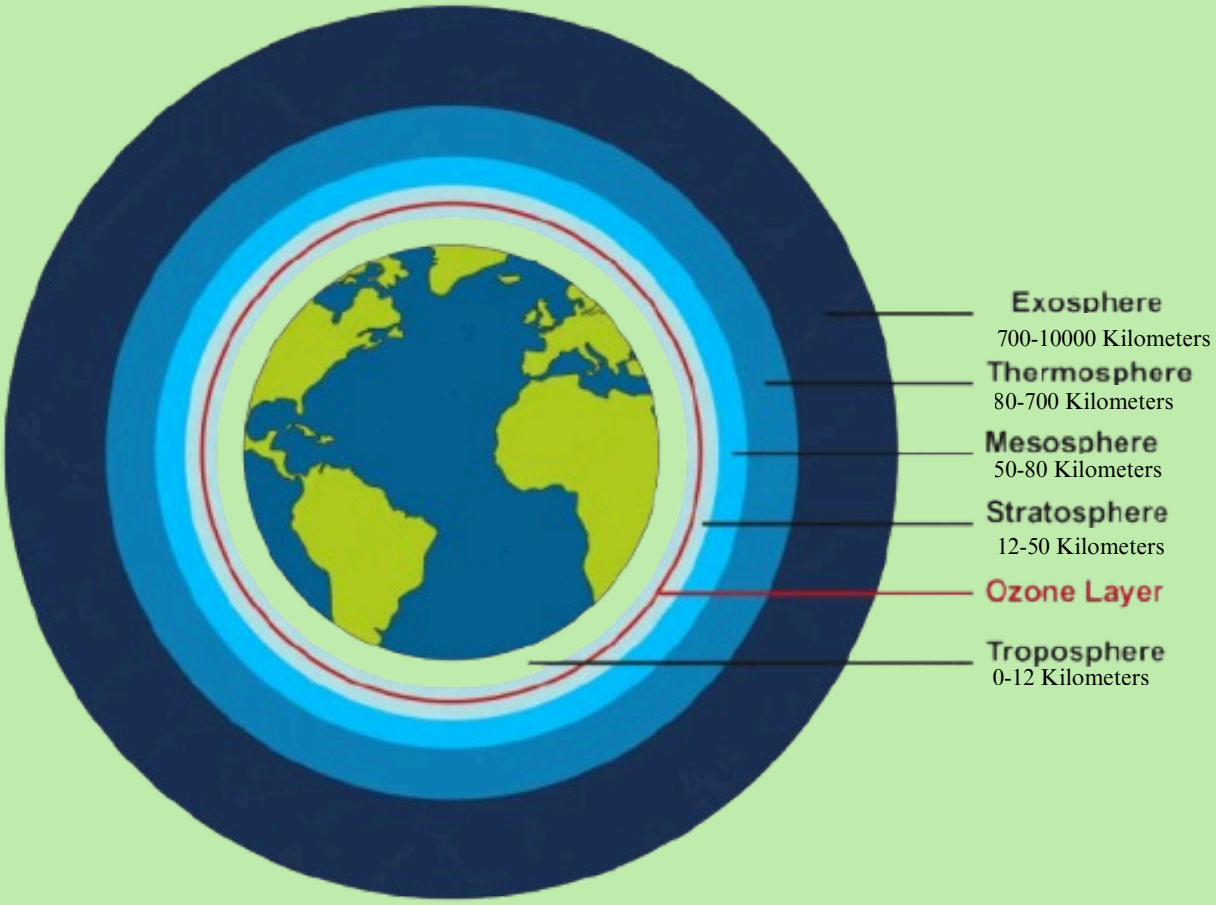
16 सितम्बर 2025

विज्ञान से वैश्विक कार्यवाही तक

विश्व ओजोन दिवस

Earth with Atmospheric layers



Introduction to World Ozone Day, 2025

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Date: September 16, every year.
This day is officially called the International Day for the Preservation of the Ozone Layer.

Origin / Why it's observed:

- The Montreal Protocol was signed on 16 September 1987, as a global agreement to phase out substances that deplete the ozone layer.
- The United Nations designated that date in 1994 to commemorate the Protocol and raise awareness about Ozone Depletion.

