

OZONE LAYER DEPLETION CAUSES, HUMAN AND ENVIRONMENTAL IMPACTS, AND MITIGATION STRATEGIES – A COMPREHENSIVE REVIEW

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Abstract

The depletion of ozone, which accelerates the emergence of ultraviolet (UV) radiation and other solar rays, has become one of the biggest threats to the world in recent years. This review article investigates the causes of depletion of the ozone layer and its effects on human health. This study provides a general overview of the ozone layer, highlighting its significance in preserving life on Earth and the scientific rationale behind its deterioration. It examines a number of human factors, such as industrial emissions, agricultural practices, and the use of certain chemicals that contribute to the depletion of the ozone layer. The effects of ozone layer depletion on human health, including a higher risk of skin cancer, cataracts, and a compromised immune system, are also covered in this article. It also identifies initiatives taken to solve this problem through international accords, such as the Montreal Protocol, and offers suggestions for future analysis and policy measures to reduce ozone layer loss and safeguard human health. Overall, this review article emphasizes the necessity for collaborative efforts to protect human well-being, while providing an insightful understanding of the causes and effects of ozone layer depletion.

Keywords: *Chlorofluorocarbons (CFCs), Ozone, Ozone Depletion, Ultra Violet (UV) Radiations, Skin Diseases*

1. INTRODUCTION

In recent decades, ozone layer depletion has emerged as a serious environmental concern, with far-reaching consequences for human health and well-being. Many human actions have negative impacts on the environment. Ozone depletion is one such example (Yang, 2020; Sivasakthivel et al., 2011). The stratospheric ozone layer acts as the Earth's natural sunscreen, protecting life from the damaging effects of the ultraviolet (UV) radiation released by the sun. This important layer of ozone molecules absorbs much of the incoming UV radiation, especially the most dangerous UV-B and UV-C rays, preventing them from reaching Earth's surface in large quantities (Bais et al., 2015). The bulk of the Earth's ozone is located in the stratosphere, notably in the ozone layer, which extends from 15 to 35 km above the Earth's surface (Fang et al., 2019). Albritton and his colleague highlight the ozone layer's exceptional ability to absorb medium frequency ultraviolet (UV) radiation spanning from 200 to 315 nm. According to their findings, the ozone layer absorbs 97–99% of the medium-frequency UV light (Albritton, 1998).

Despite being colorless like oxygen, ozone has a unique and bitter odor that distinguishes it from its counterpart. Ozone is far less abundant than oxygen in the Earth's atmosphere, accounting for just around three out of every ten million air molecules. This rarity emphasizes the importance of ozone as a screen for UV light. The process of ozone generation is known as photolysis, and it plays an important role in the breakdown of ozone-depleting substances (ODS) and contaminants in the atmosphere, greatly contributing to atmospheric composition management and ozone layer maintenance (Voulgarakis et al., 2013). When the UV energy from the sun strikes O₂ molecules, it causes them to split. Oxygen molecules react with oxygen atoms in high atmospheres to produce ozone (Matsumi et al., 2003). Stratospheric ozone is measured from the ground using units known as the "Dobson Unit" (D.U.). This unit was used to quantify the concentration of ozone in the atmosphere, providing a consistent estimate of the total quantity of ozone present. Normal ozone concentrations ranges between 300 and 350 D.U. (Ozone, 2012). This review article studies the causes of ozone layer depletion and its implications on human health, as well as makes

recommendations to reduce ozone depletion and its negative effects on human health. Understanding these factors is critical for establishing effective ways to reduce future damage and safeguard human wellbeing.

2. LITERATURE REVIEW

2.1 Ozone Layer

The ozone layer is a portion of the terrestrial stratosphere, which is mostly composed of ozone. This layer includes 90% of the ozone in the atmosphere and absorbs 97–99% of the high-frequency UV light (Petrescu et al., 2018). The ozone layer is also naturally torn down, although there is a balance between its creation and depletion. Consequently, the overall ozone level remained unchanged. The quantity of ozone in the atmosphere has changed dramatically over time, with a decrease in the stratospheric ozone layer, notably over Antarctica, and sluggish recovery since the 1990s. In contrast, tropospheric ozone concentrations have increased dramatically as a result of increasing emissions of volatile organic compounds and nitrogen oxides, currently reaching 35–40 parts per billion (ppb). The thickness of the ozone layer changes depending on altitude and season. According to Morrisette, ozone concentrations are maximum between 19 km and 23 km (Morrisette, 1989). The majority of ozone is created around the equator, where there is the most sunlight, but with winds, it moves to high altitudes and accumulates in the stratosphere (Sivasakthivel & Reddy, 2011).

