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Q7

Discuss in detail the photochemical smog emphasizing its formation, effects and mitigation. Explain the 1999 Gothenburg Protocol.

UPSC Civil Services Mains 2022 · GS III · 10 marks · Indian Economy

Indian Economy and issues relating to planning, mobilization of resources, growth, development and employment.

Core demand of the question

- Explain formation, effects and mitigation of **photochemical smog**
- Explain the 1999 Gothenburg Protocol

Revision summary

Photochemical smog forms when sunlight acts on NO_x and VOCs, producing ground-level ozone and **PAN**.

It peaks downwind in the afternoon under stagnant, sunny conditions.

Effects are respiratory harm, crop damage and material cracking; this ozone is not the stratospheric shield.

Mitigation is BS emission norms, VOC controls, public transport and regional air-shed policy.

The **Gothenburg Protocol 1999** under CLRTAP sets national ceilings on sulphur, NO_x, ammonia and VOCs to cut acidification, eutrophication and ozone.

Introduction

Photochemical smog is a brown, oxidising haze of **ozone and peroxyacyl nitrates** formed when sunlight cooks **nitrogen oxides and volatile organic compounds**. It is the Los Angeles-type smog, not the classic London sulphur fog. The **Gothenburg Protocol (1999)** is a UNECE treaty to cut the gases that make this smog and acid rain in Europe and North America.

Body

Formation

- **Primary emissions: NO and NO₂ (NO_x)** from vehicles and combustion; **VOCs** from petrol, solvents, and some industry and vegetation.
- In sunlight, NO₂ photolyses; the oxygen atom makes **O₃** with O₂. VOCs feed peroxy radicals that convert NO back to NO₂ **without destroying ozone**, so ozone accumulates.
- **PAN (peroxyacyl nitrates)** and aldehydes form in the same radical soup. Peak is typically **afternoon**, downwind of the city.
- Stagnant high pressure, a basin, and a temperature inversion trap the mix. Indian examples include summer-ozone episodes in some metros, distinct from winter PM_{2.5} smog.

Effects

- **Human health:** ozone inflames airways, triggers asthma, and reduces lung function; **PAN** is a lachrymator.
- **Plants:** ozone flecks leaves, cuts photosynthesis and crop yield.
- **Materials:** rubber and some paints crack; visibility falls.
- Ozone at the **ground** is a pollutant; ozone in the **stratosphere** is a shield. Do not confuse the two.

Mitigation

- **Cut NO_x:** Bharat Stage emission norms, catalytic converters, inspection of in-use vehicles, power-plant controls.
- **Cut VOCs:** vapour recovery at petrol pumps, solvent standards, leak control.
- Shift to **public transport, electrified fleets, and less congestion;** ozone is a regional pollutant, so one city's fleet is not enough.
- **Alert systems** and reducing outdoor work on peak ozone days protect health while emissions fall.

Gothenburg Protocol, 1999

- Protocol to the **1979 Convention on Long-Range Transboundary Air Pollution (CLRTAP)**, adopted at Gothenburg in **1999**.
- It sets national emission ceilings for **sulphur, NO_x, ammonia and VOCs**-the precursors of **acidification, eutrophication and ground-level ozone**.
- Later amendments added **fine particulate matter** and tightened ceilings. Parties are mainly UNECE (Europe, plus the United States, Canada).
- India is **not** a party in the European sense; the Protocol is still the model of **multi-pollutant, multi-effect** ceilings that Indian NO_x and VOC policy can learn from.

Flow diagram

NO_x -> Sunlight
VOCs -> Sunlight
Sunlight -> Ground ozone PAN
Ground ozone PAN -> Health crops materials
BS norms VOC control -> NO_x
BS norms VOC control -> VOCs
Gothenburg 1999 -> Ceilings Sunlight NO_x NH₃ VOC

Conclusion

Photochemical smog is sunlight plus NO_x and VOCs, yielding ozone and **PAN** that harm lungs and crops. Mitigation is cleaner vehicles, VOC control and regional air-shed action. The 1999 Gothenburg Protocol is the UNECE bargain to cap those same precursors across borders.

Facts & figures

Photochemical smog

Oxidising haze of ozone, PAN and aldehydes from NO_x + VOC + sunlight; distinct from sulphurous winter fog.

PAN

Peroxyacyl nitrates: secondary photochemical products that irritate eyes and can transport NO_x downwind.

Gothenburg Protocol 1999

CLRTAP protocol setting national emission ceilings for S, NO_x, NH₃ and VOCs to limit acid rain, eutrophication and ozone.

CLRTAP 1979

UNECE Convention on Long-Range Transboundary Air Pollution; Gothenburg is one of its protocols.

Bharat Stage norms

Indian vehicle emission standards that cut NO_x and VOC precursors of ozone.

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