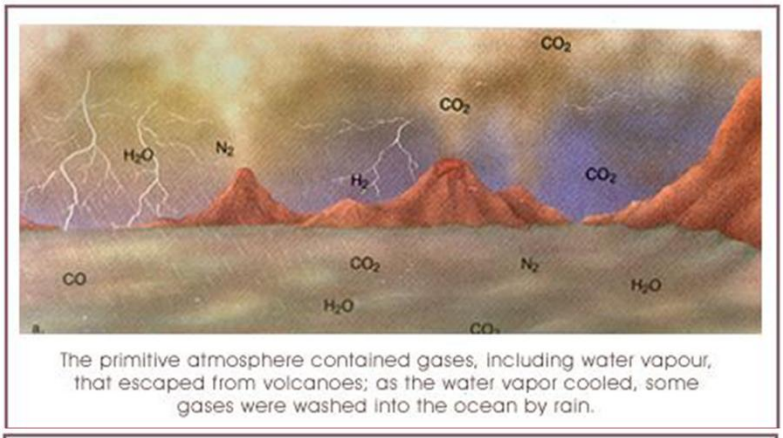
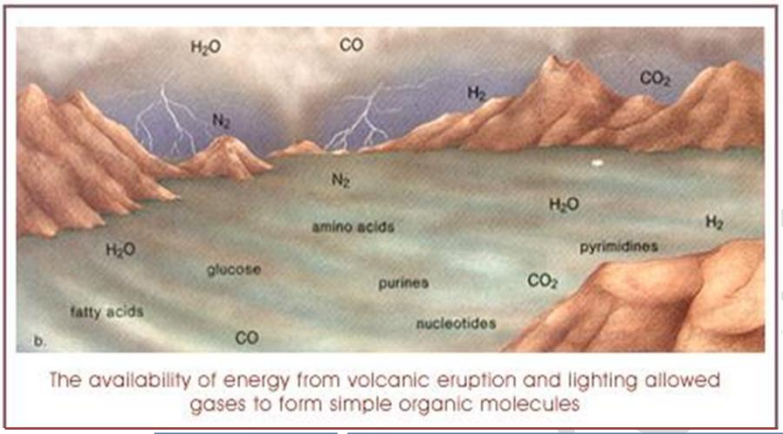
Chapter 7 Air Resources



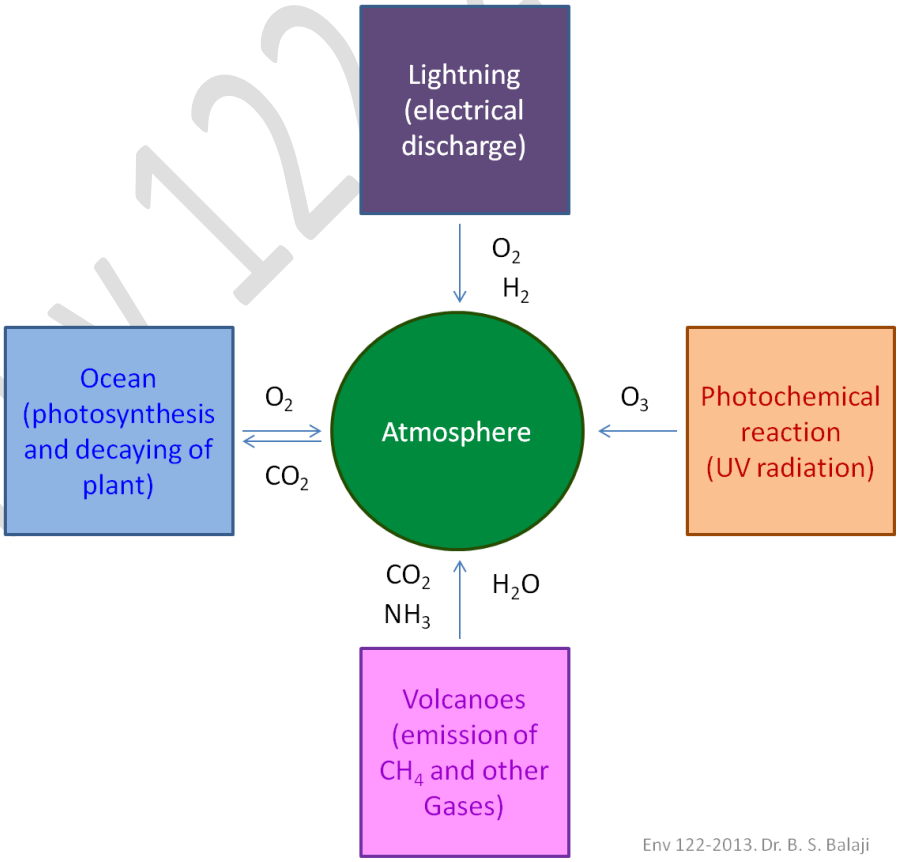
The primitive atmosphere contained gases, including water vapour, that escaped from volcanoes; as the water vapor cooled, some gases were washed into the ocean by rain.



The availability of energy from volcanic eruption and lighting allowed gases to form simple organic molecules

Origin of Atmosphere

- Volcanoes synthesised and emitted CO_2, H_2O, NH_3 from CH_4 and other gases
- First primitive molecules of life formed
- Intense bombardment of atmosphere by UV, lightning, radiation gave energy required for the complicated chemical reactions
- From this first life form single celled bacteria evolved



Origin of atmosphere

- Early aquatic organisms started producing organic matter through photosynthesis
- O_2 was liberated. It saturated the water then started filling atmosphere
- O_2 was toxic to some primitive organism hence they perished
- Other species started using O_2 for getting energy through respiration
- N_2 evolved from the Earth's interior

How was the ozone layer above the Earth's surface formed?

