An overview of the ozone layer

INTRODUCTION

" THE OZONE LAYER"

The ozone layer is a portion of earth atmosphere that contains high levels of ozone. The atmosphere is divided into five layers: the troposphere, the stratosphere, the mesosphere, the thermosphere, and the exosphere. The troposphere is the layer closest to earth and is where all weather happenings occur. The stratosphere is located directly above the troposphere, about 10-50 kilometers above the planet, and houses the ozone layer at an altitude of 20-30 kilometers. The mesosphere is located approximately 50-80 kilometers above the earth, while the thermosphere rests at an altitude of approximately 100-200 kilometers above the earth surface. Finally, the boundary of the outermost layer, the exosphere, extends roughly to 960-1000 kilometers above the earth.

The ozone found in our atmosphere is formed by an interaction between oxygen molecules (composed of two oxygen atoms) and ultraviolet light. When ultraviolet light hits these oxygen molecules, the reaction causes the molecules to break apart into single atoms of oxygen (UV light + O_2 –> O + O). These single atoms of oxygen are very reactive, and a single atom combines with a molecule of oxygen to form ozone (O_3), which is composed of three atoms of oxygen ($2O + 2O_2 \rightarrow 2O_3$).

Need for OZONE LAYER

The ozone layer is essential for human life. It is able to absorb much harmful ultraviolet radiation, preventing penetration to the earth surface. Ultraviolet radiation (UV) is defined as radiation with wavelengths between 290-320 nanometers, which are harmful to life because this radiation can enter cells and destroy the deoxyribonucleic acid (DNA) of many life forms on planet earth. In a sense, the ozone layer can be thought of as a UV filter or our planets built in sunscreen. Without the ozone layer, UV radiation would not be filtered as it reached the surface of the earth. If this happened, cancer would break out and all of the living civilizations, and all species on earth would be in jeopardy. Thus, the ozone layer essentially allows life, as we know it, to exist.

A Dobson Unit is a measurement of how thick a specific portion of the ozone layer would be if it were compressed into a single layer at zero degrees Celsius with one unit of atmospheric pressure acting on it (standard temperature and pressure – STP). Thus, one Dobson Unit (DU) is defined as . 01 mm thickness at standard temperature and pressure. Since the ozone layer over this area would form a 3 mm thick slab, the measurement of the ozone over Labrador is 300 DU.

Ozone depletion: Who is responsible?

It is important to recognize the sources of ozone depletion before one can fully understand the problem. There are three main contributors to the ozone problem: human activity, natural sources, and volcanic eruptions. Human activity is by far the most prevalent and destructive source of ozone depletion, while threatening volcanic eruptions are less common. Human activity, such as the release of various compounds containing chlorine or bromine, accounts for approximately 75 to 85 percent of ozone damage. Perhaps the most evident and destructive molecule of this description is chloroflourocarbon (CFC). CFCs were first used to clean electronic circuit boards, and as time progressed, were used in aerosols and coolants, such as refrigerators and air conditioners. When CFCs from these products are released into the atmosphere, the destruction begins. As CFCs are emitted, the molecules float toward the ozone rich stratosphere. Then, when UV radiation contacts the CFC molecule, this causes one chlorine atom to liberate. This free chlorine then reacts with an ozone (O_3) molecule to form chlorine monoxide (ClO) and a single oxygen molecule (O_2). This reaction can be illustrated by the following chemical equation: $Cl + O_3 \rightarrow O_2 + ClO$. Then, a single oxygen atom reacts with a chlorine monoxide molecule, causing the formation of an oxygen molecule (O_2) and a single chlorine atom ($O + ClO \rightarrow Cl + O_2$). This threatening chlorine atom then continues the cycle and results in further destruction of the ozone layer .

Measures have been taken to reduce the amount of CFC emission, but since CFCs have a life span of 20-100 years, previously emitted CFCs will do damage for years to come.

Natural sources also contribute to the depletion of the ozone layer, but not nearly as much as human activity. Natural sources can be blamed for approximately 15 to 20 percent of ozone damage. A common natural source of ozone damage is naturally occurring chlorine. Naturally occurring chlorine, like the chlorine released from the reaction between a CFC molecule and UV radiation, also has detrimental effects and poses danger to the earth.

