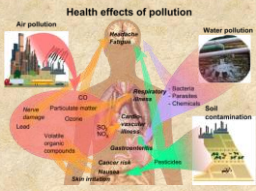
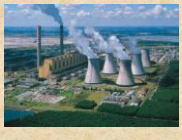
Global Impacts – Air Pollution





Introduction to the lecture

- Global impacts of air pollution lecture provide an overview of global impacts of air pollution due to the climate change.
- This lecture discusses the earth's atmosphere (characteristics, composition), thermal inversion (temperature variation, adiabatic lapse rate, thermal inversion process and smog), pollutants (carbon dioxide, nitrogen oxide, hydrocarbon emission, sulphur dioxide and particulates s pollutants).
- This lecture focuses on the impacts of air pollution due to global climate change on the human health.

Aim and Learning outcomes

- The aim is to understand the concept of global climate change impacts on the air pollution and its consequent effects on the human health.
- On completion of lecture "Global impacts-Air pollution" students will be able to:
  - Understand the general concept on the characteristics of atmosphere.
  - Understand the impacts of climate change on the atmosphere.
  - Know the mechanism of atmospheric changes due to climate change.
  - Know the impacts of air pollution on the human health.

Talk outline

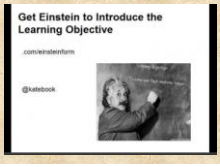
Earth's Atmosphere
- Characteristics
- Composition

Thermal Inversion
- Temperature variation
- Adiabatic Lapse Rates (ALR)
- Thermal Inversion process
- Smog

Pollutants

- Carbon monoxide (CO)
- The oxides of Nitrogen
- Hydrocarbon emission
- Sulfur dioxide
- Particulates as pollutants

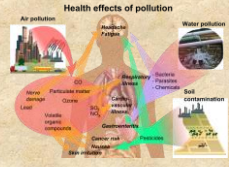
Learning Objectives



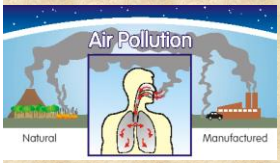
- We should know about our earth
- To understand the mechanism of environmental pollution
- To know the harmful effects of pollution
- To control the pollution level

Our Home - Planet

- We have only one home-Earth
- Polluting our environment in many ways
- Air pollution from fossil fuels
- Have adverse effects on the environment
- Difficult to mitigate the problems



What is Air Pollution

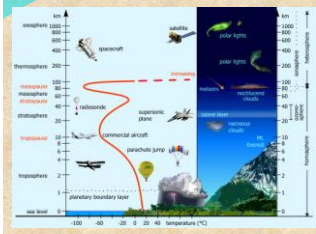


- The result of emission into the air of hazardous substances
- at a rate that exceeds the capacity of natural processes
- in the atmosphere to convert, deposit, or dilute them…

Earth Atmosphere - Characteristics

- Atmosphere weights about 5.7×10^7 tons
- One-millionth of the earth weight
- Earth surface covered by 200 million square km
- Atmosphere extends up to 100 miles over earth surface
- Half of the air below 18000 ft altitude above sea level
- Density – 1.3 kg/m^3 , pressure – 14.7 lb/in^2

Earth Atmosphere - Characteristics



- Density and pressure decrease with increasing altitude
- Above 50000 ft pressure decrease to 1.6 lb/in^2 from 14.7 lb/in^2
- Above 600 miles atmospheric pressure is essentially zero
- Temperature gradient vary from one altitude to another
- i.e. temperature vary with the height

