UN environment programme

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Govt. of Puducherry

Department of Science, Technology & Environment

Puducherry Pollution Control Committee

LiFE Lifestyle for Environment

WORLD OZONE DAY

Montreal Protocol: Advancing Climate Action

16th SEPT. 2024

#ViennaConvention

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WHAT IS OZONE ?

Ozone is a simple molecule of three oxygen atoms and it is present in the two lowest layers of the atmosphere – troposphere and stratosphere. The troposphere extends from the surface of the earth upto 12 km and stratosphere extends upto about 50km from the surface of the earth. Almost 90% of all ozone in the atmosphere is in the stratosphere.

THIS IS A
Single oxygen atom

THIS IS
Oxygen that we breathe (two oxygen atoms = O_2)

AND THIS IS
Ozone (three oxygen atoms = O_3)

OZONE (O_3) MAKES UP THE
Ozone layer high in the atmosphere

THE OZONE LAYER
Absorbs harmful ultraviolet radiation

WITHOUT THE OZONE LAYER
There are serious consequence

WHAT IS THE OZONE LAYER ?

The ozone layer is a region of high ozone concentration in the stratosphere, 15 to 35 kilometres above Earth's surface. The ozone layer acts as an invisible shield and protects us from harmful ultraviolet (UV) radiation from the sun. In particular, the ozone layer protects us from the UV radiation, known as UV-B, which causes sunburn. Long-term exposure to high levels of UV-B threatens human health and damages most animals, plants and microbes, so the ozone layer protects all life on Earth.

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HOW DOES OZONE PROTECT US FROM UV-B ?

Ozone absorbs UV-B radiation from the sun. When an ozone molecule absorbs UV-B, it comes apart into an oxygen molecule (O_2) and a separate oxygen atom (O). Later, the two components can reform the ozone molecule (O_3). By absorbing UV-B in the stratosphere, the ozone layer prevents harmful levels of this radiation from reaching Earth's surface.

HOW IS OZONE PRODUCED AND DESTROYED IN THE STRATOSPHERE ?

Ozone is being produced and destroyed all the time. As well as UV-B, the sun also emits another form of ultraviolet light, UV-C. When UV-C light reaches the stratosphere, it is completely absorbed by oxygen molecules and never reaches the Earth's surface. UV-C splits oxygen molecules into oxygen atoms. These single atoms then react with other oxygen molecules to produce ozone. So, these reactions increase the amount of ozone in the stratosphere.

But, ozone is not the only gas in the stratosphere. Other gases containing nitrogen and hydrogen are also in the stratosphere and participate in reaction cycles that destroy ozone converting it back into oxygen. So, these reactions decrease the amount of ozone in the stratosphere.

When undisturbed, the balance between the natural processes of ozone production and destruction maintains a consistent ozone concentration in the stratosphere. Unfortunately, we, humans do not leave this natural process undisturbed...

OZONE DEPLETION AND THE "OZONE HOLE"

In the mid-1970s, scientists realised that the ozone layer was threatened by the accumulation of gases containing halogens (chlorine and bromine) in the atmosphere. Then, in the mid-1980s, scientists discovered a "hole" in the ozone layer above Antarctica – the region of Earth's atmosphere with severe depletion.

So, what causes the thinning of the ozone layer around the globe and the "ozone hole" above Antarctica?

Manmade chemicals containing halogens were determined to be the main cause of ozone loss. These chemicals are collectively known as ozone-depleting substances (ODSs). ODSs were used in literally thousands of products in people's daily lives around the world.

The most important ODSs were chlorofluorocarbons (CFCs), which at one time were widely used in air conditioners, refrigerators, aerosol cans, and in inhalers used by asthma patients.

