ENVIRONMENTAL POLLUTION

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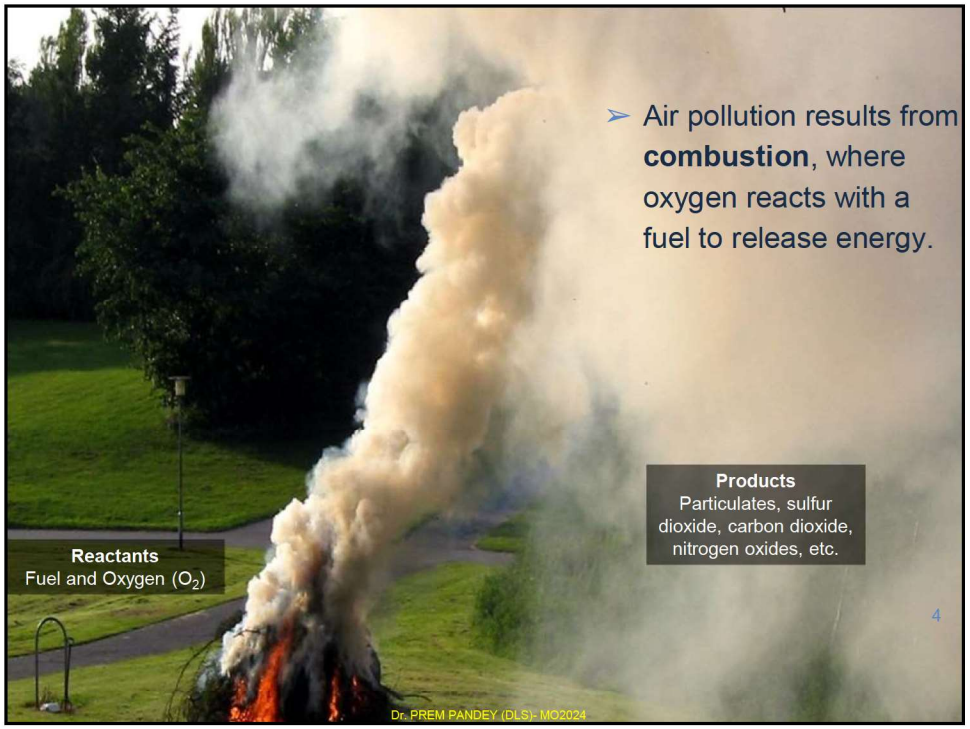
Environmental Pollution

- Any undesirable changes in physical, chemical or biological characteristics of any component of the environment, which can cause harmful effects on various forms of life or property.
- Pollution: Influence of any substance causing nuisance, harmful effects and uneasiness to organisms.
- Pollutants: any substance causing nuisance or harmful effects, then that particular substance may be called pollutants.
  - These are unwanted or undesired substances

Air Pollution

When harmful substances contaminate the environment

Refers to the very bad condition of environment in terms of quantity and quality



- Air pollution results from **combustion**, where oxygen reacts with a fuel to release energy.

Reactants
Fuel and Oxygen (O_2)

Products
Particulates, sulfur dioxide, carbon dioxide, nitrogen oxides, etc.

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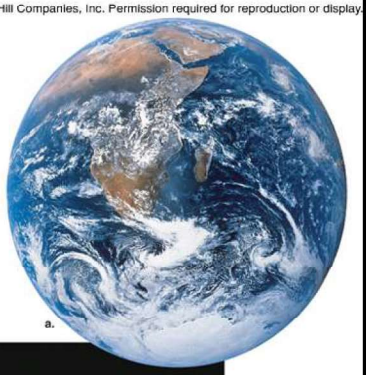
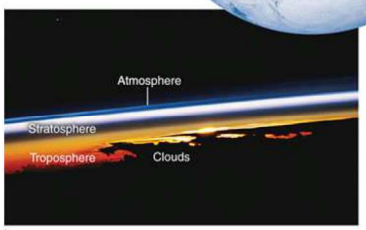
The Earth's Atmosphere

Our atmosphere = the air (specific mix of gases) around us

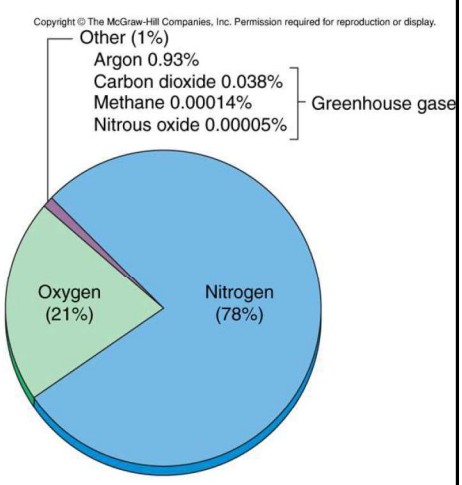
- Protects Earth from harmful solar radiation, and incoming projectiles, asteroids, etc.
- Lower atmosphere – touches surface of Earth
- Upper atmosphere – gradual transition into space
- Observed from space the atmosphere is a thin shell around Earth





The Earth's Atmosphere

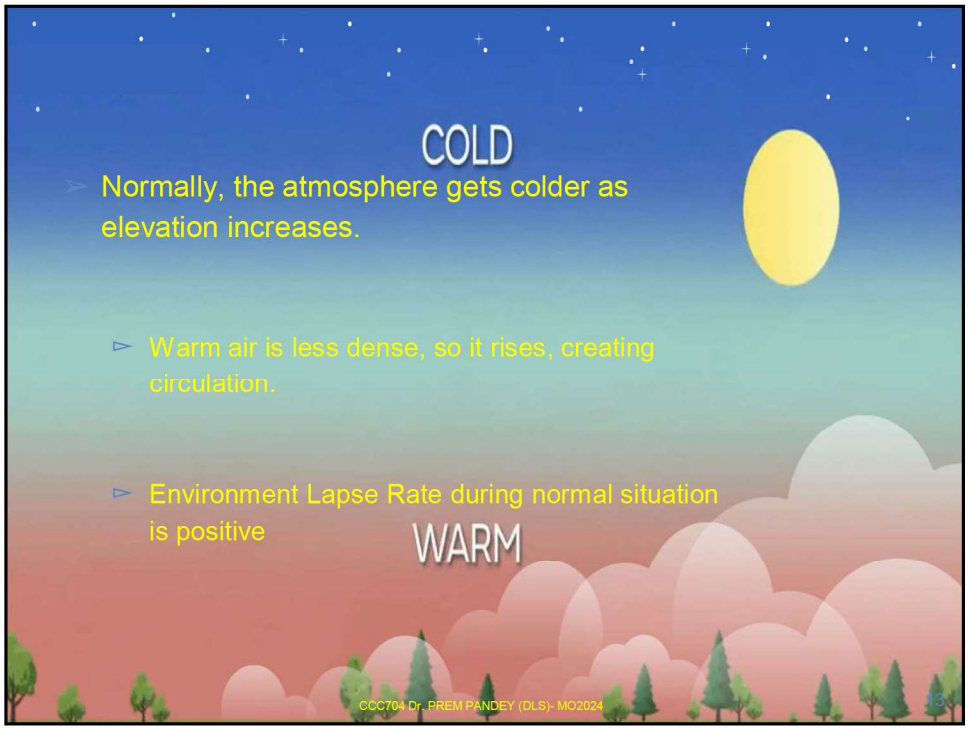
- What is the atmosphere made of?
  - Mostly Nitrogen and Oxygen
  - CO_2 is a small component but plays a large role in the greenhouse effect
  - Water vapor in the air can range from 0% over deserts to 7% in humid climates



1. Atmosphere

- Composition of each layer.
- Gravity holds 99% of atmospheric gases within 32 km of the Earth's surface
- The density of air rapidly decreases with increasing altitude.
- The accepted boundary with space is 100 Km above Earth's surface.
- Few gas molecules exist there

- The **thermosphere blocks harmful radiation from the sun. Radio-Communications possible.**
- The **mesosphere** is the layer where meteors and asteroids burn up as they approach Earth.
- The **stratosphere** has a layer of ozone that partially blocks some of the sun's UV light.
- The **troposphere** contains all of our weather, and all living organisms.
  - Air cools rapidly as the altitude increases.


COLD
Normally, the atmosphere gets colder as elevation increases.
Warm air is less dense, so it rises, creating circulation.
Environment Lapse Rate during normal situation is positive
WARM
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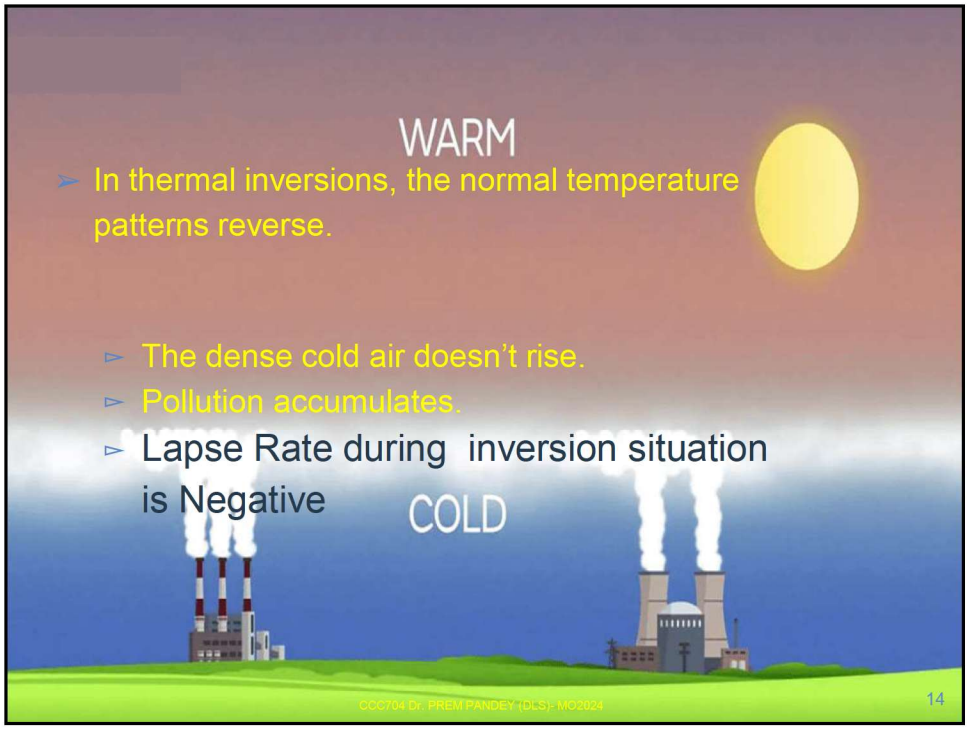
WARM
In thermal inversions, the normal temperature patterns reverse.
The dense cold air doesn't rise.
Pollution accumulates.
Lapse Rate during inversion situation is Negative
COLD
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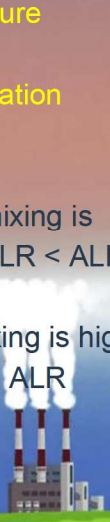
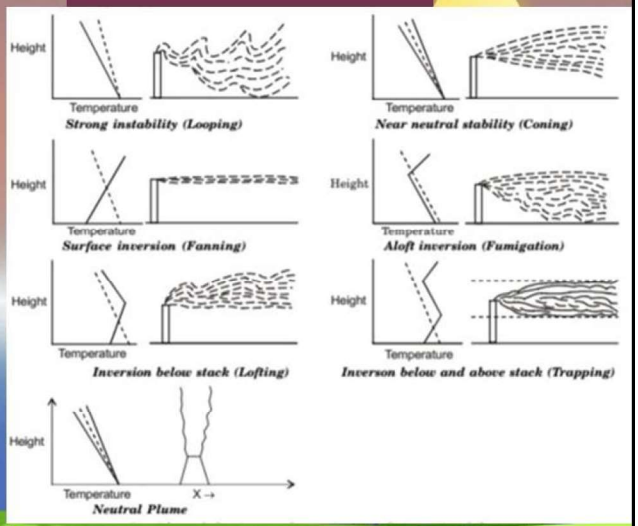
- **Meteorological Factors effecting Air Pollution**
  - Rainfall
  - Wind speed
  - Temperature
  - Humidity
  - Solar radiation

- Vertical mixing is less When ELR < ALR

Pollutant mixing is high When ELR > ALR



- Plume behaviour-



ELR – Environmental Lapse Rate
ALR Adiabatic Lapse Rate

- Urban atmosphere on a normal day:

Air Pollution

Air pollutants can be classified:

1. Natural pollutants
2. Primary pollutants
3. Secondary pollutants

Air Pollution

Since air is essential for survival, it must be kept clean and free of pollutants, like:

- oxides of carbon,
- oxides of Sulphur, and
- oxides of nitrogen.

- Discharged into the atmosphere through industrial waste units and by burning of fuels in automobiles (fossil fuel) or even bio-fuels and biomass.
- Air pollution severely affects human health;
- Responsible for acute and chronic respiratory problems such as lung infections, asthma, and even cancer.

It is also responsible for acid rain in megacities

Pure Fuels	"Dirty" Fuels
Only contain the fuel.	Additional non-combustible elements mixed in with the fuel.
Release carbon dioxide and water vapor as products.	Release many forms of air pollutants.
Methane, gasoline, ethanol	Coal, oil, wood

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AIR POLLUTION

Air pollutants can be classified:

1. **Natural pollutants**

Volcanic eruptions can generate so much polluting gases and ash into the air that the sun's rays could be blocked, and land temperature in the affected area lowered, as with the Mount Pinatubo eruption in 1991.

All **forest fires** emit **carbon monoxide**, **sulfur dioxide**, **nitrogen dioxide**, **ozone**, and particulate matter.