Finally, volcanic eruptions are a small contributor to ozone damage, accounting for one to five percent. During large volcanic eruptions, chlorine, as a component of hydrochloric acid (HCl), is released directly into the stratosphere, along with sulfur dioxide. In this case, sulfur dioxide is more harmful than chlorine because it is converted into sulfuric acid aerosols. These aerosols accelerate damaging chemical reactions, which cause chlorine to destroy ozone.

Rocket Launches May Need Regulation to Prevent Ozone Depletion

As the rocket launch market grows, so will ozone-destroying rocket emissions, if left unregulated, rocket launches by the year 2050 could result in more ozone destruction than was ever realized by CFCs.

Since some proposed space efforts would require frequent launches of large rockets over extended periods. In the policy world uncertainty often leads to unnecessary regulation, this could be avoided with a more robust understanding of how rockets affect the ozone layer.

Current global rocket launches deplete the ozone layer by no more than a few hundredths of 1 percent annually. But as the space industry grows and other ozone-depleting chemicals decline in the Earth’s stratosphere, the issue of ozone depletion from rocket launches is expected to move to the forefront.

Today, just a handful of NASA space shuttle launches release more ozone-depleting substances in the stratosphere than the entire annual use of CFC-based medical inhalers used to treat asthma and other diseases in the United States and which are now banned.

Highly reactive trace-gas molecules known as radicals dominate stratospheric ozone destruction, and a single radical in the stratosphere can destroy up to 10, 000 ozone molecules before being deactivated and removed from the stratosphere. Microscopic particles, including soot and aluminum oxide particles emitted by rocket engines, provide chemically active surface areas that increase the rate such radicals “ leak” from their reservoirs and contribute to ozone destruction.

Every type of rocket engine causes some ozone loss, and rocket combustion products are the only human sources of ozone-destroying compounds injected directly into the middle and upper stratosphere where the ozone layer resides.

Although U. S. science agencies spent millions of dollars to assess the ozone loss potential from a hypothetical fleet of 500 supersonic aircraft — a fleet that never materialized — much less research has been done to understand the potential range of effects the existing global fleet of rockets might have on the ozone layer.

Since 1987 CFCs have been banned from use in aerosol cans, freezer refrigerants and air conditioners. Many scientists expect the stratospheric ozone layer — which absorbs more than 90 percent of harmful ultraviolet radiation that can harm humans and ecosystems — to return to levels that existed prior to the use of ozone-depleting chemicals by the year 2040.

Rockets around the world use a

variety of propellants, including solids, liquids and hybrids. Ross said while little is currently known about how they compare to each other with respect to the ozone loss they cause, new studies are needed to provide the parameters required to guide possible regulation of both commercial and government rocket launches in the future.

To reduce the risk that unpredictable and more strict ozone regulations would be a hindrance to space access by measuring and modeling exactly how different rocket types affect the ozone layer.

Volcanic Aerosol Clouds and Gases Lead To Ozone Destruction

The volcanic gases released during eruptions accelerate reactions that lead to ozone destruction. The researchers found that even relatively small volcanic eruptions can destroy ozone and create localised ‘ holes’ in the stratosphere.

Previously, scientists had concentrated on the climatic effects of the tiny particles of volcanic sulphate created from the sulphur dioxide gas emitted during an eruption. For the first time, analysing data from a 2000 eruption of the Hekla volcano, Iceland, the researchers discovered that volcanic gases may also lead to the formation of ice and nitric acid particles. This is a critical finding as these particles ‘ switch on’ volcanic chorine gases, accelerating reactions that lead to ozone destruction.

Volcanic eruptions which penetrate the stratosphere can lead to the formation of the type of clouds that promote reactions with volcanic chlorine gases – gases that destroy stratospheric ozone and lead to the formation of ‘ mini-ozone holes.

The ozone hole: Why over Antarctica?