Earth Atmosphere - Composition

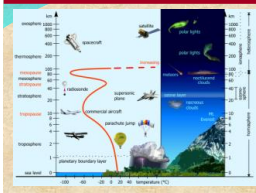
Gases	Mean percentage	Mean residence time
Nitrogen (N_2)	78	10^8 years
Oxygen (O_2)	21	10^7 years
Argon (Ar)	0.9	—
Water vapour	variable 0-3	8-10 days
Carbon dioxide (CO_2)	0.035	50-200 years
Methane (CH_4)	0.00017	7-10 years
Hydrogen (H_2)	0.00006	—
Nitrous oxide (N_2O)	0.000033	130 years
Carbon monoxide (CO)	$4 - 20 \times 10^{-6}$	5 months
Ozone (O_3)		
• tropospheric	$10^{-8} - 10^{-7}$	weeks-months
• stratospheric	$10^{-7} - 5 \times 10^{-7}$	months
Ammonia (NH_3)	$10^{-8} - 10^{-9}$	3 days
Sulphur dioxide (SO_2)	$10^{-9} - 5 \times 10^{-9}$	3 days
Nitrogen oxides (NO_x)	$10^{-9} - 5 \times 10^{-9}$	3 days
CFC (Freons)	10^{-9}	50-150 years
Peroxyacetylnitrate (PAN)	$10^{-9} - 5 \times 10^{-9}$	—
Volatile organic compounds (VOC_s)	$10^{-9} - 10^{-8}$	—

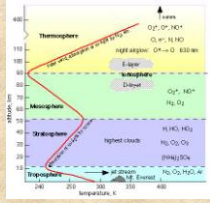
- Composition fluctuate with altitude and location
- Water vapor present usually 1%, can be high – 3%
- Carbon dioxide fluctuate with time of year and location
- Some gases are present in small amounts
- Play vital in absorption solar radiation

Earth Atmosphere - Composition

- Human being also changing composition of the atmosphere
- Results of these changes are not always predictable
- Therefore, we need to have a clear concept regarding pollution of the earth

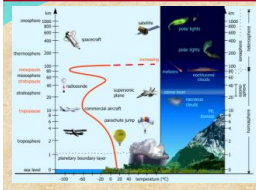
Thermal Inversion – Temperature variation

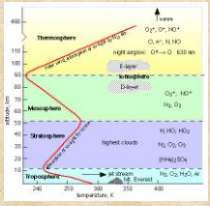




- Up to 10000 meters, temp. decrease with increasing altitude
- Temperature at ground is 20°C; - 60°C at 10000 m
- Above troposphere, temp. increase until 50000 meters through stratosphere
- Negative temp. gradient exists near earth

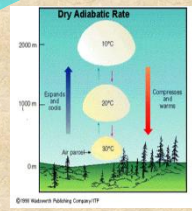
Thermal Inversion – Temperature variation

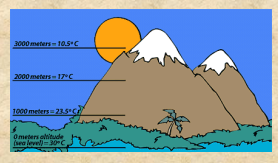




- It has important role for the dispersal of pollutants
- Due to warm air from machine or smokestack air move upward from ground till 10000 m
- No immediate problem at ground

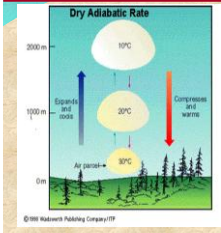
Thermal Inversion – Adiabatic Lapse Rate (ALR)

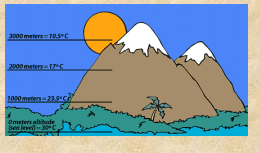




- Relationship between temp and altitude is determined by thermodynamic principles
- Temperature – altitude relationship at lower atmosphere is known as Adiabatic Lapse Rate (ALR)

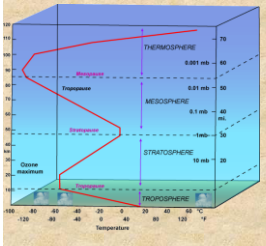
Thermal Inversion – Adiabatic Lapse Rate (ALR)





- Adiabatic means no heat energy gain or loss of some defined volume of gas
- Lapse indicates temp decreasing with increasing altitude