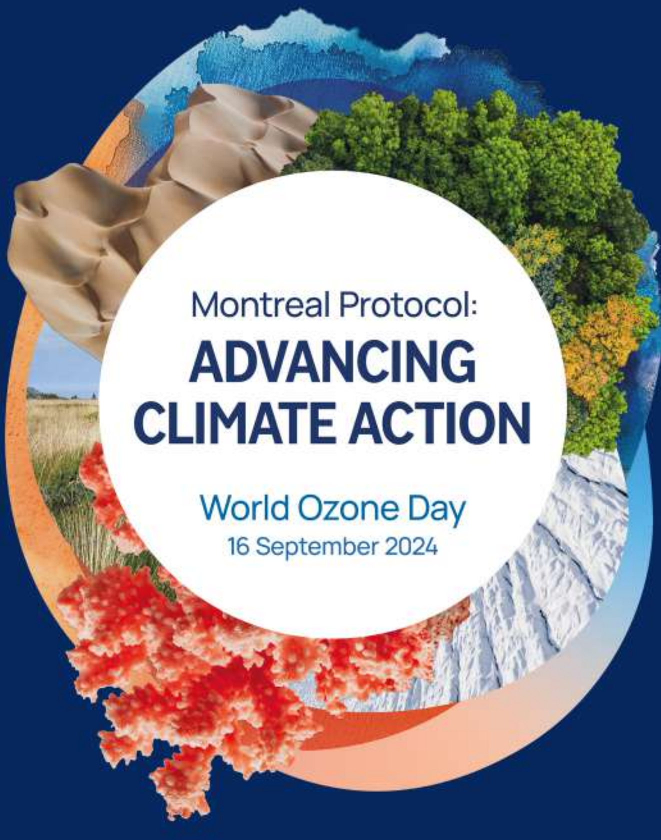
Other chemicals, such as hydrochlorofluorocarbons (HCFCs), halons and methyl bromide also deplete the ozone layer. Most of our computers, electronics and parts of our appliances were cleaned with ozone-depleting solvents. Car dash boards, insulation foams in our houses and office buildings, water boilers and even shoe soles were made using CFCs or HCFCs. Offices, computer facilities, military bases, airplanes and ships extensively used halons for fire protection. A lot of the fruit and vegetables we ate were fumigated by methyl bromide to kill pests.

How do these chemicals deplete ozone?

When a CFC molecule reaches the stratosphere, it eventually absorbs UV radiation, causing it to decompose and release its chlorine atoms. One chlorine atom can destroy up to 100,000 ozone molecules. Too many of these chlorine and bromine reactions disrupt the delicate chemical balance that maintains the ozone layer, causing ozone to be destroyed faster than it is created.

WITHOUT THE MONTREAL PROTOCOL, LARGE-SCALE DEPLETION OF THE OZONE LAYER WOULD HAVE OCCURRED WITH MAJOR CONSEQUENCES

Because of the Montreal Protocol, we have avoided a world where severe ozone holes would have occurred every year over the Arctic and Antarctic. By the mid-21st century, severe ozone depletion would have spread across the planet, including the tropics. But how large an increase in UV-B would have resulted from uncontrolled ozone depletion? And how would increased UV-B have affected people, food production, ecosystems and even construction materials? Let's explore some of the consequences of failing to control ozone depletion.



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UV-B RADIATION: NOW AND IN A WORLD WITHOUT THE MONTREAL PROTOCOL ?

Ozone depletion allows more UV-B radiation to reach Earth's surface, but UV-B also varies naturally. Levels of UV-B radiation are higher in the tropics than at temperate or polar latitudes, and higher at high altitude than at sea level. UV-B also varies predictably with season (at temperate and high latitudes UV-B reaches its maximum in mid-summer), and with time of day (peak levels occurring around mid-day). Variation in cloud also has large effects.

One way of measuring this natural variation in UV-B is through the UV-index (UVI)[WHO1]. UVI is a measure of sunburning UV radiation, and is now commonly used to show UV levels in weather forecasts. The World Health Organisation (WHO) defines any UVI greater than 11 as extreme[WHO2] but with the protection of an intact ozone layer, such high UVIs only occur at high altitude in the tropics[WHO3].

Computer models are giving us insights in to UVI in a world without the Montreal Protocol (often called the 'World Avoided'). By the middle of this century, UVI values over 25 would have occurred at most latitudes, and UVI would have reached around 50 in the tropics, so five times the current definition of 'extreme' UV radiation.

So, what causes the thinning of the ozone layer around the globe and the "ozone hole" above Antarctica?