When the topic of

the ozone layer arises, many people immediately think of the hole over Antarctica, but few know why the hole is actually there. In 1985, British scientists discovered this hole. A special condition exists in Antarctica that accelerates the depletion of the ozone layer. Every Arctic winter, a polar vortex forms over Antarctica. A polar vortex is a swirling mass of very cold, stagnant air surrounded by strong westerly wind. Since there is an absence of sun during Arctic winters, the air becomes incredibly cold and the formation of ice clouds occurs. When the sun returns in the spring, the light shining on the nitrogen oxide filled ice particles activates the formation of chlorine. This excess of ozone destroying chlorine rapidly accelerates the depletion of the ozone layer. Finally, when the polar vortex breaks up, the rapid dissolution decreases. It is evident that the effects of the polar vortex are dramatic. For about two month every southern spring, the total ozone declines by about 60% over most of Antarctica. In the core of the ozone hole, more than 75% of the ozone is lost and at some altitudes, the ozone virtually disappeared in October, 1999. The average size of the ozone hole is larger than most continents, including South America, Europe, Australia, and Antarctica, and the maximum size of the ozone hole in 1996 was larger than North America. Finally, one must note that the hole over Antarctica is truly a hole only in the Antarctic spring, when the depletion is extremely severe due to the vortex.

The hole above Antarctica has clearly proven to be detrimental. Plankton, organisms that live on carbon, light, and nutrients such as nitrogen, are near the bottom of the food chain, and are accustomed to low levels of UV. In December of 1994, on the island of Bacharcaise off Antarctica, increased levels of UV radiation decreased the number of photoplankton dramatically. Photoplankton are the main source of food for krill, which in turn are the main source of food for various birds and whales in the Antarctic region.

At this time, due to the decreased number of photoplankton, the krill level was so low that it could not support the penguin population. Thus, some penguins were forced to travel up to two hundred miles in search of food, but most returned with none. Furthermore, when summer came, only approximately ten of the 1800 hatched penguin chicks survived. This tragedy illustrates the fact that even underwater creatures are not protected from harmful UV rays, and is a perfect example of the

entire food chain

being affected due

to an increase in

the UV radiation as

a result of the

thinning ozone

layer.

EFFORTS TO REDUCE OZONE DEPLETION

Internationalefforts to attempt to limit the production and release of CFCs began once the role of CFCs in ozone destruction was established. In 1987 the United Nations Montreal Protocol was agreed and came into effect in January 1989. The countries that signed up to the protocol aim to phase out the use of CFCs globally. The main CFCs ceased to be produced by the signatories in 1995, and the European Union ceased using them in 1998, except for a very small amount in limited and essential uses such as medical sprays. Although the Montreal Protocol has been successful, it should be noted that without the subsequent amendments, recovery of the ozone hole would have been impossible.

Thehydro-chlorofluorocarbons (HCFCs) were developed to replace CFCs. These gases can still damage ozone if they reach the stratosphere, but they are less likely to since their extra hydrogen atom allows them to be destroyed in the lower layers of the atmosphere. These gases are also controlled under the Montreal Protocol and were phased out after 2004. The gases that replaced both the CFCs and HCFCs are hydro-fluorocarbons (HFCs), which do not contain any chlorine atoms and so have no ozone depleting effect. Unfortunately, many of them are powerful greenhouse gases and could contribute to global warming if emitted in large quantities.

SincetheCFCshaveatmospheric lifetimes of about 50 to 100 years, and take 5 to 10 years to reach the upper atmosphere where they are broken down, the atmosphere reacts slowly to the cuts made in emissions of these gases. Stratospheric ozone should begin to increase as the amount of chlorine and bromine decreases. However, ozone is affected by changes in other gases, such as methane, temperature changes due to climate change, and also indirectly by particles from volcanic eruptions.

Compoundscontainingbromine, such as methyl bromide (mainly of natural origin) and the brominated CFCs (halons: used mainly as fire retardants), are also ozone-depleting chemicals. While the total amount of chlorine in the lower atmosphere peaked in 1994, and is now slowly declining, the total amount of bromine is still increasing. An assessment by the World Meteorological Organization in 1998 estimated that global and Antarctic ozone levels would return to pre-1980 levels by 2050, and in 2003 evidence suggested that the rate at which ozone is disappearing had indeed slowed down markedly, although estimates as to when ozone can return to a proper balance have now been revised to the latter half of the 21st century. However, many factors influence ozone, and future levels are not completely predictable.

SOCIAL ASPECTS

The most obvious, and perhaps most important connection between society and the ozone layer is the fact that scientific research suggests depletion of the ozone layer directly and indirectly endangers the health of the population. Research has focused on connections between the depleting ozone layer and skin cancer, immuno-suppression, cataracts, and snowblindness.