2.2 Ozone Hole

In recent decades, ozone depletion has emerged as a global problem. The ozone layer, located in the Earth's stratosphere, protects life on our planet by absorbing damaging ultraviolet (UV) radiation from the sun. The phrase "ozone hole" refers to a depletion level of less than 200 Dobson Units (D.U). The ozone hole is an area of abnormally low ozone in the stratosphere above Antarctica, which was formed by chemical reactions involving chlorine and bromine in 1970. A few years ago, ozone holes were identified in the Arctic. This depletion occurs yearly during the Southern Hemisphere spring, resulting in a dramatic drop in ozone levels below 220 Dobson Units (DU), the standard threshold for designating the ozone hole. According to (Rozema et al., 2005), the rate of ozone depletion has increased by 0.5% annually since 2000. Owing to ozone depletion, UV rays reach the troposphere, resulting in greater ozone generation, which is harmful to human health because ozone is poisonous to our bodies (Fears et al., 2002). Increased ultraviolet (UV) radiation reaching the Earth's surface as a result of ozone depletion can cause a variety of negative consequences, including an increased risk of skin cancer, cataracts, and harm to marine ecosystems (Diffy, 2003; Neale et al., 2023).

3. METHOD

3.1. Scope of the Study

This review focuses on the scientific understanding of ozone layer depletion, its anthropogenic and natural causes, associated impacts on human health and the environment, and the global and regional strategies adopted to control its progression. The study addresses chemical mechanisms leading to ozone depletion, such as the role of chlorofluorocarbons (CFCs) and halons, as well as evaluates the effectiveness of international policy responses like the Montreal Protocol. It also explores the broader environmental consequences, including increased ultraviolet (UV) radiation exposure, climate interactions, and ecological disruptions.

3.2. Data Collection and Analysis

The study is based on secondary sources, including peer-reviewed scientific articles, environmental policy reports, books, and credible publications from international agencies such as the United Nations Environment Programme (UNEP), World Health Organization (WHO), and the Intergovernmental Panel on Climate Change (IPCC). A structured literature review approach was adopted to extract and organize information around three main thematic areas:

Scientific Causes of Ozone Depletion: Chemical kinetics of ozone-depleting substances (ODS), atmospheric transport, and stratospheric reactions.

Impacts on Health and Environment: Effects of UV-B radiation on skin cancer, eye damage, immune system suppression, terrestrial and aquatic ecosystems, and material degradation.

Control Strategies and Global Governance: Evaluation of international agreements, technological shifts, compliance mechanisms, and current challenges in policy implementation.

The data were categorized and synthesized to reveal both historical trends and current developments in understanding and mitigating ozone depletion.

3.3. Research Methods

This review utilizes a multidisciplinary and integrative methodology, combining environmental chemistry, public health analysis, climate science, and policy evaluation. Document analysis and thematic synthesis were employed to interpret and compare findings from diverse sources. Cross-referencing and data triangulation helped ensure the validity and reliability of the conclusions drawn.

While the study offers a comprehensive overview based on existing literature, it is limited by the absence of primary data and real-time atmospheric measurements. Future research should incorporate primary data sources such as satellite observations, ground-based monitoring, and interviews with environmental scientists and policy experts to enhance the understanding of emerging ozone-related challenges.

4. CAUSES OF OZONE LAYER DEPLETION

The primary cause of ozone layer depletion is the emission of man-made molecules, known as ozone-depleting substances (ODS). Ozone-depleting substances (ODS) include chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), halons, carbon tetrachloride, and methyl chloroform, which are widely used in industrial processes such as refrigeration, air conditioning, foam blowing agents, and fire suppression systems (Western et al., 2023; Vollmer et al., 2021). While human actions, notably the emission of ozone-depleting compounds such as chlorofluorocarbons (CFCs), have been the major cause of ozone layer depletion, natural events such as volcanoes and solar fluctuations can also impact ozone levels (Jana & Nandi, 2005).

4.1. Chlorofluorocarbons

Chlorofluorocarbons (CFCs) are chemical compounds composed of carbon, chlorine, and fluorine (Dameris, 2010). CFCs are very volatile and noncombustible; therefore, they evaporate quickly and readily reach the stratosphere, where they begin to deplete ozone molecules.

