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OzonAction COMPLIANCE ASSISTANCE PROGRAMME

OzonAction SCOOP

A TRI-ANNUAL NEWSLETTER BY UN ENVIRONMENT OZONACTION UNDER THE MULTILATERAL FUND FOR THE IMPLEMENTATION OF THE MONTREAL PROTOCOL

The Montreal Protocol and its Kigali Amendment: Ozone, Climate and Health

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THE MONTREAL PROTOCOL

The stratospheric ozone layer is the world's primary protection shield against UV radiation. During the 1980s, the scientific prediction that the ozone layer would become depleted by CFCs was shockingly confirmed by the appearance of a huge hole in the ozone layer appeared over the Antarctic. This set off alarm bells and this led a group of countries to adopt the Vienna Convention in 1985, and two years later (1987), the Montreal Protocol. The Protocol evolved through a series of amendments as the science became clearer, to phase out ozone depleting substances. Signatory parties joined forces to protect human health and the environment from the harmful effects of a damaged ozone layer, and by 2008 the Montreal Protocol had achieved universal ratification.

Dubbed "the most successful environmental treaty to date", the Montreal Protocol has brought by numerous benefits derived from ozone layer protection and human health is no exception.

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UV RADIATION – why it matters

UV radiation is electromagnetic radiation that comes from the sun and is invisible to the human eye (solar radiation is what we see and perceive coming from the sun). UV radiation carries a large amount of energy and can have negative impacts – for example by breaking chemical bonds in molecules, including DNA – but can also be beneficial according to its type. UV radiation is classified as:

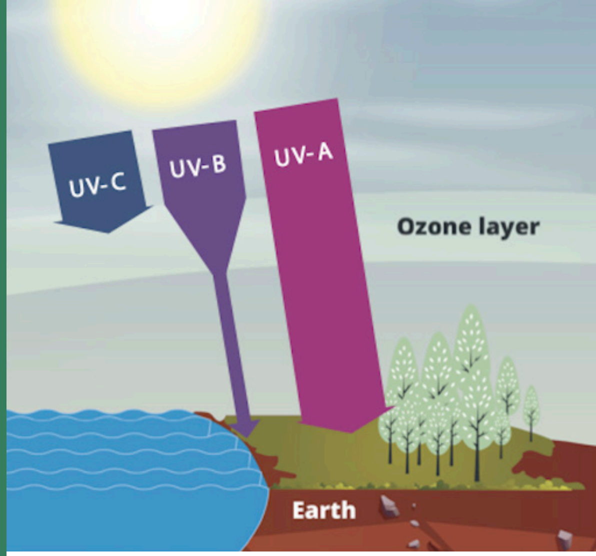


Figure 1. **At 15 – 40 km from the Earth's surface (in the stratosphere), the ozone layer acts as a protective shield against potentially harmful UV radiation. A depleted ozone layer will primarily let through UV-B.** *(UNEP, 2023)*

UV-C **with the highest energy content, and which is completely absorbed by ozone and oxygen molecules found in the Earth's atmosphere.**

UV-B **which is also absorbed by the ozone layer, but not entirely, and if reaching the Earth in high concentrations can cause skin cancers, cataracts, and a supressed immune response in humans; it can further affect plant and aquatic life and reduce the lifespan of plastics.**

UV-A **with lower energy content but still with some health hazard potential.**

UV radiation is not distributed uniformly around the planet, so in order to measure its intensity, the **UV index** was developed. This index represents the amount of harmful UV radiation causing sunburn on human skin and is internationally recognized; UV-B makes up about 90% of the UV index whilst UV-A takes up the remaining 10%. The UV index is influenced by the intensity of solar radiation, the height of the sun above the horizon (for example in the tropics the sun can be directly overhead at noon), the altitude, reflections from the ground (e.g. from fresh snow) and the amount of atmospheric ozone at a given location. Clouds can reduce UV radiation up to a point, but clouds block more sunlight than radiation, which explains why we can still get sunburn on cloudy days.

The Panels of the Montreal Protocol (EEAP, SAP and TEAP) have reported from their different standpoints that, by avoiding the increase in harmful UV radiation (particularly UV- B) that would result from ozone layer depletion, the Montreal Protocol has prevented saved the Earth from becoming inhabitable. Recent and current research is making it possible for us to understand more clearly how destruction of the ozone layer impacts not just human health but also all forms of life and all ecosystems. Decisive action taken by the parties to phase-out and replace Ozone Depleting Substances (ODS) has put the world on track to ozone layer recovery, with large benefits to humankind.

A research group in the United States, for example, reported in 2021 that as radiation levels return to pre-1980 levels, the Montreal Protocol and its amendments are "expected to prevent 443 million cases of skin cancer and 63 million cataract cases for Americans born through the end of this century", plus millions of eye cataracts (Madronich et. al., 2021). The study focused on the US population but declares that even if specific benefits vary by country or region, it is clear that this effort brings benefits to the entire planet.

Indeed, studies conducted in various countries like Canada, the Netherlands, Lithuania, Australia and the USA report a growing incidence in skin cancers including melanoma over the past 2-3 decades, including even children and adolescents in Finland. Exposure to UV radiation has been determined as one of the main causes of skin cancers, so protecting the ozone layer is vital in avoiding this serious illness. The same is true for cataracts and some kinds of eye tumors (Madronich et.al., 2024). It is sobering to consider that CFCs produced in the 1960s and 70s, depleted the ozone layer which will not recover until around 2060. Because of the 40 year latent period between UV exposure and skin cancer development, skin cancer rates will likely not return to normal before around 2100.