Theme: 2025

Theme: **"From Science to Global Action"**
This theme's meaning:

- It highlights the journey from detecting ozone depletion via scientific research, understanding its harmful effects, to taking coordinated global steps (laws, treaties, policy, technology change) to protect the ozone layer.
- It underlines that science isn't just about discovery — it must lead to real-world action.

Significance & What It Reminds Us

- The ozone layer protects life on Earth by filtering out harmful ultraviolet (UV) rays from the sun, which can cause skin cancer, cataracts, and damage to ecosystems.
- Thanks to international agreements like the Montreal Protocol (and related amendments), many ozone-depleting substances have been phased out, and there are signs of healing in the ozone layer.
- The theme encourages continuing and expanding action — not just by governments, but industries, scientists, communities, and individuals.

Natural Shield Against UV Radiation

- The ozone layer, located in the stratosphere (about 10–50 km above Earth's surface), absorbs 97–99% of the Sun's harmful ultraviolet-B (UV-B) and ultraviolet-C (UV-C) rays.
- Without this layer, the Earth's surface would be bombarded with intense UV radiation, making life as we know it almost impossible.

In conclusion:

- The ozone layer is essential for life on Earth. It acts as a protective umbrella that allows plants to grow, animals to survive, and humans to live without constant threat of harmful solar radiation. Protecting it through international cooperation (like the Montreal Protocol) has been one of humanity's greatest environmental achievements.

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History of Ozone Day (International Day for the Preservation of the Ozone Layer)

Discovery of Ozone Layer & Its Importance

- In the early 20th century, scientists discovered the ozone layer in the stratosphere (10–50 km above Earth's surface).
- They understood its crucial role in absorbing harmful ultraviolet (UV) radiation from the Sun and protecting life on Earth.

The Ozone Problem Emerges (1970s–1980s)

- In 1974, two scientists, Mario Molina and F. Sherwood Rowland, published groundbreaking research showing that CFCs (chlorofluorocarbons), used in aerosols, refrigerators, and air conditioners, could destroy ozone molecules.
- Their findings suggested that man-made chemicals were thinning the ozone layer, creating what later became known as the "Ozone Hole."
- In 1985, the British Antarctic Survey confirmed a massive ozone depletion over Antarctica, shocking the world.

Global Response – Vienna Convention (1985)

- The discovery of the ozone hole prompted urgent international discussions.
- In 1985, governments adopted the Vienna Convention for the Protection of the Ozone Layer.
- This was not legally binding but provided a framework for global cooperation and future agreements.

Montreal Protocol (1987) – The Turning Point

- On 16 September 1987, the Montreal Protocol on Substances that Deplete the Ozone Layer was signed.
- It committed nations to phasing out production and use of ozone-depleting substances (ODS) like CFCs, halons, carbon tetrachloride, and methyl chloroform.
- The Montreal Protocol became the first treaty in the history of the United Nations to be universally ratified (all 198 UN member states).
- It is considered one of the most successful environmental treaties ever created.

Recognition & Creation of Ozone Day (1994–1995)

- To honor the Montreal Protocol's adoption, the United Nations General Assembly proclaimed 16 September as the International Day for the Preservation of the Ozone Layer in December 1994.
- The first official Ozone Day was celebrated on 16 September, 1995.

Purpose of Ozone Day

- To raise global awareness about the importance of the ozone layer and the dangers of its depletion.
- To remind countries of their commitments under the Montreal Protocol.
- To celebrate global success stories, showing that collective action can solve environmental challenges.

Achievements & Progress

Since the Montreal Protocol:

- Global production of ODS has been reduced by over 98%.
- The ozone layer is healing and is projected to return to 1980 levels by around 2050–2066, depending on the region.
- The Protocol has also indirectly contributed to climate change mitigation, since many ODS are powerful greenhouse gases.

Ozone Day Today

- Every year on 16 September, Ozone Day is observed worldwide with activities such as awareness campaigns, educational events, seminars, exhibitions, and school competitions. Each year has a specific theme (e.g., “Ozone for life” in 2020, “Global Cooperation Protecting Life on Earth” in 2021).
- It reminds us that international unity and science-driven policies can protect our planet.

Causes of Ozone Depletion

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The ozone layer in the stratosphere protects life on Earth by absorbing harmful ultraviolet (UV) radiation. However, since the mid-20th century, certain human-made chemicals have damaged it. These substances are known as Ozone Depleting Substances (ODS).

