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Relationship Between Emissions of Human Activities and Ozone Layer Depletion

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Abstract

Ozone depletion always holds an importance being a protective shield to humans and environment as well. Human activities and man-made substances are playing major role to this depletion which is increasing day by day. In this paper influence of man-made substances on ozone depletion and consequences of this depletion have been discussed. Role of chlorofluorocarbons as depleting agents is more comparatively other substances. Due to ozone depletion life on earth is affecting which are resulting different consequences like skin cancer, eye diseases and destruction of crops and aquatic life. EPA has worked a lot to save the ozone and many countries have signed the treaty to reduce the usage of ozone depleting substances. These agreements have impacted positively and according to a report by Intergovernmental Panel on Climate Change; ozone is recovering due to the less production of Ozone depleting substances.

Introduction

Ozone depletion has always been center of interest for the scientists. Ozone layer serves as shield to human, animals, crops, and aquatic life. It protects life on earth from absorbing excessive ultraviolet rays. Thinning of this layer can lead to excessive absorption of ultraviolet radiations UV radiations that could destroy organic matter. Plants and planktons may not survive to play a significant role in providing food to humans and sea animals. In humans it can cause skin cancer and eye diseases including cataract (CEF, 2010).

Human activities like industrial processes and man-made compounds are depleting ozone layer excessively. These substances are CFCs (chlorofluorocarbons), halons, CH_3CCl_3 (Methyl chloroform), CCl_4 (Carbon tetrachloride), HCFCs (hydro-chlorofluorocarbons), hydro bromo fluorocarbons and methyl bromide (NOAA, 2008). These gases remain there for longtime and are not washed back by the rain and transferred to the stratosphere where release chlorine and bromine are released in the presence of UV radiations. Eventually chlorine and bromine react with ozone molecules and break them which results in depletion. Scientist have evaluated that these substances would play active role in destroying the ozone layer for many decades in the future (David, 2010)

In 1977 it was the first time when ozone layer depletion and its consequences have been acknowledged. Thirty-two countries have participated in Washington D.C. with UNEP (United Nations Environmental Program) (ICF, 2010). It was noticed that the human activities were playing a major role in this depletion. So in 1987, Montreal Protocol was introduced in which it was agreed that Chlorofluorocarbons (substances which deplete the ozone layer) should completely phase out as per given schedule (ICF, 2010). EPA has assessed how human benefits can get maximally by reducing these substances by following the Montreal Protocol in United States.

Objectives

The aim of this paper is to review the influence of human activities on ozone depletion and bio effects of this depletion. Therefore it is assumed that Man-made substances are directly impacting the depletion of ozone layer and it is increasing day by day. Secondly it is also assumed that these substances are not washed back by the rain on earth and stay there for quite long.

Effects on human health

Ozone and temperature variation are directly related but it is not the main factor of climate change. Ozone has two effects on temperature balance of the earth by absorbing solar UV radiations and by absorbing the infrared radiations emitted by earth surface. UV rays are different kinds due to their different strength (wavelength) which ranges from 400nm to 100nm. Major types are UVA, UVB, and UVC. These rays are classified according to their wavelengths UVA wave length is 315–400 nm, UVB wavelength 280–315 nm, and UVC wavelength is 100-280 nm. UVA and UVB are more potent; damage skin and can lead to skin cancer. Moreover UVC do not get through our atmosphere and sunlight so there is no evidence against them of causing any health illness (American Cancer Society, 2015).

Temperature is increasing at the earth's surface and decreasing in the higher surfaces due to the trapping of heat trapping gases like CO2 in the stratosphere. CO2 and other heat trapping gasses protect the warm surface of earth from cold air above and act like a blanket around the globe. The major ozone is loses due to the human produce substances; chlorine and bromine (Baker, 2010).