Ozone depletion and skin cancer: What is the connection?

Exposure to UV radiation increases the risk of skin cancer and causes damage to the DNA in the skin cells. DNA is extremely sensitive to UV radiation, especially UV-B radiation. UV radiation is located in the optical radiation portion of the electromagnetic spectrum, while UV-B radiation is a subdivision of the ultraviolet spectrum and consists of a wavelength of 280 to 315 nanometers. Thus, DNA is especially sensitive to radiation with a wavelength between 280 and 315 nanometers .

When UV radiation hits the skin, it can cause the cell to lock up and scramble or delete DNA information. This action causes confusion in the DNA, and the body loses control of the growth and division of the cell. If the conditions are right, the cell may become cancerous. It is important to note that not all affected cells turn into skin cancer, for many can repair themselves. However, continual exposure to UV radiation increases the risk of skin cancer due to cumulative damage of the DNA.

Skin cancer can be divided into two categories: melanoma and non-melanoma. The melanoma form of skin cancer is the more dangerous of the two. This type of cancer has the ability to spread quickly throughout the body and invade other cells. On the other hand, non-melanoma skin cancer is not to be taken lightly either, but is a less serious form of the disease. Non-melanoma skin cancers are not usually life threatening, and removal is relatively routine. However, treatment does include radiation therapy or surgery. The concern of many is that sunburn may lead to increased risk of acquiring skin cancer. Some forms of cancer are associated with sunburn, while other forms are not. Melanoma skin cancer is a form that sunburns may play a leading role in. Jan van der Leun, a Dutch scientist, explains that, light hitting the outer layer of the skin, the epidermis, triggers the production of some substances which diffuse into the dermis below. The dermis is filled with blood vessels, and the chemical substances cause them to dilate, making the skin red and warm to the touch.

The bottom line is that UV ray exposure increases the risk of skin cancer. However, controversy lies around the question of whether or not the depletion of the ozone layer will lead to more sunburns, and in turn, more skin cancer. Some scientists suggest that the skin will gradually adapt to higher UV-B levels as the ozone gradually depletes. The opponent to this theory would state that the thinning of the ozone layer would lead to more human UV-B exposure. This increased UV-B exposure would, in turn, increase the damage to the DNA making it difficult for the cell to correct the damage before it divides. This damage accumulates over time and increases the chances that a cell will turn cancerous. In addition, since UV-B radiation damages the immune system, it is much more likely that a cell will turn cancerous. In animal studies, immunosuppressive effects caused by UV-B have indeed been shown to play an important role in the outcome of both melanoma and non-melanoma skin cancers. Furthermore, states that for the non-melanoma skin cancers, the evidence is compelling and there are estimates that each percentage decrease in the stratospheric ozone will lead to a two percent increase in the incidence of these cancers. Thus, if the ozone depletes by ten percent over a certain time period, 250, 000 more people would be affected by these cancers each year.

Due to controversy in the scientific community, it is difficult to clearly state whether or not ozone depletion will lead to an increased risk of skin cancers, but scientists agree on the fact that UV-B radiation plays a large role in the formation of cancer. Thus, it may very well be that as the UV filter we call the ozone layer thins, the increased amount of UV-B radiation posed on human skin may contribute to an increased amount of skin cancer. Yet, one can only weigh all the evidence and speculate, for science has yet to provide a cut and dry answer for society to base its judgments on.

DISCUSSION

Regardless of the details of the arguments, it is obvious that the depletion of the ozone layer is a serious problem that poses many consequences to society. Although scientific controversy exists, the possibility seems high that the depletion of the ozone layer will prove detrimental if action is not taken. For example, research shows the strong possibility of a number of health risks associated with increased UV-B exposure as a direct result of the thinning ozone layer. These health risks include skin cancer, immuno-suppression, cataracts, and snow blindness.

Furthermore, the possibility that increased UV-B radiation results in lower crop yields should provide a wakeup call to those who feel the thinning ozone layer is not a problem. For if we are not able to breed UV-B resistant plants, the worlds food supply would become dramatically decreased, resulting in higher levels of famine and malnutrition.