Ozone and climate – the Kigali Amendment

In addition to the damage they cause on the ozone layer, many ODS are also greenhouse gases, often with a high Global Warming Potential (GWP). It is estimated that in the second half of the 20th century the combined effect of all ODS was the second largest source of global warming after CO2 , and that by reducing emissions from these substances the Protocol avoided between 0.5 and 1°C of global warming (UNEP 2023).

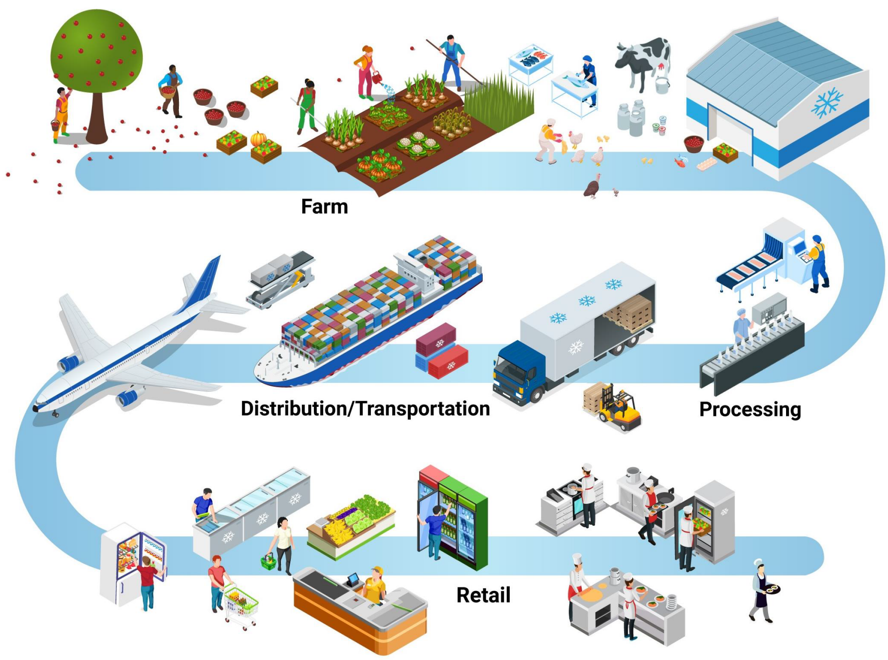
CFC-11 for example, has a GWP of 5000 (i.e.5000 times that of CO2), whilst CFC-12 has a GWP of 11,000. To replace CFCs and other ODSs, hydrofluorocarbons (HFCs) were introduced as ozone-friendly alternatives. However, they also have a high GWP although not as high as that of CFCs: as an example, HFC-134a (commonly used HFC) has a GWP of 1430. Even so, with about 780,000 tonnes of manufactured each year HFCs are important chemicals. Ninety per cent of these chemicals are used in the refrigeration and air conditioning sector (RAC), but it is important to note that HFCs were also used as a replacement for CFC in MDIs, where pharmaceutical grade HFC-134a is used and is fully emitted every time they are used. (Woodcock, 2023).

With the realization of the climate impact of HFCs, the Parties to the Montreal Protocol took urgent action to phase-down HFCs and adopting alternatives with the Kigali Amendment in 2016. The HFC phase-down can potentially avoid a further 0.3-0.5 °C of global warming by 2100.

Fortunately, solutions are underway, although the choice of alternatives is not a simple matter as side considerations arise. For example:

In the RAC sector, a range of "natural" refrigerants such as hydrocarbons (HCs), CO2 or ammonia are available, but the flammability of Hydrocarbons and the toxicity of other alternatives limit their use in some applications.

Some alternatives, low-GWP refrigerants (HFOs) are fluorine based, and they are under scrutiny in some jurisdictions which may lead to broad and restrictive regulations which limit their application.



Source: **Ozone Secretariat website**
https://ozone.unep.org/sustainable-cold-chains-virtual-exhibition

Figure 2. **General components of a cold chain**

Refrigeration and air conditioning (RAC) are essential for a very wide variety of sectors and situations including food transportation and preservation, trade of perishable products (fruits, vegetables, meats, fish, milk products, processed foods and others), health, and comfort in the home and workplace. As such, RAC impacts food security, access to vaccines and medicines, and other important aspects of daily life. This will be increasingly important climate change progresses, especially in hot countries. An efficient, sustainable cold chain is thus essential for millions of livelihoods, as illustrated in Fig 2.

CFCs – A DIRECT CONNECTION TO HUMAN HEALTH

Chlorofluorocarbons (CFCs) were a class of ODS with an additional direct connection to human health: aside from their use in foam insulation, refrigeration and aerosols, they were a key component of metered-dose inhalers (MDIs), used in the treatment of asthma and chronic obstructive pulmonary disease (COPD).

CFCs have a very long half-life (time required for their breakdown), which means that even if 99% of these substances have been phased-out already, they will still persist for many years in the atmosphere – together with their harmful effects. Considering the prolonged time lapse between UV exposure and cancer development, CFCs made 60 years ago will still be causing skin cancer 60 years from now, and this would be much worse if the Montreal Protocol did not exist (Woodcock, 2023).

Most patients can safely use propellant free low GWP inhalers (Dry powder inhalers, DPIs). However, DPIs are not suitable for all patients and so MDIs have undergone a series of transitions for environmental reasons first CFC to HFC 134a, and now to new lower GWP propellants HFC-152a or HFO-1234ze which are in late phase development. This will require a carefully managed transition needed to avoid harming patients.

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