- Between 1-2 billion years ago O_2 built up in the atmosphere
- Some O_2 molecules were split by UV radiation to single atoms
- They combined with O_2 to form O_3. Thus O_3 layer was formed
- It absorbs the harmful UV radiation coming from Sun
- Life form started from sea then moved to land
- The present composition of atmosphere is same as it was 500 million years ago
- Due to biological activities it is changing now

Composition of air

Constituents		% by volume
Major components		
	Nitrogen	78.09
	Oxygen	20.94
Minor components		
	Water vapour	0.1-5.0
	Argon	9.34×10^{-1}
	Carbon di oxide	3.25×10^{-2}

Constituents		% by volume
Trace components		
	Neon	1.82×10^{-3}
	Helium	5.24×10^{-4}
	Methane	2.0×10^{-4}
	Krypton	1.14×10^{-4}
	Nitrous oxide	2.5×10^{-5}
	Hydrogen	5.0×10^{-5}
	Xenon	8.7×10^{-8}
	Sulphur di oxide	2.0×10^{-8}
	Ammonia	1.0×10^{-6}
	Carbon monoxide	1.2×10^{-5}

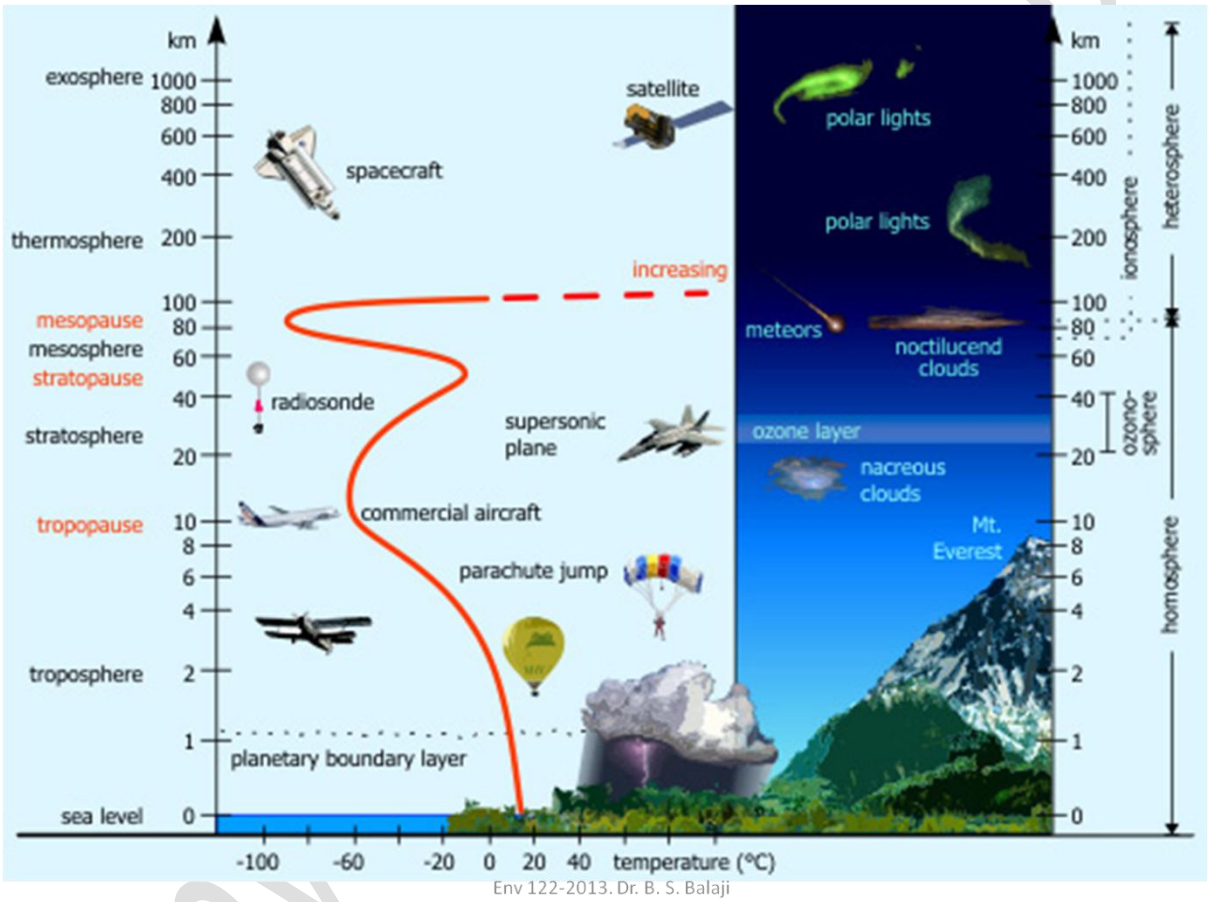
The physical parameter of the atmosphere vary with altitude. **Density** decreases with increasing altitude. **Pressure** drops as we go up. **Temperature** varies from -100 °C to 1200 °C. Atmosphere mass is very small compared to Earth's mass.

Structure of the atmosphere

What is atmosphere?

- It is the multilayer gaseous envelope that surrounds Earth
- It gives all the gases necessary for sustenance of all life forms in biosphere
- It filters harmful UV rays by filtering
- It protects the Earth from becoming too hot

Atmospheric layer	Altitude range (km)	Temperature range (°C)	Important gases
Troposphere	0-11	15 to 56	N_2, O_2, CO_2, H_2O vapour
Stratosphere	11-50	-56 to -2	O_3
Mesosphere	50-85	-2 to 92	O_2, nitric oxide (ionised)
Thermosphere	85-500	-92 to 1200	O_2, oxygen atoms, nitric oxide (ionised)



Env 122-2013. Dr. B. S. Balaji

Troposphere

What is troposphere?

- It is the lower most layer of the atmosphere
- The average height is 11 km. (16 km near equator and 6 km over poles)
- 70 % of the total mass of atmosphere is in troposphere

What is temperature inversion?

- Generally as we go up in altitude temperature decreases in troposphere
- A temperature inversion is a condition in which the temperature of the atmosphere increases with altitude

Why is troposphere more turbulent region in the atmosphere?

- Air in the tropopause is non-uniform with respect to density and temperature

- Due to the global energy flow arising from the imbalances of heating and cooling rates between equator and poles turbulence arises

Stratosphere

- Stratosphere extends from tropopause to stratopause (11-50 km)
- Temperature increases with height

What is the importance of ozonosphere?

- The lower part of the stratosphere (15-30 km) is called ozonosphere.
- Here the concentration of O_3 is higher
- It acts as a protective shield for life on Earth from Sun's harmful UV radiation
- It supplies the heat source for partitioning stratosphere and troposphere
- Due to the slow mixing, the residence time of molecules in this region is long
- When pollutant is introduced here they pose long term global-hazard

Mesosphere, Thermosphere

Mesosphere extends between 50-80 km, temperature decreases with increasing height. The temperature inversion happens at mesopause (—ve to +ve lapse rate)

In **thermosphere** temperature increases rapidly with increasing height

- **Ionosphere**: it extends up to 640 km. D, E, F1 and F2 are different layers. Since they reflect signals they play a vital role in radio-communication
- **Exosphere**: it is the upper most layer.

Air pollution

Motor vehicle exhaust:

Why is motor vehicle exhaust considered to be the most potent source of pollution in the urban atmosphere?

