BHARATHIDASAN UNIVERSITY

Tiruchirappalli- 620024,
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Programme

M.Sc., Environmental Science & Sustainable Management

Course Title:

Environmental Pollution & Toxicology(Core Choice)

Course Code: 25PGCC03

Unit-II

AIR : Air Pollution - Secondary Pollutants

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Introduction

What are Secondary Pollutants?

Pollutants formed by reactions of primary pollutants in the atmosphere

Key Topics Covered:

- ✓Ground-level ozone
- ✓Photochemical and Reducing smog
- ✓Greenhouse gases
- ✓Case studies

Example:
GLO is a secondary air pollutant
Peroxyacetyl nitrate (PAN): secondary pollutant created through photochemical reactions involving hydrocarbons and nitrogen oxides.
Aldehydes: are produced when hydrocarbons undergo partial oxidation in the atmosphere.

Chemistry and Formation of Ground-Level Ozone

What is Ozone?

O_3 is a reactive gas formed by photochemical reactions

OZONE Formation:

VOCs + NOx + Sunlight → O_3

Conditions:

Sunny -warm weather with stagnant air

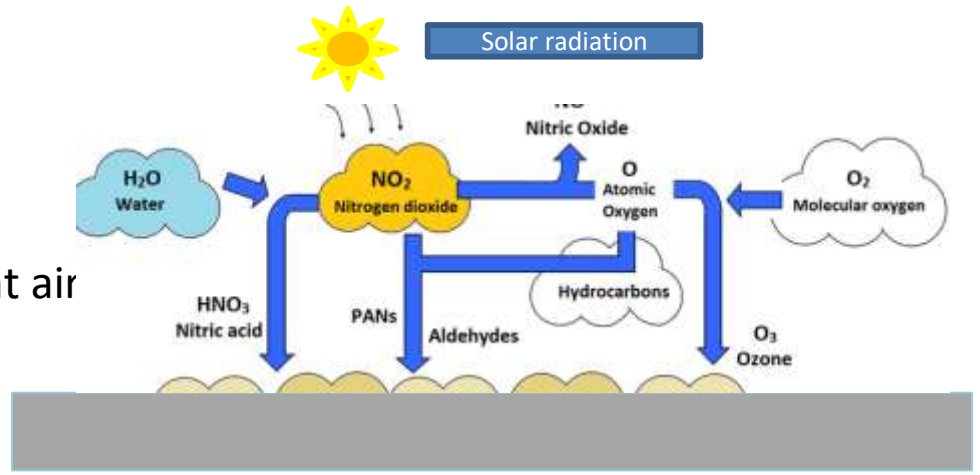


Image Source: G. Tyler Miller, Jr. and D. Hackett, "Photochemical and Industrial Smog," in *Living in the Environment*, 2nd ed. USA: Nelson , 2011, ch.20, sec.3, pp.465-471

Sources of Ground-Level Ozone

Primary Pollutants:

- Nitrogen oxides (NOx): Vehicle exhaust, industrial emissions
- Volatile Organic Compounds (VOCs): Paints, solvents, vegetation

Urban and Rural Sources:

- Urban areas: Traffic
- Rural areas: VOCs from plants and wildfires

Health effects of GLO

Health Impacts of Ground-Level Ozone

Short-Term Impacts:

- Respiratory issues: Coughing, throat irritation
- Reduced lung function

Long-Term Impacts:

- Chronic obstructive pulmonary disease (COPD)
- Increased risk of asthma

Interactive Question

Interactive Question 1

Q: Why is ground-level ozone harmful despite its importance in the stratosphere?

PHOTOCHEMICAL SMOG

Definition:

When sunlight combines with atmospheric nitrogen oxides and volatile organic compounds, a form of air pollution known as photochemical smog is created. A variety of pollutants, such as particulate matter, ground-level ozone, and other dangerous chemicals, are produced by this reaction. It can harm buildings and crops, aggravate the eyes and throat, and cause respiratory issues. Photochemical smog is a separate phenomenon that is more closely related to the chemical reactions that take place in the atmosphere.

Formation:

Interaction of sunlight with primary pollutants

Urban areas are frequently linked to photochemical smog, especially in areas with high vehicle emissions and population density.