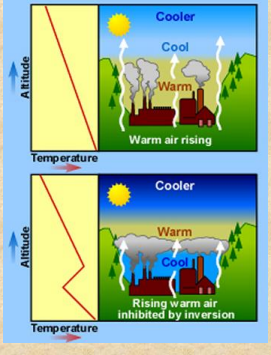
Thermal Inversion – Adiabatic Lapse Rate (ALR)



- If a warm air move upward
  - air will expand
  - Naturally temp decrease due to altitude
  - The loss of temp- dry air- -1°C/100m; wet air- -0.35°C/100m
  - Average ALR is -0.65°C/100m

- In simple: ALR is the rate at which the temp. of volume of gas will decrease naturally with altitude and vice-versa

Thermal Inversion – Thermal inversion process

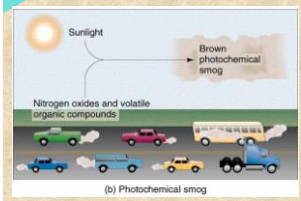


- Warm air will rise in the ambient cool air
- Due to ALR, the air at some point will be not warm respect to surrounding
- It will cease and will not rise
- In this case polluted air will not rise vertically and dispersed and trapped
- This condition is called thermal inversion

Thermal Inversion – Smog

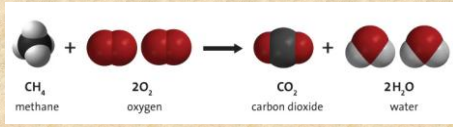
- Smog is a kind of air pollution, originally named for the mixture of smoke and fog in the air
- Classic smog results from large amounts of coal burning in an area and is caused by a mixture of smoke and sulfur dioxide.

Thermal Inversion – Smog



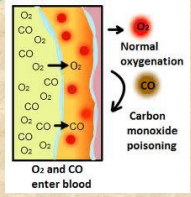
- Smog formed by the interaction of solar energy with the types of primary air pollutants emitted by automobiles and trucks

Pollutants – Carbon monoxide (CO)



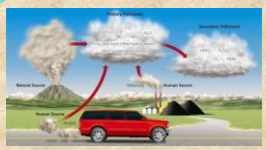
- Most of the serious air pollution is produced – direct or indirect combustion of fuels
- Ideal reaction during burning fossil fuels as – Carbon (C) + Oxygen (O2) ⟶ Carbon dioxide

Pollutants – Carbon monoxide (CO)



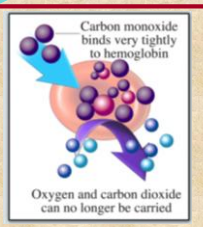
- Incomplete combustion of the carbon form carbon monoxide;
- 2 C + O2 ⟶ 2 CO
- This process take place when oxygen is insufficient to form carbon dioxide
- Source of CO is gasoline fueled internal combustion engine

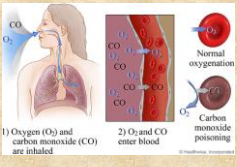
Pollutants – Carbon monoxide (CO)



- Fuel burning under high pressure and temperature and lack of oxygen
- Carbon monoxide is colorless, odorless gas that is toxic at high concentration
- Its toxicity increase when combined with hemoglobin

Pollutants – Carbon monoxide (CO)





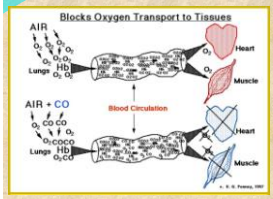
- It form carboxyhemoglobin
- Hemoglobin present in the red blood cells that carries oxygen to the tissues
- CO has more affinity to hemoglobin (200 times higher) than oxygen
- It block the normal distribution of oxygen in the blood

Pollutants – Carbon monoxide (CO)

- The effects of CO depends on the concentration and duration of exposure

Concentration (ppm)	Duration (hrs)	Cause
100	10	Headache, reduce ability to think
300	10	Nausea, loss of consciousness
600	10	Death
1000	4	death

Pollutants – Carbon monoxide (CO)