Chlorofluorocarbons (CFCs) – Major Culprit

- Sources: Refrigerators, Air Conditioners, Aerosol Sprays, Foam-Blowing Agents, and Cleaning Solvents.

How they work:

- CFCs are stable and do not break down in the lower atmosphere.
- They drift into the stratosphere, where UV radiation breaks them apart, releasing chlorine atoms (Cl).
- Each chlorine atom can destroy 100,000 ozone molecules before being neutralized.

Example reaction:

- CFC → UV light → Cl atom released
- $Cl + O_3 \rightarrow ClO + O_2$
- $ClO + O \rightarrow Cl + O_2$

(Chlorine is free again to repeat the cycle).

Halons (Bromofluorocarbons) – Even More Dangerous

- Sources: Fire Extinguishers.
- Impact: Halons release bromine atoms (Br) in the stratosphere.
- Why worse than chlorine: Bromine is 40–50 times more effective at destroying ozone compared to chlorine.

Carbon Tetrachloride (CCl_4)

- Sources: Industrial Solvents, Cleaning Agents, Feedstock for CFCs.
- Impact: Breaks down in the stratosphere to release chlorine, contributing significantly to ozone depletion.

Methyl Chloroform (CH_3CCl_3)

- Sources: Used as a Solvent in industries (e.g., cleaning metals, electronics).
- Impact: Releases chlorine when degraded, leading to ozone destruction.
- Nitrous Oxide (N_2O) – A Growing Concern
- Sources: Agricultural Fertilizers, Biomass Burning, Industrial Activities.

How it works:
In the stratosphere, N_2O reacts with oxygen to form nitric oxide (NO).
NO then reacts with ozone:
$NO + O_3 \rightarrow NO_2 + O_2$
$NO_2 + O \rightarrow NO + O_2$
This cycle destroys ozone.
Significance: Today, N_2O is considered the largest ozone-depleting emission not controlled by the Montreal Protocol.

Polar Stratospheric Clouds (PSCs) – The Ozone Hole Factor
Where:

- Mostly in Antarctica and sometimes in the Arctic.

How:

- Extremely cold conditions (below –78 °C) form PSCs.
- These clouds provide surfaces for chemical reactions that convert inactive chlorine compounds ($ClONO_2$, HCl) into active forms (Cl_2).
- When sunlight returns in spring, Cl_2 breaks apart into Cl atoms, causing massive ozone loss → the Antarctic Ozone Hole.

Natural Causes (Minor Role)

- Volcanic eruptions: Release gases and particles that can enhance ozone depletion by providing reaction surfaces for chlorine and bromine.
- Solar flares & stratospheric winds: Can slightly influence ozone levels but are not major contributors compared to man-made chemicals.

Effects of Ozone Depletion

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When the ozone layer thins, more UV-B and UV-C rays from the Sun reach Earth's surface. These high-energy rays disrupt biological systems, damage DNA, and destabilize ecosystems.

Effects on Human Health

- The most direct impact is on humans, since we are highly exposed to sunlight.

Skin Cancer

- UV-B radiation penetrates skin cells, damaging DNA.
- Leads to melanoma (the most dangerous type) and non-melanoma skin cancers.
- WHO estimates millions of new cases worldwide are linked to increased UV exposure.

Eye Disorders

- UV radiation causes cataracts, which cloud the eye's lens and can lead to blindness.
- Also causes photokeratitis (painful temporary condition, like "snow blindness") and long-term retinal damage.

Immune Suppression

- UV weakens the body's natural defenses, making people more vulnerable to infectious diseases and reducing vaccine effectiveness.

Skin Aging & Burns

- Excess UV causes premature wrinkling, pigmentation changes, and painful sunburns.

Effects on Plants and Agriculture

- Plants depend on sunlight, but too much UV harms their productivity.
- Reduced Photosynthesis
- UV damages chlorophyll and enzymes, lowering the plant's ability to make food.

Crop Losses

- Major crops like wheat, rice, soybean, maize, and cotton are UV-sensitive.
- This threatens global food security.
- Genetic Mutations
- UV exposure can damage plant DNA, leading to weaker seeds and reduced biodiversity.

Forest Ecosystems

- Trees and natural vegetation are stressed by UV, disturbing entire forest ecosystems.

Effects on Aquatic Ecosystems

- Water may absorb some UV, but many aquatic organisms near the surface are exposed.
- Phytoplankton Decline
- These microscopic plants form the base of the ocean food chain.
- UV reduces their survival, reproduction, and photosynthesis.

