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RESEARCH ARTICLE

A REVIEW ON OZONE LAYER DEPLETION, EFFECTS & IT'S SOLUTION.

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Abstract

Ozone (O_3) is a stratospheric layer that plays important role in providing support to humans for their survival. It is an essential factor for many global, biological and environmental phenomena. There are many situations where human activities have significant effects on the environment. Ozone layer damage is one of them. The objective of this paper is to review the origin, causes, mechanisms and bio effects of ozone layer depletion as well as the protective measures of this vanishing layer. The chlorofluorocarbon and the halons are potent ozone depletors. One of the main reasons for the widespread concern about depletion of the ozone layer is the anticipated increase in the amounts of ultraviolet radiation received at the surface of the earth and the effect of this on human health and on the environment. The prospects of ozone recovery remain uncertain. However, the future behaviour of ozone will also be affected by the changing atmospheric abundances of methane, nitrous oxide, water vapour, sulphate aerosol, and changing climate. The data regarding effect of ozone depletion on human was reviewed and compiled as a review paper from various published articles of international reputed journals, annual/environmental reports of recognized organization and e-books. This study clearly pointed out towards the alarming rate of how the ozone layer was being depleted and given some needful solution. The current situation of ozone depiction demands urgent remedial measures to protect lives on this earth.

Introduction:-

The ozone layer is a layer in Earth's atmosphere which contains relatively high concentrations of ozone (O_3). This layer absorbs 93-99% of the sun's high frequency ultraviolet light, which is potentially damaging to life on earth [1]. Over 91% of the ozone in Earth's atmosphere is present here.[1] It is mainly located in the lower portion of the stratosphere from approximately 10 km to 50 km above Earth, though the thickness varies seasonally and geographically[2]. The ozone layer was discovered in 1913 by the French physicists Charles Fabry and Henri Buisson. Its properties were explored in detail by the British meteorologist G. M. B. Dobson, who developed a simple spectrophotometer (the Dobson meter) that could be used to measure stratospheric ozone from the ground. Between 1928 and 1958 Dobson established a worldwide network of ozone monitoring stations which continues to

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operate today. The "Dobson unit", a convenient measure of the total amount of ozone in a column overhead, is named in his honour.

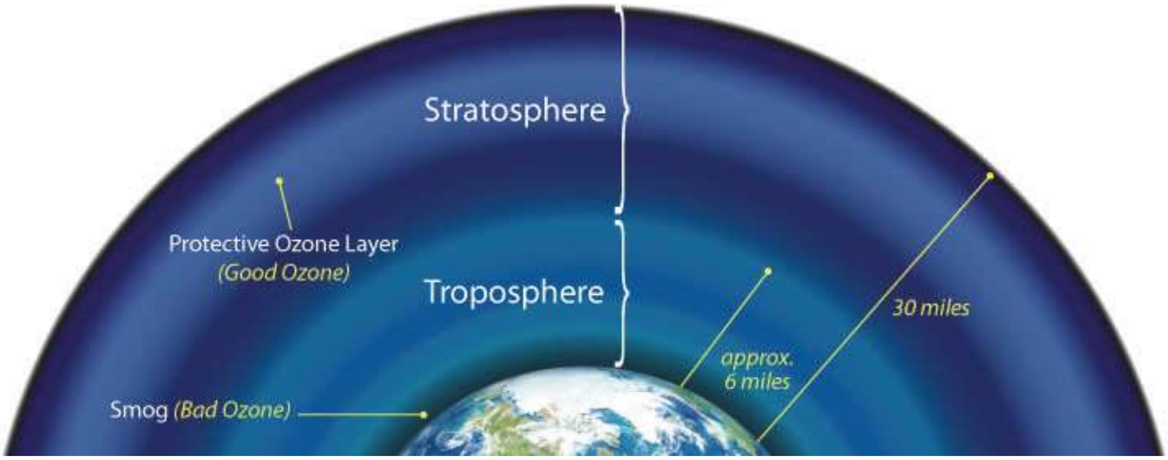

Figure 1:-Ozone “up high” in the stratosphere protects the Earth, while ozone close to the Earth’s surface is harmful.

