The Planet in Peril: Depletion of the Ozonosphere

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While direct conflict and turmoil reign over the inhabiited regions of our earth, as never before in History, Nature itself appears to have intervened, mainly due to human activities, leading to further disasters not only for human beings but for all life forms upon the earth. Principal among these effects are (1) the so called **Greenhouse Effect** leading to global warming; (2) the depletion of the Ozone Layer, surrounding the earth, resulting in the possible elimination of certain life forms and further disasters for human life; (3) the periodic phenomenon known as the El Nino, which radically changes our weather patterns and which we in Sri Lanka experienced during the unprecedented drought early in 1992. Of these phenomena (1) and (2) appear to be caused by human activity partly through ignorance and partly due to the greed for profits. It is significant that these effects were first identified byartificial satellites.

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The earth's atmosphere, through many aeons of evolution, is today highly complex. Up to about 70 km above the earth's surface we have the troposphere, consisting largely of the gases nitrogen and oxygen. They are finely balanced to permit the evolution and existence of living beings upon the earth. The temperature of the troposphere decreases in an upward direction. Above this is the stratosphere a rarefied region where the temperature begins to rise as we proceed upwards. Between heights of 150-300 km there are a series of spherical electrified layers, known as the ionosphere. it is the reflection and re-reflection of radio waves between the ionosphere and the earth that enable us to "pick up", for example, BBC from Sri Lanka.

What interests us here is a spherical layer of gas (OZONE) which exists at a height of 70-100 km above the earth. This is known as the ozonosphere. What is ozone? What is its composition? and what function does the ozonesphere fulfil? Contrary to the view of certain philosophers, Nature generally has a purpose or purposes in its activities. Without delving into the realm of the sub-atomic, matter is known to consist of atoms. Each element in Nature has its own atomic structure and is described chemically by diverse symbols: e.g. oxygen - O, hydrogen - H, nitrogen - N, Fluorine - F etc. These atoms in reality exist singly or bonded together to form molclules - e.g. oxygen O_2 (two atoms of oxygen), nitrogen - N_2 hydrogen - H_2, chlorine - Cl, etc. For instance in our troposphere, nitrogen exists as N_2, oxygen as O_2 etc. More atoms are also bonded together in many instances to form complex molecules, with properties that differ from their component atoms - e.g. carbon dioxide CO_2, common salt - Nacl etc.

Our Sun - like other stars and unlike the nine planets revolving around it - produces its own radiation - heat, light and a variety of other radiations ranging from the smallest wavelengths to the longest (radio waves). Only a small fraction of the light emitted by the sun is visible to the human eye. Among these invisible radiations is the ultra-violet, ranging in wavelength from 200 nm to 400 nm (nm: nano metre; where 1 nm= 10-9

metre = 1/9zeros). After plant life evolved upon the earth, oxygen (O_2) was released which formed a viable constituent of our atmosphere.

Reactions between O_2 and ultra-violet light from the sun resulted in the conversion of O_2 (oxygen) into ozone (O_3) at a height where the oxygen density was appropriate for these reactions. The spherical layer, known as the ozonosphere was created. Opposite processes generally tend to co-exist in Nature. Even as the ozonosphere was created by the sun's radiations, it developed the property of absorbing excessive ultraviolet light from the sun. An excess of ultra-violet radiation could have a deleterious effect on living organisms, including human life.

A fine balance was created between the ultra-violet emissions from the sun and the ozonosphere, which permitted only a minimal amount of ultra-violet light to reach the earth. This amount in certain circumstances could be of a health giving nature to humans and other living organisms. Such fine balances are common to Nature - both physically and chemically. in fact, the ozonosphere acts as an effective umbrella against excessive ultra-violet emissions from the sun.

Ultra-violet light from the sun can be roughly divided into three categories, depending on their wavelengths. They differ in their degrees of absorption by the ozonosphere:

Category	Wavelength	Absorption by the Ozonosphere
UV - C	200 - 290 nm	Fully absorbed
UV - B	290 - 320 nm	Partially absorbed
UV - A	320 - 400 nm	Not absorbed

Thus, UV - C, at present poses no threat to life on the earth. Such was the natural situation of our earth for a few billion years.