4.2. Hydrochlorofluorocarbons

Hydrochlorofluorocarbons (HCFCs) are a group of chemical compounds often employed as refrigerants, solvents, and foam blowing agents. While they were first introduced as substitutes for chlorofluorocarbons (CFCs), which were discovered to be major contributors to ozone depletion, it is now clear that HCFCs also have a negative influence on the ozone layer (Vollmer et al., 2021). The Montreal Protocol's efforts to phase out HCFCs attempt to reduce their influence on the ozone layer and move toward ozone-friendly alternatives to safeguard the Earth's stratospheric ozone layer in the long run. It is feasible to alleviate the negative impacts of HCFCs on the ozone layer and climate by limiting their production and usage, as well as by implementing alternative technologies.

4.3. Halons

Halons are a family of compounds that are frequently employed as fire extinguishers owing to their ability to control flames. However, halons have been shown to have a major influence on ozone depletion (Al-Awad et al., 2018). The principal way halons contribute to ozone depletion is by releasing Cl atoms into the stratosphere. Once released, these chlorine atoms can catalytically destroy ozone molecules, thereby lowering the total quantity of ozone in the stratosphere (Faeth et al., 2003). The fact that 20% of the total chlorine loading in the stratosphere contributes considerably to ozone depletion is most likely due to the influence of chlorine-containing chemicals such as chlorofluorocarbons (CFCs) on the ozone layer (Von Clarmann, 2013). Another study suggested that bromine-containing halons have significantly higher ozone-depleting potential than chlorofluorocarbons. Bromine-containing halons, such as halon-1211 and halon-1301, have significant Ozone Depletion Potentials (ODPs) owing to the presence of reactive bromine atoms in their chemical structures. These bromine atoms can catalytically destroy ozone molecules in the stratosphere, thereby contributing to ozone depletion (Ravishankara et al., 2009).

4.4. Carbon Tetrachloride

Carbon tetrachloride (CCl₄), a halogenated molecule, has been identified as an ozone-depleting chemical (Lunt et al., 2018). Despite its relatively low atmospheric concentration in comparison to other ozone-depleting

substances such as chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), it contributes to ozone layer depletion by releasing chlorine atoms in the stratosphere (Lunt et al., 2018; Oram et al., 2017). These chlorine atoms can catalyze the breakdown of ozone molecules, helping deplete the ozone layer and generate ozone holes. However, its use has decreased dramatically owing to its negative impact on the environment and human health. One of the most serious issues regarding carbon tetrachloride is its role in ozone depletion (Oram et al., 2017).

4.5. Methyl Chloroform

Methyl chloroform, commonly known as 1,1,1-trichloroethane (TCA), is a chemical molecule with a wide range of industrial applications, including solvents, cleaning agents, and aerosol propellants. However, its usage has decreased dramatically owing to its negative environmental consequences, such as its contribution to ozone layer depletion (Oram et al., 2017). The primary mechanism by which methyl chloroform contributes to ozone depletion is the release of chlorine atoms into the atmosphere during decomposition (Khalil et al., 1984). Once released into the atmosphere, methyl chloroform can be degraded by sunlight (photolysis) or combined with other compounds to produce Cl atoms. These chlorine atoms subsequently engage in catalytic cycles that deplete ozone molecules in the stratosphere (Oram et al., 2017).

4.6. Unregulated Launches of Rockets

Unregulated rocket launches can have consequences for ozone depletion owing to the emission of exhaust gases into the upper atmosphere (Ryan et al., 2022). Rockets often employ liquid or solid propellants, which include chemicals such as chlorine and bromine. When these propellants burn during a rocket launch, they emit halogen compounds into the stratosphere (Rosemary, 2017). Chlorine is one of the most significant ozone-depleting chemicals emitted during rocket launches. Chlorine is predominantly released as hydrochloric acid (HCl) and chlorine oxide (ClO). Once released into the atmosphere, these chlorine compounds can react with ozone molecules, breaking them apart and lowering total ozone levels. Similarly, bromine compounds emitted during rocket launches contribute to ozone depletion. Bromine is primarily released as bromine oxide (BrO) and bromine monoxide (BrO₂). These chemicals can also react with ozone molecules, resulting in their destruction (Ryan et al., 2022; Rosemary, 2017). The total quantity of chlorine emitted into the stratosphere by solid rocket engines annually is 725,000 kg (0.725 kilotons), which is comparable to that associated with industrial halocarbons (Prather et al., 1990).

