CHAPTER – 11

Summery, conclusions, findings and future scope of work

11.1 Summery and conclusions

Environmental Engineering is a subject under Civil Engineering stream, which deals with the impact of the various pollutants, automobile and industrial exhaust fumes, hazardous and toxic substances, solar radiation etc, on the earths abiotic and biotic environment. It also deals with the control and protection. Public health Engineering is a part of Environmental Engineering which deals with the risk assessment on public health due to various pollutants, Hazardous substances, Toxic elements, Carcinogens, Bacteria, Radiation Hazards etc, it also deals with the control and protection. The whole world is developing rapidly, with this progress the new environmental challenges are coming infront of the Environmental Engineers. Today the atmosphere of most of the big cities of the world are covered with smog, which are very much harmful to the human health. The rivers, lakes etc are suffering from the poorly treated sewage and industrial discharges which polluting the enviroment, even the underground water sources are contaminated with toxic chemicals in some places, which increases the risk to public health. These were some of the problems to the environmental Engineers for the last few decades.

But, after the discovery of atmospheric Ozone depletion and its impact on earth's environment, it has become one of the most vital challenge for the Environmental Engineers, and this new challenge has compelled the Environmental Scientists and Engineers for further research on this issue. The Scientists and Engineers of - United States Environmental protection Agency (USEPA), United Nations Environmental Programme (UNEP), WMO, NASA, NOAA and others are already involved in work on this issue. The Scientists and Engineers of third world countries, particularly the countries near equator and tropics need be urged to get themselves involved in finding the proper solution for this global problem.

In Environmental Engineering, atmospheric ozone depletion and radiation hazards and its consequences on earth's environment, is a most dreaded global problem. This threat of ozone layer depletion has thrown a challenge to many of the environmental scientists.

Atmospheric ozone is a very minor constituent, its amount is on the average only 2.5 mm thick [reduced to S.T.P.]

Though ozone is a minor constituent of earth's atmosphere, it plays the vital role on the survival of abiotic and biotic environment. The ozone layer acts as an atmospheric filter screen, which protects life on earth against the deleterious effects of solar ultraviolet radiation (mainly 280 n.m. to 320 n.m. wavelength).

The Global ozone assessment by world Meteorological organisation (WMO) and others confirmed that atmospheric ozone is declining not only in polar regions but also throughout the world. So far various investigators presented different findings about this dreaded global aspect, but no definite conclusions about the causes of ozone depletion are available, although most of them are aware and agree about the consequences. For better understanding of this survival problem of earth's environment a long-term study and observation is needed continuously to assess the role of different parameters affecting the ozone layer.

It is known that solar UV radiation is responsible for atmospheric ozone formation as well as destruction. In the present dissertation attempt have been made to investigate the different causes of atmospheric ozone depletion. Attempt has also been made to study whether the solar radiation itself is the main cause responsible for ozone depletion. In the course of investigation, the ozone data of three stations in Antarctica such as "Halleybay", "Mcmurdo" and "Syowa" had been obtained. In Arctica ozone data of "Barrow" is considered. In Mid latitudes for both the hemispheres, the ozone data of stations "Bucharest" and "Lauder" are retrieved. In tropical geographical belt the stations "Dumdum" and "Jalpaiguri" have been considered.

For the stations in Antarctica, Arctica, Midlatitudes, and the stations in tropical region, the analysis have been made with respect to globally observed solar radiations/analytically extrapolated solar UV radiation.

It is observed from the world ozone data for different latitudes that the atmospheric (mainly stratospheric) ozone concentration is maximum in Arctic geographical belt, medium value of ozone concentration found in the Antarctica and also in Midlatitudes and low value of ozone concentration found in equatorial / tropical geographical belt, although atmospheric ozone is formed in the stratosphere mainly near the equator/tropics and after formation it is being carried out to higher latitudes by stratospheric wind.

Further the water vapour content is high in the stratosphere over the equator/tropics, which have the high potential to destroy atmospheric ozone. In addition to this if chemical loss by ClOx, NOx, BrOx etc takes place then the situation will be most alarming for this tropical and equatorial region.Ozone protective layer itself being very thin, a further thinning of this layer in this region of the earth will aggravate the situation by having a high dosage of U.V radiation penetration through this thin layer of Ozone throughout the year. The consequences of exposure by the high dosages of harmful U.V radiation in this region are manifold. . In fact this high dosage of deleterious UV radiation may have the potential to influence human and animal health such as cataract, viral infections, damage of natural immune system, skin cancer, sunburn, Photoaging of skin. Also it can influence climatic condition,viz.changes of rainfall distribution pattern , increase of air temperature leading to heat related illness and many other form of weather disturbances.

