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Ozone Layer Depletion: Causes, Effects and Prevention

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ABSTRACT

The purpose of this study was to review the Causes, effects and prevention of the ozone layer depletion. Ozone layer is a part of the stratosphere which absorbs the harmful ultraviolet (UV) rays of the sun and prevents it from reaching the earth surface. Industrial activities, release chemicals into the air that can destroy ozone layer, this process known as ozone layer depletion. The main causes of ozone layer depletion are Chlorofluorocarbons (CFCs), Halons (HCFCs) and NO_X (nitrogen oxides), depletion of stratospheric ozone, led to increased ultraviolet radiation at the earth's surface as well as spectral shifts to the more biologically damaging shorter wavelengths, which is harmful to the human, plants and ecosystem. An international environmental initiative to lessen ozone depletion is known as the Montreal Protocol. This agreement required all nations to impose legal obligations on the reduction of CFCs and other comparable chemical compounds. As a result, an international fund has been set up to assist in introducing these nations to new and environmentally friendly technologies and chemicals.

Keywords: Chlorofluorocarbons, Halons, Ozone depletion, Ultraviolet radiation.

INTRODUCTION

The ozone layer and its depletion are currently hot themes in public discuses on climate change. It is well recognized that the primary causes of the stratospheric ozone layer depletion are CFCs and halocarbons (Dameris, 2010). The ozone layer is a part of Earth's stratosphere, It contains high concentration of ozone (O_3) in relation to other parts of the atmosphere (Zachary and Ward, 2020). This region contains up to 91% of the ozone found in the Earth's atmosphere. It is mostly found in the lower stratosphere, around 10 - 50 km from Earth (Khari, 2019). When the natural equilibrium between ozone production and destruction in the stratosphere is skewed towards destruction, ozone depletion results. Earth would thus be directly exposed to the sun's heat and harmful UV radiation (Udoh, 2014). Chlorofluorocarbons and Halon are substances found in foams, aerosols, and refrigerants that are composed of combinations of the elements carbon, fluorine, and chlorine. These CFCs rise up into the atmosphere they rise up into the atmosphere to meet up with and destroy ozone molecules (Changotra and Baharti, 2018). Over the past two decades, the advent of a new generation of satellite, hyperspectral atmospheric gauges, which simultaneously perform radiation measurements with high spectral resolution and sampling rate, wich have significantly improved our ability to detect and quantify a number of tropospheric trace gases, including ozone (Di Noia et al, 2013). Chemical composition of Earth atmosphere is changing due to releasing of chemicals like CFCs, halons from industries, agriculture and due to combustion of fossil fuel. All these factors led to ozone depletion. It has varied from 3% to 20% (Binabdullah, 2021). Stratospheric ozone depletion, due to air pollution, has led to an increase in ultraviolet radiation at the Earth's surface as well as a spectral shift to shorter, more harmful wavelengths (Craig et al, 2014). Ultraviolet radiation causes skin cancer and cataracts, weakens the human immune system, and damages agricultural ecosystems, natural ecosystems, and the built environment (Bais et al, 2018). According to Montreal Protocol different phase out schedules have been established for the production of CFCs (Kim et al, 2011). The problem of climate change is one of the most significant issues of the present time. Considering this issue , the researchers decided to conduct this study on the destruction of the ozone layer and about it's causes, effects, and prevention.

MATERIALS AND METHODS

A comprehensive literature search was performed using Google Scholar database using the search terms "Ozone layer depletion" ,"causes of ozone layer", and "effects of stratospheric ozone depletion". The literature search included about 37 articles reviewed, among them 14 articles, UNEP and EPA reports were selected as original references, they published from 2009 to 2022, these articles have close relations with research topic.

RESULTS

Fully halogenated chlorofluorocarbons are made by catalytically replacing chlorine from chlorocarbons with fluorine by reaction with anhydrous hydrofluoric acid (Bredsdorff and Nielse. 2014). CFCs are produced by several manufacturers and sold under various trade names such as Freon, Flugene or Frigen (Sharma, 2019). These chemicals have many applications like, as coolants in refrigerators, freezers, and air conditioners in buildings and automobiles. It is also used in firefighting equipment, aerosols, the production of installation foam, the production of industrial solvents. CFC emissions can reach the stratosphere and destroy ozone molecules there (Udoh. 2014). HCFCs and CH_3Br are still fairly widely used for many applications in developed countries (Aljeran and Khan, 2009). NOx largely contributes to the depletion of stratospheric ozone. The sources of NO_x are industrial processes, burning of fossil fuels, and biofuels (Dameris, 2010). Table 1 shows a number of fluorocarbons and halocarbons with specific areas of Application.

Table 1: Existing Chlorofluorocarbons and halocarbons with specific areas of uses (Khari. 2019).

Table 1. Existing Chlorofluorocarbons and halocarbons	
Area of use	**Deferent types**
Refrigerant	CFC-114,HCFC-22,R-502,HCFC-152a,HCFC-142b
Aerosols	HCFC-22,HCFC-142b
Blowing agents	HCFC-123,HCFC-141b.HCFC-22
note: the numbers and letters indicate deferent types of CFCs and HCFCs.	