With the speedy development of technology and industrialisation new chemicals came into usage in the form of foams, solvents, sprays (insecticides, weedi-cides etc.), refrigeration and air- conditioning, leading to the slow release of a variety of chlorine - based compounds into the atmosphere. These rose over the years to stratospheric levels causing disastrous effects in the ozonosphere. known as CFC's

Parts per Trillion (1 Trillion = 10^{12} or a million)

Year pre Industrial	CCl_4	CH_3CCl_3	$CCl_{13}F$ (CFC 11)	$CCl_{12}F_2$ (DFC 12)	$CHCl\ F_2$ (CFC 22)	$C_2Cl_3\ F_3$ (CFC 113)	Total Gaseous Chlorine
	0	0	0	0	0	0	0
1959	315.8	x	x	x	x	x	x
1960	316.8	x	x	x	x	x	x
1961	317.5	x	x	x	x	x	x
1962	318.3	x	x	x	x	x	x
1963	318.8	x	x	x	x	x	x
1964	x	x	x	x	x	x	x
1965	319.9	x	x	x	x	x	x
1966	321.2	x	x	x	x	x	x
1967	322.0	x	x	x	x	x	x
1968	322.8	x	x	x	x	x	x
1969	323.9	x	x	x	x	x	x
1970	325.3	x	x	x	x	x	x
1971	326.2	x	x	x	x	x	x
1972	327.3	x	x	x	x	x	x
1973	329.5	x	x	x	x	x	x
1974	330.1	x	x	x	x	x	x
1975	331.0	104	120	200	x	x	1,202
1976	332.0	106	133	217	x	x	1,290
1977	333.7	115	148	239	x	x	1,416
1978	335.3	123	159	266	x	x	1,544
1979	336.7	116	167	283	46	x	1,621
1980	338.5	121	179	307	52	x	1,755
1981	398.8	122	185	315	59	x	1,797
1982	341.0	121	193	330	64	x	1,863
1983	342.6	126	205	350	71	24	1,983
1984	344.3	130	213	366	76	27	2,072
1985	345.7	130	223	384	85	31	2,163
1986	347.0	127	232	404	98	35	x
1987	348.7	133	247	421	105	41	x
1988	351.3	133	263	439	x	52	x

(x - Not available)

(chlorofluoro-carbons) their growth is indicated below ("world Resources" 1990-1991, published by the World Resources Institute in collaboration with UNEP and UNDP):

The Process of Ozone Depletion by UV Radiations Acting on CFC's

C: Carbon atom
Cl: Chlorine atom
F: Fluorine atom

CFC molecules are transported to the stratosphere. In the stratosphere, UV radiation from the sun is strong enough to split the chlorine atoms off the CFC molecule.The free chlorine atom attacks an ozone molecule. An oxygen atom splits off, binds to the chlorine and forms chlorine monoxide. The rest of the ozone molecule is left as an ordinary oxygen molecule. The chlorine monoxide is not stable, however. A free oxygen atom can steal its oxygen, leaving the chlorine atom ready to go after another ozone molecule. Each chlorine atom can destroy up to 100,000 ozone molecules. (From a UNEP feature, reproduced in " The Island" science page of May 14, 1992)

Observations made by artificial satellites have considerably improved our knowledge of trends in the ozonosphere. A few years ago studies revealed that a "hole" (actually a considerable thinning) had occurred in the ozonosphere over Antarctica over an area of 26 million Km^2 which is roughly the area of South America. Recently, another "hole" has been discovered in the ozonosphere over the Arctic. The decline in the ozone layer occurs at high and mid-latitudes in both hemispheres both during the winter and spring/ summer. NASA investigations show that the ozone over the northern hemisphere fell significantly between 1969 and 1986. Similar changes may have occurred in the southern hemisphere but the available data is insufficient for any reliable analysis.