Fuel combustion in motor vehicle is the primary source of air pollution.

1. **Exhaust system**
    - Emission include particulate matter, SO_2, NOx, un-burnt hydrocarbon, CO
2. **Fuel tank and carburetor**
    - Evaporation of fuel from fuel tank occurs. When the engine stops heat built up in the carburetor and that leads to loss of fuel.
3. **Crankcase**
    - Some gas vapour escape between walls and the piston, which thereafter enter the crankcase and finally discharged to atmosphere.

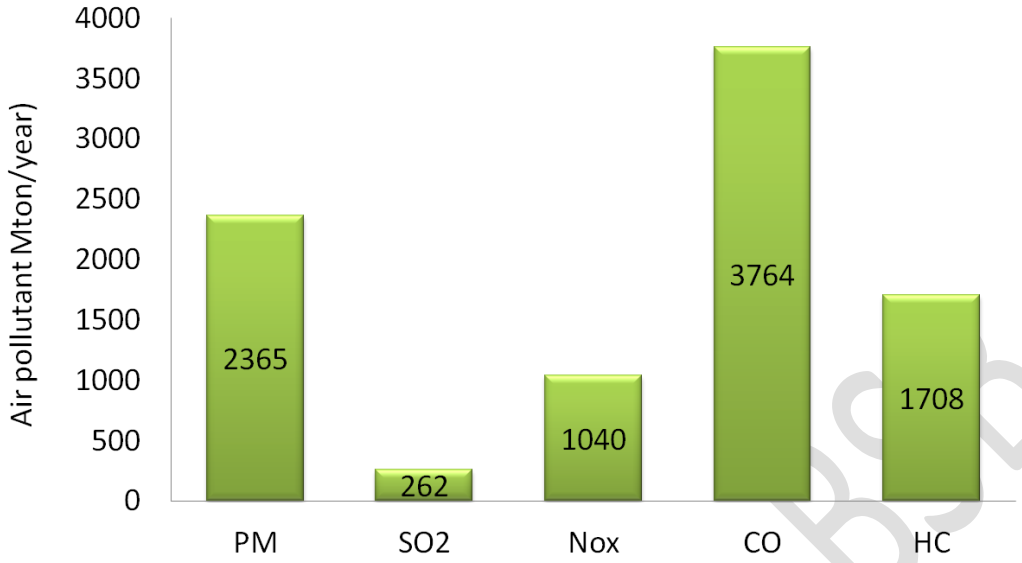
Agricultural sources

- Ploughing up of agricultural field
- Use of agricultural chemicals eg. Pesticides
- Field refuse burning

Air pollutant source are grouped according to their number and spatial distribution

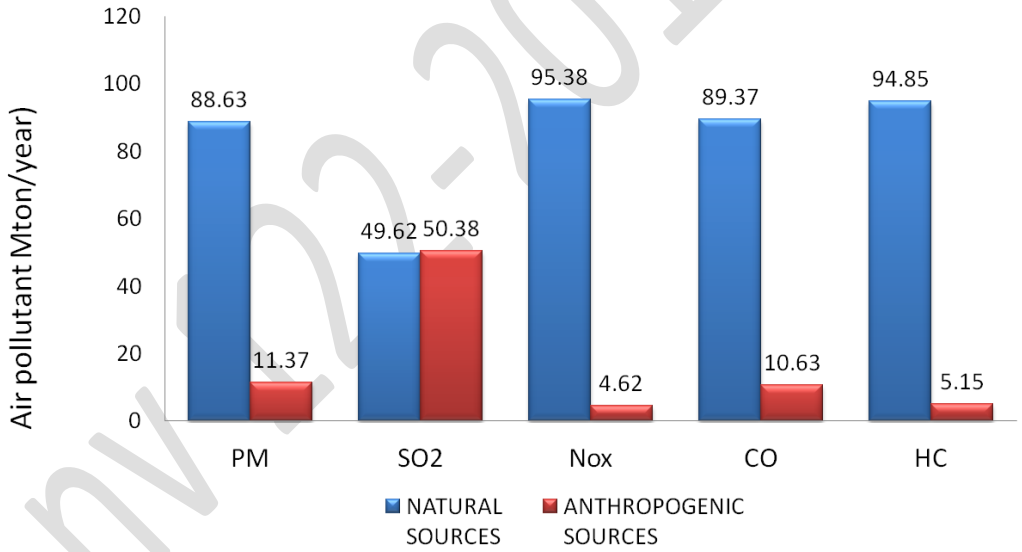
1. **Single or point source**
    - Point sources are large stationary sources of pollution. Eg. Industrial chimneys
2. **Multiple or area source**
    - When pollutants are released directly into the atmosphere from an entire area, without the help of any primary exhaust system
        1. Stationary area eg. Residential area, parking lot, storage

2. Mobile area eg. Vehicle, ship, auto mobile



Estimated global emission of major air pollutants

Env 122-2013. Dr. B. S. Balaji



Major air pollutants

Env 122-2013. Dr. B. S. Balaji

Effects of air pollution on human health

The air we breathe not only supports life but also damages it (pollution).

Why should the pollutant concentration in air be maintained at magnitudes lower than those permissible in food or water?

- We inhale 22-44 X 10^3 L or 25-50 Kg of air/day (22,000 times/day, each time 1-2 L). The amount of food we consume is only 1.5-2 kg/day. The amount of water we take is also 1-2 L/day. The quantity of air consumed is 15-20 times higher by weight in food or20,000 times more by volume in water consumed. Since the air intake is very large the pollutant should be very small. Allowed pollutant (SO_2, NOx, HCl) concentration in air is few parts per hundred million (pphm) where as 50 pphm or 0.5 ppm Hg is allowed in fish (food). An amount of 0.3 ppm or 3,00,000 mg/m^3 of Pb in water is harmful to man compared to 1.5 mg/m^3 of Pb in air which is deadly. Moreover man can survive without food for 5 weeks and without water for 5 days where as he will die in 5 min if there is no air

What are the factors which govern the impact of air pollutants on human health?

1. The type of pollutants
2. Concentration and duration of the pollutants
3. Age and health condition of the exposed man

What are the adverse effects of air pollution on human health

1. Acute effects: it manifests themselves immediately upon short term exposure to air pollutants at high concentrations
2. Chronic effects: it becomes evident only after prolonged exposure to low levels of air pollution

How do air pollutants enter the human body

1. Through respiratory system
2. Through direct contact with eye and skin
3. Through ingestion
4. By swallowing during internal respiratory cleaning action

What are the effects of major air pollutants on human health?