Stratospheric ozone is depleting and UV radiation is increasing which is playing an active role to cause serious health problems. These radiations have acute and chronic health effects e.g. skin redness, tanning, and peeling while on the other hand it causes photo keratitis, photo conjunctivitis and Chemosis in eyes which is simply known as swelling. These radiations cause the non-melanoma cancers in light skinned population. It has been evidenced that these radiations are also playing major role in causing melanoma skin cancers. And the rate of these cancers has been increasing dramatically over the last twenty years. Exposed areas especially head, neck, arms, and hands are more prone to have it. Non-melanoma skin cancers including basal cell and squamous cell carcinomas are most common in the United States (Norval, 2007).

Experiments on animals have shown that the UV radiations decrease the immunity towards skin cancer, infectious agents, and other antigens (Sivasakthivel & Reddy, 2011) On the other hand UVB have positive effect on vitamin D it means it increases the production of vitamin D. According to a survey in 2009 by National Health and Nutrition Examination most of the people in US are deficient of vitamin D (<17.8ng/dl).

Acute health effects

Acute health effects of skin are erythema (sunburn), skin tanning due to increase melanin production, and peeling while on the other hand it causes the thickness of skin which is also skin

damage. Skin damage also depends on skin type; people with light skin are more prone to get skin damage rather than those who are black. In eyes it causes photo keratitis, photo conjunctivitis and Chemosis which are simply known as swelling. These can be healed in a short period of time (48 h) and usually they do not require treatment (Sivasakthivel & Reddy, 2011).

One study was performed on rats to evaluate the acute effects of UV radiations. Rats were exposed two kinds of radioactive waves (2mV/cm2) which produced the absorption of radiation about 1.2 W/kg for whole body. After four hours exposure single and double stranded DNA of brain cells of rats has been observed by using micro gel electrophoresis. Impairment of DNA cells was seen but there was no difference between effects of two the forms of radiations (Lai, 2009).

Chronic health effects

Chronic health effects of ozone layer depletion are skin freckling, age spots, vitiligo, and skin cancers (non-melanoma & melanoma).

i) Effects on eyes

For eyes long term exposure towards UV rays lead to cataract (clouding of the eye's lens) of the posterior and subscapular forms. It depends on the wavelength of the UV radiation. For example, UV-B radiation at 280-320 nm is a risk factor of cortical cataract. UVA damage skin and can lead to skin cancer. Moreover UVC do not get through our atmosphere and sunlight so there is no evidence against them of causing any health illness (UNEP, 1998). Other eye effects are squamous cell cancer of cornea and conjunctiva. Experiments have shown that the UV radiations decrease the immunity towards skin cancer, infectious agents, and other antigens (Sivasakthivel & Reddy, 2011).

ii) Effects on Lungs

Ozone is considered major oxidant of photochemical smog and it causes oxidation of molecules freely or by radical reactions. It causes the oxidative stress, airway damage, airway hyper responsiveness, and neutrophil towards the lungs. In case of lungs it produces biphasic reaction; initially it alters the membrane permeability and causes cell injury; Secondly in repair phase it increases metabolic activities and results in proliferation. It was determined that hyper responsiveness and neutrophil was healed by treating with hydroxyurea. But those subjects who did not get treatment and were exposed to ozone depleting substances (chlorine showed relative higher levels of neutrophil and acute hyper responsiveness of lungs (O'Byrne, 1984). Ozone is highly oxidative and it is a risk factor for young children, elderly and for those with pre-existing illnesses like asthma or other respiratory diseases.

iii) Neurotoxic Effects

Bromopropane is considered as neurotoxic agent. In 1995, unexpected amenorrhea, oligozoospermia and anemia were discovered in Korean workers exposed to solvents containing 2-bromopropane. Bromopropane, which is chlorofluorocarbons; considered toxic for spermatogenesis and hematopoietic cells formation. This epidemiological study has been performed on male rats and significant reductions in the number of erythrocytes, platelets, and

leukocytes, testicular germ cell loss, and seminiferous atrophy were observed in group who were exposed to 2-bromopropane (Yu, 2001).