Natural pollutants

Natural pollutants are the result of natural phenomena

- **Forest fires started by lightning**
- **Dispersal of pollen, soil erosion and volcanic eruptions**
- **Discharge of volatile organic compounds (VOCs) from leaves and trees**
- **Decomposition or putrification of organic matter, dead organisms, etc.**
- **Natural radioactivity**

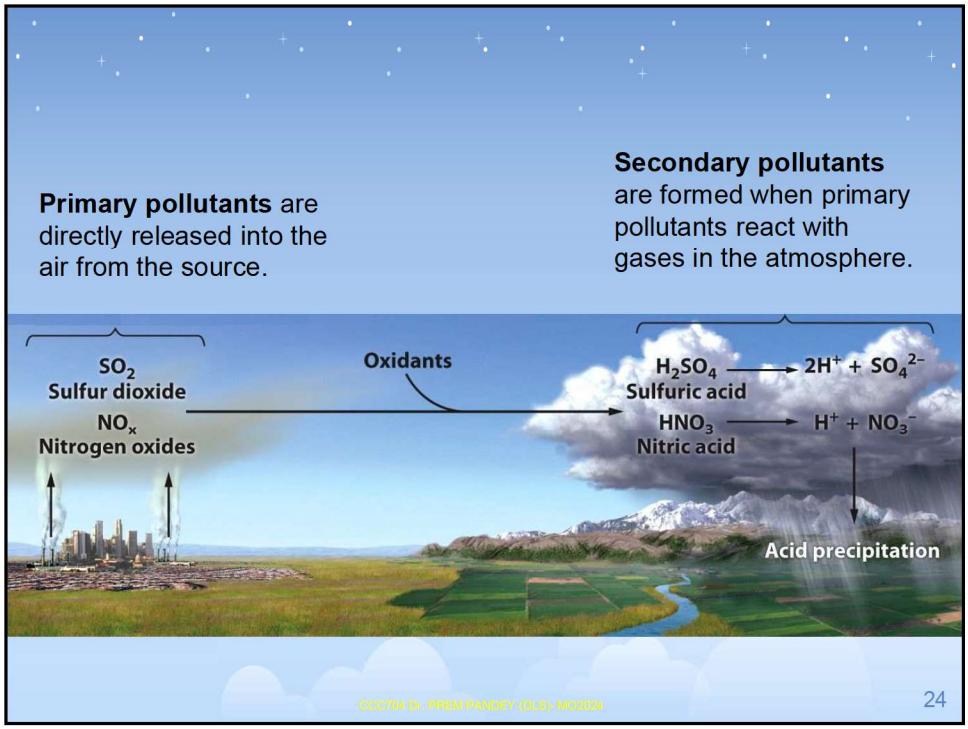
Primary pollutants:

2. Primary pollutants: Primary air pollutants are emitted directly into the air from sources.

Primary pollutants such as CO, CO2 are emitted directly into the atmosphere from fossil fuel and bio-fuel burning; others are NOx, SO2, hydrocarbons, and SPM.

They can have effects both directly and as precursors of secondary air pollutants (chemicals formed through reactions in the atmosphere).

Examples, SO2, NO, NO2, CO, Volatile compounds



Secondary pollutants:

3. Secondary pollutants are formed from the primary by further chemical reaction in the atmosphere

- $2SO_2 + O_2 = 2SO_3$
- $SO_3 + H_2O = H_2SO_4$

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Secondary pollutants:

Examples of a secondary pollutant include ozone.

NO2, which is formed as NO combines with oxygen in the air;

Acid rain, which is formed when sulphur dioxide or nitrogen oxides react with water to form Sulphuric Acid.

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Major air pollutants- gaseous

Oxides of Carbon (CO2, CO)

- Source: Combustion of coal, oil and other fuels for production of energy. Manufacturing and transport, biomass burning
- Effect: CO2 plays a major role in greenhouse effect. Produces weak carbonic acid adding to acid rain.
- CO affects human health by binding to haemoglobin, which may result in asphyxia; haemoglobin has 250 times more affinity for CO as compared to O2

Oxides of Carbon (CO2, CO) -gaseous

Health effect: for CO

- Headache,
- weakness,
- fatigue and drowsiness,
- asphyxiation, fatal in large doses.

- Impairment of O2-carrying capacity of blood flow;
- aggravates health disorders.

Adverse effects on central nervous system, perception and reflexes. Vision and brain damage

Major air pollutants -gaseous

Oxides of Sulfur (SO2, SO3)

- Source: Combustion of sulfur-containing fuel, such as coal, petroleum extraction and refining. Paper manufacturing; ore smelting for metal extraction
- Effect: SO2 has minimum deleterious effects as it can cause severe damage to human and other animal lungs and is an important precursor to acid rain; causes corrosion of paints and metals, injury or death to animals and plants

Oxides of Sulfur (SO2, SO3)

Health effect:

- irrigation to eyes, nose, and mucous lining;
- shortness of breath,
- cough and choking;
- tissue fluid accumulation, swelling (edema);
- chronic bronchitis,
- pulmonary fibrosis,
- acute and chronic asthma;
- aggravation of pre-existing heart and lung diseases

Major air pollutants -gaseous

Oxides of Nitrogen (NO, NO2, N2O)

- Source: Burning of fuels; biomass burning; by-product in the manufacture of fertilizers; by-product during nitration process such as manufacturing of Trinitrotoluene (TNT)
- Effect: Form secondary pollutants;
  - Peroxy acetyl nitrate (PAN)- Lachrymatory substance: it irritates lungs and eyes.
  - Nitric acid (HNO3); Acid rain
- Suppression of plant growth; tissue damage; irritation to eyes,

Oxides of Nitrogen (NO, NO2, N2O)

Health effect: for NO2

- Irritation of eyes;
- irritation to respiratory tracts,
- edema of respiratory tract;
- reducing lung function; reduction in oxygen-carrying capacity of blood,
- diminished pulmonary function;
- slow immune response;
- prone to vivid infection

Major air pollutants -gaseous

Hydrocarbons, VOCs (Methane, Ethane, Propane, Butane, Ethylene, Benzene, Benzopyrene)

- Source: Evaporation from gasoline tanks, carburettors, burning of fuels, biomass, microbial activity of sewage, industrial process involving solvents
- Effect: May be *carcinogenic to humans;* higher concentration are toxic to plants and animals; some are more reactive and produce photochemical smog on reaction with sunlight

Hydrocarbons, VOCs (Methane, Ethane, Propane, Butane, Ethylene, Benzene, Benzopyrene)

Health effect: for CH4 and C2H6

- Coughing,
- eye irritation,
- drowsiness

polycyclic aromatic hydrocarbons including benzene and benzopyrene are ***carcinogenic*** and can be fatal

Major air pollutants-Solids

Suspended Particulate Matter (SPM) solid particles, dust, soil, sulphate salts, soot, silica [aerosols]

- Source: Fuel combustion, building construction, mining, thermal power plants, stone crushing, industrial processes, forest fires, refuse incineration
- Effect: Chronic effects on respiratory system; deposition on the surface of green leaves thus
  - interfering with absorption of CO_2 and release of O_2;
  - blocking of sunlight;

  Particles of size ranging 0.1-10 um cause greatest lung damage (PM_{10} and $PM_{2.5}$)

Suspended Particulate Matter (SPM) solid particles, dust, soil, sulphate salts, soot, silica [aerosols]

Health effect:

- Irritation to throat and respiratory tract,
- effects on lungs,
- decreased pulmonary functions;
- stress on heart;
- carcinogenic affects;
- premature mortality,
- death from respiratory illness and cardiovascular failure

Major air pollutants

Photochemical oxidants O_3, Peroxyacyl Nitrates (PANs), formaldehyde (CH_2O), Acetaldeyde (CH_3CHO), Hydrogen peroxide (H_2O_2), Hydroxyl radical (HO)

- Source: Photochemical reactions in the atmosphere that involve sunlight, oxides of nitrogen and hydrocarbons
- Effect: Haze and smog production; irritation to eyes, nose and throat; respiratory problems; blocking on sunlight
- Health effect: Similar to above

Major air pollutants

Pollutants obtained from burning of fossil fuels and bio-fuels.

Pollutants	Source	Toxic gases
Carbon monoxide	Combustion of coal and petrol	Toxic gas
Carbon dioxide	Combustion of coal and petrol	Carbon dioxide is a non-toxic gas. It is considered as greenhouse gas
Sulphur dioxide	Combustion of coal and petrol	Causes suffocation and affects lungs
Oxides of nitrogen Nitrogen oxide and Nitrogen dioxide	Combustion of coal and petrol	Both are toxic, but nitrogen dioxide is more harmful for humans and plants
Particulate matter	Combustion of coal and petrol	Affects lungs

Air Pollution in India

Air Pollution in India is estimated to kill **1.5** million people every year; it is the fifth largest killer in India.

India has the world's highest death rate from chronic respiratory diseases and asthma, according to the WHO.

In Delhi, poor quality air damages irreversibly the lungs of 2.2 million or 50 percent of all children.

Delhi-NCR air pollution

- The air quality in Delhi according to a WHO survey of 1600 world cities, is the worst of any major city in the world.
- Two other cities in India have worse air quality than Delhi:
  - Gwalior in Madhya Pradesh, and
  - Raipur in Chahhattisgarh.
- Delhi-NCR air pollution has reached alarming levels.
- Delhi's Air Quality Index is at 500+ (hazardous stage).
- The level of particulate matter is at 955 u g/m3 which is 16 times higher than the permissible limit.

Causes of poor air quality in Delhi

- Motor vehicle emissions are one of the causes of poor air quality.
- According to some reports, 80 per cent of $PM_{2.5}$ air pollution is caused by vehicular traffic, though other reports suggest the percentage is lower.
- Other causes include wood-burning fires, fires on agricultural land, exhaust from diesel generators, dust from construction sites, construction waste dumping, road dividers and burning garbage. and illegal industrial activities in Delhi.

Causes of poor air quality in Delhi

The Badarpur Thermal Power Station, a coal-fired power plant built in 1973, is another major source of air pollution in Delhi.

Despite producing less than 8% of the city's electric power, it produces 80 to 90% of the particulate matter pollution from the electric power sector in Delhi.

Causes of poor air quality in Delhi

- During the Great smog of Delhi in **November 2016,** the Badarpur Power Plant was temporarily shut down to alleviate the acute air pollution, but allowed to restart on **February 1, 2017.**
- But now it has been closed permanently.

Union Carbide, Bhopal Disaster in 1984

The Bhopal disaster, also referred to as the Bhopal gas tragedy, was a gas leak incident in India, considered the world's worst industrial disaster.

Pesticide Sevin (UCC's brand name for Carbaryl) using methyl isocyanate (MIC) as an intermediate;

MIC leaked and resulted in the disaster.

Union Carbide, Bhopal Disaster in 1984

It occurred on the night of 2–3 December 1984 at the Union Carbide India Limited (UCIL) pesticide plant in Bhopal, Madhya Pradesh.

Over 500,000 people were exposed to methyl isocyanate (MIC) gas and other chemicals. The toxic substance made its way into and around the township located near the plant.

Union Carbide, Bhopal Disaster in 1984

- Estimates vary on the death toll. The official immediate death toll was 2,259. The Government of Madhya Pradesh confirmed a total of 3,787 deaths related to the gas release.

Fog, Haze, Smog

Mist and fog are caused by water droplets suspended in the air, and the only difference is how far you can see.

Haze is the reflection of sunlight off air pollution.

Haze and Smog results from pollutants.

Visibility

Fog and mist are due to water droplets in atmosphere.

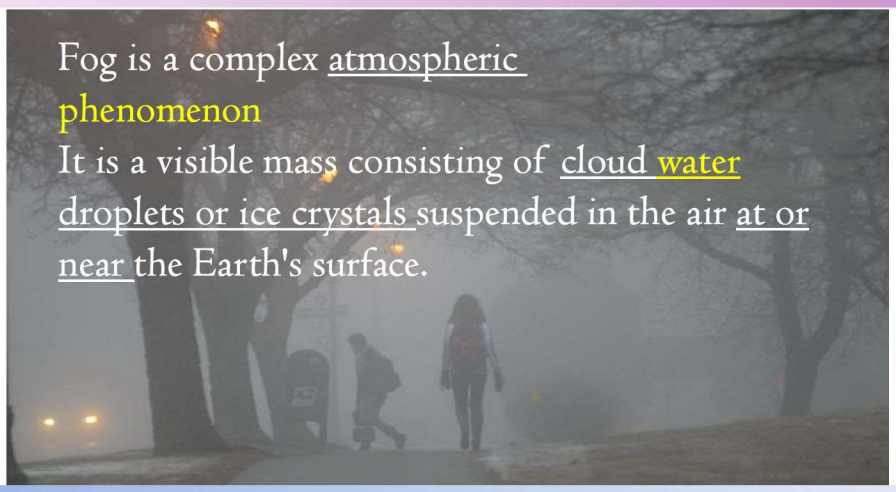
Whereas, haze is due to air pollutants.

Visibility-

- FOG- less than 1 Km (even less than 50 to 100 m sometimes)
- Mist- between 1 to 2 km
- Haze- more than 2 to 5 km.

Fog Mist Haze

Fog, Haze, Smog



- Fog and mist are types of "hydrometeors", or water based things in the atmosphere like rain.
- Haze and other things like smoke and dust are "lithometeors".

Fog

- Fog can be considered a type of low-lying cloud and is heavily influenced by nearby bodies of water, topography, and wind conditions.
- In turn, fog has affected many human activities, such as shipping, travel, and warfare.

Fog in Ganges Basin

- Every year, fog formation over Indo-Gangetic Plains (IGP) of Indian region during winter months of December-January is believed to create numerous health hazards (fog with other pollutants), economic loss and cross-country transportation of aerosols.
- In winter, ground temperatures are lower than those of the upper atmosphere layers, inhibiting the dispersion of air and pollutants and thus, the cool outside air will cause moisture to condense in to fog.

SMOG

Smog is a kind of air pollution, originally named for the mixture of smoke and fog in the air.

Classic smog results from large amounts of coal burning in an area and is caused by a mixture of smoke and sulfur dioxide, Ground-level ozone, and other gases.

Smog

Classic smog results from large amounts of coal burning in an area and is caused by a mixture of smoke and sulphur dioxide.

In the 1950s a new type of smog, Photochemical Smog was came to existence.

Threat of air pollution to health during some severe episodes:

1)Donora smog, US (1948),

2) Great London smog (1952)

a. London Type SMOG

- This type of smog comes from coal smoke combining with the water vapor and liquid water in cool, humid or foggy air.
- Term coined by Dr. Henry Antoine Des Voeux in his 1905 paper, "Fog and smoke".
- The Great Smog of 1952 darkened the streets of London and killed approximately 4,000 people in the short time of four days (a further 8,000 died from its effects in the following weeks and months).
  - Requires humid/foggy, stagnant air
  - have lots of coal burning, or similar activities
  - $SO_2 + H_20 \rightarrow H_2SO_4$

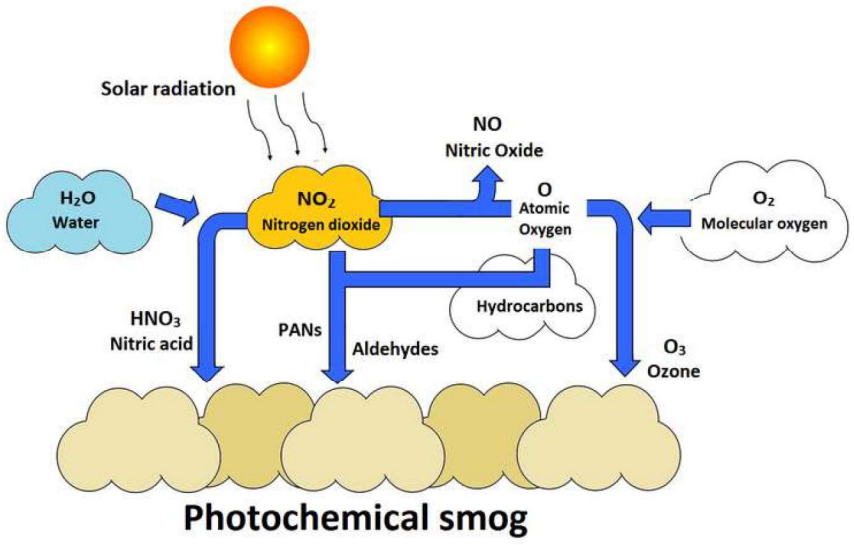
B. Photochemical smog or LA type smog (Los Angeles type smog):

- Recognized in 1943, Identified as coming from auto exhaust, primarily.
- Verified in 1951 by Haagen Smith.
- Requires clear, sunny skies (since L.A. photochemical smog requires sunlight for at one of the key chemical reactions).