In this paper the causes, mechanism and bio-effects of ozone layer depletion on humans were addressed. It is revealed that introduction of Chlorofluorocarbons (CFCs) in the environment is the most rated cause of said depiction. Ozone depletion is allowing the UV radiation to earth surface. The exposure to these radiations is severely affecting all life forms on earth, especially the humans. Permanent or temporary blindness, skin cancer and immunity suppression are the main effects of these radiations reported by various researchers on humans. The prospects of ozone recovery are still undiscovered. The current situation of ozone depiction demands urgent remedial measures to protect lives on this earth.

Ozone:-

First of all we have to know about ozone. Without ozone, life on Earth would not have evolved in the without ozone, life on Earth would not have evolved in the way it has. The first stage of single cell organism development requires an oxygen-free environment. This type of environment existed on earth over 3000 million years ago. As the primitive forms of plant life multiplied and evolved .They began to release minute amounts of oxygen through the photosynthesis reaction (which converts carbon dioxide into oxygen) [3].The build up of oxygen in the atmosphere led to the formation of the ozone layer in the upper atmosphere or stratosphere. This layer filters out incoming radiation in the "cell-damaging" ultraviolet (UV) part of the spectrum. Thus with the development of the ozone layer came the formation of more advanced life forms. Ozone is a form of oxygen. The oxygen we breathe is in the form of oxygen molecules (O_2) -two atoms of oxygen bound together. Normal oxygen which we breathe is colourless and odourless. Ozone, on the other hand, consists of three atoms of oxygen bound together (O_3).Most of the atmosphere's ozone occurs in the region called the stratosphere. Ozone is colourless and has a very harsh odour. Ozone is much less common than normal oxygen. Out of 10 million air molecules, about 2 million are normal oxygen, but only 3 are ozone. Most ozone is produced naturally in the upper atmosphere or stratosphere. While ozone can be found through the entire atmosphere, the concentration occurs at altitudes between 19 and 30 km above the Earth's surface. This band of ozone-rich air is known as the "ozone layer". [4] Ozone also occurs in very small amounts in the lowest few kilo meters of the atmosphere, a region known as the troposphere. It is produced at ground level through a reaction between sunlight and volatile organic compounds (VOCs) and nitrogen oxides (NOx), some of which are produced by human activities such as driving cars. Ground-level ozone is a component of urban smog and can be harmful to human health. Even though both types of ozone contain the same molecules, their presence in different parts of the atmosphere has very different consequences. Stratospheric ozone blocks harmful solar radiation - all life on Earth has adapted to this filtered solar radiation .Ground-level ozone, in contrast, is simply a pollutant. It will absorb some incoming solar radiation, but it cannot make up for ozone losses in the stratosphere.

Ozone Hole:-

In some of the popular news media, as well as in many books, the term "ozone hole" has and often still is used far too loosely. Frequently, the term is employed to describe any episode of ozone depletion, no matter how minor. Unfortunately, this sloppy language trivializes the problem and blurs the important scientific distinction between the massive ozone losses in Polar Regions and the much smaller, but nonetheless significant, ozone losses in other parts of the world. Technically, the term "ozone hole" should be applied to regions where stratospheric ozone depletion is so severe that levels fall below 200 Dobson Units (D.U.), the traditional measure of stratospheric ozone. Normal ozone concentration is about 300 to 350 D.U [3]. Such ozone loss now occurs every spring time above Antarctica, and to a lesser extent the Arctic, where special meteorological conditions and very low air temperatures accelerate and enhance the destruction of ozone loss by man-made ozone depleting chemicals (ODCs) .