Ozone is formed in stratosphere and is also naturally broken down so its amount remains constant in stratosphere. Amount of ozone is maximum in poles and is minimum in tropics. It also has seasonal changes but locally it remains constant (Binabdulla, 2021). Ozone layer is completely free of clouds and other weather conditions, this is why it is advantage to fly long- distance supersonic aeroplanes/jets through this layer. CFCs themselves do not destroy the ozone layer, when it exposed to UV radiation, free chlorine is produced. free chlorine and ClO (oxycholoro) atoms appear in the stratosphere (Ross et al , 2019) .This free chlorine atom reacts with ozone and produces ClO and oxygen molecules (O_2).This ClO free radical reacts with oxygen atoms and produces chlorine free radicals and oxygen molecules. Now this chloride free radical destroys the ozone layer in the stratosphere and causes ozone depletion (Binabdullah, 2021). Technically, the term "ozone hole" should be applied in areas where stratospheric ozone deficiency is so severe, this level falls below 00 Dobson units (DU), traditional measures of stratospheric ozone. The general ozone concentration is approximately 300 to 350 DU (Khari et al, 2019). HCFCs are generally more reactive in the troposphere because they contain hydrogen (H) in addition to chlorine, fluorine, and carbon. HCFCs are 88 to 98% less effective than CFC-11 in depleting stratospheric ozone because their chemical removal occurs primarily in the troposphere (Ross et al, 2019). Figure 2 shows the types of CFCs, Halons and their effective substitutes.

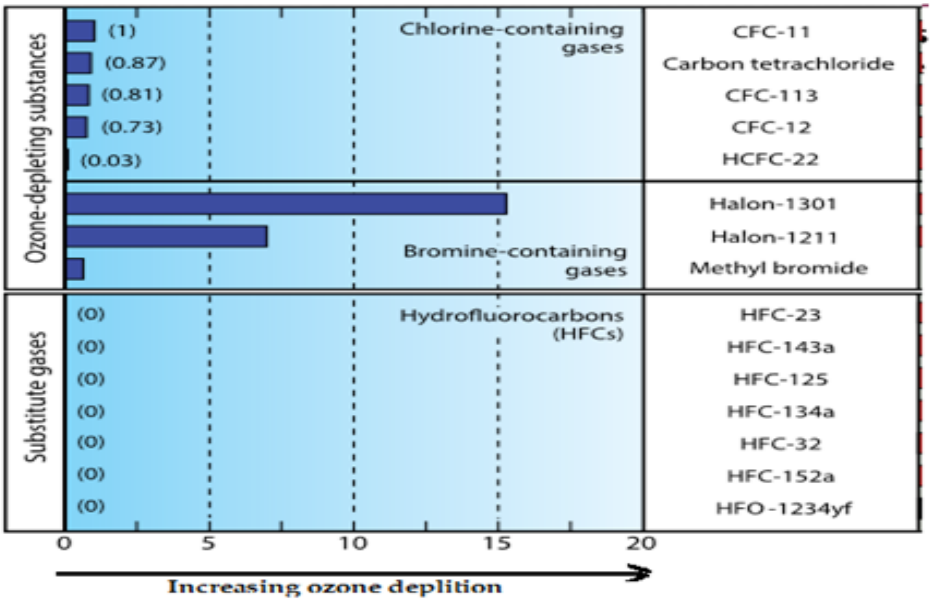

Figure 1. Ozone depleting gases and their substitutes (w/m^2) (Ross et al., 2019).

Only 5% of the UV spectrum of sunlight reaching the Earth's surface and is most powerful in causing biological effects on skin (Skobowiat, 2011). UV radiation and skin pigmentation strongly influence the risk of skin cancer (D'Orazio and et al, 2013). UV rays are harmful for our eyes, direct exposure to UV rays can lead to Cataract Problems or snow blindness (Sharma, 2019).Ozone-induced climate changes currently have significant effects on terrestrial and aquatic ecosystems. Many animals and plants change or move their territories to higher latitudes and altitudes, while increased exposure to UV radiation causes zooplankton to move into deeper water (Barnes et al, 2019). Increased UV radiation can reduce plant photosynthesis and growth; alter the time of flowering, as well as the number of flowers (Udoh, 2014).

DISCUSSION

Many novel refrigerants are suggested to replace the natural refrigerants, whether they be pures, mixes, or naturals. These appear to be the most promising options for usage in heat pumps, air conditioners, and refrigeration. The depletion of the ozone layer is an international issue that transcends national boundaries. International cooperation can help to find a solution to this issue. The Montreal Protocol has prevented the stratosphere's ozone layer from being destroyed. Ozone layer changes are expected to be geographically variable over the next few decades, with peaks and falls. In the mid-latitudes of the northern and southern hemispheres, column ozone is expected to return to 1980 levels in the 2030s and 2050s, respectively, and in Antarctica in the 2060s. Only a few key knowledge gaps need to be filled in order to increase stratospheric ozone. Understanding the basic responses of humans and other living things to ultraviolet radiation, especially how they respond to various UV, to comprehend the whole range of UV radiation's beneficial as well as harmful impacts on people and other living things, as well as how UV scales are altered.

SUGGESTIONS

- Try to use products which are labelled, ozone-friendly.
- Unplugging the electronic instruments when they are not in use.
- Do not use cleaning solvents containing CFCs or ammonia.
- Minimize time outdoors during (10 am to 4 pm).
- Get Vitamin D safely by relying on diet and supplements rather than UV exposure.

CONCLUSION

Ozone layer is continuously depleting which is highly alarming situation of recent time. CFCs, HCFCs are real causes for ozone destruction. If we restrict or decrease their applications or replace them in everyday life, we can protect ourselves from the dangerous impacts of UV radiation. It is the right time to change behavior towards the environment by creating awareness among people. However, Montreal protocol activities have shown the commitments in all over the world. We are the member of world community so we need to consider this issue. There are so many men made chemicals, which need to be controlled in order to overcome the problems of ozone depletion and decline its harmful effects.

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