NOx + ROG + sunlight --> O3 + NO2

Where, ROG (Reactive Organic Gases) from unburned gasoline and NOx are oxides of nitrogen

- 1943, July 26, Los Angeles, California: A smog so sudden and severe that "Los Angeles residents believe the Japanese are attacking them with chemical warfare.
  - 1948, October 30–31, Donora, Pennsylvania: 20 died, 600 hospitalized, thousands more stricken.
  - 1966, November 24, New York City, New York: Smog kills at least 169 people.
  - Mexico City, December 2010-
  - Santiago, Chile and Tehran, Iran (December 2005)



Peroxyacyl nitrates

Favorable conditions for high concentrations of SMOG

- **London smog:** formed due to presence of SO_2 and humidity in the air which combines to form H_2SO_4 fog which gets deposited on particulate.
  - **temperature inversion –**
  - **Formed during winter season particularly in morning hours- low temperature-**
  - **humid foggy, stagnant air**
  - air will look sooty, dirty, foggy (involves smoke and Fog)
  - Cause problems in lungs.
- **LA smog:** It is formed due to photochemical reaction taking place when air contains NO_2 and hydrocarbons.
  - It is misnomer- does not involve fog and smoke.
  - temperature inversion
  - Formed **during summer- afternoon -Hot sunny, stagnant weather- when photochemical reaction occur.**
  - air looks hazy, brownish in color, especially when you fly into LAX!!
  - Cause irritation in the eye.

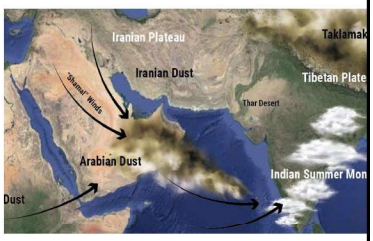
Atmospheric pollution- DUST

•Wind blown dust and debris, including plastic bags, are blown seaward from landfills and other areas.

•Dust from the Sahara moves into the Caribbean and Florida during the warm season

•Dust can also be attributed to a global transport from the Gobi and Taklamakan deserts across Korea, Japan, and the Northern Pacific to the Hawaiian Islands.

• Dust has potential to influence monsoons, hurricanes and even fertilize rainforests.



Atmospheric pollution

•Since 1970, dust outbreaks have worsened due to periods of drought in Africa.

•The USGS links dust events to a decline in the health of coral reefs across the Caribbean and Florida

South Asian pollution haze - Atmospheric Brownish Clouds

An intense fog/aerosol layer can be clearly seen prevalent over Indo Gangetic Plains which is shown as a thick mass of white haze on 07-09 November, 2008.

This specific case-episode corresponds to Punjab agricultural crop residue burning.

Pollution Outflow over northern Indian Ocean

1)the Arabian desert with flow over the western Arabian Sea,

2)the Indo-Pakistan desert and the west coast of India,

3) central India and the Ganges Valley, flowing over the Bay of Bengal

4) southeast (SE) Asia.

Aerosols

Aerosols are Micron-size particles of solid or liquid phase, dispersed in the atmosphere.

Aerosols are colloid of types- fluid or solid in the gas.

Aerosols are not stable, and ranges from 0.01 to 1 micron

Aerosols are produced by various physical and dynamical processes, which govern their formation and growth in to the atmosphere.

What will affect the deposition of Aerosols.

- Particle size,
- density,
- shape,
- hygroscopic or hydrophobic character, and
- chemical reactions of particles

Aerosols

- Aerosols are mixed with each other, externally and internally, changing their
  - optical,
  - physical and
  - chemical properties.

- Main processes of mixing:
  - gas-to-particle conversion,
  - coagulation,
  - condensation,
  - hydration,
  - aging.

Aerosols

Sources: Natural & Anthropogenic Origin

Size: Running over few nanometers to 100 µm. Depending on the size, aerosols are classified into three categories:

1. **Aitiken nuclei mode→ ~ 0.001 to 0.1 µm**
2. **Accumulation mode → ~0.1 – 1.0 µm**
3. **Large mode/giant particle > 1.0 µm**

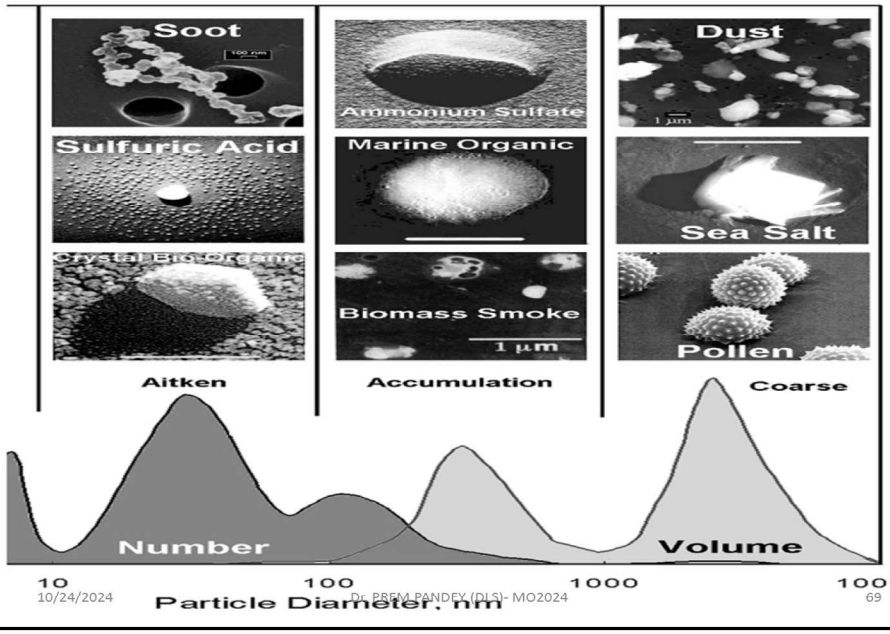
Aerosol Types

Desert-dust, urban/industrial, biomass-burning, marine (marine sulfate, sea spray)





Aerosol size and shape



Aerosol Adverse Impacts

- Affects human health, mainly respiratory (aerosols are not stable)
- Affects degradation of air quality and visibility- Sea salt, dust, and volcanic ash are three common types of aerosols.
- Significant attenuation of UV radiation
- Significant contribution in atmospheric chemistry reactions
- Affects the vertical temperature profile, influence in the atmospheric stability.

The various chemical and photochemical reactions that occur in the atmosphere are primarily determined by

  - the temperature,
  - composition,
  - humidity, and
  - intensity of sunlight.

- The absorption of solar radiation in the ultraviolet region causes photochemical reactions in the atmosphere

Aerosol Adverse Impacts

- Cause scattering & absorption of solar radiation, modification of the earth-atmosphere energy budget (direct aerosol effect)
- Act as Cloud Condensation Nuclei (CCN) for water vapor formation (indirect effect).
- Contribution in changes of the cloud microphysical properties (albedo, lifetime, optical depth) as well as in the hydrological cycle.

Control – Managing Air Pollution

Two approaches exist for control of air pollution: Effluent Control and Preventive Techniques.

- Desulphurization of coal
- Exhaust gases (mainly SO2) are passed through a slurry of calcium carbonate or magnesium hydroxide and removed….filters.
- Formation of nitrogen oxides is prevented by passing steam over Sulphur-free coal
- Exhaust gases can be prevented by using catalytic converters. Even CO is converted into CO2.
- Installation of electrostatic precipitators in the chimney and by using industrial filters
- Use of renewable alternative sources (non-polluted)

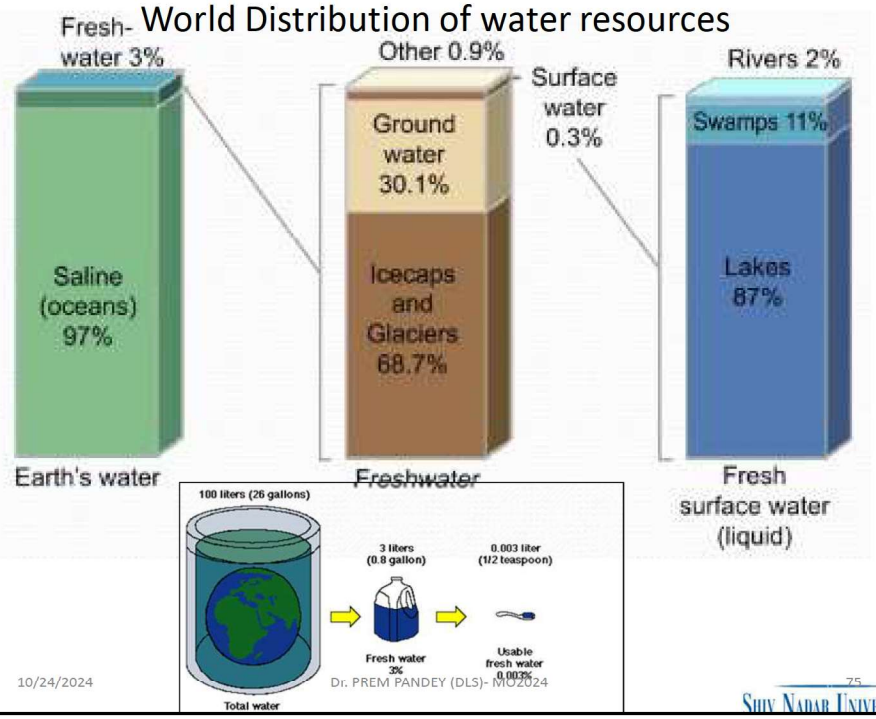
Control – Managing Air Pollution

India has to take measures to improve air quality. Some attempts are:

- Using unleaded fuel for automobiles
- Discouraging use of diesel vehicles
- Putting greater emphasis on pollution created by automobiles..pollution control checks in vehicles.
- Reducing the use of fossil fuels
- Increasing the use of nuclear energy

Water Pollution

World Distribution of water resources



Causes of Water Pollution

- About 40% of Deaths worldwide are caused by Water Pollution.
- Water Pollution is Caused by **organic** and inorganic industrial wastes and affluents discharged into rivers.

- **Water Pollution** can be defined as alteration in **physical, chemical,** or **biological** characteristics of water through natural or human activities and making it unsuitable for its designated use.
- Fresh Water present on the earth surface is put to many uses. It is used for drinking, domestic and municipal uses, agricultural, irrigation, industries, navigation, recreation. The used water becomes contaminated and is called waste water.

Water Pollution

- Water pollution is the degradation of the water quality that makes it unsafe or harmful to humans, animals and aquatic life.
- Any physical, chemical and biological change that degrades the quality of water results in water pollution.
- The major human-generated sources are sewage, garbage and refuse, industrial and agricultural wastes, runoff , fertilizers pesticides.

Water Pollution

Types of water Pollutants

- Biological Agents: disease-causing organisms, bacteria, protozoa and worms. Diseases, like cholera, dysentery, gastroenteritis, typhoid, viral hepatitis, influenza.
- Chemical Agents: water soluble, insoluble, or O2-demanding wastes, organic chemicals, radioactive substances.
  - Organic and inorganic nutrients cause eutrophication that adds to the waste in the water bodies.
- Physical Agents: Suspended solids, sedimentary solids. Effects are silting, filling of dams, muddy water.

Water pollution

Pollutants	Sources	Effects
Biological agents: bacteria, parasitic fungi, protozoa	Human sewage, animal-plant wastes, decaying organic matter, industrial wastes, natural lands and urban run-offs	Decomposition of O2-consuming bacteria depletes dissolved O2 in water; death of fish, destruction od plant life, foul odour, poisoned livestock
Chemical agents: acids, salts, metals (lead and mercury), plant nutrients (phosphates and nitrates)	Natural run-offs from land; industrial waste; acid deposition; leaded gasoline, lead smelting, pesticides; agricultural run-offs; mining, domestic sewage; food-processing units; detergents	Toxic to various life forms and human through food chain, can cause genetic and birth defects; water becomes unfit for domestic, agricultural and industrial uses; upsets ecosystems of water bodies; causes eutrophication
Organic chemical, agrochemicals, detergents, chlorine compounds, oil, grease and plastics	Agriculture, forestry: pest control industries: home and industrial wastes; paper industry; bleaching process; machine and pipeline wastes; oil spills	Toxic to aquatic life forms as well as organisms that depend on such water bodies; eutrophication of water bodies

Water pollution

Pollutants	Sources	Effects
Radioactive substances	Nuclear wastes from research laboratories and hospitals; processing of uranium ore; nuclear plants	Radioactive substances enter the food chain and cause birth and genetic defects; causative agents for cancer
Physical agents	Run-off from agriculture; mining, forestry; construction activities; power plants, industrial cooling	Increase in temperature lowers the solubility of oxygen in water; reduction of biotic life in waterbodies

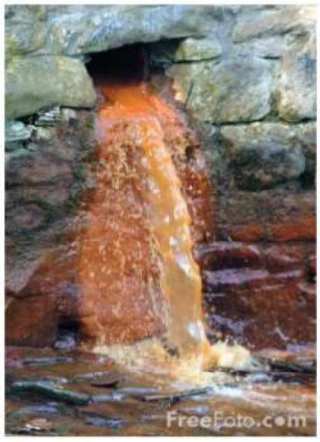
Freshwater pollution

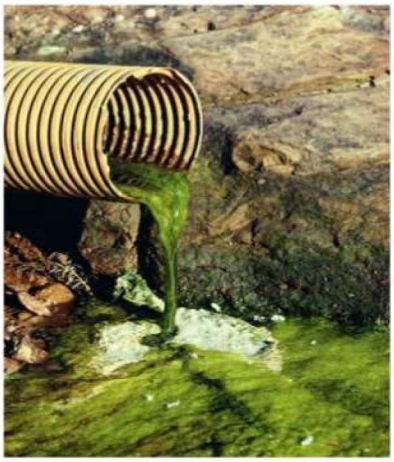
Source of contamination	Contaminants discharged into fresh water
Agriculture run-offs	Agrochemicals (pesticides, herbicides and fungicides)
Accidental spill of chemicals	Different chemicals
Leakage from surface storage tanks or pipeline	Gasoline, oil
Run-offs from industrial sites such as factories, refineries, mines	Solvents, chemicals
Radioactive material-processing units	radioactive materials
Air fallout in rivers. lakes	Particulates, metals, pesticides
Source of contamination	Contaminants discharged into fresh w

Groundwater pollution

Source of contamination	Contaminants discharged into groundwater
Domestic wastes	Pathogenic organisms, nutrients and solids
Industrial wastes	Toxic heavy metals along with hazardous organic and inorganic effluents
Agricultural wastes	Fertilizers, pesticides, insecticides, herbicides. Leaches from agricultural land containing nitrates, phosphates and potash pollute groundwater

Water Pollution Pictures





Effects of Water Pollution

- Diseases like Cholera
- Malaria
- Typhoid (spread during the rainy season)
- Aquatic life gets destroyed

How to Avoid Water Pollution

- Rivers should not be used for washing clothes or bathing animals in.
- Harvesting of Rainwater to meet water requirements.
- Dams &embankments must be created.
- The rivers must not be contaminated.
- In sacred river like Ganga the dead bodies shouldn't thrown.

