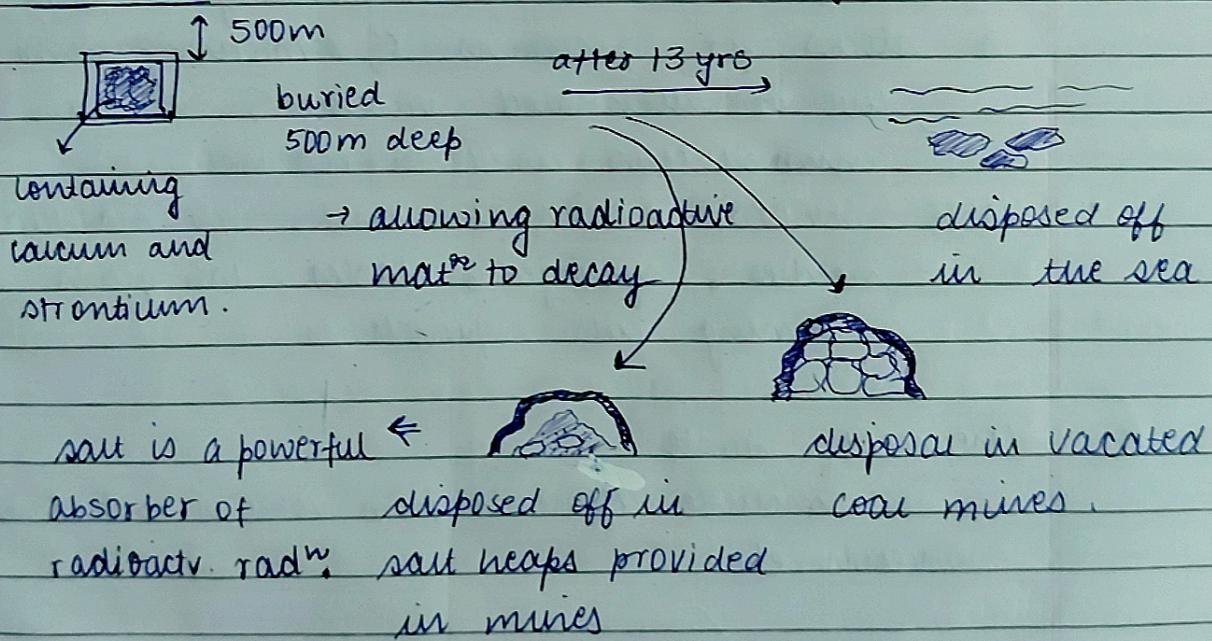
- discharge from nuclear rxn.
- mining & ore processing
- industrial use of nuclear energy
- leakage from underground detonations
- use of radioisotopes in medicine industry, agriculture & research operatn.
- nuclear weapons
- nuclear bombs

2. EFFECTS

- damage living organisms
- Somatic damage : damage to organism, resulting in sickness or death. effects appear immediately after exposure. (usually in form of cancer, years later)
- Genetic damage : damage which passes through one genⁿ to next. affects CHROMOSOMES causing mutation in genes

3. METHODS OF DISPOSAL

- Disposal in ground : soil absorbs radioactive material easily.



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2. Biomedical waste

- waste generated by human or animal healthcare facilities, medical or veterinary and teaching, healthcare establishments,
- HUMAN ANATOMICAL WASTE : tissues, organs, body parts, (doesn't include teeth, hair, nail)
- ANIMAL WASTE : tissues, organs, fluid blood and blood products, body fluids contaminated with blood, body fluids removed for diagnosis or surgery, items dripping with blood.
- MICROBIOLOGY LAB WASTE : laboratory cultures, stocks for specimens of a microorganism, live or attenuated vaccines, human or animal cells used in research.
- WASTE SHARPS : clinical and lab material, needles, syringes, blades, lab glass causing cuts & punctures.

3. Chemical waste

- include effluents from various industries, solvents etc.

TREATMENT & DISPOSAL METHODS (HAZARDOUS WASTE)

RCRA: Resource Conservation and Recovery Act

TREATMENT OF HAZARDOUS WASTE

Physical Process	Chemical Process	Biological Process	Incinerat ⁿ	Land disposal
→ Sedimentation	→ Neutralizat ⁿ			→ Landfills
→ Adsorption	→ Chemical precipitat ⁿ			→ Surface impoundment
→ Aeration				→ Underground injections
→ Reverse Osmosis	→ Oxidation			
→ Ion exchange process				
→ Electro dialysis				

1. PHYSICAL PROCESSES

- gravity sepⁿ, phase change systems,
(air & steam coming out of volatiles from big wastes)
and various filtering operatn.