4.7. Global Warming

Thus, global warming is not a direct cause of ozone depletion. However, there is an indirect relationship between these two occurrences. The cooling effect of ozone depletion in the stratosphere driven by higher amounts of chlorine and bromine from human-produced pollutants can exacerbate the cooling effect of global warming in the stratosphere. This is because the same greenhouse gases that produce global warming also chill the stratosphere, accelerating ozone depletion (Morgenstern et al., 2018).

4.8. Nitrogenous Compound

Nitrogenous chemicals, notably nitrous oxide (N₂O), significantly influence the ozone layer. Nitrous oxide is a powerful ozone-depleting substance (ODS) that contributes to ozone breakdown in the stratosphere (Ravishankara et al., 2009). It is created naturally by a variety of biological processes, including soil microorganisms decomposing organic materials as well as through human activities such as agriculture, sewage treatment, and industrial operations (Ussiri & Lal, 2012).

5. Adverse Effects of Ozone Layer Depletion

Depletion of the ozone layer can have a variety of negative implications on human health, ecosystems, and the environment because it allows UV radiation to penetrate Earth. These radiations can cause serious illnesses in people, such as skin cancer, eye damage, and genetic alterations, as well as harm aquatic life, biogeochemical cycles, and air quality (Solomon, 2008; Anwar et al., 2015).

5.1. Effects on Eyes

Ozone layer depletion can have an impact on the eye, largely through increased exposure to ultraviolet (UV) light from the sun. Cataracts are the most common cause of blindness, worldwide. A 1% drop in ozone level increases

the incidence of cataracts by 0.3% to 0.6%. UV radiation can induce photokeratitis, cataracts, pterygium, and blindness (Dobson, 2005).

5.2. Effects on Skin

Ozone layer depletion can have a negative impact on the skin, mostly because of the increased exposure to ultraviolet (UV) radiation from the sun. UV radiation is a proven carcinogen, and increasing exposure to ozone depletion increases the risk of developing skin cancers such as melanoma, basal cell carcinoma, and squamous cell carcinoma (Tian & Yu, 2009; Anderson & Sarma, 2012). The skin is the portion of the body most exposed to UV light. UV radiation is also known to cause breast cancer and leukemia (Wargent & Jordan, 2013). Ozone depletion exacerbates the negative effects of UV radiation on the skin, increasing the risk of skin cancer, premature aging, sunburn, photosensitivity responses, and immunological suppression (Diffey, 2003; Van der leun, 2002).

5.3. Effects on Human Immunity

Excessive UV radiation can have a major detrimental effect on immunity (Hart et al., 2011), increasing the risk of infections, skin cancer, poor wound healing, worsening of autoimmune illnesses, and decreased vaccination efficiency (Hart et al., 2011; Gupta et al., 2013). UV radiation causes alterations in skin photoreceptors and antigen-presenting cells, resulting in immunosuppression (Programme, 2016).

5.4. Respiratory and Lung Diseases

Depletion of the ozone layer can have serious consequences for lung disorders, particularly due to increased exposure to ultraviolet B (UV-B) radiation from the sun. UV-B radiation is hazardous to human health and can worsen respiratory disorders in various ways, including increased allergen exposure and direct lung damage (Usyal & Schapira, 2003). UV-B radiation can directly damage the lung tissue, causing inflammation and oxidative stress. This can exacerbate existing lung disorders and increase the chances of acquiring respiratory illnesses, including lung cancer (Norval et al., 2007).

5.5. DNA Damage

UV light directly damages DNA by producing photoproducts via photon absorption by DNA bases, particularly pyrimidine bases such as thymine and cytosine. The direct absorption of UVB photons causes the creation of pyrimidine dimers and other photoproducts, which can result in mutations and genetic harm. UV radiation also has an indirect effect on DNA because photons are absorbed by non-DNA chromophores such as endogenous photosensitizers. This indirect absorption produces reactive oxygen species, such as singlet oxygen, which may damage DNA via photooxidation (Norval et al., 2007; Ravanat et al., 2001).

5.6. Effect of Food Shortage on Human Population

While ozone depletion does not directly create food shortages, its impacts on agricultural production, weather patterns, marine ecosystems, and animal health can contribute to food insecurity in various parts of the world (Bornman et al., 2015; Williamson et al., 2019).