Water Quality Standards

A. STANDARDS FOR COAL MINES (Stipulated by Ministry of Environment and Forests (MoEF), Vide Notification No. GSR 742(E), Dt: 25.09.2000)

EFFLUENT WATER QUALITY STANDARDS :

(a) Standards

- **pH**
- **Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD)**
- **Total Suspended Solids (TSS)**
- **Oil & Grease (O & G)**
- **-- 5.5 to 9.0**
- **-- 250 mg/l**
- **-- 100 mg/l**
  -- 200 mg/l (Land for irrigation)
- **-- 10 mg/l**

Water Quality Standards

B. GENERAL STANDARDS* FOR DISCHARGE OF ENVIRONMENTAL POLLUTANTS

C. INDIAN STANDARDS FOR DRINKING WATER - SPECIFICATION (BIS 10500 : 1991)

D. TOLERANCE LIMITS FOR INLAND SURFACE WATERS SUBJECT TO POLLUTION (IS: 2296-1982)

E. PRIMARY WATER QUALITY CRITERIA FOR BATHING WATER
(Water used for organised outdoor bathing)

- **Desirable limit** is the limit beyond which the water is not acceptable for consumption, but still may be tolerated in the absence of an alternative source.
- **Permissible limit** Such tolerance may be up to **the permissible limit**, beyond which the water is to be straightforwardly rejected.

Sl.No	Substance or Characteristic	Requirement (Desirable Limit)	Permissible Limit in the absence of Alternate source
Essential characteristics			
1.	Colour, (Hazen units, Max)	5	25
2.	Odour	Unobjectonable	Unobjectionable
3.	Taste	Agreeable	Agreeable
4.	Turbidity (NTU, Max)	5	10
5.	pH Value	6.5 to 8.5	No Relaxsation
6.	Total Hardness (as $CaCo_3$) mg/lit.,Max	300	600
7.	Iron (as Fe) mg/lit,Max	0.3	1.0
8.	Chlorides (as Cl) mg/lit,Max.	250	1000
9.	Residual,free chlorine,mg/lit,Min	0.2	--
Desirable Characteristics			
10.	Dissolved solids mg/lit,Max	500	2000
11.	Calcium (as Ca) mg/lit,Max	75	200
12.	Copper (as Cu) mg/lit,Max	0.05	1.5
13	Manganese (as Mn)mg/lit,Max	0.10	0.3
14	Sulfate (as SO_4) mg/lit,Max	200	400
15	Nitrate (as NO_3) mg/lit,Max	45	100
16	Fluoride (as F) mg/lit,Max	1.9	1.5
17	Phenolic Compounds (as C_6H_5OH) mg/lit, Max.	0.001	0.002
18	Mercury (as Hg)mg/lit,Max	0.001	No relaxation
19	Cadmiun (as Cd)mg/lit,Max	0.01	No relaxation
20	Selenium (as Se)mg/lit,Max	0.01	No relaxation
21	Arsenic (as As) mg/lit,Max	0.05	No relaxation
22	Cyanide (as CN) mg/lit,Max	0.05	No relaxation
23	Lead (as Pb) mg/lit,Max	0.05	No relaxation
24	Zinc (as Zn) mg/lit,Max	5	15
25	Anionic detergents (as MBAS) mg/lit,Max	0.2	1.0
26	Chromium (as Cr^{6+}) mg/lit,Max	0.05	No relaxation
27	Polynuclear aromatic hydro carbons (as PAH) g/lit,Max	--	--
28	Mineral Oil mg/lit,Max	0.01	0.03
29	Pesticides mg/l, Max	Absent	0.001
30	Radioactive Materials		
	i. Alpha emitters Bq/l,Max	--	0.1
	ii. Beta emitters pci/l,Max	--	1.0
31	Alkalinity mg/lit,Max	200	600
32	Aluminium (as Al) mg/l,Max	0.03	0.2
33	Boron mg/lit,Max	1	5

Indian Standard of Drinking water

Parameter	Desirable-Tolerable	*If no alternative source available, limit extended upto*
Physical		
Turbidity (NTU unit)	< 10	25
Colour (Hazen scale)	< 10	50
Taste and Odour	Un-objectionable	Un-objectionable
Chemical		
pH	7.0-8.5	6.5-9.2
Total Dissolved Solids mg/l	500-1500	3000
Total Hardness mg/l (as $CaCO_3$)	200-300	600
Chlorides mg/l (as Cl)	200-250	1000
Sulphates mg/l (as SO_4)	150-200	400
Fluorides mg/l (as F)	0.6-1.2	1.5
Nitrates mg/l (as NO_3)	45	45
Calcium mg/l (as Ca)	75	200
Iron mg/l (as Fe)	0.1-0.3	1.0

Consequences of Water Pollution

- There will be serious crisis of clean water all over the world, if wastage is not avoided and pollution is not checked.
- Water pollution changes the physical water properties (color, taste, temperature) and makes it acidic, alkaline or saline due to the presence of dissolved or suspended chemical substances.
- Deadly diseases -such as cholera, diarrhea, tuberculosis, typhoid, dysentery, Jaundice.
- Liver cirrhosis, renal failure, neural disorders.
- Contamination of water with toxic substances (arsenic, cyanide, ammonia, mercury, lead, phenol, pesticide) causes many diseases
  - ITAI-ITAI by cadmium / Minamata by mercury (hg) toxicity.
- Millions of people in the developing countries die from water-borne diseases.

Consequences of Water Pollution

- Water gets polluted by the discharge of industrial wastes, sewage, domestic wastes, and discharge of agrochemicals into water bodies.
- Another cause for marine pollution is the petroleum spills due to accidents in oil tankers.
- Major threats by mercury, cadmium, nitrate, fluoride (in excess quantities), arsenic, lead, pesticides, chromium and cobalt
- Water pollution can be of point sources and/or non-point sources

Sources of Water Pollution

Nonpoint source pollution (NPS)

NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters and ground waters.

Point sources pollution

A point source is a single, identifiable source of pollution, such as a pipe or a drain. Industrial wastes are commonly discharged to rivers and the sea in this way.

Diseases from microorganisms in polluted water

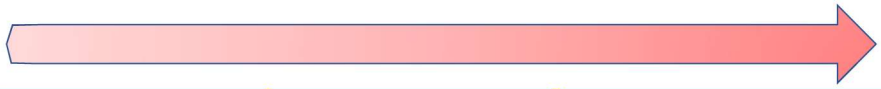
Organism	Source	Disease
Ascaris sp.	Polluted water, dried sludge used as fertilizer	Nematode worms
Bacillus anthracis	Waste water spores	Anthrax
Brucella sp. and waste water	Transmitted by infected milk man, and contagious abortion	Brucellosis, Malta fever in sheep, goat and cattle
Escherichia coli	Polluted water	Diarrhoea
Entamoeba histolytica	Contaminated water	Amoebic dysentery
Leptospira sp.	Caused by sewarage rats	Leptospirosis
Mycobacterium tuberculosis	Waste water	Tuberculosis
Salmonela paratyphi	Waste water	Paratyphoid fever
Salmonela typhi	Waste water	Typhoid fever
Shigella sp.	Polluted water	Bacillary dysentery
Vibrio cholerae	Polluted water	Cholera
Virus	Waste water	Poliomyelitis, hepatitis

Eutrophication

- An increase in chemical nutrients, typically compounds containing nitrogen or phosphorus, in an aquatic ecosystem.
- It can result in an increase in the ecosystem's primary productivity (excessive plant growth and decay), and further effects including lack of oxygen and severe reductions in water quality, fish, and other animal populations.

Eutrophication

- The biggest culprit are rivers that empty into the ocean, and with it the many chemicals used as fertilizers in agriculture as well as waste from livestock and humans.
- An excess of oxygen depleting chemicals in the water can lead to hypoxia and the creation of a dead zone.



Oligotrophic	Mesotrophic	Eutrophic
TSI (0- 40)	(40 -60)	(60- 100)
Good quality	Fair	poor quality
Least	moderate	highest biological
Least sediment	Moderate	high amount
High DO	moderate	Low or no DO

Black and Grey Waste Water

Blackwater is any waste from toilets or urinals. Greywater is wastewater that has been used for washing, laundering, bathing or showering.

Wastewater includes both black Water and greywater (also spelled as Gray water).

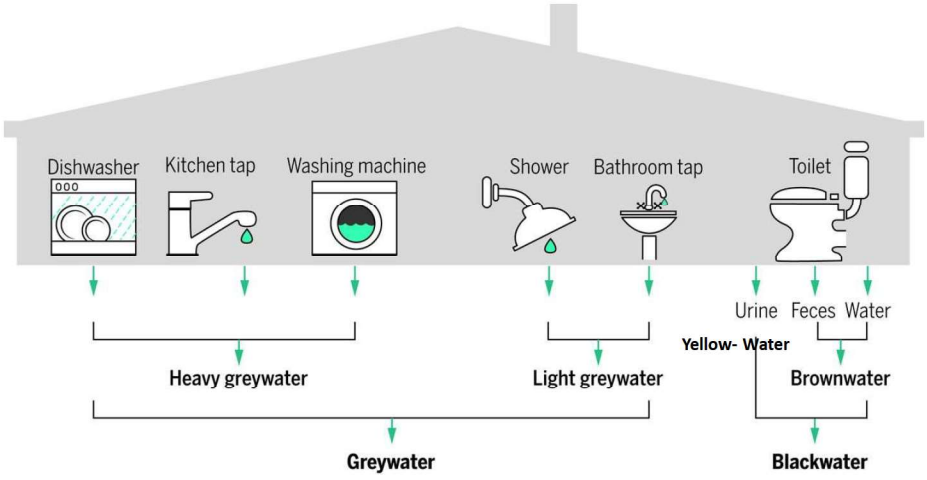
It's not illegal to dump gray water, or empty your grey tanks, on the ground in open, public areas.

This is primarily where dispersed camping is allowed. However, in areas where the manages developed camp-grounds, recreational areas, or wildlife preserves, they may prohibit such activity on a case-by-case basis.

Types of waste water (domestic)

- **Blackwater:** Water that contains the pathogens of faeces and the nutrients of urine that are diluted in the flush water.
  - **Black water** contains human waste and is unsafe
  - waste doesn't break down and decompose in water fast or effectively enough for use in domestic irrigation without the risk of contamination.
- **Greywater Water:** Water coming from domestic equipment other than toilets (e.g., bathtubs, showers, sinks, washing machines) is called greywater.
  - **Gray water** has some bacteria but it can be filtered and reused in gardens or lawns, if done properly.
  - It can be broken down and safely reabsorbed into an active garden or lawn.

Grey water and black water



Soil/Land pollution

Soil pollution

The top fertile Soil is only 6 inches deep and it takes about 15 years to built 1 cm of soil.

Formation of soil materials-

- Alluvial soil deposited by water. Transported by river and usually deposited along the river's pathway either flood plain or river bed.
- Aeolian- soil deposited by wind: Typically developed from sandy parent material through wind actions. transported by wind action and deposited along its way- sand dunes.
- Colluvial soil deposited down due to gravitational force. Weathered material transported by gravity actions such as steep slopes.
- Eluvial : Weathered material formed still at or near its point of formation.

Soil pollution

- Apart from natural causes, human beings harmed the land surface
  - by using it (agriculture, development),
  - by taking things out of it (mining, deforestation) and
  - by putting undesirable things on it (waste disposal).
- Contamination of soil with anomalous concentration of toxic substances.
  - Exposure of soil containing high concentration of Benzene increases risk of Leukaemia.
  - Soil pollution examples- dumping waste, land development, excessive pesticides/ chemicals.

Soil pollution

Most common pollutants involved-

- Petroleum hydrocarbons,
- Solvents,
- pesticides/ insecticides
- Heavy metals- Arsenic, lead, mercury.
- Plastics & Micro- plastics

- Soil pollution is often accompanied by a decrease in availability of nutrients, threats to soil micro-diversity.
- Any activities that lead to other form of soil degradation (erosion, compaction) may indirectly worsen the contamination effects on soil, and remediation becomes more tedious.

Soil pollution

- Some of the major effects on soil are:

1. Loss of Biodiversity: Cutting trees and plants has led to the destruction of flora and fauna. According to International Union of the Conservation of Nature (IUCN), by 2050 about 50,000 plant species will become extinct of threatened.

2. Soil erosion: Soil erosion is the purpose of loosening, detachment and removal of soil components and nutrients.

- It is caused by the flow of water and blowing of winds.

- Human contribution is by LULC changes, making soil very susceptible to weather phenomena.

Soil pollution

- In India land is used to dump all types of wastes. Sanitary landfill requirements are not followed at all. The contamination of soil and groundwater through landfills is called leaching.
- The major types of wastes generated from different sources are:

Waste	Source of waste
Urban waste	Municipal, sewage, industrial and domestic effluents, hospital waste
Industrial waste	Slag, lime, sludge, brine mud, scraps of metals, glass, ferrous and non-ferrous metals, wool, fly ash, plastics, effluents
Domestic waste	Organic waste from kitchen, crockery, tin cans, plastic cans, bottles, bags, cloth rags, paper, straw, etc
Rural waste	Pesticides, herbicides, agricultural rin-off
Nuclear-plant waste	Radioactive hazardous wastes

Soil pollution

- Soil pollutants affect Lithosphere, Atmosphere, Hydrosphere, Biosphere.
- Soil pollutants mainly chemical (toxic) can bio-accumulate and bio-magnify at the higher levels of food chain, through run off and mixing with water as well as other factors, and enter food chain.
  - Bio-accumulation refers to the entry of a pollutant from the environment to the first organism in the food chain.
  - Bio-magnification is the phenomenon of increase in the concentration of a pollutant from one link in a food chain to another

Marine Pollution

Marine pollution

- Ocean are the final sink of all natural and manmade pollutants. Rivers discharge their pollutants into the sea. The sewage and garbage of **Coastal cities** are also dumped into the sea. The other sources include, discharge of oils, grease, detergents, and radioactive wastes from ships.