iv) Effects on Skin

Skin cancer rates are increasing which are thought to be in large part associated with increased UV radiations due to Ozone layer depletion. This study was performed to determine the rate of skin cancer and actinic keratosis cases which were treated by the dermatologist in South Florida. The incidence is high in that particular area due to ozone depletion and UV radiations. These high rates were due to the behavior and attitude of population of that particular area towards sun exposure. Non-melanoma skin cancers including basal cell and squamous cell carcinomas are most common in United State. And rate of them have been increased dramatically from last twenty years. Exposed areas like head, neck, arms, and hands are more prone to get this disease. After the United States, Australia has the high incidence rates (56 new cases per year per 100,000 for men and 43 for women) of non-melanoma skin Cancer (Leiter & Garbe, 2008). High mortality rate due to skin cancer would have great importance for future medical needs in commercial and Medicare age population as well. On the other hand a lot of work is being done by the health bodies for prevention so that it could be diagnosed and treated early and mortality rate could be decreased (Mark & Matthew, 2012).

Non-melanoma skin cancers and actinic keratosis are accelerated due to extensive exposure towards UVR. So people who are been exposed towards Ultra violet radiations should get early treatment and early diagnosis so that high mortality and morbidity rates could be avoided. Basal and squamous cell carcinomas are less lethal and they can be cure by treatment sometimes extensive surgery is required. Though malignant melanoma skin cancers are less common but those are more dangerous; being lethal. And it is very difficult to estimate about the impact of ozone depletion on it because of its uncertainty. UVA and UVB both are considered the cause of malignant melanoma cancers (Mark & Matthew, 2012).

Epidemiological Effects

Ozone Hole

The ozone layer is a protective shield for entire earth and it resides in the stratosphere. It absorbs the Ultraviolet (UV)-B radiations (280- to 315- nanometer (nm) partially from the Sun. Due to the destruction of this layer these radiations cannot be absorbed and they will reach to the human and causes the illnesses such as cataract, skin cancer, and immune system problems. It also affects the other lives (aquatic life & plants) on earth. Other UV (Ultraviolet) radiations are not absorbed by this layer (ENVIROPOL, 2014)

This layer resides 10 to 40 kilometer high above the earth and only 10 or less of every million molecules of air are ozone. From past 60 years human activities are playing active role to destroy this layer. This layer has been destroying rapidly due to chemical reactions produced by the human activities over the Antarctica in every spring. It was confirmed that ozone levels vary by season and latitude (NASA, 2014).

According to NASA (2014) *"Over the course of two to three months, approximately 50% of the total column amount of ozone in the atmosphere disappears. At some levels, the losses approach 90%. This has come to be called the Antarctic ozone hole"*

In the winter a vortex of winds enter in the pole and it separates the polar stratosphere. A thin cloud is formed by the mixture of nitric oxide and the sulphuricacid when temperature falls down (below -78°C/-109°F). These clouds are in the form of ice crystals. Chemical reactions Takes place at the surfaces of crystals and releases the active forms of CFCs (chlorine & fluorine). This activation results in Ozone depletion and "Ozone Hole" appears. Opposite Reaction happens in spring season. Temperature begins to rise and ice starts to melt. It evaporates and ozone starts to recover. The ozone hole is defined geographically as the area wherein the Total ozone amount is less than 220 Dobson Units. Dobson unit is the most common unit for measuring the ozone concentration. It measures the number of molecules which would be requiring forming the pure ozone layer. According to scientist the total amount of ozone layer in the atmosphere is 300 Dobson units which is 3mm and 0.12 inches thick (NASA, 2008). The ozone hole has steadily grown in size (up to 27 million sq. km.) and length of existence over the past two decades (Charles, 2006).