5.7. Effect of Ozone Layer Depletion On Biogeochemical Cycles

The loss of the ozone layer can influence biogeochemical cycles (carbon, nitrogen, oxygen, water, and sulfur cycles), which are critical processes that govern the movement of elements and compounds between living organisms and the environment (Zepp et al., 2007; Erickson III et al., 2015). Although ozone depletion predominantly affects the stratospheric ozone layer, its indirect effects on biogeochemical cycles can have far-reaching implications for ecosystems, climate, and human health. Understanding these intricate connections is critical for reducing the impact of ozone depletion and improving environmental sustainability.

5.8. International Agreements

International agreements are critical in combating ozone layer depletion by coordinating worldwide efforts to minimize and eventually remove ozone-depleting chemicals (ODS). The Montreal Protocol on Substances that Deplete the Ozone Layer, enacted in 1987 and subsequently modified and strengthened multiple times, is the most important international accord concerning the ozone layer. The Montreal Protocol is based on the Vienna Convention for the Protection of the Ozone Layer, approved in 1985. This treaty provided the groundwork for international

collaboration to conserve the ozone layer and served as a predecessor to the Montreal Protocol (Umbtbayeva et al., 2023).

The Kigali Amendment to the Montreal Protocol, enacted in 2016, aimed to reduce the production and use of hydrofluorocarbons (HFCs), which are strong greenhouse gases and ozone-depleting compounds. This adjustment is intended to lessen the consequences of climate change while simultaneously safeguarding the ozone layer (Birmipili, 2018; Wijermars, 2022). While these international agreements have helped reduce the production and consumption of ozone-depleting substances, resulting in a significant recovery of the ozone layer, the Montreal Protocol is regarded as a landmark multilateral environmental agreement that has effectively addressed the issue of ozone layer depletion.

5.9. Ozone Recovery

Ozone recovery refers to the progressive healing and restoration of the Earth's ozone layer as a result of international accords, such as the Montreal Protocol, which aims to reduce and eventually eliminate ozone-depleting chemicals (ODS). In recent years, there have been promising signs of recovery in the Earth's ozone layer, marking a watershed moment in global environmental research. The recovery of ozone layer depletion from 2000 to 2023 was a slow process. The Antarctic ozone hole peaked in the 2000s, covering 29.9 million square kilometers (11.5 million square miles) (Jhanwar, 2022). In 2005, the use of ozone-depleting chemicals regulated by the Montreal Protocol decreased by 90-95% in nations that had signed the accord. In 2014, scientists detected a slight rise in stratospheric ozone, which they ascribed to global compliance with international conventions governing the phase-out of ozone-depleting chemicals (ODS).

In 2016, additional research indicated that stratospheric ozone concentrations grew in the high stratosphere, indicating a steady recovery of the ozone layer (Ball et al, 2019). According to a United Nations report from 2018, the Antarctic ozone hole will gradually shrink, while stratospheric ozone levels will continue to climb (Stone et al., 2021). In 2019, scientists discovered the smallest ozone hole since 1982, with an area of 16.3 million square kilometers (6.3 million square miles), and by 2021, the size of the Antarctic ozone hole has dropped to 24.8 million square kilometers (9.6 million square miles), down from its highest extent in 2000 (Jhanwar, 2022). The ozone layer is expected to be restored within four decades by 2023, thanks to the worldwide phase-out of ozone-depleting chemicals, which are already helping to combat climate change.

According to a 2018 United Nations report, the Antarctic ozone hole is expected to gradually close, with stratospheric ozone concentrations returning to 1980 levels by the 2060s. Above the Arctic, ozone levels are predicted to rebound to 1980 levels by the mid-2030s. The projected rise in ozone would be slow owing to the long residence periods of CFCs and other halocarbons in the atmosphere (Beuermann et al., 2020).

