



From Sky to Soil: The Growing Threat of Global Environmental Changes

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Human activities have transformed the environment in many ways, often without immediate visible consequences. Over time, actions such as industrialization, deforestation, and excessive use of fossil fuels have led to declining air and water quality, depletion of natural resources, and rising levels of pollution. Some impacts are direct, while others occur as chain reactions within Earth's complex systems. Among the most serious global environmental issues are ozone depletion, increased UV-B radiation, the greenhouse effect, and acid rain, all closely interconnected and largely driven by human influence.

Ozone Layer: Earth's Invisible Shield

High above the Earth, at about 15–30 km in the stratosphere, lies the **ozone layer**, a thin but vital protective shield made up of ozone (O₃) molecules. Though present in small quantities, it performs a crucial function absorbing harmful ultraviolet radiation from the sun, especially UV-B rays. The thickness of the ozone layer is measured in Dobson Units (DU). A normal level is around 300 DU, while values below 220 DU indicate serious depletion. Naturally, ozone is continuously formed and broken down through photochemical reactions, maintaining a balance. However, human activities have disturbed this balance.

Ozone Depletion: Causes and Mechanism

Ozone depletion refers to the thinning of this protective layer due to certain man-made chemicals. Substances like chlorofluorocarbons (CFCs), halons, and other ozone-depleting substances (ODS) rise into the atmosphere and release chlorine and bromine atoms. These atoms act like catalysts, breaking down ozone molecules repeatedly. A single chlorine atom can destroy thousands of ozone molecules. Bromine, although present in smaller amounts, is even more destructive up to 100 times more effective. This process weakens the ozone layer, allowing more harmful radiation to reach the Earth.

UV-B Radiation: A Growing Threat

Sunlight consists of different types of radiation, but only a small portion is visible to the human eye. Beyond this lies ultraviolet (UV) radiation, which is divided into:

- **UVC (100–280 nm):** Most dangerous, but completely absorbed by ozone
- **UVB (280–320 nm):** Partially absorbed; harmful to living organisms
- **UVA (320–400 nm):** Least harmful and reaches Earth

The ozone layer absorbs nearly all UVC and most UVB radiation. However, when ozone depletion occurs, more UV-B radiation reaches the surface, posing risks to humans, plants, and ecosystems.

Greenhouse Effect: Warming the Planet

The greenhouse effect is a natural process that keeps the Earth warm enough to sustain life. Sunlight enters the atmosphere, and while some is reflected back into space, the rest is absorbed by the Earth's surface. This energy is later released as heat (infrared radiation).

Greenhouse gases trap this heat and prevent it from escaping, maintaining a stable temperature. However, human activities have intensified this process.

Types of Greenhouse Effect

- **Natural Greenhouse Effect:** Maintains Earth's average temperature (~15°C)
- **Enhanced Greenhouse Effect:** Caused by human activities, leading to global warming

Major Greenhouse Gases

- Carbon dioxide (CO₂) – from fossil fuels and deforestation
- Methane (CH₄) – from agriculture and livestock
- Nitrous oxide (N₂O) – from fertilizers
- Water vapour – natural but influenced by temperature
- Fluorinated gases – highly potent industrial gases

Acid Rain: Pollution Returns to Earth

Acid rain is another consequence of atmospheric pollution. Normally, rainwater is slightly acidic (pH ~5.6), but when pollutants like sulfur dioxide (SO₂) and nitrogen oxides (NO_x) mix with water vapour, they form strong acids sulfuric acid and nitric acid. These acidic substances fall back to Earth through:

- **Wet deposition:** Rain, snow, or fog
- **Dry deposition:** Dust and gases settling on surfaces

Acid rain can travel long distances before falling, affecting areas far from pollution sources.

Impacts of global environmental problems

These environmental issues are interconnected and have widespread consequences:

1. Climate and atmosphere

- Rising global temperatures
- Melting glaciers and rising sea levels
- Increased extreme weather events

2. Human health

- Skin cancer and eye damage due to UV radiation
- Respiratory diseases from air pollution
- Heat stress and spread of diseases

3. Agriculture

- Reduced photosynthesis due to UV-B exposure
- Crop damage and lower yields
- Increased pest and disease outbreaks

4. Aquatic ecosystems

- Damage to phytoplankton
- Fish mortality due to acidified water
- Coral bleaching due to warming oceans

5. Soil and microorganisms

- Nutrient loss and soil degradation
- Reduced microbial activity
- Decline in soil fertility

6. Forests and biodiversity

- Leaf damage and reduced growth
- Increased vulnerability to pests
- Loss of biodiversity

7. Materials and infrastructure

- Corrosion of metals
- Damage to buildings and monuments
- Degradation of plastics and rubber

Major sources of environmental problems

Human activities are the primary drivers:

- **Industries:** Emission of greenhouse gases and pollutants
- **Fossil fuels:** Burning coal, oil, and gas releases CO₂
- **Automobiles:** Major source of NO_x and CO₂
- **Deforestation:** Reduces carbon absorption
- **Household appliances:** Release CFCs
- **Population growth:** Increases demand for resources

Control measures and global efforts

1. Montreal Protocol (1987)

A global agreement to reduce ozone-depleting substances:

- Phasing out CFCs and halons
- Promoting safer alternatives
- Supporting developing countries

2. Acid Rain Control (EPA Programme)

- Limits SO₂ and NO_x emissions
- Uses emission permits and regulations

3. Cleaner Technologies

Power Plants

- Use low-sulfur fuels
- Install scrubbers

Automobiles

- Catalytic converters
- Cleaner fuels

Renewable Energy

- Solar and wind power
- Reduced pollution

Mitigation Strategies

Ozone Protection

- Avoid CFC-based products
- Use eco-friendly refrigerants

UV-B Protection

- Use sunscreen and protective clothing
- Limit sun exposure

Greenhouse Gas Reduction

- Shift to renewable energy
- Promote afforestation
- Improve energy efficiency

Acid Rain Control

- Reduce industrial emissions
- Use clean fuels
- Restore affected ecosystems

Conclusion

The changes in our atmosphere did not happen overnight. Over decades, human activities have slowly altered its natural balance. Harmful gases released from industries, vehicles, and power plants have weakened the ozone layer, intensified the greenhouse effect, and returned to Earth as acid rain. These issues are not isolated—they are interconnected parts of a larger environmental crisis. However, solutions are within reach. Through global cooperation, technological innovation, and responsible behavior, it is possible to restore balance and protect the Earth for future generations. The challenge now is not just awareness, but action.

References

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