Ozone Layer:-

The ozone layer is not really a layer at all, but has become known as such because most ozone particles are scattered between 19 and 30 km (12 to 30 miles) up in the Earth's atmosphere, in a region called the stratosphere. The concentration of ozone in the ozone layer is usually under 10 parts ozone per million [5]. Without the ozone layer, a lot of ultraviolet (UV) radiation from the Sun would not be stopped reaching the Earth's surface, causing untold damage to most living species. In the 1970s, scientists discovered that chlorofluorocarbons (CFCs) could destroy ozone in the stratosphere. Ozone is created in the stratosphere when UV radiation from the Sun strikes molecules of oxygen (O_2) and causes the two oxygen atoms to split apart. If a freed atom bumps into another O_2, it joins up, forming ozone (O_3). This process is known as photolysis. Ozone is also naturally broken down in the stratosphere by sunlight and by a chemical reaction with various compounds containing nitrogen, hydrogen and chlorine. These chemicals all occur naturally in the atmosphere in very small amounts. In an unpolluted atmosphere there is a balance between the amount of ozone being produced and the amount of ozone being destroyed. As a result, the total concentration of ozone in the Stratosphere remains relatively constant. At different temperatures and pressures (i.e. varying altitudes within the stratosphere), there are different formation and destruction rates. Thus, the amount of ozone within the stratosphere varies according to altitude. Ozone concentrations are highest between 19 and 23 km [6]. Most of the ozone in the stratosphere is formed over the equator where the level of sunshine striking the Earth is greatest. It is transported by winds towards higher latitudes. Consequently, the amount of Stratospheric ozone above a location on the Earth varies naturally with latitude, season, and from day-to-day. Under normal circumstances highest ozone values are found over the Canadian Arctic and Siberia, whilst the lowest values are found around the equator. The ozone layer over Canada is normally thicker in winter and early spring, varying naturally by about 25% between January and July. Weather conditions can also cause considerable daily variations.