Volcanoes Eruptions and Ozone Depletion

Volcanism has always been center of discussion in terms of climate changes. It was under discussion even 2000 years ago when Mount Etna's (Italy) eruptions have dimmed the sun and resulted in cooling effect. This cooling effect led to shrivel of crops which resulted in food shortage in Italy and Egypt. Impact of volcano eruptions on climate is difficult to understand. Volcanism initiates the basic mechanisms which play significant role in the globe change process (USGS, 2005).

On many timescales volcanoes eruptions has always been an important natural cause of climate change. Early detection of climatic response towards tropical eruption would be beneficial for society. E.g. areas at risk can be evacuated from the residents over there before the incident. It is difficult to estimate the effect of anthropogenic influences on climate including greenhouse effect, gases, aerosols, and ozone depleting substances so it is better to separate anthropogenic fluctuations in the climate record from others. Furthermore study of volcanoes eruptions help to understand the radioactive and dynamical changes in climate due to natural and anthropogenic forces. It also helps to improve the climate models which have been designed for the improvement of environment by studying the radioactive and dynamic changes (Robock, 2000).

It has been studied that volcanoes eruptions emit sulfur gases in stratosphere in the form of ash. These sulfur gases are converted into the sulfur aerosols and they stayed there for about 1 year (e-folding residence time). The term *e*-folding time is used similarly in the case of exponential decay, to refer to the timescale for a quantity to decrease to 1/*e* of its previous value. It has also seen that large ash particles fall out much quicker than smaller one and they produce responses in climate. These aerosols cool the stratosphere by strewing the solar radiations back into the space but at the same time; these aerosols are absorbing the solar and terrestrial radiations which results in heating the stratosphere (Kirchner, Stenchikov, Graf, & Robock, 1999)

In winters, this heat produced by the aerosols; increases pole to equator gradient temperature in tropical areas. It is more in tropical areas than in high latitudes. This enhanced temperature gradient make stronger polar vortex which results in the production of stationary wave pattern of tropospheric circulation. This stationary pattern causes heat production in winter and makes it warm in Northern Hemisphere Continents. Conversely this effect is more in higher latitude areas in summer. These aerosols also facilitate the heterogeneous chemical reactions which decreases the UV radiations absorption and irradiative heat in stratosphere. And net result is still heating (Robock, 2000).

A research has been performed to evaluate the climate pattern for two years. They have collected the data from NASA Jet Propulsion Laboratory DAAC (Drug Abuse Alternative Center) to evaluate the sensitivity of climate temperature. They ran the general circulation model, calculated the temperature by climatologically mean sea surface temperature and compared it with the El Nino and La Nina periods (complex hot and cold weather patterns. This comparison showed the cooling effect in the troposphere and conversely heating effects in Northern Hemisphere. In simple words this model showed that aerosols yields troposphere cooling, general stratosphere heating and troposphere warming pattern in winter.

In 1991, 20 million tons of sulfur has been injected into the atmosphere due to eruption of Mount Pinatubo in Philippine. This eruption has blasted ash particles 19 km high in the atmosphere. It has changed the circulation pattern around the globe by impacting the climate, lowering the amount of radiation to the surface of earth, and by decreasing the temperature in troposphere. Gases and solids remained in the air for three weeks but outpouring of gasses and ash affected the climate pattern for years (Stenchikov et al., 1998).

Manmade substances are adding more to destroy the ozone content. From last several decades choline, bromine, and fluorine has been used in pesticides, refrigerators, fire extinguishers, solvents, and aerosol propellants. Chlorine and bromine are the biggest culprits to destroy the ozone molecules. According to estimation 1 chlorine atom can destroy 100,000 ozone molecules as it remains in atmosphere. Bromine is ten times more potent than chlorine. Volcanoes are the largest source of bromine. Other natural sources of bromine are Dead Sea, ocean water, and certain brine wells. And aerosols produced by the ash provide surface to CFCs for chemical reactions in the mid latitude f stratosphere. Moreover, bromine oxide (BrO) has been measured in number of volcanic plumes around the globe and human activities are contributing for these substances (chlorine & bromine) around 80-82% while volcanic eruptions are responsible for 18%-20% (eSchoolToday, 2010).