Even with the Montreal Protocol to protect the ozone layer, we should all try to avoid too much exposure to the sun to reduce the risk of disease such as skin cancer and cataracts that are cause by overexposure to UV-B radiation. But what if the Montreal Protocol had not been successful? How would the major diseases have been affected by unchecked ozone depletion on this world-avoided?

Skin cancers in a world without the Montreal Protocol

There are strong links between over-exposure to UV radiation and the development of the three most common forms of skin cancer (malignant melanoma, basal cell carcinoma and squamous cell carcinoma). Even now, with the successful implementation of the Montreal Protocol, skin cancers are amongst the most common forms of cancer, especially in pale-skinned populations

Understanding how the prevalence of skin cancers would have increased with uncontrolled ozone depletion comes from computer models of the world avoided. These models combine our understanding of how ozone-depleting substances affect the ozone layer, of how changes in ozone affect UV radiation and of how UV radiation affects the incidence of skin cancers.

For example, one global model suggests that by 2030 the successful implementation of the Montreal Protocol will be preventing about two million skin cancers every year. A longer-term model focussed on health effects in people born in the USA between 1890 and 2100. This model estimates that protecting the ozone layer will have prevented a total of approximately 443 million cases of skin cancers and 2.3 million skin cancer deaths in the USA alone. This includes 8-10 million cases of malignant melanoma. As yet there are no long-term world-avoided models for skin cancers globally. However, all the existing models lead to the same conclusion. Uncontrolled ozone depletion would have substantially increased the risk of skin cancers worldwide.

Eye disease in a world without the Montreal Protocol

Exposure to high levels of UV radiation leads to an increased risk of cataracts. The World Health Organisation already considers cataracts as a priority eye disease. Cataracts are responsible for around half of blindness world-wide, equivalent to about 20 million people in 2010. At the moment a world-avoided model for cataracts is only available for the USA. This model indicates that failure to control ozone depletion effectively would have led to almost 63 million additional cataract cases in people born in the USA between 1890 and 2100.

Other health effects in a world without the Montreal Protocol

As well as skin cancers and cataracts UV radiation can have other health effects. These effects include the production of vitamin D in the skin that is beneficial to health. In the world we live in now, with effective protection of the ozone layer, there is a balance between the positive and negative effects of UV-B. Had we failed to protect the ozone layer that balance would have swung dramatically towards the negatives, above all the increased risks of skin cancer and cataracts. By avoiding these negative consequences, the Montreal Protocol has made a major contribution to good health and well-being, one of the sustainable development goals adopted by all United Nations Member States in 2015.

Damage to food security

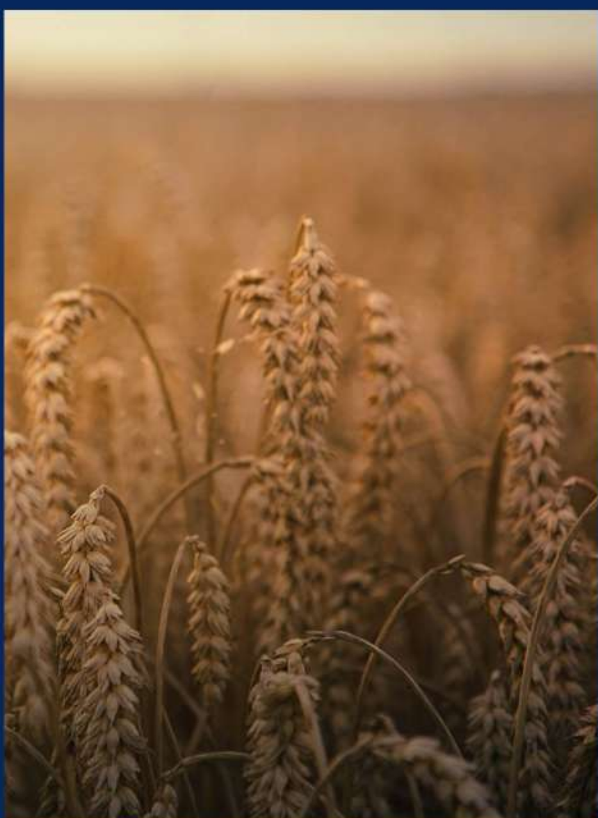
Over the course of evolution, animals, plants and microbes have developed mechanisms that allow them to cope with the variation in UV-B radiation that they experience in their normal environments, protected by the intact ozone layer. This includes the plants and animals that we all rely on for our food.