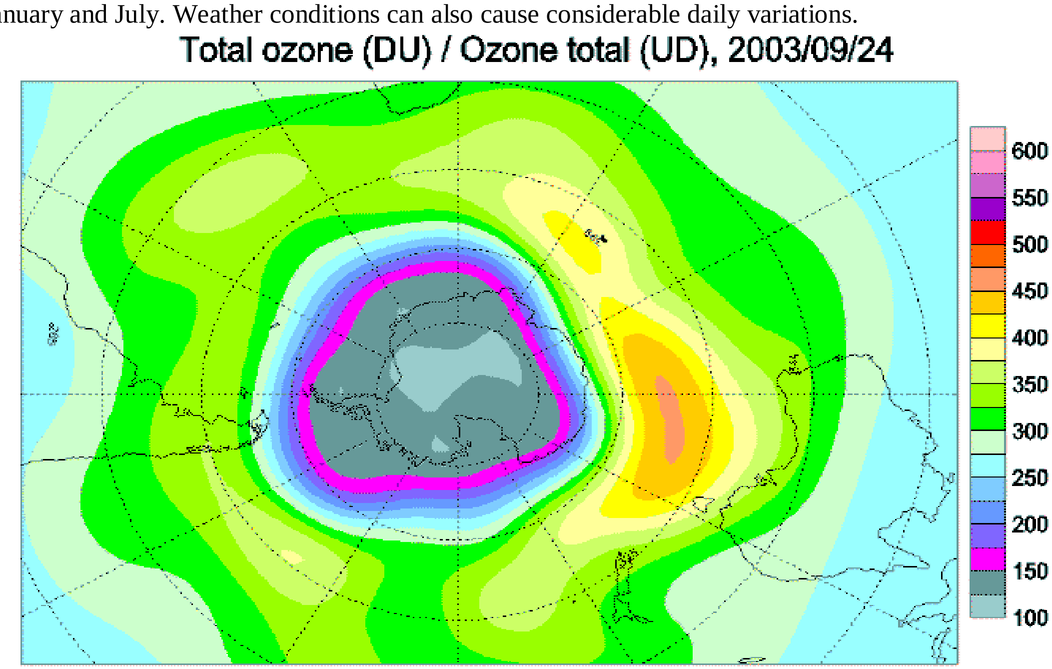

Figure 2:-Ozone layer depletion over Antarctica

Ozone depletion over India:-

With so much worry about the rapid ozone depletion taking place in various parts of the earth, Indian scientists are closely monitoring the ozone layer over India for possible depletion trends. Opinions are many and varied. According to S K Srivastava, head of the National Ozone Centre in New Delhi, there is no trend to show total ozone depletion over India. V.Thaphyal and S M Kulshresta of the Indian Meteorological Department also point out that for the period 1956 to 1986 "ozone measurements exhibit year to year variability, but do not show any increasing or decreasing trend over India." However, former director of the National Ozone Centre, K Chatterji, now with Development Alternatives, warns that there is no case for complacency. He asserts that his calculations exhibit an ozone depletion trend in the upper, layers of the stratosphere over New Delhi and Pune from 1980 to 1983 in the month of October when the Antarctic ozone hole is at its maximum. Since India already receives high doses of ultraviolet (UV-B) radiation, and is at the threshold go to speak, effects of ozone layer depletion could he far more disastrous in India. A P Mitra, former director general of the Council of Scientific and Industrial Research, clarifies that while there is no trend in the total ozone value, there is some evidence of ozone depletion at higher altitudes - at about 30 to 40 km - even over the tropics. He argues, however, that there is insufficient data and that the depletion may be due to solar cycles and other natural phenomena. However, the effects of CFCs and belong cannot be ruled out. Total column ozone data has been recorded over India for a long time. A network of stations using Dobson spectrophotometers to measure total ozone, some six times a day, covers Srinagar, New Delhi, Varanasi, Ahmadabad, Pune and Kodaikanal. Ozone profiles are also regularly recorded using balloons. Ozone levels are the lowest during November and December and the highest in summer. Across the country, variations do exist. In Kodaikanal, the total ozone is 240 to 280 Dobson units (DU), in New Delhi 270 to 320 DU and in Srinagar 290 to 360 DU. One Dobson unit is the equivalent of 0.01 mm of compressed gas at a pressure of 760 rare mercury and 0°C.B N Srivastava of the National Physical Laboratory, who been working on incident UV radiation levels, says that during summer, at noon, the UV-B radiation with a wavelength of 290 nanometer (nm) is equivalent to levels attained in the Antarctica during the ozone hole period. He warns that even a slight depletion of the ozone layer over India may lead to large percentage changes in UV-B radiation over the country. According to eminent skin specialists in New Delhi, the incidence of skin cancer in India is low, but they admit that the surveys conducted to identify any trends are inadequate. Controlled studies to observe the effects of changing UV- B radiation concentrations on crops are on, they said. However no field surveys have been done in the country as yet.

Depth discussion:-

Three forms (or allotropes) of oxygen are involved in the ozone-oxygen cycle: oxygen atoms. Global monthly average total ozone amount atomic oxygen, oxygen gas (O_2 or diatomic oxygen) and ozone gas (O_3 or tri atomic oxygen). Ozone is formed in the stratosphere when oxygen molecules photo dissociate after absorbing an ultraviolet photon whose wavelength is shorter than 240 nm. This produces two oxygen atoms. The atomic oxygen then combines with O_2 to create O_3. Ozone molecules absorb UV light between 310 and 200 nm, following which ozone splits into a molecule of O_2 and an oxygen atom. The oxygen atom then joins up with an oxygen molecule to regenerate ozone. This is a continuing process which terminates when an oxygen atom "recombines" with an ozone molecule to make two O_2 molecules:

$$O + O_3 \rightarrow 2\ O_2$$

The overall amount of ozone in the stratosphere is determined by a balance between photochemical production and recombination. Ozone can be destroyed by a number of free radical catalysts, the most important of which are the hydroxyl radical (OH·), the nitric oxide radical (NO·) and atomic chlorine (Cl·) and bromine (Br·). All of these have both geogenic and anthropogenic (manmade) sources; at the present time, most of the OH· and NO· in the stratosphere is of natural origin, but human activity has dramatically increased the levels of chlorine and bromine. These elements are found in certain stable organic compounds, especially chlorofluorocarbons (CFCs), which may find their way to the stratosphere without being destroyed in the troposphere due to their low reactivity. Once in the stratosphere, the Cl and Br atoms are liberated from the parent compounds by the action of ultraviolet light, e.g. ('h' is Planck's constant, 'ν' is frequency of electromagnetic radiation)