- CO – half life is 0.2 years
- Then it converted to Carbon dioxide with OH molecules in the tropopause
- Every year 290 millions ton's released to atmosphere

Talk outline

Earth's Atmosphere
- Characteristics
- Composition

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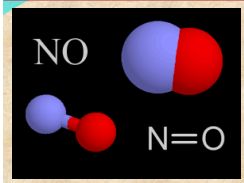
- Thermal Inversion process
- Smog

Pollutants

- Carbon monoxide (CO)
- The oxides of Nitrogen
- Hydrocarbon emission
- Sulfur dioxide
- Particulates as pollutants

Pollutants – Oxides of Nitrogen (1)

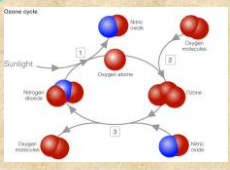


- Nitrogen-Oxygen mixture air is heated to over 1100 degree Celsius
- The N and O will combine to form Nitrogen oxide (NO)
- If the cooling process slow, the reaction will reverse and decompose back into N_2 and O_2

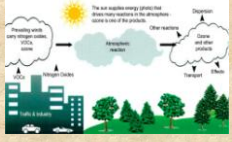
Pollutants – Oxides of Nitrogen (2)

- If cooling process is rapid in case of engine it will not decompose and will exhaust as NO
- Internal combustion of a engine will release 4000 ppm NO (if no control)
- Coal fired steam generator 200 to 1200 ppm of NO
- NO is less toxic than NO_2

Pollutants – Oxides of Nitrogen (3)

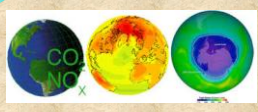


- NO is much more prevalent in engine combustion, NO_2 also produce
- However, NO react with ozone, O_3 and form NO_2



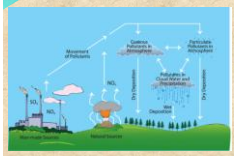
- After 10 hrs 50% of NO will convert to NO_2
- As NO_2 is more toxic than NO, therefore more importance for environment study

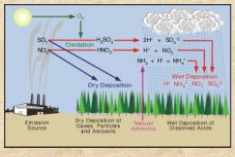
Pollutants – Oxides of Nitrogen (4)



- Sometimes NO and NO_2 together noted as NO_x
- NO is colorless , NO_2 is reddish brown gas
- NO_2 can be smelled at 0.5 ppm in the air and 5 ppm begins to affect respiratory system

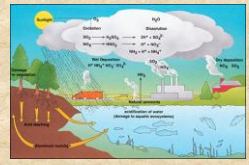
Pollutants – Oxides of Nitrogen (5)





- 20 to 50 ppm- strong odor, eyes become irritated, damage to the lungs, liver and heart
- at 150 ppm-serious lung problems if 3-8 hrs exposure
- NO_2 in the atmosphere are converted to nitric acid in the presence of water (HNO_3)
- NO_x play important role in photochemical reaction to form smog NO_2+sunlight ⟶ NO+O

Pollutants – Oxides of Nitrogen (6)



- In this reaction ultraviolet and blue portions of the spectrum-absorbed
- Resulting atomic oxygen can react with O_2 to form O_3, $O+O_2 \rightarrow O_3$; $O_3+NO \rightarrow NO_2+O_2$
- This reaction cycle continues as sunlight present

Pollutants –Hydrocarbon emission and photochemical smog (1)

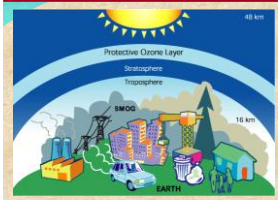


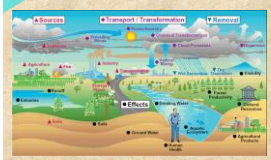
Fig. 14.2 Photochemical smog occurs where sunlight acts on vehicle pollutants.