Marine pollution

Oceans are the ultimate sink of pollutants that are either directly dumped in the form of wastes or reach there as run-off through streams, canals, rivers or accidental oil spills.

Pollution of oceans, seas, estuaries, salty marshes, etc is called marine pollution.

Marine pollution

Over the globe about 200 million gallons of petroleum enter the seas each year as a result of

- –extractions,
- –transportation, and
- –consumption of oil and its products.

Marine pollution

- In oil spill, the low-boiling aromatic hydrocarbons cause the immediate death of aquatic organisms.
- Toxic substances also evaporate and released in the atmosphere.
- Floating oils can coat the feathers of marine birds and some mammals, such as seals.

Marine pollution

- There are three main sources of inputs of pollution into the ocean:
  - Direct discharge of waste into the oceans,
  - Runoff into the waters due to rain, and
  - Pollutants that are released from the atmosphere

Marine pollution

- Pollutants enter rivers and the sea directly from urban sewerage and industrial waste discharges, sometimes in the form of hazardous and toxic wastes.
- Inland mining for copper, gold. etc., is another source of marine pollution.
- Most of the pollution is simply soil, which ends up in rivers flowing to the sea.

Marine pollution

- Some minerals discharged in the course of the mining can cause problems, such as copper,
- Copper, a common industrial pollutant, which can interfere with the life history and development of coral polyps.

Ship's pollution

Ships can pollute waterways and oceans in many ways.:

- Oil spills can have devastating effects.
- While being toxic to marine life, Polycyclic Aromatic Hydrocarbons (PAHs), the components in crude oil, are very difficult to clean up, and last for years in the sediment and marine environment.

Ship's pollution

- Discharge of cargo residues from bulk carriers can pollute ports, waterways and oceans.
- In many instances, vessels intentionally discharge illegal wastes despite foreign and domestic regulation prohibiting such actions.

Ship's pollution

- It has been estimated that container ships lose over 10,000 containers at sea each year (usually during storms).
- Ships also create noise pollution that disturbs aquatic life.

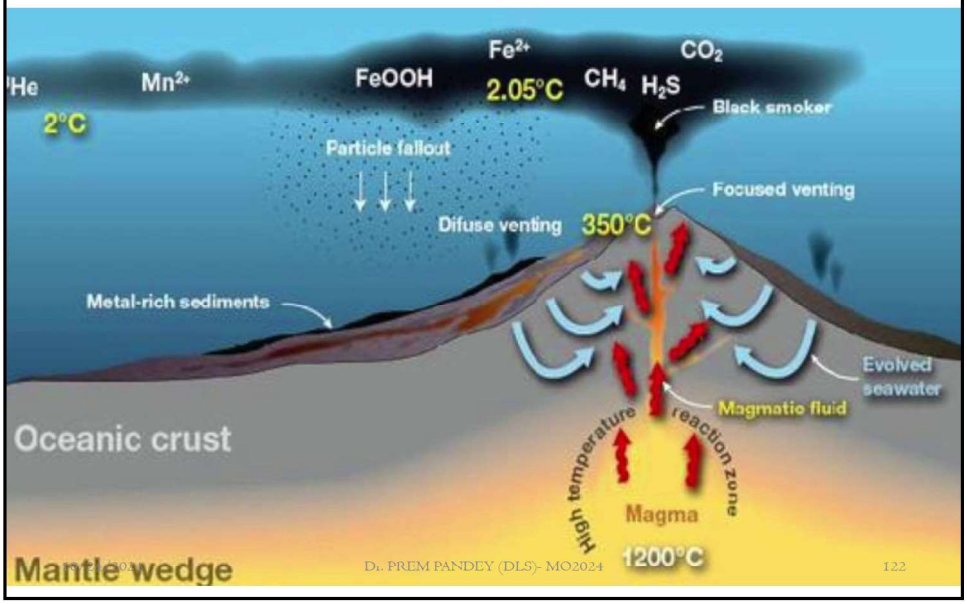
Ship's pollution

- Ballast water taken up at one port (from sea) and released in port (in another region) is a major source of unwanted exotic / invasive marine life.
- The invasive freshwater zebra mussels, native to the Black, Caspian and Azov seas, were probably transported to the Great Lakes in US/Canada via ballast water from a trans-oceanic vessel

Deep Sea Mining

- Ocean mining sites are usually around large areas of poly metallic nodules or active and extinct hydrothermal vents at about 1,400 - 3,700 meters below the ocean's surface.

Hydrothermal vents on the Ocean Floor



Deep Sea Mining

Hydrothermal vents are like geysers, or hot springs, on the ocean floor.

- Along mid-ocean ridges where tectonic plates spread apart, magma rises and cools to form new crust and volcanic mountain chains. Seawater circulates deep in the ocean's crust and becomes super-heated by hot magma.
- The vents create sulfide deposits, which contain precious metals such as silver, gold, copper, manganese, cobalt, and zinc.

Deep Sea Mining

The deposits are mined using either hydraulic pumps or bucket systems that take ore to the surface to be processed.

- result in disturbances to the benthic layer,
- increased toxicity of the water column.
- Increased water temperature due to mixing.
- Effect upwelling and down welling phenomenon.

Deep Sea Mining

- Sediment plumes from tailings.

Removing parts of the sea floor disturbs the habitat of benthic organisms, possibly, depending on the type of mining and location, causing permanent disturbances.

Deep Sea Mining

- Near bottom- plumes occur when the tailings are pumped back down to the mining site.
- The floating particles increase the turbidity, or cloudiness, of the water, clogging filter-feeding apparatuses used by benthic organisms, who feed mostly on dead organic matters.
- Example: *Sea anemones, Sponges, Corals, Sea stars, Sea urchins, Bivalves, Crabs, Barnacles, and Mussels*

Deep Sea Mining

- Surface plumes cause a more serious problem. Depending on the size of the particles and water currents the plumes could spread over vast areas.
- The plumes could impact zooplankton and light penetration, in turn affecting the food web of the area.
- Aside from direct impact of mining the area, leakage, spills and corrosion would alter the mining area's chemical makeup.

CO_2-Acidifying the Oceans

Climate change is raising ocean temperatures and raising levels of carbon dioxide in the atmosphere.

- These rising levels of carbon dioxide are acidifying the oceans.
- This, in turn, is altering aquatic ecosystems and
  - modifying fish distributions, with impacts on the sustainability of fisheries and the livelihoods of the communities that depend on them

Acidification

- The oceans are normally a natural carbon sink, absorbing carbon dioxide from the atmosphere.
- Because the levels of atmospheric carbon dioxide are increasing, the oceans are becoming more acidic.
- Biological organisms made of calcium carbonate becoming vulnerable to dissolution, affecting coral and the ability of shellfish to form shells.

Acidification

- Oceans and coastal ecosystems have removed about 25% of the carbon dioxide emitted by human activities between 2000 and 2007 and about half the anthropogenic CO_2 released since the start of the industrial revolution.
- Rising ocean temperatures and ocean acidification means that the capacity of the ocean carbon sink will gradually get weaker.

Acidification

- A report from NOAA scientists published in the journal Science in May 2008 found that large amounts of relatively acidified water are upwelling (*an oceanographic phenomenon that involves wind-driven motion of dense, cooler, and usually nutrient - rich water towards the ocean surface, replacing the warmer, usually nutrient-depleted surface water.*) to within four miles of the Pacific continental shelf area of North America
- continental shelf - This area is a critical zone where most local marine life lives or is born.

Other pollutants

- Some plastic additives are known to disrupt the endocrine system (BPA –bisPhenol-A) when consumed, others can suppress the immune system or decrease reproductive rates.
- Floating debris can also absorb persistent organic pollutants/toxins such as PCBs (Polychlorinated biphenyls) and dioxins, from seawater, including PCBs, DDT and PAHs.
- Aside from toxic effects, when ingested some of these are mistaken by the animal brain for estradiol, causing hormone disruption in the affected animals.

Other Pollutants

- Apart from plastics, there are particular problems with other toxins that do not disintegrate rapidly in the marine environment.
  - Examples of persistent toxins are PCBs, DDT, pesticides, dioxins, phenols and radioactive waste.

Other Pollutants

- Heavy metals are metallic chemical elements that have a relatively high density and are toxic or poisonous at low concentrations.
- Examples are mercury, lead, nickel, arsenic and cadmium. Such toxins can accumulate in the tissues of many species of aquatic life in a process called bioaccumulation.
- They are also known to accumulate in benthic environments, such as estuaries and bay muds: a geological record of human activities of the last century.

Marine pollution

Marine oil spills can be controlled by some well-known ways:

- Skimming: This is the simplest method. It should be used in the shortest possible time after spilling has occurred; otherwise, the wind will spread the oil over large surface, making the skimming very difficult.
- Use of absorbers: Some absorbents, such as polyurethane, saw dust and chopped straw are spread on the surface of the oil and then skimmed off.
- Burning of oil slick: Although the method is useful, it causes extensive air and thermal pollution.
- Microorganisms: The most effective method to clean up oil pollution is by using oil-eating bacteria.
- Chemical additives: These are used to solidify oil from water surface and then the solid material is skimmed off.

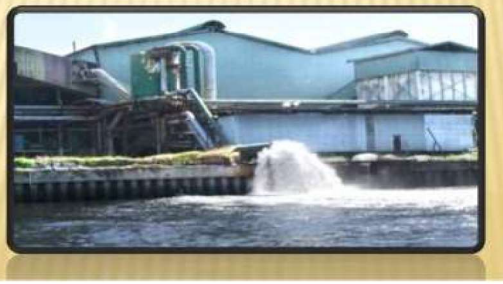
Mitigation

- Either the human population is reduced, or
- A way is found to reduce the ecological footprint left behind by the average human.
- The second way is for humans, individually, to pollute less. That requires social and political will….
- The most important strategy for reducing marine pollution is education
  - Awareness
  - Research
  - Dissemination

Thermal Pollution

THERMAL POLLUTION

- Thermal Pollution of water is caused by the rise in temperature of water. The main source of thermal pollution are the thermal and nuclear power plants. The power generating plants use water as coolants and release hot water into the original source. Sudden rise in temperature kills fish and other aquatic animals.



Thermal Pollution

- Release of heat into the atmosphere and water bodies is called thermal pollution.
- Heavy and small industries use water for cooling purposes. This water gets heated and then released into water bodies, thereby increasing the temperature.
- Natural causes of thermal pollution are the forest fires and the volcanic eruptions.

Thermal Pollution

- If the temperature in oceans is raised by 1 degree, the environment becomes lethal to sensitive organisms.
- The release of heated water into a water body changes:
  - its temperature,
  - decrease in the concentration of dissolved oxygen.
  - Detrimental effects on aquatic animals.
- In industries, storing and cooling the heated water before discharging or even reuse it. Use of cooling towers.

Sound

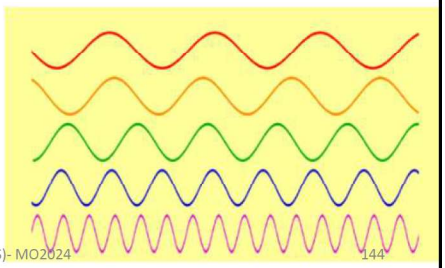
- Sound is a vibration that propagates as an acoustic wave, through a transmission medium, (such as a gas, liquid or solid).
- In human physiology and psychology, sound is the reception of such waves and their perception by the brain.
- Sound is a type of energy made by **vibrations.**
- When an object vibrates, it causes movement in surrounding air molecules.
- These molecules bump into the molecules close to them, causing them to vibrate as well and so on…
  - Sound is **Mechanical Wave** (does not able to travel in Vacuum).
  - Sound waves are **longitudinal waves**
    - Means propagation of vibration of particles is parallel to the energy wave direction.
    - Speed of Sound is lowest in Gases.

Nature of sound

Sound, manifestation of vibration, travels in wave patterns through solid, liquid and gases.

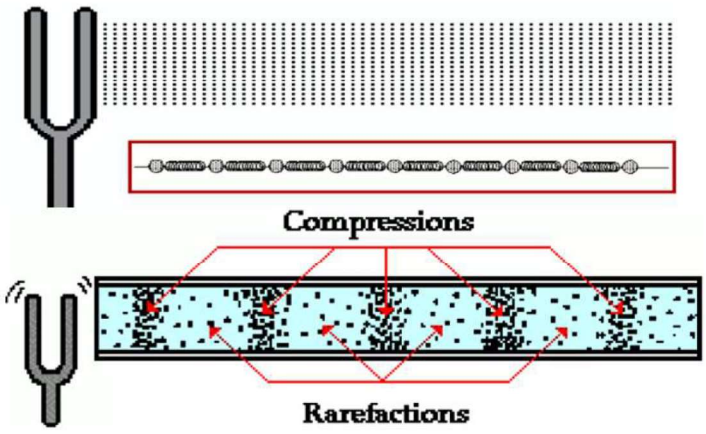
- Waves are caused by vibration of molecules,
- Follow sine functions
- Typified by amplitude and wavelength (frequency).

Sound waves of equal amplitude with increasing frequency from top to bottom



Sound propagation

Sound is longitudinal wave



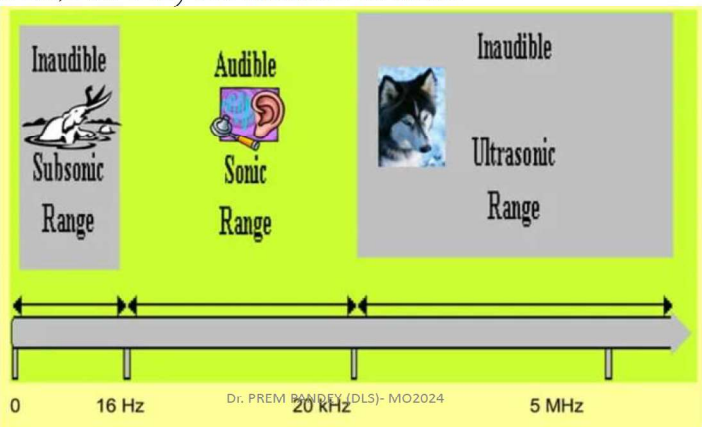
Sound power and intensity

- **Pressure, P, usually Pascals**
- **Frequency, f, usually Hertz** — $P = 1/f$
- **Intensity, I, usually W/m²** — $I = W/A$
- **Bels, L', derived from logarithmic ratio** — $L' = \log (Q/Qo)$
- **Decibels, L, derived from bels** — $L = 10*\log (Q/Qo)$

E.g. Implications of the decibel scale: doubling sound level would mean that the sound will increase by 10*log2 = +3dB
Ten times the sound level = 10*log10 = +10dB

Human Hearing and frequency

- Infrasonic waves are those that are too low-frequency (below 20 Hz) for humans to hear.
- Audible sound waves are those that humans can hear.
- Ultrasonic sounds waves are those that are too high-frequency (above 20,000 Hz) for humans to hear.