$$CFCl_3 + h\nu \rightarrow CFCl_2 + Cl$$

The Cl and Br atoms can then destroy ozone molecules through a variety of catalytic cycles. In the simplest example of such a cycle, [2] a chlorine atom reacts with an ozone molecule, taking an oxygen atom with it (forming ClO) and leaving a normal oxygen molecule. The chlorine monoxide (i.e., the ClO) can react with a second molecule of ozone (i.e., O3) to yield another chlorine atom and two molecules of oxygen. The chemical shorthand for these gas-phase reactions is:

$$Cl + O_3 \rightarrow ClO + O_2$$
$$ClO + O_3 \rightarrow Cl + 2\ O_2$$

The overall effect is a decrease in the amount of ozone. More complicated mechanisms have been discovered that lead to ozone destruction in the lower stratosphere as well. A single chlorine atom would keep on destroying ozone (thus a catalyst) for up to two years (the time scale for transport back down to the troposphere) were it not for reactions that remove them from this Ozone depletion. Lowest value of ozone measured by TOMS each year in the ozone hole. Cycle by forming reservoir species such as hydrogen chloride (HCl) and chlorine nitrate ($ClONO_2$). On a per atom basis, bromine is even more efficient than chlorine at destroying ozone, but there is much less bromine in the atmosphere at present. As a result, both chlorine and bromine contribute significantly to the overall ozone depletion. Laboratory studies have shown that fluorine and iodine atoms participate in analogous catalytic cycles. However, in the Earth's stratosphere, fluorine atoms react rapidly with water and methane to form strongly-bound HF, while organic molecules which contain iodine react so rapidly in the lower atmosphere that they do not reach the stratosphere in significant quantities. Furthermore, a single chlorine atom is able to react with 100,000 ozone molecules. This fact plus the amount of chlorine released into the atmosphere by chlorofluorocarbons (CFCs) yearly demonstrates how dangerous CFCs are to the environment. [3]

Effects of ozone layer depletion:-

1. Ozone depletion is affecting the human health and environment negatively, as it allows the penetration of UV radiations to reach the Earth. These radiations can cause severe diseases in humans such as Melanoma type of skin cancer, breast cancer and leukaemia, eye damage and genetic mutations etc. [9].
2. Furthermore the ozone depletion is affecting the aquatic life, biogeochemical cycles, air quality and also contributing in Global warming, but in this review paper our main focus is on the effects of ozone depletion on human health [1].
3. The major cause of blindness in this world is cataracts. There would be 0.3% - 0.6% increase in risk of cataract if there will be 1% decrease in Ozone level [14].
4. Eye lens can be damaged by oxidative agents. Oxidative oxygen produced by UV radiation can severely damage eye lens and cornea of eye is also badly damaged by UV radiation [15]-[17].
5. Photokeratitis, cataract, blindness all are caused due to UV rays [18].
6. Epidemiological studies of Melanoma indicate that the incidence of melanoma is increasing in those countries having high ratio of cases [21]-[23]. As UV radiations can penetrate more easily in thin skin so there is greater number of incidence is found in thin skinned people. It is found that the incidence of Melanoma is more in children than adults. The chance of incidence of melanoma is correlated with UV exposure furthermore the survival chance of melanoma is less in boys as compared to girls [24] [25]. As the intensity of radiation increases in summer so the risk of melanoma in thin skinned people is increased in summer and it is more in females as compared to males as their skin is thinner than males [26] [27].There is considerable relationship between melanoma risk and intermittent sun exposure and sunburn history[28]. There is also a direct relationship between air travelling and melanoma incidence [29]. However the studies revealed that genetic factors contribute more for having melanoma disease than behavioral aspects [30].The epidemiological studies of non melanoma skin carcinoma (NMSC) indicates that its risk is more in young females in lower limbs [16] [20] and sunbathing increases its risk five times in trunk region. Exposure to UV radiations can also result in suppression of immune response to skin cancer, infectious diseases and other antigens [1].
7. The immune suppression is due to changes in skin photoreceptors and antigen presenting cells that are brought by UV radiations [31]. More increase in depletion of ozone results in more decrease in immune system [10].
8. Depletion of ozone layer is also causing the problem of food shortage to humans. UV radiations are disturbing developmental and physiological processes which is decreasing the productivity of crops. As humans are heavily dependent on crops for food so there is a great chance if depletion of ozone layer is not checked it may cause seriously shortage of food to humans [30]. Researches also show that UV radiations can also be used to enhance yield of crops by the use and application of phyto hormones [37] [38].