A. **Particulate matter**
   - Depends on size and characteristics
   - Enters through respiratory system
   - Inhaled matter can be deposited in various regions of respiratory system

1. Particulates >10 μ retained in the **nose**
2. Particulates <10 μ which enter respiratory system are called inhalable or *respirable suspended particulate matter* (*RSPM*). 5-10 μ deposits in **nasal cavity and trachea**
3. Fine particles (0.5-5 μ) travel up to lower respiratory system and deposits in the walls of **bronchioles**
4. Particles less than 0.5 μ may reach and settle in the **alveoli** (the functional unit of lung where transfer of O_2 from air to the pulmonary capillaries and diffusion of CO_2 in the opposite direction takes place). These particulates cause major damage to respiratory system

What are the adverse effects of particulate matter on human health?

- Particulate matter may interfere with the clearing mechanism of the respiratory tract. The effects include slowing of ciliary beat and mucus flow in the bronchial tract which may cut off the main cleaning mechanism
- Particulate matter may act as carriers of absorbed/adsorbed toxic gases such as SO_2, NOx, and produce synergistic effect. Particulate matter and the toxic gas both can cause serious health issues

PM conc. in mg/m^3	Other factors (SO_2, mg/m^3)	Averaging time (hr)	Effects
750	715	24	Increased daily death rate; bronchitis illness increases
300	600	24	Acute worsening of chronic bronchitis
185	105-265	Annual mean	Increased lung diseases
100	120	Annual	Mean respiratory disease increases

- Particulate matter may intrinsically be toxic (chemical and physical properties). Mainly metal pollutants are dangerous. Be, Se, V, B, As, Cr, Mn (minor pollutant)

Toxic trace metals	Sources	Effects
Lead	Auto exhaust, lead batteries, paints	Neurotoxic, affects circulatory system, behavioural disorder
Cadmium	Tobacco smoke, incineration of plastic, coal, zinc, refining of metals	Cardiovascular disease, kidney, liver damage, hypertension
Nickel	Tobacco smoke, combustion of coal, diesel, manufacturing of steel, non-ferrous alloy, catalysis	Respiratory damage, lung cancer
Mercury	Combustion of fossil fuel, evaporation from ore mining, exhaust from smelting, paints	Nerve and brain, kidney damage congenital birth defect, fetus death

B. **Gaseous pollutants**
   - Depends on concentration, period of exposure, solubility
   - Highly soluble gas (SO_2) absorbed in upper part of respiratory system
   - Insoluble gas (CO, NOx) go deep to alveoli of the lungs

1. **SO_2**: irritant gas; affects mucous membrane; acute effect – confined to upper respiratory tract; chronic effect - respiratory infection; forms SO_4 aerosol ($H_2O + SO_2$ -→ H_2SO_4) leading to sever health problem

Conc. of SO_2 (ppm)	Effects
0.2	Lowest level causing human response
0.3	Threshold for taste recognition
0.5	Threshold for odour recognition
1.6	Threshold for inducing reversible bronchio-constriction
8-12	Immediate throat and eye irritation
20	Immediate coughing

2. **NOx** : Nitric oxide (NO), nitrogen dioxide (NO_2). NO is harmless. But NO_2 is harmful. Under moist condition it can reach up to alveoli gets converted into acids and cause damage to tissues. NO_2 is also carcinogenic.
   NO_2 along with hydrocarbon act as *photochemical smog* leading to secondary pollutant formation. They also cause damage to human health

Conc. of NO_2 (ppm)	Exposure	Effects
0.06-0.1	2-3 yr	Increase in acute respiratory disease
Up to 0.1	6 months	Increase in acute bronchitis disease
0.12	<24 hr	Human olfactory threshold
5	10 min	Increase in airway resistance
90	30 min	Pulmonary edema

3. **CO**: when inhaled it goes directly to lungs and to the blood stream. It forms carboxy haemoglobin (COHb). It is a stronger ligand than O_2. Cells are now deprived of O_2 and they die due to asphyxiation. Chronic effects of CO are not known. Though CO is not carcinogenic it enhances the activity of other pollutants.

COHb in blood (%)	Effects
1-5	Blood flow to vital organ affected; heart patient suffer
5-9	Visual light threshold increased; chest pain induced
10-20	Respiration difficulty, vision problem, severe heart patient may die
20-30	Headache, nausea
30-40	Severe Headache, nausea, vomiting
40-50	Slurring of speech, tendency to collapse
50-60	Convulsion, coma
60-70	Fatal coma if not treated immediately

4. **Hydrocarbons**: Aromatic HC are more dangerous than aliphatic and alicyclic ones and cause acute irritation to mucous membrane. Excess of HC increases mucous secretion which blocks respiratory tracks causing coughs. This leads to trachea of lungs. Benzopyrene (present in tobacco, charcoal) is carcinogenic. A higher HC content in the absence of O_2 creates narcotic effects. Some HC can damage to DNA and cell growth.
5. **Photochemical oxidants**: O_3 is the major product of oxidation. Exposure to O_3 leads to chest pain, headache, difficulty in articulation, damage to RBC.
   Other oxidants produced in photochemical smog are peroxyacyl nitrate (PAN), peroxypropynol nitrate (PPN), peroxybutyl nitrate (PBN).

Concentration (ppm)		Exposure	Effects
O_3	0.1-1.0	1 hr	Increase airway resistance
	1.0-3.0	2 hr	Extreme fatigue, sever cough
	9.0	-	Pulmonary edema
Total photo chemical pollutant	0.1	Instantaneous	Eye irritation
	0.05-0.06	1 hr	Aggravation of asthma
	0.03-0.3	1 hr	Impaired performance of athletes

Effects of air pollution on flora

- The leaf structure are damaged by air pollution. Plant growth and photosynthesis are also affected. When particulate matter deposits on the leaf they clog stomata and disturb the photosynthesis.

What are the morphological changes in the vegetative system caused by pollution?