6. RESULTS AND DISCUSSION

The findings of this review align with previous studies (Yang, 2020; Sivasakthivel & Reddy, 2011) in identifying chlorofluorocarbons (CFCs), halons, and other ozone-depleting substances (ODS) as the primary drivers of stratospheric ozone depletion. However, recent studies (Western et al., 2023; Vollmer et al., 2021) highlight unexpected increases in emissions of certain hydrochlorofluorocarbons (HCFCs) despite global regulations, suggesting gaps in enforcement. This contrasts with earlier optimism (Petrescu et al., 2018) regarding ozone layer recovery due to the Montreal Protocol's success. While earlier works (Matsumi & Kawasaki, 2003; Von Clarmann, 2013) emphasized chlorine and bromine reactions as the dominant ozone destruction pathways, recent research (Ravishankara et al., 2009; Lunt et al., 2018) underscores the growing role of nitrous oxide (N₂O) and carbon tetrachloride (CCl₄) as emerging threats. Additionally, Ryan et al. (2022) introduce a novel concern: rocket launches and space debris emissions contributing to ozone depletion, a factor not extensively covered in earlier literature.

Consistent with Solomon (2008) and Anwar et al. (2015), this review confirms that increased UV-B radiation due to ozone depletion elevates risks of skin cancer (Fears et al., 2002; Diffey, 2003), cataracts (Dobson, 2005), and immune suppression (Hart et al., 2011). However, newer studies (Norval et al., 2007; Uysal & Schapira, 2003) provide deeper insights into interactions between ozone depletion and climate change, exacerbating respiratory diseases due to ground-level ozone formation. Ecologically, earlier works (Rozema et al., 2005; Bornman et al., 2015) focused on UV-B damage to terrestrial plants, while recent research (Neale et al., 2023; Williamson et al., 2019) highlights complex interactions in aquatic ecosystems, where UV radiation affects phytoplankton productivity

and marine food webs. This shift reflects a broader understanding of cascading environmental impacts beyond initial observations.

The Montreal Protocol remains the cornerstone of ozone protection, as affirmed by Andersen & Sarma (2012) and Birmipili (2018). However, while Albritton (1998) and Morrisette (1989) documented early policy successes, recent studies (Western et al., 2023; Oram et al., 2017) reveal ongoing challenges, including illegal ODS production and delays in phasing out substitutes like HCFCs. The Kigali Amendment (Wijermars, 2022) marks progress in addressing hydrofluorocarbons (HFCs), yet enforcement gaps persist, particularly in developing nations (Al-Awad et al., 2018). Ball et al. (2019) and Stone et al. (2021) note recent Antarctic ozone hole variability, suggesting that while long-term recovery is underway, climate change-induced atmospheric shifts may delay full restoration. Early models (Prather et al., 1990; Dameris, 2010) predicted steady ozone recovery by mid-21st century, but Fang et al. (2019) caution that rising N₂O emissions and climate feedback loops could prolong depletion. Unlike the optimistic outlook of Petrescu et al. (2018), Morgenstern et al. (2018) argue that increasing greenhouse gases may alter stratospheric circulation, complicating recovery trajectories.

7. CONCLUSION

The comprehensive review of ozone layer depletion highlights both the progress made and the challenges that remain in addressing this critical environmental issue. Early research established the fundamental role of human-made chemicals in ozone destruction, leading to landmark international agreements like the Montreal Protocol. While these efforts have successfully reduced many ozone-depleting substances, recent findings reveal ongoing concerns, including unexpected emissions of regulated compounds and emerging threats from other pollutants. The impacts of ozone depletion on human health and ecosystems remain severe, with increased risks of skin cancer, immune disorders, and damage to both terrestrial and aquatic life. Furthermore, the interaction between ozone recovery and climate change presents new complexities that require integrated solutions.

Moving forward, it is essential to strengthen global cooperation to enforce existing regulations, address newly identified ozone-depleting substances, and develop strategies that account for the interconnected nature of atmospheric changes. Continued scientific research, policy innovation, and public awareness will be crucial in ensuring the full recovery of the ozone layer and protecting both human health and the environment for future generations.

8. RECOMMENDATIONS

The following four recommendations were made to avoid ozone depletion and reduce its negative impacts on human health and the environment.

1. Policies should be implemented to minimize the production and use of ozone-depleting compounds, including bans and phase-outs, to speed the transition to ozone-friendly alternatives.
2. Encourage the use of sustainable practices and technologies, including energy efficiency, renewable energy, and eco-friendly alternatives to reduce ozone-depleting chemicals and greenhouse gases.
3. Raising public awareness and education about conserving the ozone layer through outreach efforts and educational activities. Empower individuals and communities to make educated decisions and embrace environmentally friendly practices.
4. Encourage international cooperation and coordination to combat ozone depletion. Strengthen agreements such as the Montreal Protocol and support capacity-building programs in underdeveloped countries to adopt effective ozone protection measures.

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