Studies from Antarctica tell society that increased UV radiation can directly affect the food chain. Recall the decrease in food supply as a result of reduced levels of photoplankton in Antarctica. This may seem like an isolated, non-significant, and remote problem; however, this incident illustrates the dangers of reduced food supply and alteration of the food chain as a result of the thinning ozone layer. Even though the photoplankton were located at the bottom of the food chain, the whole chain was affected. In the future, problems like this could potentially affect the global food web and result in an overall decrease in food supply. Thus, realize that the dangers posed by ozone depletion are real now, and will be in the future, if action is not taken.

Take Action: Teamwork does the trick

Although the earth will be able to heal itself if the CFC level continues to stay as it is, the depletion of the ozone layer is still a problem that society should be concerned with. In order for earth to repair the damage humans have posed on the ozone layer, society must take an active role. There are many tasks individuals can involve themselves in to help combat the problem of ozone depletion. First of all, one can simply check product labels for ozone friendly status. Many companies have gone to great lengths to remove CFCs from their products. These products do not do as much damage to the ozone layer, and thus, are denoted as ozone friendly. A collaborative effort by society not using products with CFCs is a major step toward the healing of the ozone layer.

Unfortunately, many products still used in society are detrimental to the ozone layer. For example, CFCs marketed under the trade name Freon are used in appliances with refrigerants such as refrigerators and air conditioners. When individuals must dispose of products with refrigerants in them, certain actions must be taken in order to prevent the CFCs from escaping from the disposed product. For example, when an agency, such as a waste hauling company, comes to pick up the unwanted appliance, check to make sure refrigerant-recovery equipment is used by the agency. This equipment allows for the disposal of refrigerants without damage to the ozone layer.

Society can also help the problem of ozone depletion through education, as well as through various donations. If individuals contribute time or money to environmental agencies focused on healing the ozone layer, the agencies will be able to organize activities promoting the understanding of the ozone problem. If society is educated through these means, more individual efforts will be taken to make ozone smart decisions such as using ozone friendly products.

Although thinning ozone may not directly affect the generation growing up today, future generations depend on the actions taken now. Thus, it is important for society to recognize that the thinning ozone layer is a problem and to take action in order to ensure the safety and survival of future generations.

Result

It is very much clear from the above discussions that there is an urgent need of the hour to realize the importance of the very critical ozone layer which is just like a god gift to human civilisation.

It acts as a protection shield which prevents the dangerous and harmful UV rays entering the earth surface. It job is to filter those harmful particles present in the rays that can lead to severe destruction of mankind, wealth and property.

The impact of ozone depletion can be seen on the world`s economy today it has slow down the progress of not only any particular nation rather it is a global phenomenon which is hindering development.

According to surveys conducted it has been seen that year 1998 observed max. decline in amount of ozone depletion.

SUMMARY

The ozone layer is essential for protecting society from harmful UV radiation by acting as a filter. However, this protective layer has been thinning due to three main sources: human activity, natural sources, and volcanoes. Human activity is responsible for the most damage to the ozone layer, thus, society should recognize that much can be done to prevent ozone layer damage.

In 1985, in a region over Antarctica, the yearly polar vortex had caused the ozone layer to deplete so greatly, that it could be classified as a hole. In 1996, this hole was large enough to cover Antarctica.

The depletion of the ozone layer does not come without problems. Scientific research has suggested the probability that increased UV-B radiation as a result of the thinning ozone layer leads to increased cases of skin cancer, immuno-suppression, cataracts, and snowblindness due to radiation damage of the DNA. Additionally, experiments have shown a correlation between increased UV radiation and crop damage due to UV radiation damaging the plants DNA. Some scientists, however, feel that this will not be a problem in the future due to the possibility of breeding UV resistant crops and plants.

Many national governments and agencies recognized the problem of ozone depletion, and therefore, united in 1987 to sign the Montreal Protocol. This agreement was implemented to decrease CFC levels in order to help protect the thinning ozone layer.

Clearly, ozone depletion is a dangerous problem due to possible disease outbreaks and famine as a result of increased UV-B radiation. However, society can collectively attempt to combat this problem by relatively simple means such as education and the practice of ozone smart behavior. For if society acts now, future generations will be handed a safe and healthy planet.