Necrosis: It is killing or collapse of plant tissue

Chlorosis: The loss of green plant pigment

Abscission: It is dropping of leaves

Epinasty: Curling of leaf due to rapid growth on the upper side of the leaves

Pigmented lesions: They may result with dark brown, black or purple spot appearing on the leaf surface

Pollutants	Dose	Effects
PM	Severe	Affects photosynthesis, quality, vigour, hardness
SO_2	Mild	Interveinal chlorotic bleaching of leaves
	Severe	Necrosis in Interveinal areas
NOx	Mild	Suppressed growth, leaf bleaching
C_2H_2	Mild	Epinasty, abscission
Aldehyde	Severe	Necrosis
PAN	Mild	Bronzing of lower surface of leaves, suppress growth
O_3	Mild	Flecks on upper surface, suppress growth
	Severe	Collapse of leaves, Necrosis, bleaching
Fluorides	Mild	Necrosis at leaf tip
Pesticide	Mild	Defoliation, dwarfing, curling, twist, growth reduction
Cl_2	Mild	Bleaching between veins, tip, leaf abscission

What are the factors which regulate plant-response to pollutants?

- Genetic variability affects the plant-response to pollutants. Genetic variability changes the morphological, physiological and bio-chemical characteristics of the plants. Some plants are affected by F^- but resistant to SO_2.

- Sensitivity of plants to various pollutants depends on genetic factors, climatic factors, fertility of the soil and availability of water. The important climatic factors affecting response of plants to air pollutants are temperature, humidity, light quality, light intensity and duration of light.

Effects of air pollution on fauna

Animals are affected by air pollutants in two-step process.

1. Accumulation of the air borne contaminant in the vegetation and forage
2. Subsequent poisoning of the animals when they eat the contaminated vegetation

Effect of fluorine on animals

What are the adverse effects of fluorine poisoning on animals?

- Lack of appetite, rapid loss in weight, decline in health vigour, lameness, periodic diarrhea, muscular weakness and death. Fluorine is protoplasmic poison. It has affinity towards Ca and affects normal calcification. It affects teeth formation. Tooth symptoms are indicators of chronic fluorosis. Since fluorine accumulates in bone, it leads to bone lesion. It affects leg bones, jaw bones and ribs. Lameness followed by stiffness of joints occur. Skeletal structures are affected permanently. Cattle and sheep are easily affected by fluorine. Horses are less affected and poultry are resistant to fluorine.

Effect of arsenic on animals

Arsenic occurs as impurity in many ores.

What are the adverse effects of arsenic (As) poisoning on animals?

- As in dust leads to intoxication of cattle. Acute poisoning lead to severe salivation, thirst, vomiting, diarrhea, uneasiness, feeble and irregular pulse and respiration rate. Cattle stamps, become restless, body trembles, develop abnormal temperature and death may occur. Chronic exposure affects nervous system, leads to paralysis and death. Sheep are easily affected by As. Cattle and Horses are resistant to As.

Effect of lead on animals

Smelters, coke ovens, lead batteries emit toxic lead fumes.

What are the adverse effects of lead poisoning on animals?

- Acute Pb poisoning may lead to fast and weak pulse, complete loss of appetite, paralysis of digestive tract and diarrhea. Some animals may fall suddenly due to stiff legs and convulsion.
- Chronic Pb poisoning results in paralysis of muscle of the larynx (voice box), difficulty in breathing. Paralysis of the throat also occurs.

Effect of ionising radiation on animals

- This occurs due to nuclear bomb testing and radioactive fallout from nuclear plants. It may be acute or chronic dose or exposure. Acute affects within hrs to weeks. Chronic leads to blood cancer, shortening of life span, genetic or mutation effect.

Effect of pollution on property

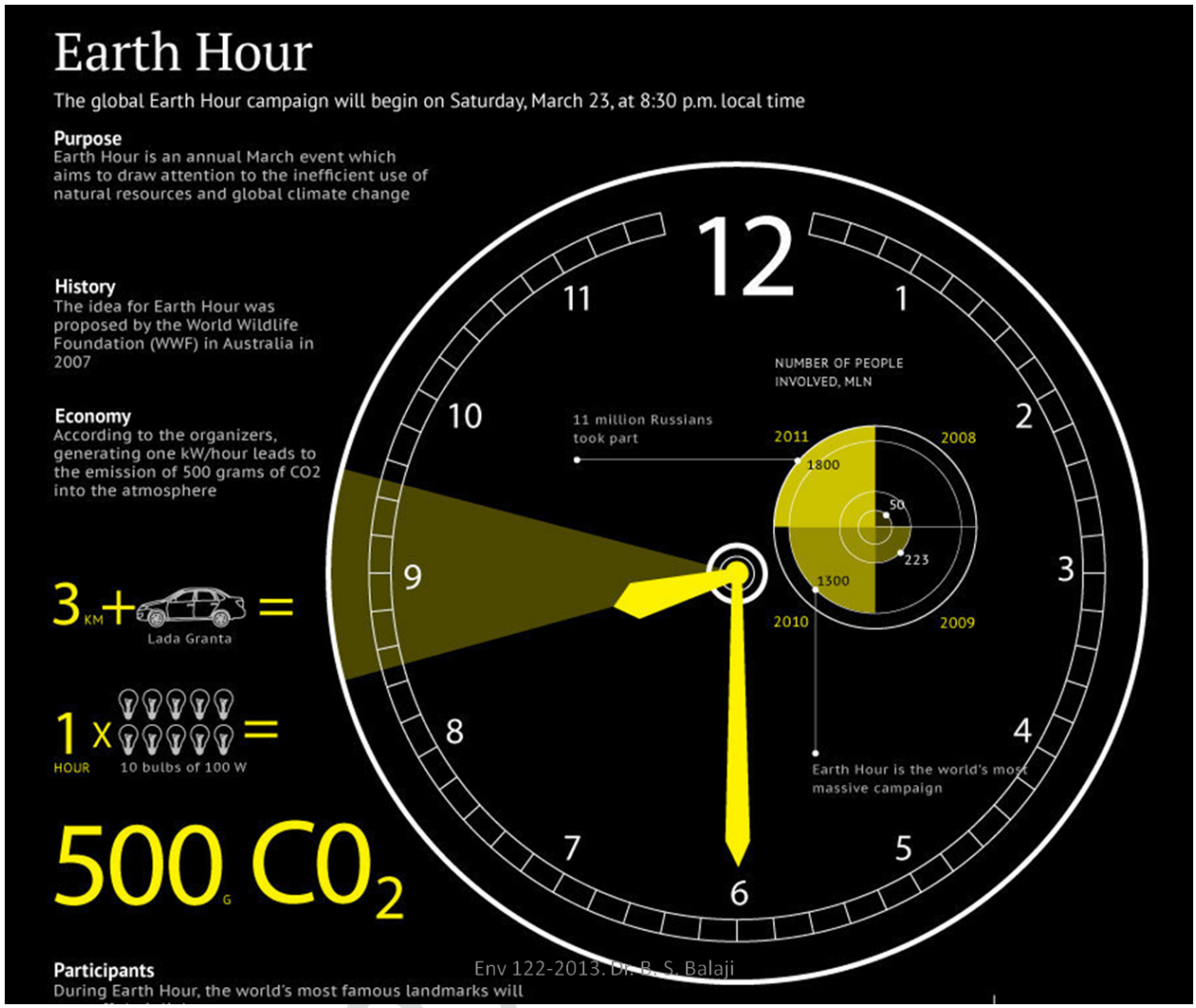
Corrosion of metals, soiling and eroding of building surfaces, rubber cracking etc.