Health Effects

- According to the USEPA, there are direct links between noise and health.
- Noise pollution adversely affects the health of millions of people.
- Noise pollution can damage physiological and psychological health.
- High blood pressure, stress related illness, sleep disruption, hearing loss, and productivity loss are the problems related to noise pollution.
- It can also cause memory loss, severe depression, and panic attacks.

Why Noise Pollution is neglected ??

- Invisible Effects
- Indirect Effects
- Inefficient Awareness

WHAT IS NOISE POLLUTION?

- Sound that is unwanted or disrupts one's quality of life is called as noise. When there is lot of sound in the environment, it is termed as noise pollution.

- Sound becomes undesirable when it disturbs the normal activities such as working, sleeping, and during conversations.
- It is an underrated environmental problem because of the fact that we can't see, smell, or taste it.
- World Health Organization stated that "Noise must be recognized as a major threat to human well-being"

Noise Pollution

- Any unwanted, disturbing or harmful sound that is capable of impairing or interfering with our normal hearing has the capacity to cause stress and is called noise pollution.
- The first response to excessive noise is annoyance. Excessive noise causes adrenalin to be released in the body resulting in faster heartbeat, high blood pressure and tense muscles.
  - In extreme cases, or excessive noise for longer durations it may lead to permanent hearing loss.
- Sound intensity is measured using sound pressure on the decibel scale (dB).
- dB stands for decibel and is a unit of sound measurement. This unit measures the loudness of a sound or the strength of a signal, computed as the signal to noise ratio.
- The pressure volume is converted to loudness level via a mathematical formula.

Noise Pollution

The average decibel level of human speech is estimated between 55 and 65 decibels.

- A whisper is considered the lowest decibel level of human speech.
- Breathing- 10 dBA. A whisper is between 20-30 dB A. On the other hand, a human scream can reach decibel levels between 80 and 125 dB A.
- Sound is described in terms of Loudness (amplitude) and Pitch (frequency)
- Loudness (also sound pressure level- SPL) measured in logarithmic units called decibels. A high-pitch sound seems louder than a low-pitch sound at the same pressure.
  - The unit for pitch is dBA.
- A sound becomes damaging at a pressure level of 70 dbA and painful hearing damage above 120 dbA.
- db and dbA are logarithmic scales. A rise of 10 db causes a ten-fold increase in sound pressure. dB is a relative unit of measurement equal to one tenth of a bel (B).
- Types of noise: traffic noise, industrial noise, community noise.

Area Code	Category of area/zone	limits in dB(A) leq*	
		day time	Night time
(A)	Industrial area	75	70
(B)	Commercial area	65	55
(C)	Residential area	55	45
(D)	Silence zones	50	40

*dB(A) Leq denotes the time weighted average of the level of sound in decibels on scale A which is relatable to human hearing. Source: Central Pollution Control Board, India

Noise Pollution

- Marine life can be susceptible to noise or sound pollution from sources such as passing ships, oil exploration seismic surveys, and naval low-frequency active sonar.
- Sound travels more rapidly and over larger distances in the sea than in the atmosphere.
- Marine animals, such as cetaceans (a whale, dolphin, or porpoise), often have weak eyesight, and live in a world largely defined by acoustic information.
  - This applies also to many deeper sea fish, who live in a world of darkness.
  - They used to sense their surroundings through echolocation.

Noise Pollution

- Between 1950 and 1975, ambient noise in the ocean increased by about ten decibels (that is a ten-fold increase).
- Noise also makes species communicate louder, which is called the Lombard vocal response.
- Whale songs are longer when submarine-detectors are on. If creatures don't "speak" loud enough, their voice can be masked by anthropogenic sounds.
- These unheard voices might be warnings, finding of prey, or preparations of net-bubbling. When one species begins speaking louder, it will mask other specie voices, causing the whole ecosystem to eventually speak louder.

Source of Noise pollution

- Transportation system
- Industrial Noise-
  - Printing press
  - Bulldozers
  - Loaders
- Loud Speakers
- Construction sites
- Household noise
  - Mixer
  - TV
  - Load speaker and Home Theaters
- Ships and Oil fields
- Loud speakers
- Appliances







Sources of Noise Pollution

- Transportation systems are the main source of noise pollution in urban areas.
- Construction of buildings, highways, and streets cause a lot of noise, due to the usage of air compressors, bulldozers, loaders, dump trucks, and pavement breakers.
- Industrial noise also adds to the already unfavorable state of noise pollution.
- Loud speakers, plumbing, boilers, generators, air conditioners, fans, and vacuum cleaners add to the existing noise pollution.

Effects of Noise Pollution on Humans

- Irritation
- Lack of concentration
- Fatigue
- Pupil dilation
- Mental Illness
- Changes in Immunity system
- Cardiovascular problems & Heart attack
- Decrease in hearing efficiency
- Hearing loss- temporary or permanent deafness
- Sleep Disturbance & Sleep interference
- Aggressive behavior
- Speech interference
- Increase in stress
- Birth defects or abortion is caused

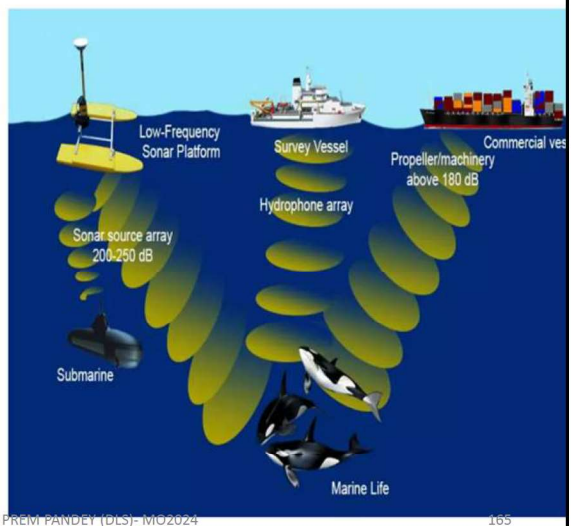
Effects of Noise Pollution on Animals

- Hearing Loss
- Masking
- Damage nervous system
- Create navigation problems
- Reduction of useable habitat
- Death of certain species
- Psychological Effects
- Behavioral Effects
- Genetic problems

Effects of Noise Pollution on Aquatic Life

Under water noise pollution

- UNP is intense human-generated noise in the marine environment. It is caused by use of explosives, oceanographic experiments, geophysical research, underwater construction, ship traffic, intense active sonars and air guns used for seismic surveys for oil and related activities.



Effects of Noise Pollution on Aquatic Life

1. • Complexity in Communication
2. • Complexity in Reproduction System
3. • Change in behavior
4. • Complexity in Hunting
5. • Affect in Nervous System
6. • Radiation of Radioactive Waves

What to do?

- Imposing Laws Strictly

  The Environmental (Protection) Act 1986, was implemented to regulate noise pollution.

- Use Updated Technologies that make less sound
- Increasing Social Awareness
- Using more sustainable transport system

Control of Noise Pollution

1) Control at receiver's end:-

- For people working in noisy areas ear protection aids like ear plugs, muffs, noise helmets, head phones etc should be provided it reduces occupational exposure.

2) Controlling at source:-

- This is only possible if working method is improved.
- Design new machines to replace noisy ones.
- Proper lubrication and better, maintenance of machines.
- Installing noisy machines with sound absorbing materials.
- Using Silencer to control noise from automobiles etc.

3) Zoning:-

- Increased distance between source and receiver by zoning of noisy industrial areas like bus stand and railway stations away from silence zones near residential areas, educational institutions and hospitals.

Control of Noise Pollution

4) Sound Insulation:-

- A) Sound insulations can be done by constructing windows with more than one panes of glass and filling the gap with sound absorbing material.
- B) Acoustical tiles, perforated plywood can be fixed on wall, ceilings, floors to reduce noise.

5)Planting of Trees:-

- Planting of trees and shrubs along roads, hospitals, educational institutions help in noise reduction to a considerable extent.

6)Legislative measures:-

- Strict legislative measures need to be enforced to control the nuisance of noise pollution some of the measures are
  - A) Minimum use of loud speakers, near silence zones.
  - B) Banning Pressure horns in automobiles
  - C) Framing a separate noise pollution act.

Solutions for Noise Pollution

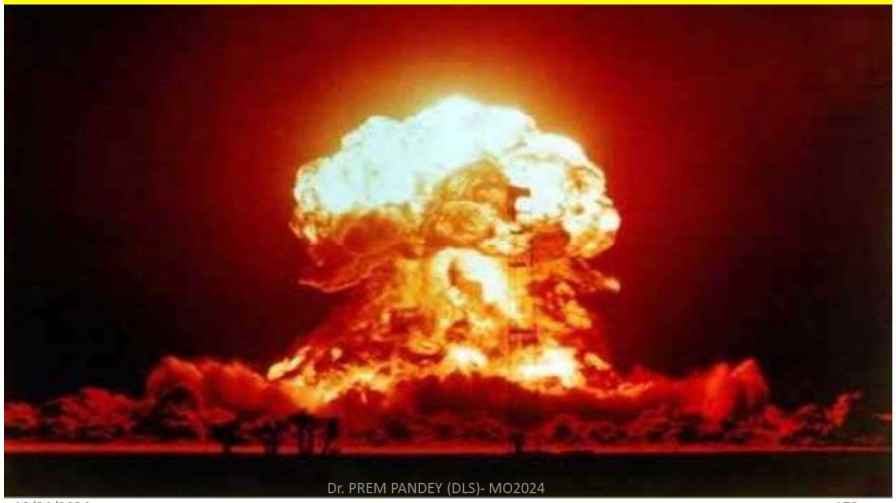
- Planting bushes and trees in and around sound generating sources is an effective solution for noise pollution.

- Regular servicing and tuning of automobiles can effectively reduce the noise pollution.
- Buildings can be designed with suitable noise absorbing material for the walls, windows, and ceilings.
- Workers should be provided with equipments such as ear plugs and earmuffs for hearing protection.

Solutions for Noise Pollution

- Similar to automobiles, lubrication of the machinery and servicing should be done to minimize noise generation.
- Soundproof doors and windows can be installed to block unwanted noise from outside.
- Regulations should be imposed to restrict the usage of play loudspeakers in crowded areas and public places.
- Factories and industries should be located far from the residential areas.

Radioactive Pollution



WHAT IS ACTIVE POLLUTION?

- **Radioactive pollution** can be defined as the emission of high energy particles or radioactive substance into air, water or land due to human activities in the form of radioactive waste.

Radioactive Pollution

- Radioactivity is the spontaneous disintegration of certain atomic nuclei accompanied by emission of alpha particles (helium nucleus), beta particles (electrons or positrons) or gamma rays.
- Radioactivity is measured in Becquerel (Bq), which is the quantity of the element that produces one disintegration per second.
  - An older unit is the curie, named after Pierre and Marie Curie.
  - (1 Bq in: is equal to Curie: $2.703\times10-11$ Ci ≅ 27 pCi)
- Natural sources of radioactive pollution include rocks with radioactive nuclides, such as U-239, Th-234, Ra-226. Production of radioactive material requires:
- Mining: Harmful effects firstly on the people involved in mining. Use of gas masks, spectacles, gloves. No part of the body to be left exposed.

TYPES OF RADIATION

Types of Radiation	Mass	Charge	Stopped By
Alpha	4	+ 2	Thin Sheet of Paper
Gamma Ray	No Mass	No Charge	Several Inches of Lead or Steel
X Ray	No Mass	No Charge	Several Inches of Lead or Steel
Beta	1/2000	- 1	Thin Aluminum
Neutron	1	0	High Hydrogen Content

Alpha (α) particle

is two protons and two neutrons; lowest penetrating power.

$^{4}_{2}He$

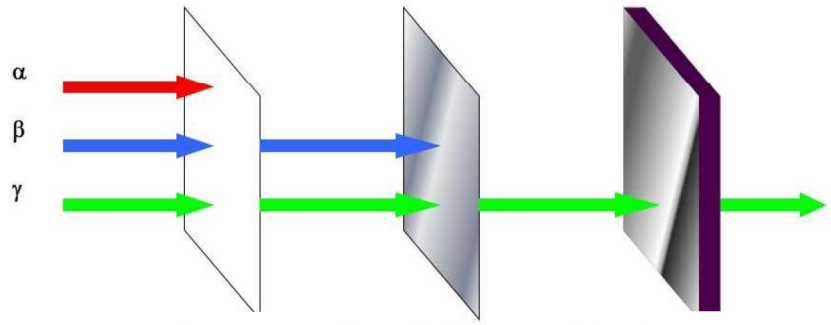
Beta (β^-) particle

$^{0}_{-1}e$ is a high-energy electron.

Gamma ray

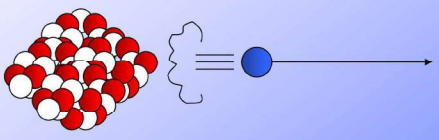
γ is energy released from a nucleus. Highest penetrating power.

Radiation and their power to penetrate



Beta Decay

A beta particle is a fast moving electron which is emitted from the nucleus of an atom undergoing radioactive decay.



Beta decay occurs when a neutron changes into a proton and an electron.

Gamma Decay

Gamma rays are not charged particles like α and β particles.

Gamma rays are electromagnetic radiation with high frequency.

When atoms decay by emitting α or β particles to form a new atom, the nuclei of the new atom formed may still have too much energy to be completely stable.

This excess energy is emitted as gamma rays (gamma ray photons have energies of ~ 1 x 10^{-12} J).

Radioactive Pollution

- Tailing: waste materials generated from mining are known as tailing. Have to be safely disposed or stored.
- Refining and fuel fabrication waste: During refining and purification of uranium, some radioactive waste is generated.
- Man-made sources: Nuclear fission, atomic bomb, accidental leakage of radiation from nuclear reactors.

Exposure to radioactivity causes -Severe biological effects, alter the structure of DNA or other bio-molecules, causing cancer and genetic defects.

Uranium Mining

- Uranium mining is the process of extraction of uranium ore from the ground.
- The worldwide production of uranium in 2019 amounted to 53,656 tonnes.
- Kazakhstan, Canada, and Australia are the top three producers and together account for 68% of world uranium production.
- Other important uranium producing countries in excess of 1,000 tonnes per year are Namibia, Niger, Russia, Uzbekistan and China.
- Uranium from mining is used almost entirely as fuel for nuclear power plants

Uranium mining

- **Uranium is mined by in-situ leaching (57% of world production) or by conventional underground or open-pit mining of ores (43% of production).**
- **During in-situ mining, a leaching solution is pumped down drill holes into the uranium ore deposit where it dissolves the ore minerals.**
- **The uranium-rich fluid is then pumped back to the surface and processed to extract the uranium compounds from solution.**

Uranium can be extracted from sea water.