The term "smog" was first used in the early 20th century to describe the mixture of smoke and fog that frequently afflicted urban areas. Ozone, NOx, VOCs, secondary aerosols

Impacts of Photochemical Smog

On Health:

Aggravates heart and respiratory ailments

Affects mucus cell,eyes

On Environment:

Reduces crop yields, damages vegetation

On Visibility:

Reduces clarity and contributes to haze/smoky conditions

SMOG: REDUCING SMOG

What is Reducing Smog?

Sulfur-based smog common in cold, damp climates

Sources:

Coal burning (SO_2)

Impacts:

Acid rain, reduced visibility, respiratory problems

CAUSES OF PHOTOCHEMICAL AND REDUCING SMOG

Photochemical Smog:

High NOx and VOC levels, intense sunlight

Reducing Smog:

High SO_2 emissions, low wind speeds

Nitrogen oxides may combine with water to form nitric acid. b. Alternatively, they may react with sunlight to produce nascent oxygen atoms, **which then combine with molecular oxygen** to **form ozone** .

The nitric acid formed can either: a. Precipitate resulting in acid rain. b. Remain suspended in the smog. 5. Localization: Smog tends to form over cities due to the high concentration of vehicles.

Interactive Question

Interactive Question 2

Q: How does photochemical smog differ from reducing smog in terms of formation and impacts?

GREENHOUSE GASES (GHGS)

Major GHGs:

- Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), fluorinated gases

Sources:

- CO_2: Fossil fuel combustion
- CH_4: Agriculture, landfills
- N_2O: Fertilizers, industrial processes

GREENHOUSE GASES (GHGs)

Impacts of Greenhouse Gases

On Climate:

- Rising global temperatures
- Increased frequency of extreme weather events

On Ecosystems:

- Habitat loss, biodiversity threats

On Oceans:

- Ocean acidification, rising sea levels

CASE STUDY I EFFECTS OF GHGS ON THE ATMOSPHERE

Greenhouse Effect:

- Traps heat in the Earth's atmosphere

Consequences:

- Global warming, climate change

Positive Feedback Loop:

- Melting ice → Reduced albedo → More heat absorption

CASE STUDY II CASE STUDY – DELHI SMOG CRISIS

Problem Statement:

- Severe smog episodes caused by a mix of photochemical smog and crop residue burning

Sources:

- Vehicle emissions, industrial pollution, stubble burning

Impacts:

- Health emergency, economic losses

STANDARDS& REGULATIONS

REDUCING SECONDARY POLLUTANTS:

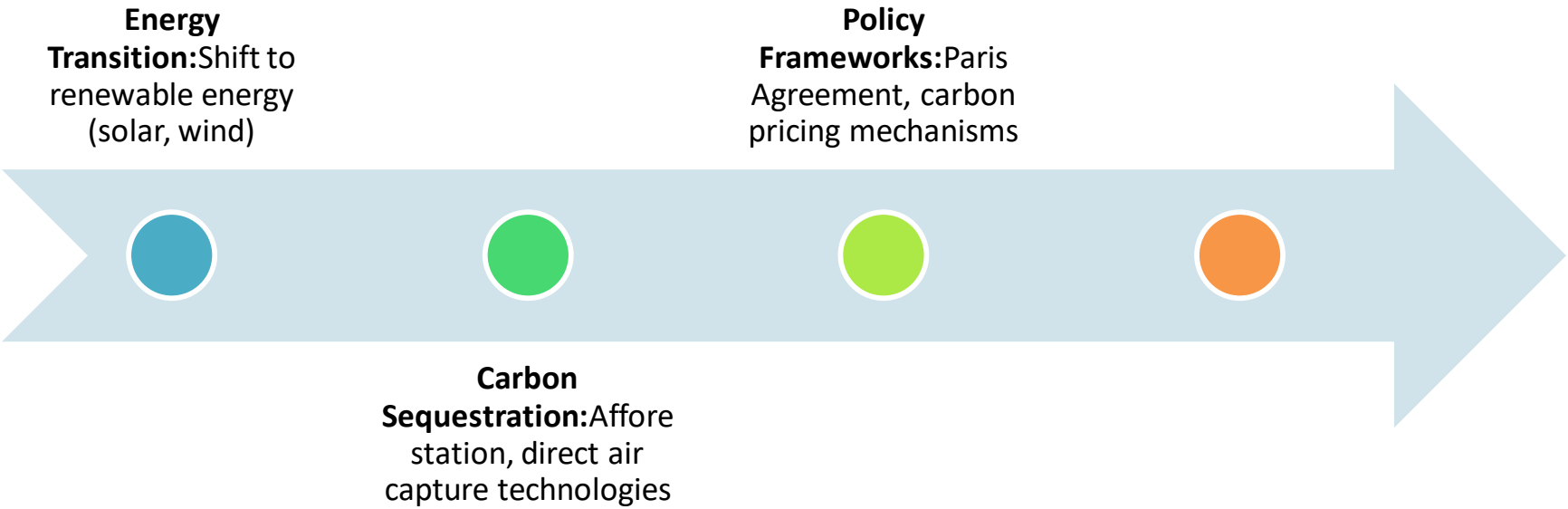
- **Technological Solutions:**
  - Catalytic converters for Nox
  - VOC control through vapor recovery systems.
- **Policy Measures:**
  - Air quality standards, vehicle emission norms.
- **Public Initiatives:**
  - Promoting public transport, reducing fossil fuel use, avoiding stubble burning .