A large number of events have occurred in the past two fifty years. These events drawn attention towards potential climatic change due to largest effect on English Speaking World (America, Australian, England). For example in 1816, Tambora Eruption produced a year without summer and in 1783 eruption in Iceland affected the summer across the Europe. These all were alarming conditions for the world and it was extent to rule out the reasons of these potential changes (Robock, 2000). Ozone content has been destroyed 5 to 8 percent more after the Pinatubo incident in highly populated areas. (Stenchikov et al., 1998). According to Groisman (1985) a Russian scientist, warm winter in Russia was also due to the volcanic eruptions. He has explained it as enhanced pole to equator gradient.

Legislation for ozone depletion

EPA has worked significantly to save the stratospheric ozone layer, the environment and the health of people over the past several years. Phase out of ozone depleting substances is essential to recover the stratosphere. For this purpose more than 190 countries have signed an agreement (Montreal Protocol) including the United States. According to that agreement these countries are trying to minimize the production of Ozone Depleting Substances (ODS) and they are phasing out in groups. Worldwide phasing out of ODS is required to recover the Ozone layer. According to a report by the Intergovernmental Panel on Climate Change; ozone is recovering due to the less production of ODS and it has not grown thinner since 1998 over most of the world (ICF, 2010).

Economically, every dollar pays twenty times of societal health which has been invested in ozone protection. According to an estimate it will save 4.2 trillion in societal health in United States. Initially it was very difficult for organizations, industries, government around the world and other businesses to eliminate these substances (CFCs, halons, CCl4, CHCl3). But companies have thought optimistically and invested a lot to phase out these substances. Moreover, this elimination has also influenced the greenhouse effect which is considered a major factor of global warming. Some industries took traditional path; retrofitting equipment, re-engineering products or processes, or finding in-kind replacements and some has found it an opportunity to invent new technologies and products. For example chlorofluorocarbons were used in air conditioners, refrigerators, degreasers, fire extinguishers, furniture, computers, and aerosol cans; later on these CFCs had been replaced by HCFCs (Hydrocarbons) (EPA, 2007).

CFCs gases remain in atmosphere for a longtime and are not washed back by the rain. These gases are transferred to the stratosphere where chlorine is released in the presence of UV radiations. Chlorine obstructs the ability of ozone layer to prevent the earth from dangerous UV radiations. Eventually chlorine reacts with ozone molecules and breaks them which results in ozone depletion. It has been evaluated that these substances would play active role in destroying the ozone layer for many decades in the future Moreover; chlorine presence over the Antarctica was also confirmed by NASA (1988) in a report.

Scientists have evaluated that nitrous oxide would play significant role in destroying the ozone layer for many decades. Natural sources, human activities like industrial processes and byproduct of agricultural fertilization are the major reason of emission of nitrous oxide. N2O is considered more potent substance for ozone depletion because it is responsible for the largest anthropogenic emissions and its global lifetime is approximately 114 days (Portman, Ravishankara & Daniel, 2012). During this study two things were observed 1) Fertilizer ammonia is hydrolyzed by the urease in the soil 2) It is nitrified by the soil microorganisms. This fertilizer derived nitrous oxide is very harmful to the stratospheric ozone layer. Such kind of nitrification can be control by the nitrapyrin (AAAS, 1997).

Later on further studies have been performed and it was evidenced that ozone depletion is not only harmful for the crops and animals but can also lead to serious illnesses in humans. These radiations cause the non-melanoma cancers in light skinned population. It has been evidenced that these radiations are also playing major role in causing melanoma skin cancers. Non-melanoma skin cancers including basal cell and squamous cell carcinomas are most common in

United State. And rate of it has been increased dramatically from last twenty years. Exposed areas especially head, neck, arms, and hands are more prone to have it (Norval, 2007)