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NASA figures for the northern hemisphere are as follows:

Decline in the Ozone Layer (1969-1986)

Latitude	Winter change	Summer change
53^0-64^0	-6.2%	+0.4%
40^0-52^0	-4.7%	-2.1%
30^0-39^0	-2.3%	-1.9%

Professor G.O.P. Obasi, Secretary General of the WMO (World Meteorological Organisation), shows that "in four of the past five years the ozone hole over the Antarctic was deeper and larger than any ever observed.

"The latest findings show higher chlorine concentrations in Arctic air over Eastern Canada and Northern New England than any previously observed in the Arctic or the Antarctic."

A Scientific Assessment Report, co-ordinated by WMO and UNEP, prepared by more than 100 scientists from 28 countries, stated that the ozone layer is being depleted at an even faster rate than predicted.

"Depletion now covers North America, a large part of South America and Asia, nearly the whole of Europe, Australia and New Zealand. The tropics are the only areas which are not affected" (for the present of course!)

What are the ill-effects of excessive ultra-violet radiation upon life forms that exist on the earth? The principal agent, as we have shown earlier is UV-B. The worst effects on human beings are skin cancers, both benignant and malignant. For every 1% decrease in ozone, it has been estimated that benign skin cancers will increase by 3%. Protracted exposure to sunlight of those with light skins would more readily acquire benign skin cancers. Unfortunately, white-skinned tourists visiting tropical resorts frequently sun-bathe and expose themselves readily to UV radiation, particularly to acquire a tan.

Current estimates predict a 5% to 10% ozone depletion of mid-atitudes in summer by the year 2000 AD, compared to the mid-1970's. Dr. Mostafa K Tolba, UNEP's Executive Director, writes: "If there were a sustained 10% loss of ozone, one could expect a 26% increase in the incidence of non melanoma skin cancer. The full consequences of our past folly will be painful."

The US has had a somewhat varying malignant skin cancer rate of about 7,800 per year, resulting in death. Over the past 35 years this death rate has increased by 200%.

Scientists have other worries. The rate of development of cataracts in human eyes have shown a pronounced increase by excessive exposure to ultraviolet radiation.

They also worry about the possible effect of increased UV-B radiation on aquatic organisms. According to the micro-biologist head of UNEP: "This could reduce phytoplankton bio-mass and change the composition and diversity of species. In turn, this may reduce marine food production at the bottom of the food chain and consequently, the food supply to fish and mammals higher on the food chain.".

Halting or substantially reducing the depletion of the ozone layer by the elimination or substituting of CFC's by other chemicals requires a global effort, the co-operation of countries largely responsible for their generation in industry. The 1987 Montreal Protocol and the 1990 London Amendment to this Protocol is certainly a step in the correct direction. Dr. Mostafa K. Tolba writes thus: " A 1996 total phase-out of CFC's halons and other chemicals controlled by the 1990 London Amendment of the Montreal Protocol will speed up the recovery of the ozone layer by 10 to 15 years.

"In terms of human health this could mean a total of about a million fewer cases of skin cancer and about 350,000, fewer cases of cataract-induced blindness per year".

However, despite the "best laid plans of mica and men" (Steinbeck), politics and economics play an ever increasing role in human affairs, including their efforts to harness and control Nature, to make the World a better place to live in. The severe conflicts now ravaging our planet-from north to south, from east to west -and the unprecedented "recession" developing in intensity tend to influence the efforts of scientists to "control" Nature and protect the future of the human race.

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A few cases of hope do exist, strangely in the developing world: Laws have been passed, though half-heartedly, to ban the use of CFC's. China has embarked on a limited programme, banning the use of CFC's and the development of refrigeration alternatives. Mexico has announced that, with adequate financing (!) it will follow the same phase-out schedule as certain developed countries. Singapore has reported a 60% reduction in CFC use since 1986, the highest reduction of any country in the world. (From the science page of "The Island" - May 14, 1992).

However, the situation remains grim. The Executive Heads of WMO and UNEP concur that "faced with the expanded threat of ozone depletion, the original provisions of the 1987 Montreal Protocol and the 1990 London Amendment and Adjustments are quite clearly insufficient.

"A total phase-out by 2000 AD seems far too leisurely an approach. As we now know, time is not on our side."

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