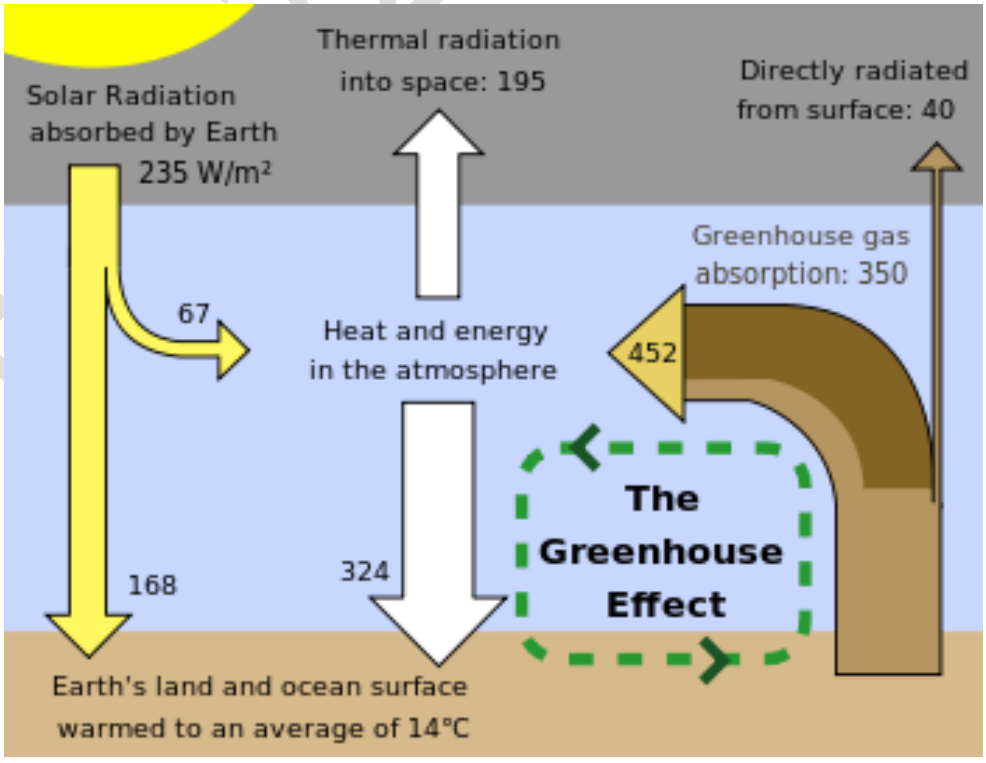
Mechanism of action involves

1. **Abrasion**: PM of considerable size travelling at higher speed causes this
2. **Chemical action**: Pollutants react directly and irreversibly on materials
3. **Absorption**: Certain material absorb some pollutant and get damaged

4. **Corrosion**: This is chemical or electrochemical attack on metals. (rusting of Fe)
5. **Deposition and removal**: Solid and liquid PM deposited on a surface may damage the material by spoiling its appearance.

Material	Air pollutants	Effects
Metals and alloys	SO_2, NO_2, acid gases	Corrosion of metal, spoilage of surface, loss of metal, loss of strength
building material	SO_2, NO_2, acid gases	Soiling, discoloration, erosion
Textiles	SO_2, NO_2, NH_3, O_3, PM, acid gases	Soiling and reduction in life due to abrasive action, loss of tensile strength, staining
paints and varnishes	SO_2, H_2S, PM	discoloration
Paper	SO_2, acid gases	Embrittlement and discoloration
Rubber	O_3, PAN, NO_2	Cracking of rubber, weakening
Leather	SO_2, acid gases	Disintegration, powdered surface
ceramics	Acid gases	Change in surface appearence





Global Effects of air pollution

Greenhouse effect CO_2 (60 %), CFC (22 %), CH_4 (12 %), NOx (6 %)

Impact of Greenhouse effect on environment

1. Global warming
2. Rising of sea-level
3. Worsening of health effects
4. Disruption of water cycle
5. Changing forest and natural areas
6. Challenges to agriculture and food supply
7. Effect on the ozone layer
8. Effect on oceanic climate

Control of greenhouse effect

1. Reduction in fossil fuel
2. Develop advanced technologies for maximum energy harvesting
3. Find alternate source of energy (solar, tidal, wind)
4. Afforstation and reforestation
5. Avoiding water-logging (produce CH4)
6. Reduce CFC

What is a green house?

A glass house where heat energy is trapped. The glasses of the green house allow the visible (short wave) radiation of sun light to enter but prevent long wave infra red rays from leaving the glass house. Glass being non-transparent to these wave lengths, it absorbs and reflects the IR radiation.

What are the major green house gases?

CO_2, CH_4, CFC and N_2O

Source of CO_2: Primary source combustion of fossil fuel. Secondary source oxidation of carbon compounds in the marshes and forests.

Sink of CO_2: Plants are the major sink. Ocean also act as sink by removing CO_2 as bicarbonate.