Crops need sunlight for photosynthesis, so cannot avoid exposure to UV-B. They have evolved systems that reduce or repair damage, including pigments that act as 'sun-screens'. As with human health, there is a balance between the positive and negative effects of UVB on plants. Uncontrolled ozone depletion would have shifted this balance very much towards the negative.

Increased exposure to UV radiation can damage aquatic food chains and cause direct damage to crustaceans and fish eggs. As a result, uncontrolled ozone depletion would have threatened fisheries and other aquatic resources that make a significant contribution to global food supply.

As yet there are no 'world avoided' models for food production. There are 'ball-park' figures of the relationship between ozone depletion and plant growth. These suggest that a 10 per cent reduction in stratospheric ozone might reduce plant production by about 6 per cent. If this relationship holds for the very severe ozone depletions expected in the world avoided then uncontrolled ozone depletion would have substantially reduced crop production globally.

Overall, while we cannot yet quantify the loss in food production, it is clear that without the Montreal Protocol ozone depletion would have made it progressively harder to deliver the sustainable development goal of zero hunger.



Damage to our environment

Just as uncontrolled ozone depletion threatens food production, it also threatens plants, animals and microbes in natural ecosystems. Those ecosystems provide the 'ecosystem services' that we all rely on for clean air and clean water, and to absorb carbon dioxide for the atmosphere.

Life on land

As with crops, wild plants are able to cope with current levels of UV-B radiation, but their growth can be reduced by large increases in UV-B. Most animals also seem to be able to avoid the damaging effects of current levels of UV-B radiation. We do not know at what point animals' protection mechanisms would have been overwhelmed by the unprecedented increases in UV-B in the world avoided. Even so, damage to plants would reduce the food available for herbivores, with consequences for the whole food web.

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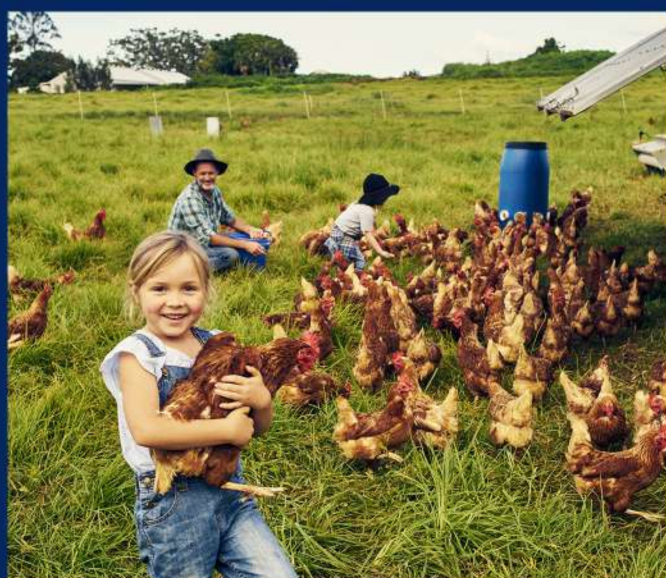
LIFE ON LAND



Life below water

Oceans are the Earth's biggest ecosystems. They contain micro-organisms, animals and plants that provide us with half of the oxygen we breathe and much of the food we eat. A healthy ocean is vital to our survival.

In the oceans, lakes and rivers UV-B has adverse effects on many different aspects of the biology of organisms across the food web. While there are no 'world avoided' models for ecosystem responses, large increases in UV-B then whole food webs would have been disrupted, threatening biodiversity and ecosystem services.

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LIFE BELOW WATER

Ecosystems

Through these effects on ecosystems, large-scale increases in UV-B could alter the exchange of carbon dioxide between the atmosphere and the biosphere. Increased UV radiation also stimulates the breakdown of decaying leaves and other organic matter. Together, the effects of increased UV-B would reduce the ability of ecosystems to trap carbon dioxide, including carbon dioxide produced by human activities. In this way, large-scale ozone depletion would have worsened the build-up of carbon dioxide in the atmosphere that is causing climate change. Changing UV-B also alters the cycling of nitrogen and other chemicals in the environment, which may worsen air pollution.