The uranium concentration of sea water is low, approximately 3.3 parts per billion or 3.3 micrograms per liter of seawater. Since the 1960s research was being conducted in the United Kingdom, France, Germany, and Japan but now this research has been halted due to low recovery efficiency.

Mining of radioactive ore in India

- India has uranium reserves in Rajasthan, Jharkhand, Chhattisgarh, Meghalaya, Telangana, Andhra Pradesh and Karnataka. It is currently operating mines in Jharkhand and Andhra Pradesh (Uranium Corporation of India).
- The is Jaduguda Mine, a uranium mine in Jaduguda village in the Purbi Singhbhum district of Jharkhand, produces up to 25% of the raw materials needed to fuel India's nuclear reactors.

Which is the largest uranium mine in India?

- The largest uranium is Tummalapalle Mine in Tumalapalli village located in Kadapa of the Indian state of Andhra Pradesh.
- Results from research conducted by the Atomic Energy Commission of India in 2011 made the analysts conclude that this mine might have *one of the largest reserves of uranium in the world.*

Thorium in India

- The main world resources of thorium are associated with monazite placer deposits in India, Brazil, Australia, the USA, Egypt, and Venezuela. India is the largest producer of the radioactive Thorium in the world.
- Thorium cannot in itself power a reactor; unlike natural uranium, it does not contain enough fissile material to initiate a nuclear chain reaction.
- As a result it must first be bombarded with neutrons to produce the highly radioactive isotope uranium-233 – 'so these are really U-233 reactors,'

Thorium reserves in India

- As of May 2013, the country's thorium reserves were 11.93 million tonnes (monazite, having 9–10% ThO2, with a significant majority (8.59 Mt; 72%) found in the three eastern coastal states of Andhra Pradesh,
- The beach sand on the West Coast of India, particularly in **Kerala**, contains one of the rich deposits of thorium in the world.
- The country's nuclear power program is being built entirely dependent on these rich resources.

Type of pollution

- **Continuous Pollution:** This type of condition exists in uranium mines, nuclear reactors, test labs etc. where the humans are under continuous exposure to radioactive contaminants and protective clothing is required to avoid radiation exposure.
- **Accidental Pollution:** This type of condition exists during accidental exposure to radiations by virtue of equipment failure, radiation leak, faulty protective equipment etc.
- **Occasional Pollution:** This condition exists during isolated experiment or test of nuclear substance.

Effects

- **On Human Beings**

.► The impact of radioactive pollution on human beings can vary from mild to fatal; **the magnitude of the adverse effects largely depends on the level and duration of exposure to radioactivity**. Low levels of localized exposure may only have a superficial effect and cause mild skin irritation.

- ► Long-term exposure or exposure to high amounts of radiation can have far more serious health effects. Radioactive rays can cause irreparable damage to DNA molecules and can lead to a life-threatening condition.

The rapidly growing/dividing cells, like those of the skin, bone marrow, are more sensitive towards radioactive emissions.

On the other hand, cells that do not undergo rapid cell division, such as bone cells and nervous cells, aren't damaged so easily.

Skin cancer, lung cancer and thyroid cancer are some of the common types of cancers caused by radiation effect.

NUCLEAR REACTOR ACCIDENTS

Almost 99 such nuclear accidents have been occur through out worldwide.

56 of 99,have been occurred only in USA.

Nuclear Reactor Accidents

- Serious nuclear power plant accidents include
  - The Fukushima Daiichi nuclear disaster (2011),
  - Chernobyl disaster (1986),
  - **Three** Mile Island accident (1979), and
  - The SL-1 accident (1961).
- Nuclear power accidents can involve loss of life and large monetary costs for remediation work.
- About 99 accidents ---56 in US alone...!.

MAJAR NUCLEAR ACCIDENTS.

- **Three Mile Island, United States – 28 March, 1979 (INES Level 5)**
- one of the elements of the power plant's system malfunctioned .

Chernobyl, Ukraine (former Soviet Union) – 26,april,1986 (INES Level 7)

a series of events led to the explosion of the reactor number four at the Chernobyl Nuclear Power Plant

Fukushima, Japan –11,march 2011 (INES Level 7)

9.0 magnitude earthquake struck off the coast of Japan. The resulting tsunami (49 feet tall) hit the Fukushima I Nuclear Power Plant 51 and experienced meltdown.

NUCLEAR BOMBS

- Radioactive pollution that is spread through the earth's atmosphere is called "**Fallout**"
- The best example of fallout is the nuclear bomb attack on **Hiroshima and Nagasaki, Japan** in 1945 by United States of America during world war 2.

Effects of Radiation Exposure on Human Health

- Although a dose of just 25 rems causes some detectable changes in blood, doses to near 100 rems usually have no immediate harmful effects. Doses above 100 rems cause the first signs of radiation sickness including:
  - nausea
  - vomiting
  - headache
  - some loss of white blood cells

Rem, unit of radiation dosage (Roentgen Equivalent Man)

Hiroshima & Nagasaki bombing

August 6, 1945, Hiroshima

directly killing an estimated 80,000 people. By the end of the year, injury and radiation brought total casualties to 90,000–140,000

On August 9, 1945, Nagasaki

Almost 75,000 people died and more affected by radiation.

Prevention

- I) Nuclear devices should be exploded under ground.
- (II) Contaminants may be employed to decrease the radioactive emissions.
- (III) Production of radio isotopes should be minimised.
- (IV) Extreme care should be exercised in the disposal of industrial wastes contained with radionuclide's.
- (V) Use of high chimney and ventilations at the working place where radioactive contamination is high.
- .

- (VI) In nuclear reactors, closed cycle coolant system with gaseous coolants of very high purity may be used to prevent extraneous activation products.
- (VII) Fission reactions should be minimised.
- (VIII) In nuclear mines, wet drilling may be employed along with underground drainage.
- (IX) Nuclear medicines and radiation therapy should be applied when absolutely necessary and earth minimum doses

Solid Waste Management

Solid Waste Management

Municipal Solid Waste (MSW) is the term used to describe most of the **non-hazardous solid waste** disposed in a city, town or village. Sources includes homes, commercial establishments, institutions, hospitals.

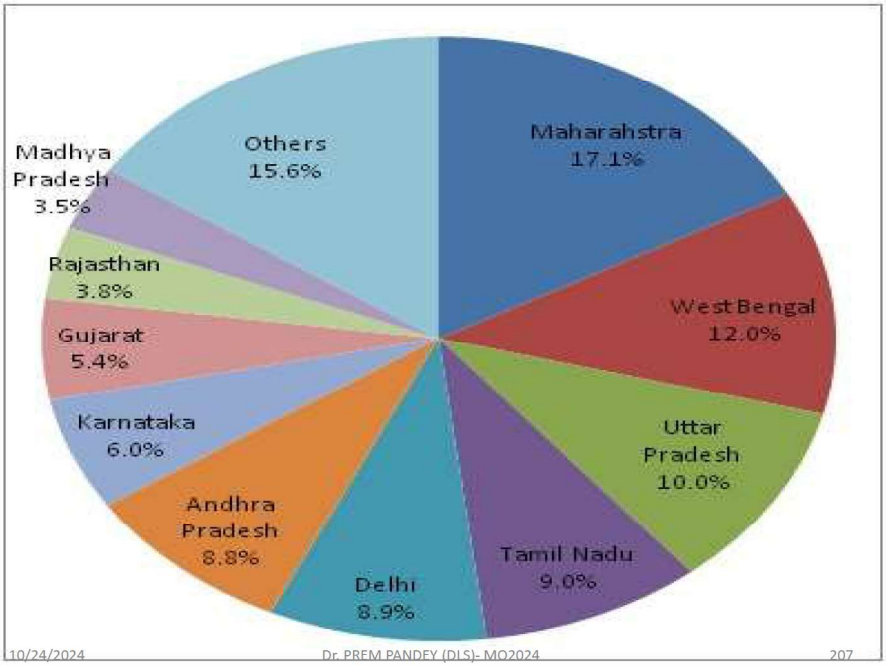
Food waste, paper, plastics, metal, glass, and also contain small quantities of hazardous waste- batteries, discarded medicines, chemicals etc.

- However, MSW **does not include industrial effluents, agricultural run-off, debris from construction and demolition activities, sewage and mining wastes.**
- India produces about **62 million tones of solid waste per year (as of Nov 2022)** and the approximate cost for their disposal is **>400 million INR.**

Waste Generation

Sl.no	Type of waste	Waste generated (MT/day)	% waste composition
1	Domestic household	1870	37.18
2	Commercial establishments	350	6.95
3	Hotels & restaurants	666	13.24
4	Institutions	125	2.48
5	Parks & gardens	69	1.38
6	Street sweeping	325	6.47
7	Waste from drains	175	3.47
8	Markets	479	9.52
9	Temples	35	0.70
10	Chicken, mutton, beef, fish stalls	164	3.26
11	Cinema halls	15	0.30
12	Function halls	88	1.74
13	Hospitals	35	0.69
14	Construction and demolition	635	12.62
Total		5030	100.00

Gurunathan Raj , P.Joseph , B.L.S.Harsha , K.Ravi Varma , Y.Sarath Chandra, V.SrinivasPLANNING V II Sem



Solid Waste Management

Waste Minimization

- **Process modification:** Most of the starting materials are incorporated into final products.
- **Concentration of waste:** Using techniques of evaporation and precipitation, the amount of hazardous waste can be reduced considerably.
- **Segregation of waste:** It is useful to separate non-hazardous wastes and from hazardous ones. The volume of the latter decreases making it easier to handle and treat.

Solid Waste Management

The strategy for waste management includes the components:

(Avoid- Minimize- Reduce- Reuse- Replace- Recycle-Treat- Decompose)

- **Source reduction**
- **Re-use**
- **Recycling**
- **Disposal** (sanitary landfill, incineration)
  - **Manure-vermi-composting.** It is useful to separate the vegetable and perishable waste and convert it into manure. The process is called vermi-composting. The final product is obtained to form soil rich in nutrients and can replace chemical fertilizers.

Solid Waste Management

A waste is considered hazardous if it has one of these characteristics:

- **Ignitability** – catches fire easily
- **Corrosiveness** – wears away other material
- **Reactivity** – reacts with water or explodes on reaction with other chemicals
- **Radioactivity** – releases ionizing radiation
- **Toxicity** – produces symptoms of metabolic disorder, poisoning or malformations

Solid Waste Management

The toxicity of hazardous waste can be reduced by physical, chemical or biological methods

- **Physical methods:** Such as phase separation (including the steps of lagooning, prolonged storage in tanks, and sludge drying in beds), absorption on charcoal or resin filters for absorbing toxins.
- **Chemical methods:** Neutralization, oxidization, reduction and ion-exchange
- **Biological methods:** Use of bacteria, soil microorganims, biodegradation can be accomplished by aerobic and anaerobic procedures

Solid Waste Management

Disposal of wastes

- **Landfill disposal: Disposal of the hazardous waste in properly operated sanitary landfills.**
- **The area must be lined with a non-porous substance such as clay or high-density polyethylene (HDPE)-plastic membrane to prevent from leaking into surrounding areas and polluting underground water.**

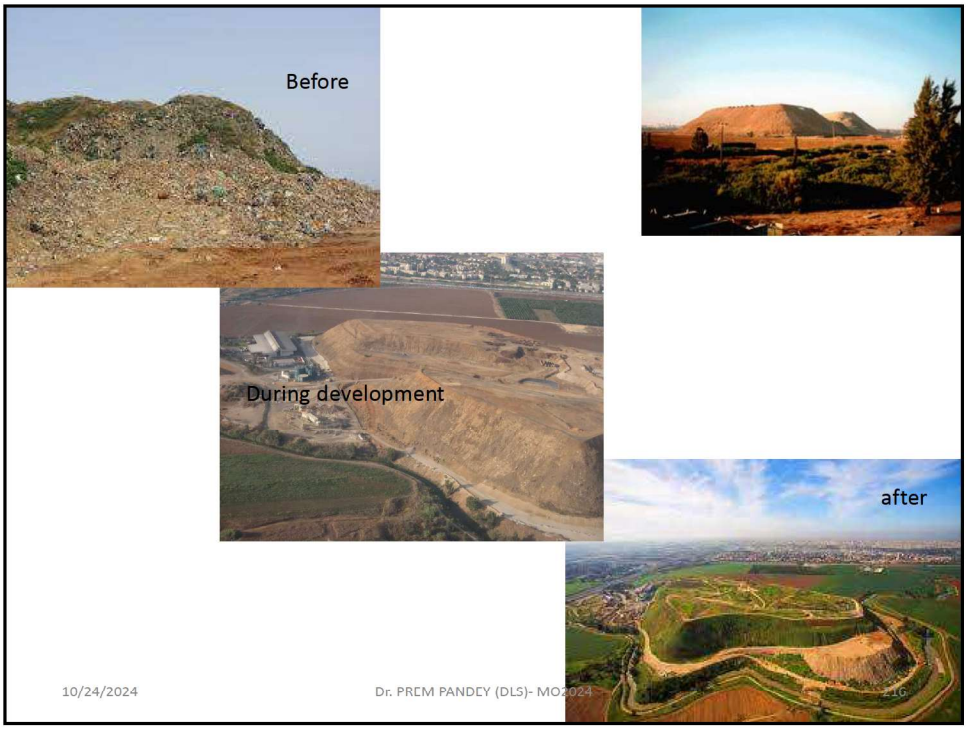
Waste generation in Delhi

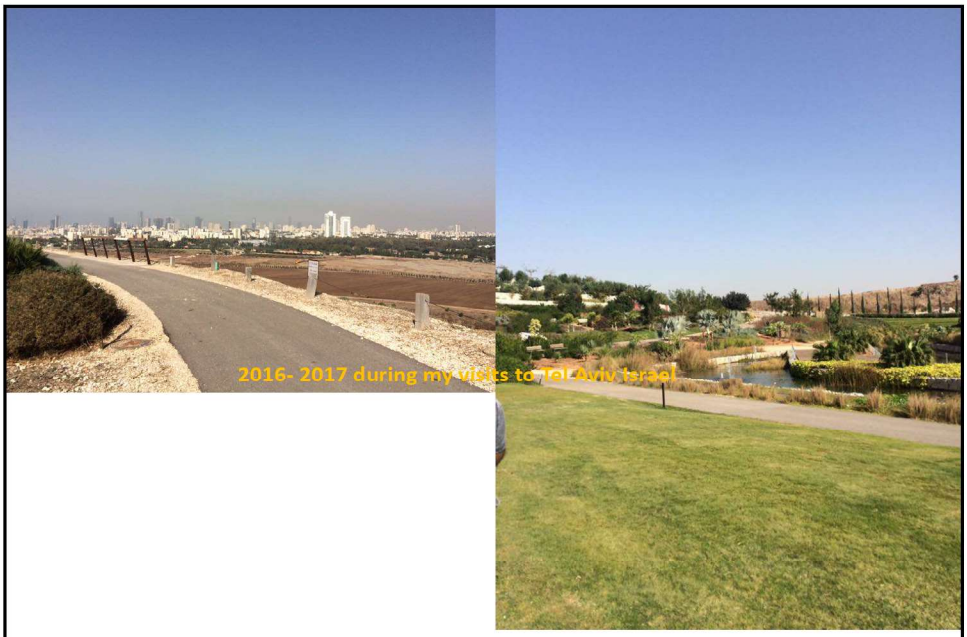
- Over **9,500 tonnes per day (TPD) of garbage is generated per day in the city. About 8,000 TPD** of waste is collected and transported to **three landfill sites** at **Bhalswa, Okhla and Ghazipur.**
- Actual waste generation in the city could be much higher, as a bulk of the waste is managed by the informal sector.
- According to an estimate, there are about **150,000 rag pickers** in Delhi.
- Landfill sites in Delhi had exceeded their capacity way back in 2008 **and most of these sites have contaminated groundwater in and around their neighbourhood.**

Rag pickers in Delhi and dumps of garbage within city limits

Ariel Sharon Park, Israel

- an environmental park along the lines of Ayalon river, in the area between Ben Gurion Airport and Highway.
- area is 8.5 square km big, and was intended to be the "green lung".
- established on the former **Hiriya** (waste dump site at Tel Aviv, Israel)
- After accumulating 25 million tons of waste, the Hiriya facility was shut down in August 1998. Disturb air traffic and pose threats to life.
- Hiriya is visible on approach into Ben Gurion International Airport as a flat-topped hill.
- Three recycling facilities have been established at the foot of the mountain:
  - a waste separation center,
  - a green waste facility that produces mulch and
  - a building materials recycling plant.
- The waste dump and its surrounding area have been renovated into a large park that is still under construction.