Conclusion:-

Under the auspices of United Nations Environment Programme (UNEP), Governments of the world, including the United States have cooperatively taken action to stop ozone depletion with the "The Montreal Protocol on Substances that Deplete the Ozone Layer", signed in 1987. Scientist's are concerned that continued global warming will accelerate ozone destruction and increase stratospheric ozone depletion. Ozone depletion gets worse when the stratosphere (where the ozone layer is), becomes colder. Because global warming traps heat in the troposphere, less heat reaches the Stratosphere which will make it colder. Greenhouse gases acts like a blanket for the troposphere and make the stratosphere colder. In other words, global warming can make ozone depletion much worse right when it is supposed to begin its recovery during the next century. Maintain programs to ensure that ozone-depleting substances are not released and ongoing vigilance is required to this effect. In fact, global warming, acid rain, ozone layer depletion, and ground-level ozone pollution all pose a serious threat to the quality of life on Earth. They are separate problems, but, as has been seen, there are links between each. The use of CFCs not only destroys the ozone layer but also leads to global warming. A large number of environmental problems such as ozone depletion and global warming are associated with increased development and economic growth throughout the world during the last century. The halocarbon refrigerants used in the refrigeration and air-conditioning systems have become a subject of great concern for the last few decades. The earth is the only planet that supports life and thus preserving ozone layer and reducing the release of greenhouse gasses are the essential steps required for the protection of life. The stratospheric ozone helps in limiting the influx of harmful UV-B and green- house gas. UV radiation imposes a significant influence on the growth and development of fungi, plants and humans. The fungal diseases on plants have receding effects due to the inhibition of sporulation caused by exposure to UV radiation. In plants, UV radiations resulted in reduced plant height, fresh-weight, dry-weight, seed germination and seedling growth. The plants also showed mutant formation that alters the growth properties which are detrimental to optimal utilisation of the plant products. There have been a significant number of studies till date which have described negative implications of UV response for plant development. However, numerous studies have also reported the positive aspects of UV radiations wherein it plays an important role in the evolution of plant and animal species. Therefore, one has to take the larger argument of the protective role of ozone layer along with its phytogenic response. For this purpose, different conventions and protocols have been adopted to control ozone depletion and its impacts on all life forms. These protocols banned the use of ozone depleting substances (ODSs) in both developed and developing countries. Chlorofluorocarbons (CFCs) have been found to be the main cause of ozone depletion and have many health impacts.

Way Point:-

1. One of the easiest ways to reduce damages caused to the ozone layers by limiting the use of vehicles. This is because vehicular emissions eventually result in the release of smog. This in turn also damages the ozone layer causing it to deteriorate. If you are looking for ways on how to prevent ozone depletion, then you do have certain effective option. You can choose to take public transport or use a bicycle.
2. Use of eco friendly and natural cleaning products for house hold chores is a great way to prevent ozone depletion. This is because many of these cleaning agents contain toxic chemicals that interfere with the ozone layer.
3. Pesticides may be an easy solution for getting rid of weed, but are harmful for the ozone layer. The best solution for this would be to try using natural remedies, rather than heading out for pesticides.
4. Do not use fire extinguishers that contain halon.
5. Minimize high altitude aircraft flights.
6. Vehicle air conditioning units should be checked regularly.
7. Reduce deforestation.
8. Wear thinner clothes to remain cool in summer, rather than the usage of air conditioners.
9. Use HCFC’S free refrigerators.
10. Built public awareness regarding the effects of CFCs.

In the late 70’s the world was taken by surprise with a study that triggered a red alert pertaining to the destruction caused to the ozone layer. It had all the necessary information that helped us to understand what exactly was going on. Even the facts in the study clearly pointed out towards the alarming rate of how the ozone layer was being depleted.

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