Impact on Marine Food Webs

- Fewer phytoplankton, fewer fish, affects marine mammals, birds, and humans who rely on seafood.

Damage to Fish Larvae & Amphibians

- Fish eggs and larvae are extremely sensitive to UV, reducing populations.
- Amphibians (frogs, salamanders) suffer from embryo death, growth abnormalities, and population decline.

Effects on Animals

- Just like humans, animals exposed to higher UV levels face:
- Skin cancers and sunburns (especially livestock grazing outdoors).
- Eye damage such as cataracts.
- Weaker immune systems, making them prone to diseases.

Effects on Ecosystems & Biodiversity

- Disrupted Food Chains
- From plants on land to phytoplankton in oceans, primary producers are harmed → entire food chains collapse.
- Loss of Biodiversity
- Sensitive species decline or disappear, reducing ecological balance.
- For example, amphibians (already vulnerable) are severely affected.
- Ecosystem Imbalance
- Forest productivity, soil microorganisms, and aquatic systems all face stress, changing natural cycles.

Effects on Climate and Environment

Stratospheric Cooling

- Ozone absorbs heat; less ozone means stratospheric cooling, which changes wind and weather patterns.

Impact on Climate Change

- Many ozone-depleting substances (CFCs, halons) are also greenhouse gases, trapping heat and worsening global warming.

Antarctic Ozone Hole Impact

- The thinning over Antarctica has altered wind circulation and rainfall patterns in the Southern Hemisphere.

Substances Phased Out Due to Ozone Depletion

The Montreal Protocol (1987) was a landmark international treaty to protect the ozone layer by phasing out chemicals known as Ozone-Depleting Substances (ODS). These substances release chlorine (Cl) and bromine (Br) in the stratosphere, which destroy ozone (O_3) molecules.

Chlorofluorocarbons (CFCs)

- Examples: CFC-11, CFC-12, CFC-113
- Uses: Refrigerators, Air Conditioners, Aerosol Propellants, Foam Blowing Agents, Solvents.
- Reason for phase-out: Each chlorine atom from CFCs can destroy up to 100,000 ozone molecules.
- Phase-out: Completely phased out by 2010 in developed countries (developing countries got extended timelines).

Halons

- Examples: Halon-1211, Halon-1301
- Uses: Fire Extinguishers (especially for aircrafts and sensitive electronics).
- Reason for phase-out: Extremely high Ozone Depletion Potential (ODP), higher than CFCs.
- Phase-out: New production largely banned, though some essential uses allowed under strict control.

Carbon Tetrachloride (CCl_4)

- Uses: Solvent, Cleaning Agent, raw material for CFC production.
- Reason for phase-out: Releases chlorine that depletes ozone.
- Phase-out: Phased out except for some feedstock uses.

Methyl Chloroform (1,1,1-Trichloroethane)

- Uses: Cleaning and degreasing in industries.
- Reason for phase-out: Significant ODP.
- Phase-out: Banned in most countries under the protocol.

Hydrochlorofluorocarbons (HCFCs)

- Examples: HCFC-22, HCFC-141b
- Uses: Transitional replacement for CFCs (in ACs, refrigeration, foam).
- Reason for phase-out: Lower ODP than CFCs, but still harmful.
- Phase-out: Currently being phased out; full elimination targeted by 2040 (developing countries).

Methyl Bromide (CH_3Br)

- Uses: Soil fumigation, pest control in agriculture.
- Reason for phase-out: Releases bromine, which destroys ozone 50 times more efficiently than chlorine.
- Phase-out: Almost fully phased out except for critical agricultural uses.

Result of Phase-out:

- The ozone layer is now healing and is expected to return to 1980 levels by the 2060s.
- The Montreal Protocol is considered the most successful environmental treaty in history.

Current Scenario of Ozone Depletion

- In 2024, the ozone hole over Antarctica was smaller compared to many years since the 2000.
- The recovery trend is steady but slow; some years still show larger holes due to meteorological factors.

Outlook / Projections

- If countries continue following the Montreal Protocol and its amendments (and properly controlling substitutes), the ozone layer is expected to largely recover by mid-21st century. Global pre-1980 levels: around 2040, Arctic ~2045, Antarctic ~2066.

Remaining vigilance is needed

- Continued Monitoring, ensuring illegal emissions are curbed and excepting the better substitutes that do not harm climate.