SEDIMENTAT^N : • involves gravity settling & natural floating
• separate solids from liquids

sedimentat^N tanks → solid floating on surface removed by
skinning device.

→ floatation is ~~not~~ encouraged

by introducing finely divided

✓ bubbles into waste stream.

when the bubble rise -

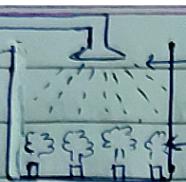
they collect the particles & the combinatn
is skinned out.

ADSORPTN : • dissolved hazardous subst that would never settle
out can be removed by this technique

contaminant → absorbents (granular activated carbon) SA: $1000 \text{ m}^2/\text{g}$
water ← GAC Filter: gets clogged by contaminants
filtered water
and is regenerated, an expensive process.

→ regeneration is done by burning the contaminants
from surface of the absorbent granules or using a
solvent. Carbon filters which cannot be regenerated
due to contaminant composition must be disposed off.

AERATION : • process typically use the process of aeration to drive
the contaminants out of solution.



contaminated water sprayed down through packing material in a tower.

- blown up carrying away the chemical that are relatively volatile.

→ This process removes 95% of VOCs (volatile organic compounds) such as ~~CO₂~~ $\text{C}_2\text{H}_5\text{CH}=\text{CH}_2$, $\text{C}_2\text{H}_5\text{CH}=\text{CH}_2$, C_6H_6 , $\text{C}_6\text{H}_5\text{CH}_3$ etc.

→ sometimes ~~and~~ ADSORPTION is combined by AERATION and many volatile and non volatile compds are removed

A AERATION → ADSORPTION

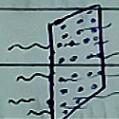
↳ this extends the life of carbon b/c no clogging with volatile compds take place.

REVERSE
OSMOSIS

contaminated
water

semi

permeable
membrane



hazardous chem left
behind,

ION
EXCHANGE

special exchange ~~ion~~ resins are used to remove toxic substances from waste water.

ELECTRO
DIALYSIS

for purifying brackish water, is also used to remove hazardous substances.
Metal ~~salt~~ salts from electroplating rinses are removed this way.

2. CHEMICAL PROCESSES

- hazardous waste is converted into less hazardous form ~~and~~ and sometimes useful products are formed.

NEUTRALIZAT^N: • hazardous material : $\text{pH} < 2$ or $\text{pH} > 12.5$

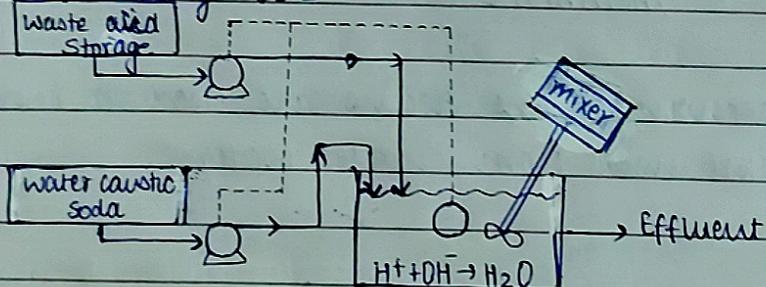
Neutralizat converts these material to less hazardous.

ACIDIC: neutralized by $[\text{Ca}(\text{OH})_2]$

→ the waste water is continuously stirred with $\text{Ca}(\text{OH})_2$ in chemical reactor.

→ The rate of addition of lime is controlled with FEEDBACK CONTROL SYSTEM that monitors pH and adjust the feed.

ALKALINE: neutralised by adding acid directly or by bubbling CO_2



CHEMICAL PRECIPITAT^N: - removing heavy metals from liquid.
• pH dependant

pH of waste water
is adjusted that
solubility of toxic
metal decreases

\rightarrow ppt is formed

removed by
settling or
filtration



lime

insoluble

hydroxide

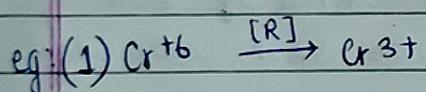
- waste contains several metals: more than one stage precipitation of a mix
- metal is present in low conc.: then metals are precipitated as sulphides as they have less solubility (ppt) only disadvantage: H_2S toxic gas may be formed if alkalinity is not maintained
- Pb, Cd and Ni precipitate as carbonates.