Source of CFC: Refrigerant gases in refrigerators and air conditioners

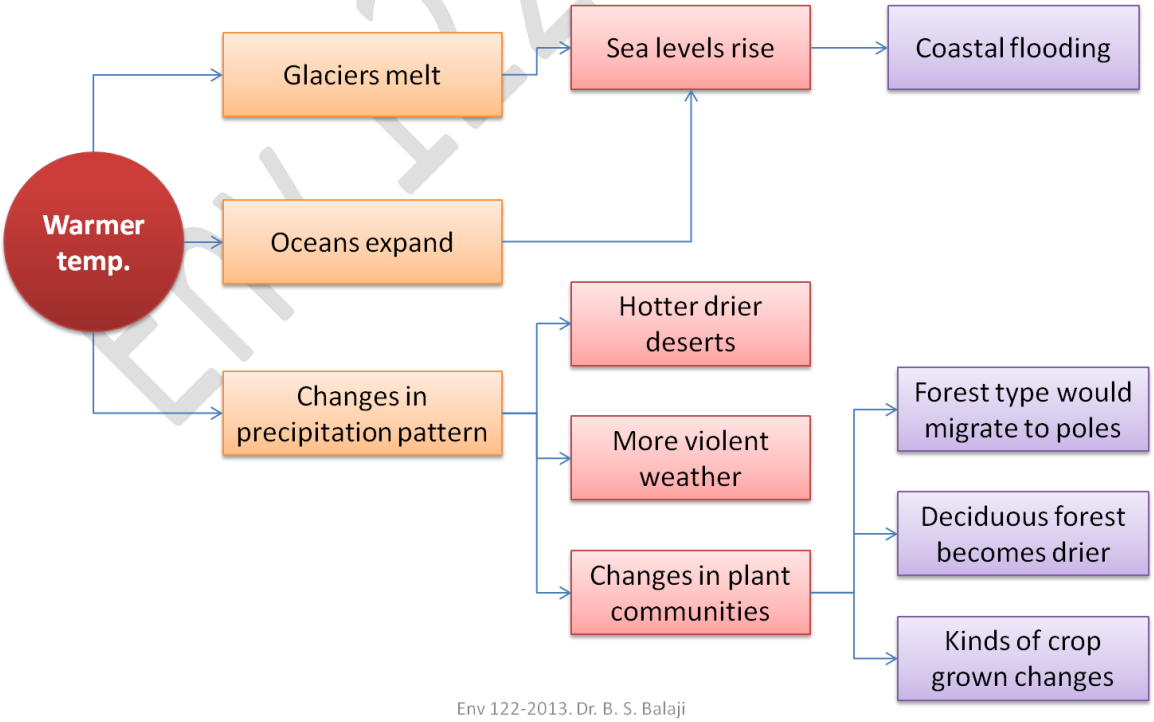
Source of CH_4: Bacteria release CH_4. these bacteria are found in guts of termites, ruminant animals like cattle.

Source of N_2O: Fossil fuels and feritilisers.

Characteristics of major greenhouse gases

Properties	CO_2	CFCs	CH_4	N_2O
IR absorption (mm)	4-15	8-12	3-8	4-9
Residence time (yr)	2-4	75-110	10-12	150-200
Atm. Conc. (ppm)	356	0.005	1.7	0.3
Annual rate of increase (%)	0.4	5.0	1.0	0.3
% contribution to GHE	60	22	12	6
More effective than CO_2	1	15,000	30	200
Sources	Combustion of fossil fuel	Propellant, refrigerant	Rice production, bacteria	fertiliser
Sinks	Plants, oceans	Injection of C_2H_6, C_3H_8	Oxidation	Stratospheric, aerobic

Effect of Global warming

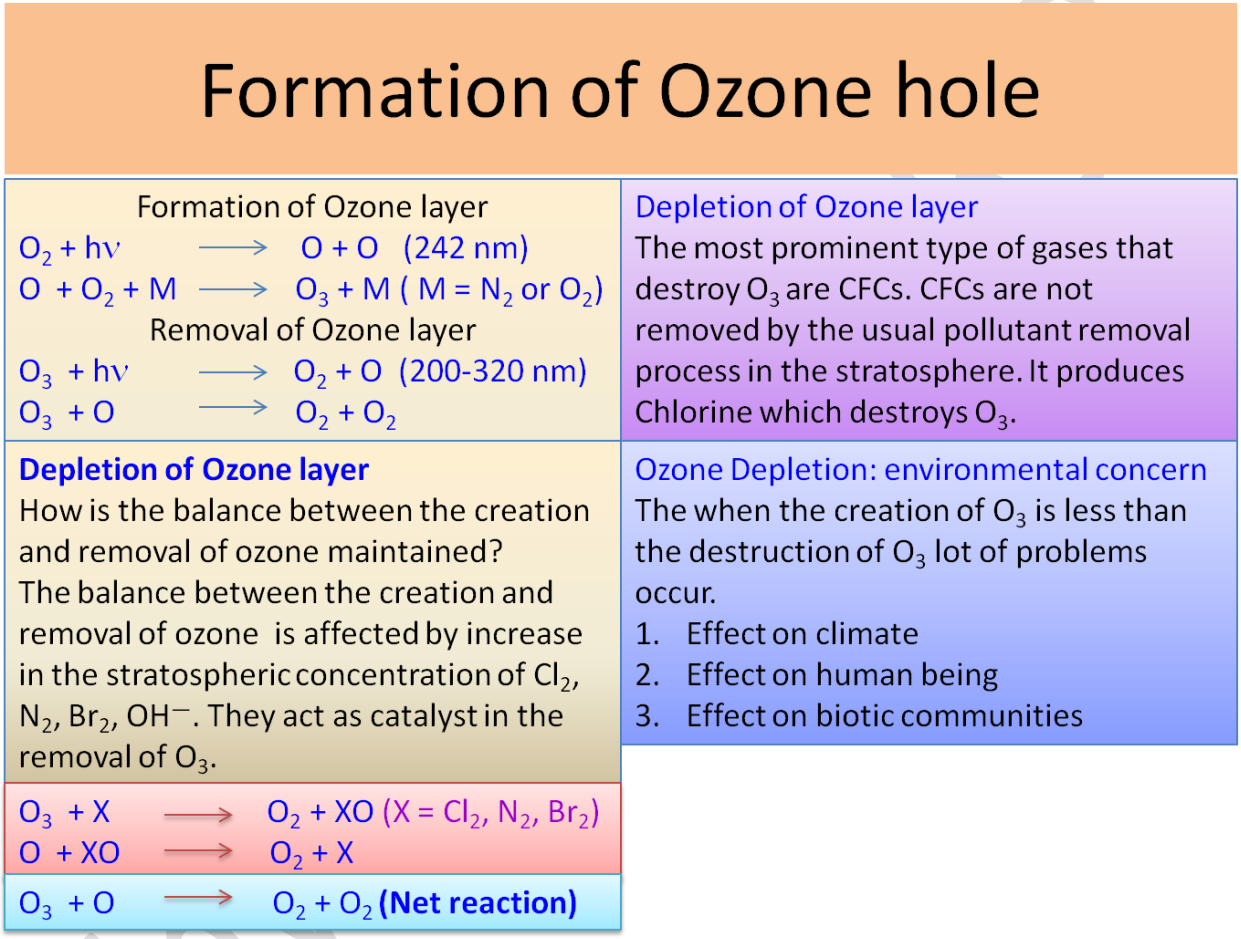


How do climatic changes affect human health?