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Do's to Protect the Ozone Layer

Switch to Eco-Friendly Products

- Use products that are labeled CFC-free or ozone-friendly.
- Replace old Refrigerators, Air Conditioners, and Fire Extinguishers with modern eco-safe models.
- Choose natural refrigerants (like ammonia, propane, or CO_2-based coolants) instead of harmful chemicals.

Save Energy & Reduce Emissions

- Conserve electricity by turning off unused lights, fans, and devices.
- Use energy-efficient appliances (5-star rating, LED bulbs, inverters).
- Switch to renewable energy sources like Solar Panels or Wind Energy where possible.
- Less energy consumption = less demand on industries = fewer ozone-damaging gases released.

Promote Sustainable Transportation

- Reduce vehicle use → carpool, cycle, walk, or use public transport.
- Switch to electric vehicles (EVs) or hybrids.
- Maintain vehicles properly to reduce harmful exhaust emissions.

Plant More Trees & Protect Forests

- Trees absorb carbon dioxide and release oxygen, balancing the atmosphere.
- Deforestation increases greenhouse gases → worsens ozone damage.
- Participate in tree plantation drives, urban gardening, and reforestation programs.

Safe Disposal & Recycling

- Old ACs, refrigerators, and foam products may still contain ozone-depleting substances (ODS).
- Dispose of them safely through certified recycling centers.
- Reduce single-use plastics and recycle wherever possible.

Spread Awareness & Educate Others

- Share knowledge about the importance of the ozone layer in schools, communities, and workplaces.
- Celebrate World Ozone Day (16th September) with awareness rallies, poster-making, and debates.
- Encourage eco-clubs, green movements, and youth participation.

Support Policies & Global Efforts

- Governments worldwide enforce the Montreal Protocol and Kigali Amendment to phase out Ozone Depleting Substances (ODS).
- Support eco-friendly laws, bans on harmful chemicals, and industries using green technologies.
- Encourage businesses to adopt sustainable practices and reduce emissions.

Don'ts to Protect the Ozone Layer

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Don't Use Products Containing CFCs (Chlorofluorocarbons)

- CFCs were commonly used in old refrigerators, air conditioners, aerosol sprays, and foam products.
- When released, CFCs rise up into the stratosphere where UV radiation breaks them down, releasing chlorine atoms.
- A single chlorine atom can destroy thousands of ozone molecules.
- That's why we must avoid outdated appliances and non–ozone-friendly sprays.

Don't Use Ozone-Depleting Substances (ODS)

- Chemicals such as Halons (used in fire extinguishers), Carbon Tetrachloride (industrial solvent), and Methyl Chloroform are highly destructive to ozone.
- Many of these are now restricted under the Montreal Protocol (1987), but they may still be found in older products.
- Buying or supporting such substances adds to ozone depletion.

Don't Dispose of Old Refrigerators or ACs Carelessly

- Old cooling systems often contain CFCs or HCFCs as refrigerants.
- If these appliances are simply dumped, the gases leak out and reach the upper atmosphere.
- They continue to damage ozone for decades.
- Safe disposal or recycling is essential to prevent leakage.

Don't Overuse Vehicles

- Vehicles emit Nitrous Oxide (N_2O) and other pollutants that harm the ozone layer.
- Excessive dependence on personal vehicles increases emissions.
- Public transport, carpooling, and electric vehicles are better alternatives.

Don't Burn Waste or Plastics in the Open

- Burning garbage, leaves, or especially plastics releases toxic gases like dioxins, carbon monoxide, and nitrogen oxides.
- These gases rise up and indirectly contribute to ozone depletion and air pollution.

Don't Buy Products Without Checking the Label

- Many products today are marketed as "Ozone-Friendly" or "CFC-Free.
- Supporting products without such certification may unknowingly support ozone-depleting industries.

Don't Encourage Deforestation

- Cutting trees not only increases CO_2 (a greenhouse gas) but also disturbs the natural balance of gases in the atmosphere.
- While CO_2 itself doesn't destroy ozone directly, climate imbalance and warming accelerate ozone depletion processes.

Summary:

To protect the ozone layer, we must avoid harmful chemicals, reduce pollution, and prevent careless actions that release ozone-depleting substances. Every small choice — from the products we buy to the way we dispose of waste — matters for the protection of this vital shield around our planet.