OXIDATN

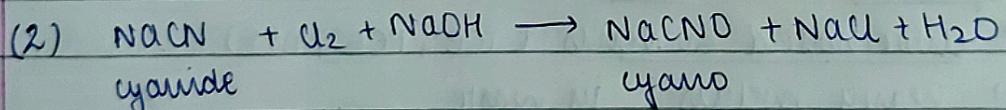
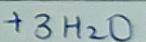
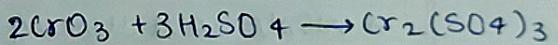
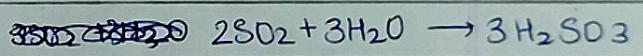
REDNCTN:

PROCESS

• oxdⁿ states subst. convert
have diffⁿ → to oxdⁿ state
tonicity which is less toxic. (by oxdⁿ redⁿ process)

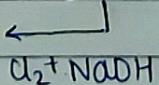
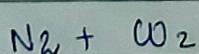


(less toxic)



cyanide

cyano



(complete destⁿ
of cyanide)

- U^{+4} , Hg, Pb, Ag, cl organics

3. BIOLOGICAL PROCESSES

- microorganisms oxidizes organic matter to $\text{CO}_2 + \text{H}_2\text{O}$

micro-organism
(survive on N, P,
C and energy)

they get C and energy
from other organisms that
are susceptible to toxic subst.

Site biodegradation : bacteria degrade org. compd in soil and groundwater on the site itself

M1 → organism already exist in soil and groundwtr, nutrients are provided to it

M2 → population of microorganism is altered by seeding with new micro orgn.

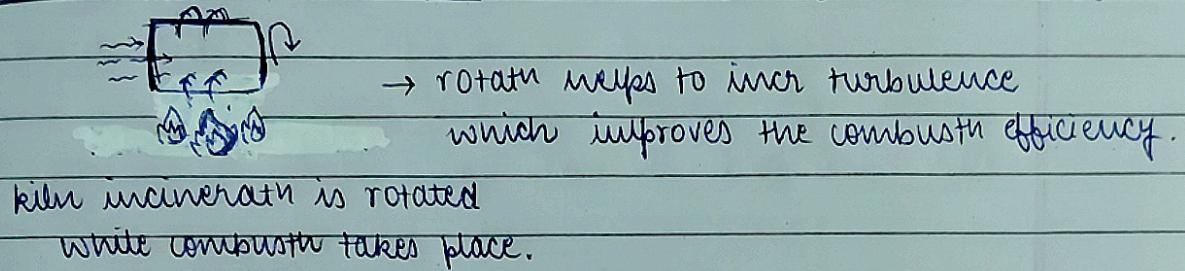
→ waste containing gasoline and diesel is treated.
→ chlorinated solvents (TCE, PCE, DCE)
→ heavy metals in waste

4. INCINERATION

- effective with org. containing hazardous subst: carcinogens (causing cancer), mutagens (causing mutation), teratogens (causing birth defects)
- not all inorganic compds are not destroyed
- volatile subst. at $T < 2000^\circ\text{F}$ get added in air and causes air pollution.
- DRE (destruction and removal efficiency)
DRE of 99.99% means that 1 molecule of an org. compd is released to the air for every 10,000 molecules.

LIQUID INJECTION INCINERATOR: waste contⁿ gases, liquids, and slurries are pumped through an atomizing nozzle. \Rightarrow Resulting mix is mixed with air & fuel gas burned at high T.

ROTARY KILN INCINERATOR: all waste can be treated.



→ Emission include unburned organic compd. : CO₂, N₂, SO_x

5. DISPOSAL OF e-WASTE

- discarded computers, office electronics, devices, mobiles, television sets, refrigerator.
- ewaste destined to for reuse, resale, salvage, recycling or disposal.

Substances in e-waste:

1. CRT : Pb, Cd, Be, Br flame retardants
2. Hg : fluorescent tubes, tilt switches (doorbells, thermostats)
3. S : Lead acid batteries
4. Ca : light sensitive resistors, corrosion resistance alloys, Ni-Cd batteries.
5. Pb : solder, CRT monitor glasses, Pb acid batteries, PVC
6. Cooling & freezing subst : ozone depletn subst, CFCs, HCFCs.

Recycling

e-waste → collect → dismantling → pre processing → end processing