Interactive Question

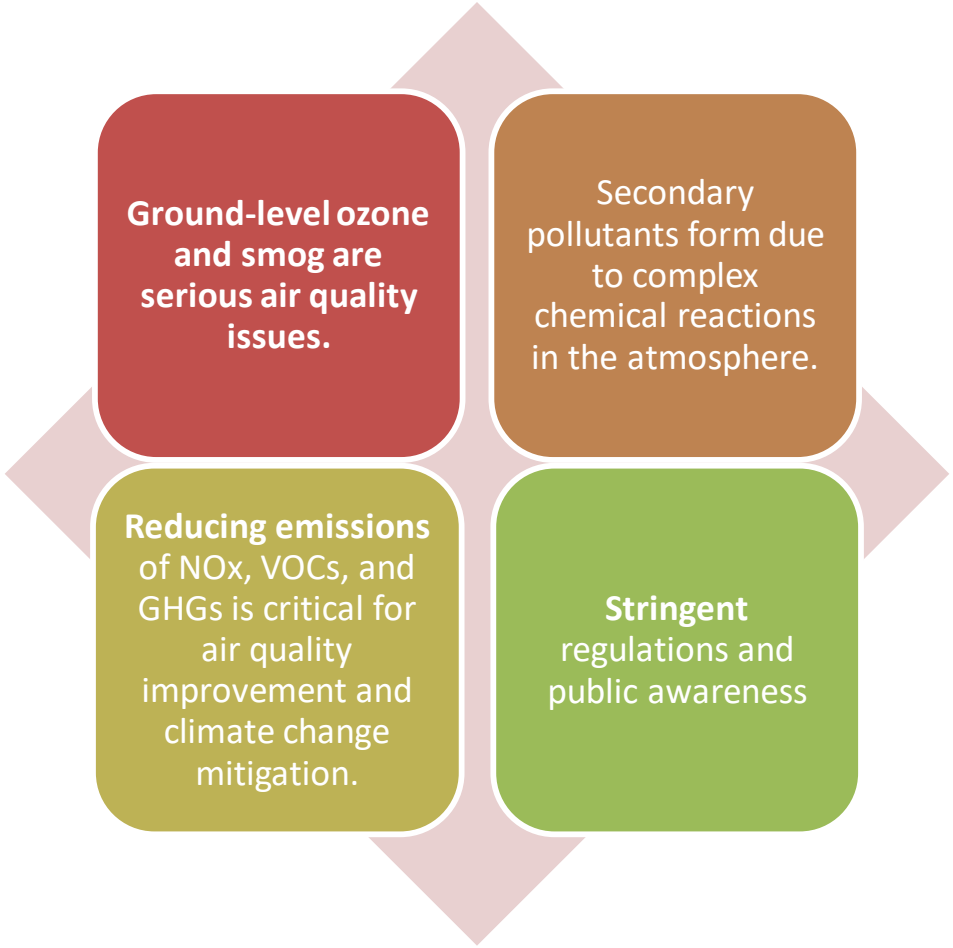
Interactive Question 3

Q: What measures can urban planners adopt to reduce photochemical smog formation in cities?

MITIGATION STRATEGIES FOR GREENHOUSE GASES



Summary & Key Takeaways



References

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- "Environmental Pollution and Control" by C. S. Rao
- **Reports and Guidelines:**WHO Air Quality Guidelines
- IPCC Reports on Climate Change
- **Websites:**CPCB Air Quality Reports (India)
- NASA Climate Change and Global Warming

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