Warmer temperature increase the risk of mortality from heat stress. Diseases like malaria, dengue, yellow fever, encephalitis and cholera are likely to spread more. Warmer and humid condition enhance the growth of mould and bacteria can lead to contamination of food and thus food poisoning.

How do climatic changes affect crop yield?

A CO_2 concentration of 550 ppm increases crop yield in some area whereas it may decrease the yield in other areas. A warmer climate reduce flexibility in crop distribution and increase in irrigation demands. Expansion of pest also increase vulnerability of plants.



Global Effects of air pollution

1. **Effect on climate**
   a) Depletion of O_3 layer leads to more UV absorption. It leads to increase of temp., thus global warming.
   b) CFCs also cause increase of CO_2. Depletion of O_3 leads to increase of H_2O_2 in troposphere.
   c) This induces acid rain.
2. **Effect on human beings**
   a) Increases incidences of Skin cancer
   b) Decrease in immunity level makes people prone to infectious diseases

c) Retards physical growth and affects mental development of human beings

3. **Effect on biotic communities**
   a) Decrease in photosynthesis by plants
   b) Fertilized crops are affected easily by UV radiation
   c) When the amount of P increases resistivity to UV radiation decreases
   d) Rate of evaporation of water increases which results reduction in soil moisture
   e) Phytoplanktons are also affected

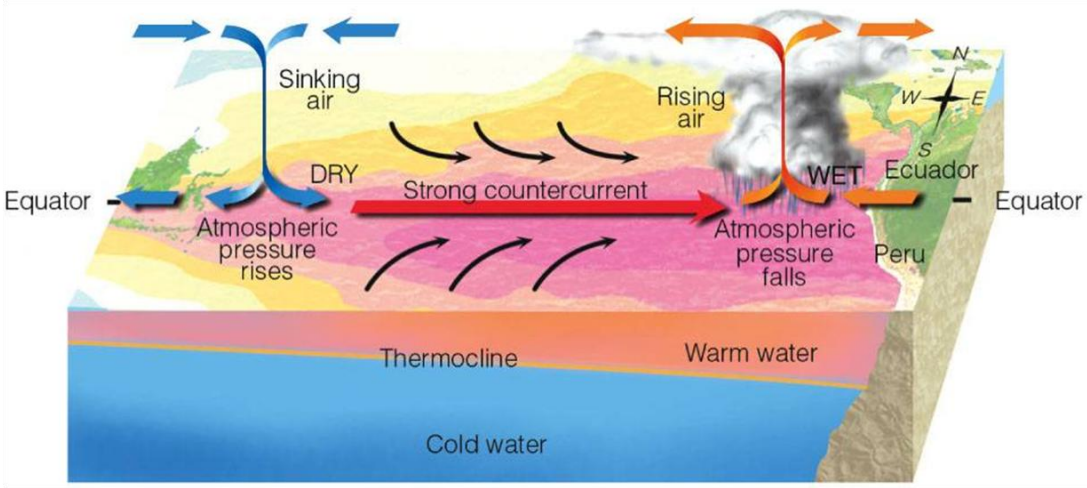
Protection and maintenance of O_3 layer

- To promote reduction in the production and consumption of O_3 depleting chemicals
- Produce and propagate use of alternative chemicals

El Niño

What is El Niño?

- This is described as warmer-than-normal sea surface temperatures in the central and eastern Pacific Ocean, near the equator off the west coast of South America.
- The easterly trade winds become weaker, and can even reverse direction. The warm Pacific Ocean becomes nearly stationary or pushes eastward and gains heat. Besides affecting weather, El Niño has also been known to hurt fishing off the coast of Peru.



How does El Niño affect the Peruvian economy?

Cold water is rich in nutrients. It is good for fishes. When the El Niño occurs the temperature raises and it affects the anchovy fishery that is key to Peruvian economy. When the fish dies it affects the birds which are depended on these fishes. Since the number of birds decreases their deposits (dung) which is a manure reduces. Thus El Niño affects Peruvian economy.

What are the impacts of El Niño on the weather conditions prevalent on Earth?

Changes in the atmospheric pressure over Indian ocean (in the west) are always reflected by opposing changes in pressure over south-eastern Pacific (in the east). i.e. If one raises the other falls. This is called Southern Oscillation.

What are the adverse effects of El Niño?

Abnormal weather conditions, floods, storms, devastating forest fires are few adverse effects. The secondary consequence may be exposure of communities to epidemics, loss of normal shelter, food and water supplies. The long term consequences are soil erosion due to wind and rain.

ENSO

What is ENSO?

El Niño and Southern Oscillation are called ENSO. ENSO has four phases

- *Precursor*: It indicates high atmospheric pressure in the eastern Pacific with a corresponding fall in the west. Early trade winds blow harder pushing the sea water towards Indonesia, sea level raises
- *Onset Phase*: In December, the sea surface temp. drops in western Pacific and raises in the east. Increased rain fall occur in the dry regions (Pacific coastal area of Peru, Ecuador, Chile).
- *Growth phase*: The conditions intensify. Winds continue to blow from west to east. Rainfall near Indonesia reduces but in the west it increases.
- *Decay phase*: Gradual weakening of westerly wind follows.

How can the adverse effects of El Niño be reduced?

In India effort to increase the rabi (winter) crop production is considered to be a correct step to reduce the dependence on the monsoon rain-fed kharif (monsoon) crop. In Ethiopia seeds and fertilizers were given to farmers during spring planting.

Acid Rain

What is acid rain?

It is caused when coal.oil is burnt. S and N are releases as SO_2 and Nox. This leads to acid rain.

Environmental consequences of acid rain

1. Acidification of soil: the H ions in the rain water which are rendered acidic by CO_2 are neutralised by Ca and Mg present in the soil. Thus lime in soil acts as a natural filter. When the inputs are more acidic for a proplonged time, the buffering action by the soil can not continue. This results in release of toxic metals like Cd, Cu, Al
2. Acidification of surface water: acid rain degrades lakes. Fish die. It also destroys phytoplankton.
3. Acidification of ground water: when the geological environment composed of Si-rich and Ca-deficient rocks (granite, sandstone, quartzite) base production can not cope up with acid rain.
4. Effect of acid rain on plants: acid rain increases the heavy metal content as well as reduces availability of nutrients in the soil.
5. Effect of acid rain on material: it affects architecture and buildings. Limestone and marble are affected mostly.

Control/mitigation of acid rain

1. Reduce the sulphur emission. Use fuel having less S content. Or remove S by desulphurization
2. Reduce NOx emission.
3. Reduce HC emission.