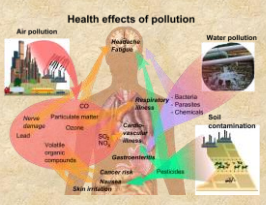
- 60 Years ago in 1943 Los Angel experienced new kind of air pollution
- For several years nature and origin of this type pollution is mystery
- Finally A.J. Haagen-Smith and his colleagues solved the problem. However research continue till now

Pollutants –Hydrocarbon emission and photochemical smog (2)

- Various hydrocarbons form strong oxidant such as ozone, O_3
- For photochemical smog-basic ingredients are sunlight, NO_2 and hydrocarbon
- Most of the NO_2 and HC are related to automobile emission
- In Los Angels air 56 different species of the HC observed

Pollutants –Hydrocarbon emission and photochemical smog (3)





- Various HC sources come from different sources
- Aromatic olefins, formaldehyde and acroleins that cause eye irritating
- Photochemical smog - chronic sinus trouble, bronchitis other respiratory problems also lung cancer and chronic pulmonary diseases
- Two plant diseases - smog injury and grape stipple

Pollutants –Hydrocarbon emission and photochemical smog (4)

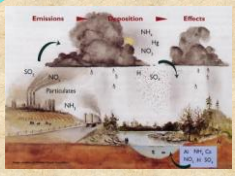
- Main sources - CO, NO, HC are sourced from petroleum powered transportation system, combustion engine automobiles
- Automobile is the main source of pollution
- 1970's automobiles - the main source
- Now decreased. Even the emission is toxic

Pollutants – Sulfur dioxide (1)

- Sulfur is present in fossil fuels
- Sulfur dioxide is an important atmospheric pollutants

- when fossil fuels is burned -various compounds of sulfur converted to SO_2
- Colorless , nonflammable gas

Pollutants – Sulfur dioxide (2)



- Major sources are stationary, coal and oil burning electric power plant
- Next are copper, zinc, lead industries

- 1/3 of the sulfur compounds come from man-made source
- Natural source of sulfur mainly decay of terrestrial and marine organic matter

Pollutants – Sulfur dioxide (3)

- Present in the form of H_2S, converted to SO_2 in one or two days reacting with O_3
- SO_2 oxidized to form SO_3, which combine with moisture to form H_2SO_4 or sulfate salt
- Building material marble, limestone are severely affected by SO_2

Pollutants – Sulfur dioxide (4)

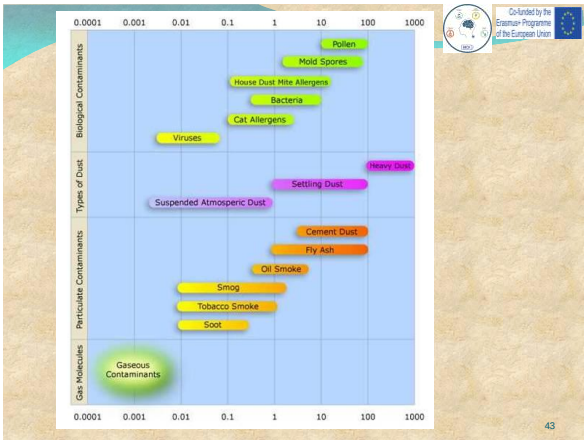
- Various crops and trees suffer damage
- Before coal burning, coal washed with water and due to high density FeS_2 removed from solution
- It can be removed from the stacked gases after burning

Pollutants – Particulates as pollutants (1)

- Particulates as pollutants is different from gaseous pollutants
- Particulate can be solid or liquid having certain size and chemical composition
- Aerosol is a solid or liquid matter suspended in the atmosphere

Pollutants – Particulates as pollutants (2)

- Source : ocean spray, dust from fields, volcanic ash and forest fire
- Natural : 14 times higher than man made
- Man made particulates are emitted from high density populated area
- Fly ash and coal combustion



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43