Industrial leadership has been provided by DuPont™ for about two decades in the protection of stratospheric ozone. In the 1970s, company has decided to invest in this project so that it could be find out that CFCs are affecting the stratospheric ozone. By the time the Montreal Protocol was signed, DuPont™ had already led the chemical industry by abandoning CFCs and developing alternatives. The company helped to form the international Programmed for Alternative Fluorocarbon Toxicity Testing (PAFT), through which it invited producers to examine the environmental impacts of the potential new alternatives (Peter, 1992)

Programs to Protect Ozone Layer

United Nations Environment Program

This agency was formed in 1972 by the Maurice Strong as a result of United Nation Conference on Human Environment. This agency played significant role in promoting environmental science and assisting the developing countries in implanting the policies for the prevention of environment. It provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations (UNEP, 1998).

Environmental Protection (Ozone Protection) Policy2000

This policy was a huge step towards the ozone reduction in Western Australia. It was formed after seven year review of the original ozone protection policy in1993. In this policy it was stated that the ozone layer can be protected by replacing the chlorofluorocarbons with non-ozone depleting agents (hydrocarbons & refrigerant 134A). The main purpose of this policy is to reduce the emission of ODS and protecting the earth from UV radiations due to the reduction of ozone present in stratosphere It was also mentioned in this policy that the industries can get penalties (10,000$ corporate & 5000 $ individual) on using ODS. This policy was implemented by the co-operation of industries with the government (EPA, 2015)

Australian Chlorofluorocarbon Management Strategy

These programs have been formed for the check and balance of CFCs in Australia. This Strategy describes the legislation developed and actions that have been carried out to date by Australia. It also outlines Australia's continued commitment to the effective management of chlorofluorocarbon (CFC) stocks in Australia until a complete phase out of the use of CFCs can be achieved. This Australian Chlorofluorocarbon Management Strategy represents the commitment made by Government, industry and the community to the effective phase-out of CFCs in Australia. Though a lot of work has been done to phase out the CFCs but still there is challenge to eliminate the CFCs produced by the pharmaceutical industries and laboratories (Environment Australia, 2001).

Ozone Protection and Synthetic Greenhouse Gas Management Act 1989 (and associated regulations and amendments)

According to this act import, export, and the end use of ODS is controlled. The main aim of this act is to protect the environment from these emissions. It was developed after receiving public submissions, as well as consultation with an industry representative technical working group, individual stakeholders, and Commonwealth agencies (OPSGGM, 1989). According to this act accountability of the ODS has been maintained. Because every country who have signed the Montreal Protocol were supposed to follow the rules strictly for import and export of the ODS. The objectives of this Act are following (Environment Australia, 2015)

Ultraviolet index forecast

Ozone depletion, according to weather changes, cause distinctive measures of UV radiation to reach the Earth at any given time. Considering these variables, the UV Index predicts the level of sunlight based UV radiation and shows the danger of overexposure on a scale from 0 (low) to 11 or all the more (to a great degree high). A unique UV Alert may be issued for a specific territory, if the UV Index is estimated to be higher than ordinary. UV index is calculated by the National Weather Service across the US and EPA publishes this information which is calculation about expected risk towards the UV radiations overexposure (EPA, 2015).

Discussion and Conclusion

Human activities are impacting the ozone layer on large scale which has bad effects on human and animal health. Ozone layer depletion has severe health problems to humans. Plants and planktons may not thrive, which play significant role in providing food to humans and sea animals as well. Ozone is considered major oxidant of photochemical smog and it causes oxidation of molecules freely or by radical reactions. Temperature is increasing at the earth's surface and decreasing in the higher surfaces due to the trapping of heat and gases like CO2 in stratosphere. CO2 and other heat trapping gasses protect the warm surface of earth from cold air above and act like a blanket around the globe. The major ozone is loses due to the human produce substances; chlorine and bromine. Although emissions of CFCs around the developed world have largely ceased due to international control agreements (Montreal Protocol), the damage to the stratospheric ozone layer will continue well into the 21st century.

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