2016- 2017 during my visits to Tel Aviv Israel


KHANPUR
KHANPUR
KHANPUR
GHAZIPUR

Pollution from Landfills

- Landfill gas is the principal component of emissions to air from landfill sites.
- It is an end-product of the anaerobic process of degradation of biodegradable wastes once the waste has been deposited to landfill.
- Methane is emitted from the landfill sites.
- Once in the landfill, chemicals can leach into the ground water by means of precipitation and sur- face runoff.
- New landfills are required to have clay or synthetic liners and leachate (liquid from a landfill containing contaminants) collection systems to protect ground water

Negatives of landfills

Disadvantage of Landfills

- **Landfills are Partially Responsible For Climate Change. One tonne of biodegradable waste can produce about 400–500 cubic meters of landfill gas. Mainly CH4 ...**
- **Methane Lights up Easily. ...**
- **Contaminate Soil, surface and ground Water.**
- **Landfills Affect Wildlife. ...**
- **Accidents Can Happen like fire..**
- **Worsen air quality and impact surrounding environment.**
- **Landfills Affect Human Health.**

What are *alternatives* to landfills?

In addition to waste reduction and recycling strategies.

There are various alternatives to landfills-

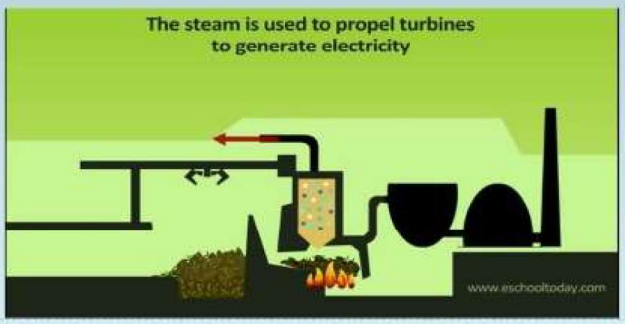
- **waste-to-energy incineration,**
- **anaerobic digestion,**
- **composting,**
- **mechanical biological treatment,**
- **pyrolysis and**
- **plasma arc gasification.**

Solid Waste Management

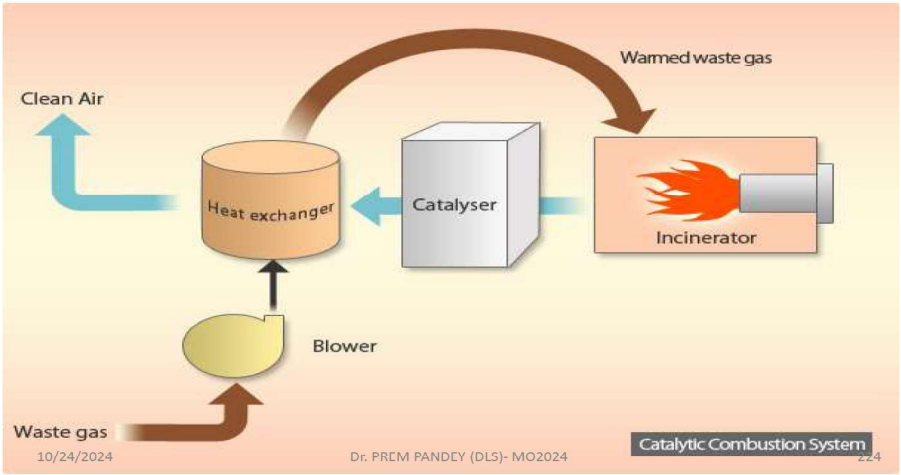
- **Incineration: In this process the waste is burnt, which detoxifies it.**
- **The flue gases are released to the atmosphere, and the slag or ash produced is deposited in a landfill. The wastes having inflammable material are incinerated.**
- **Flue gas** is the **gas** exiting to the atmosphere via a **flue**, which is a pipe or channel for conveying exhaust **gases** from a fireplace, oven, furnace, boiler or steam generator.
- Quite often, the **flue gas** refers to the combustion exhaust **gas** produced at power plants.

2. INCINERATION

- Incineration is a waste treatment process that involves the combustion of solid waste at 1000C.
- waste materials are converted into ash, flue gas, and heat.
- The ash is mostly formed by the inorganic constituents of the waste and gases due to organic waste.
- the heat generated by incineration is used to generate electric power.



Mercury, cadmium, arsenic, Sulphur, phosphorus .



Solid Waste Management

- **Dumping at sea:** Hazardous waste has to be put in sealed containers before dumping into deep seas.
- Disposal of waste into sea is governed by international and national legislation.
- The direct dumping into sea is prohibited, particularly waste containing organo-silicon compounds, halogenated organics, mercury, cadmium, carcinogenic waste and plastics.

Removal of plastic waste from a drain for recycling

Automatic sorting (based on shape/ size colour, types) which depends on various-

- physical,
- optical or
- electronic properties of plastics,

has been developed and employed successfully in developed countries.

- But such methods prove to be difficult and expensive because of variety of size, shape and colour of plastic objects

Waste to Energy

- A **waste-to-energy plant** is a waste management facility that combusts wastes to produce electricity.
- This type of power plant is sometimes called a trash-to-energy, municipal waste incineration, energy recovery, or **resource recovery** plant.
- **Waste-to-energy generation** is being increasingly looked at as a potential energy diversification strategy, especially by Sweden, which has been a leader in waste-to-energy production over the past 20 years.

Energy from Waste

- **The typical range of net electrical energy that can be produced is about 500 to 600 kWh of per ton of segregated waste incinerated.**
- **Thus, the incineration of about 2,200 tons per day of waste will produce up to 50 MW of electrical power.**

Energy from Waste

The first Power plant at Okhla uses about 2000mt of municipal waste delivered in 40 dumper trucks to produce 16 MW of electricity.

ROJECT HIGHLIGHTS

- **The largest integrated waste to power project in India**
- **The 1st of its kind with a 16 MW power project**
- **State-of- the-art technology and environment friendly**
- **Real, measurable and long term benefits in terms of climate change and mitigation**
- **Generate renewable power and reduce the need for landfills**
- **Lowers the risk of groundwater contamination.**
- **Reduces dependence on fossil fuels, a major contributor to greenhouse gas emissions.**
- **Maximizes the recycling and re-use of resources (water, metals, ashes)**

Energy from Waste

- The **24 megawatt (MW) Narela-Bawana waste-to-energy plant** of the North Delhi Municipal Corporation was inaugurated by Union Urban Development Minister M. Venkaiah Naidu at the Civic Centre.

- Another **Waste-to-energy plant** is coming up at **Ghazipur** to produce **12 MW** power by processing 2,000 tonnes **waste** per day,

Waste management in India

Innovations in fecal sludge management

Several research has been carried out in the FSTP for effective and sustainable management of fecal sludge.

1. The London Educational institution of Hygiene and Tropical Medicine
   - Introduced the larvae of black soldier fly (BSFL).- a non-disease spreading, non-nuisance fly species (*Hermetiaillucens*).
   - to feed on pit latrine waste.
   - As the larvae develop on the faecal material, they increase in size, reducing the mass of the waste, and converting the dangerous pit material into a potentially useful soil conditioner or **fertiliser**.
   - Once the larvae have developed into pre-pupae, they can be harvested. These pre-pupae are high in fat and protein and have an economic value as a suitable replacement for conventional protein sources in **animal feeds**.

Innovations in fecal sludge management

2. **GenRobotics**, a Kerala research team:
   - A tech start-up has launched an Iron-Man style semi-automatic robot named '**Bandicoot**'.
   - The first of its kind exoskeleton robot in the country to clean manholes without the need for human beings having to enter the pits (manual scavenging eradication).

- Their invention made waves in the state due to its huge potential social impact **against manual scavenging – a practice banned in India** nearly two decades ago, yet actively practiced in almost every state.
- Thanks to the Bandicoot, sanitary workers to stop endangering their lives on a daily basis. They no longer have to enter clogged manholes filled with hazardous gases.

e-Waste management in India

- According to the Associated Chambers of Commerce and Industry (ASSOCHAM) predictions, **"India will generate 130 million tonnes of e-waste by 2018 from the current 93.5 million tonnes in 2016. And by 2020, India is expected to generate 5.2 trillion tonnes of e-waste".**
- **Today, India is one of the worlds most disposed area.**

Waste management in India

As per Rule 4 of the Municipal Solid Wastes (Management and Handling) Rules, 2000,

- "every municipal authority is responsible for infrastructure for segregation and processing of municipal solid waste (MSW), *commonly known as* ***garbage***"

Waste management in India

- In India, Many dangerous garbage including plastics is disposed off in many Indian landfills.
- The MSW rules are based on the principle that the best way to keep streets clean is **not to dirty them in the first place**. So a city without street bins will ultimately become clean and stay clean.

Solid Waste Management Rules, 2016

Duties of waste generators

1. Duties of Ministry of Environment, Forest and Climate Change
2. Duties of Ministry of Urban Development
3. Duties of Department of Fertilisers, Ministry of Chemicals and Fertilisers.
4. Duties of Ministry of Agriculture, Government of India.
5. Duties of the Ministry of Power
6. Duties of the Secretary-in-charge, Urban Development in the States and Union territories
7. Duties of District Magistrate or District Collector or Deputy Commissioner
8. Duties of the Secretary-in-charge of Village Panchayats or Rural Development Department in the State and Union territory
9. Duties of Central Pollution Control Board.
10. Duties and responsibilities of local authorities and village Panchayats of census towns and urban agglomerations.

Solid Waste Management Rules, 2016

Duties of waste generators

11. Duties of State Pollution Control Board or Pollution Control Committee
12. Duty of manufacturers or brand owners of disposable products and sanitary napkins and diapers
13. Duties of the industrial units located within one hundred km from the refused derived fuel and waste to energy plants based on solid waste
14. Criteria for Duties regarding setting-up solid waste processing and treatment facility
15. Criteria and actions to be taken for solid waste management in hilly areas
16. Criteria for waste to energy process.
17. Time frame for implementation.-
18. State Level Advisory Body.
19. Annual report
20. Accident reporting

Solid Waste Management Rules, 2016

SCHEDULE I [see rule 15 (w),(zi), 16 (1) (b) (e), 16 (4)]

Specifications for Sanitary Landfills

(A) Criteria for site selection.
(B) Criteria for development of facilities at the sanitary landfills.
(C) Criteria for specifications for land filling operations and closure on completion of land filling.
(D) Criteria for pollution prevention.
(E) Criteria for water quality monitoring.
(G) Criteria for plantation at landfill Site
(H) Criteria for post-care of landfill site
(I) Criteria for special provisions for hilly areas.
(J) Closure and Rehabilitation of Old Dumps-

Solid Waste Management Rules, 2016

SCHEDULE II [see rule 16 (1), (b), (e), 16 (4))

Standards of processing and treatment of solid waste.

(A)Standards for composting.-

(B)Standards for treated leachates

(C)Standards for incineration:

7 Ways To Reduce Air Pollution and You Can Start Living a Pollution Free, Healthy Life

Step 1: Understand Where Air Pollution Comes From

Step 2: Reduce Your Use of Automobiles

Step 3: Plant More Plants

Step 4: Go Solar

Step 5: Get the Lead Out

Step 6: Never Dust Again

Step 7: Get Cozy

What can we do? Preventive measures

What can we do? Preventive measures

- Industrial and municipal treatment plants should be used.
- The sludge left should be converted into bio-fertilizers.
- Industrial effluents should be treated at the factory site only and the effluents that are free from pollutants should be discharged into water bodies.
- If water is used in any industrial operation, it should be treated and should be reused in the same industry after removal of pollutants.
- Any gaseous effluents should be passed through electrostatic precipitators (to remove suspended particulate matters) and scrubbers (to remove oxides of carbon, nitrogen and sulphur).

What can we do? Preventive measures

- Any waste or by-product generated in any industry should be used for making other useful products- recycling
- All manufacturing units should be designed to avoid the possibility of accidents and release volatile solvents into the atmosphere.
- In any chemical process, all starting material should be incorporated into the final product.
- Chemical fertilizers should be used in bare minimum amount.
- Any nuclear waste should be disposed following the standard procedures.

Some of the environmental concerns

- Humans are responsible for increasing atmospheric concentration of CO_2 by about 30%.
- We use more than half of the accessible freshwater resources.
- Over 50% of terrestrial nitrogen fixation is due to human activities.

Role of individual in prevention of pollution

- **Guidelines to be followed: Guidelines** for individuals to find out solutions against pollution
- **Plantations: Plants** reduce –
  - air pollution,
  - protection of forests,
  - kitchen gardens,
  - conserve fossil fuels,
  - conserve resources,

do not smoke, say no to plastics, recycle material, family planning

Plants which reduce indoor pollution

Top ten plants for removing formaldehyde, benzene, and carbon monoxide from the indoor air:

- Areca Palm (*Chrysalidocarpus lutescens*)
- Lady Palm (*Rhapis excelsa*)
- Bamboo palm (*Chamaedorea seifrizii*) .
- Rubber Plant (*Ficus robusta*)
- Dracaena "Janet Craig" (*Dracaena deremensis*)
- Philodendron (*Philodendron* sp.)