Damage to outdoor materials

Exposure to UV-B also damages natural and synthetic materials. Vulnerable materials include wood, plastic, rubber and even the materials used in some solar panels. These materials, widely used in buildings, agriculture and commercial products, are already designed to minimize the damage caused by UV.

Large-scale depletion of the ozone layer causing greater exposure to the sun's UV rays would increase this damage and weaken these materials. This would have led to more rapid deterioration and the need for additional UV protection, increasing the cost and reducing the reliability of many products.

What you can do ?

Even though we are well protected by the ozone layer we should all be aware of our exposure to UV radiation. You can help safeguard yourself and your family by AVOIDING EXCESSIVE SUN EXPOSURE.

- **Wearing Sunglasses**
- **Using Sunscreen**
- **Checking UV index**
- **Using your shadow to measure UV levels**

Take care of your appliances to minimize ozone layer impact

The success of the Montreal Protocol means that 99 per cent of the ozone-depleting substances (ODSs) are now controlled. But older refrigerators, freezers or air-conditioning units may still contain ozone-depleting substances that were produced before controls were put in place. By using refrigerators, air conditioners and other equipment responsibly you would assist in protecting the ozone layer and climate too.

Timeline

- **1974** Discovery of CFCs are harming the ozone layer.
- **1977** The World Plan of Action
- **1985** Antarctic hole
- **1987** Montreal Protocol adoption
- **1988** First control measures
- **1989** Montreal Protocol enters into force
- **1990** Ozone phase-out begins
- **1991** Multilateral Fund becomes operational
- **1992** London Amendment enters into force
- **1993** International Ozone Day proclaimed
- **1994** Copenhagen Amendment enters into force
- **1996** Developing countries freeze HCFCs
- **1997** First developing country control measures take effect
- **1998** Protocol adjustments enter into force
- **1999** Montreal Amendment enters into force
- **2002** Beijing Amendment enters into force
- **2003** Montreal Protocol wins praise
- **2004** Developed countries phase out methyl bromide
- **2005** Largest Antarctic ozone hole recorded
- **2007** HCFC phase-out accelerated
- **2008** Universal ratification achieved
- **2009** Climate change impact measured
- **2010** All parties phase out fully hydrogenated ODSs
- **2012** Skin cancer prevention recognized
- **2013** Healing of ozone layer confirmed
- **2014** All four Protocol Amendments ratified
- **2015** HFC phase-down pathway agreed to
- **2016** Kigali Amendment adopted
- **2019** Kigali Amendment enters into force
- **2020** Kigali Amendment exceeds 100 ratifications

The solution

In the 1980s, the global community decided to do something about ozone depletion. With growing evidence that CFCs were damaging the ozone layer and understanding of the many consequences of uncontrolled depletion, scientists and policy makers urged nations to control their use of CFCs. In response, the Vienna Convention for the Protection of the Ozone Layer was adopted in 1985, followed by the Montreal Protocol on Substances that Deplete the Ozone Layer in 1987. They are the first international environmental treaties to be universally endorsed by 198 nations of the world.

The Vienna Convention
The Montreal Protocol
The Kigali Amendment

Ozone treaties and SDGs

The ozone layer protects people and life on Earth. The Ozone Secretariat works with all nations to protect the ozone layer. Successfully protecting the ozone layer help deliver many of the Sustainable Development Goals.

India and the Montreal Protocol

India became a signatory to the Montreal Protocol in 1992.

India is entitled to assistance from the multilateral fund in its efforts to phase out ODS and switch over the non-ODS technologies.

India mainly manufactured and utilized 7 of the 20-substance controlled under the protocol. These are CFC -11, CFC 113, CRC-12, Halon-1301, Halon -1211, Carbon tetrachloride, Methyl Bromide and Methyl chloroform.

In India, the implementation of the Montreal Protocol comes within the ambit of the ministry of environment, forests and climate change.

The ministry has established an ozone cell to implement the protocol.

As per the national Strategy for ODS phaseout, the Ministry has notified the Ozone Depleting Substance (Regulation and Control) Amendment Rules, 2014, have been published by the central Government in the Gazette of India, Under the Environment (Protection) Act, 1986.

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