Unfortunately there is shortage of systematic observational data for long period which can be put to critical study, and this is the main obstacle to work on this environmental problem for this region, near tropics, where most of the people do not have proper education and consequently not aware of harmful solar UV related damages. Near tropic the air temperature and humidity are high throughout the year and in addition, the high dosage of deleterious solar U.V. radiation may lead to many biological damages besides climatic change.

Inspite of absence of sufficient systematic observational data an attempt has been made to study the impact of ozone change on environment (impact on climate) at "Jalpaiguri" with the daily data of column ozone (which has been retrieved from the NASA internet website) and available meteorological parameters of place like Jalpaiguri. Perhaps this is the first attempt to work on Ozone concentration variation with meteorological parameters and its impact on environment in sub-Himalayan region around "Jalpaiguri".

In absence of recorded Ozone data of Jalpaiguri for prolonged period, it was not possible to study the Ozone concentration variation for year to year, so nothing can be said about the Ozone concentration depletion at Jalpaiguri. So an attempt has been made to derive long period Ozone data (1979 to 1999) of Jalpaiguri using statistical model with respect to Ozone data of Dumdum which is available since 1979.

11.2 The findings of present dissertation work are as follows.

(1) In Antarctica the extreme decrease of Ozone concentration which has been

termed as "Ozone hole" occurs during southern late Winter to Spring and the correlation coefficients between the Ozone concentration and solar flux or the components of solar flux are highly positive and significant at 5% level, during Antarctic late Winter to Spring. That means with the increase of solar flux or the components of solar flux, the Ozone concentration should increase and vice-versa. If solar radiations or the Components of solar radiations which are associated with solar activity would have been responsible for this high decrease of Antarctic Ozone concentration, then the correlation coefficients between Ozone concentration and solar radiation or components of solar radiation should have been highly negative during Antarctic late Winter to Spring. That means with the increase of solar flux or the components of solar flux, the Ozone concentration should decrease and vice-versa. But the observation shows that the correlation coefficients are highly positive, and are significant at 5% lelvel.

Thus it may be concluded that solar parameters are not responsible for Antarctic Ozone depletion. There may be some other causes for this depletion. Taking cue from the earlier work on the subject and considering the physical possibilities it may be inferred that the man made pollutants (ClOx, NOx, BrOx etc) and some natural phenomena (HOx, sulphate aerosols from volcanic eruption, transportation of Ozone through stratospheric wind etc) may be responsible for this Antarctic Ozone depletion. The observation made by WMO (1998) shows that the spring time Ozone hole in Antarctic region will continue in coming years.

(2) In Arctic Station "Barrow" the decrease in Ozone concentration is quite noticeable in the Arctic season Spring and Autumn. The spring time Ozone loss during 1980 to 1993 was 19.36%, which is 16% in 1997 with respects to 1980. This great loss of Ozone concentration during the period 1980 to 1993 may be due to the volcanic eruption of Mt. Pinatubo, which has increased the sulfate aerosol in the upper atmosphere and have the potential to destroy significant amount of atmospheric Ozone, on the other hand the Ozone loss in Autumn during the period 1980 to 1997 was 8.35%. It is observed that the Ozone concentration at Barrow is maximum during the season spring and minimum during the season Autumn. The WMO (1998) assessment predicted a further large loss of atmospheric Ozone for Arctic region in coming years.

To investigate the role of solar flux for such drastic reduction of Ozone concentration in Arctic station Barrow the correlation coefficients are calculated between Ozone concentration and solar UV flux in the region for the period 1979 to 1984 (as UV flux data from Nimbus 7 satellite are available for Nov.'78 to Oct.'84) and it is observed that most of the correlation coefficients are highly positive and significant at 5% level during the Arctic season Autumn, when the Ozone concentration is minimum. Further the correlation coefficients are calculated between Ozone concentration and 10.7cm solar radio flux, (which has been used as a proxy of solar UV flux, the calculated correlation coefficient between Solar UV flux and radio flux is 0.95) during the period 1979 to 1999 and it is found that the most of the correlation coefficients are highly positive and significant at 5% level during the Arctic season Autumn, when Ozone concentration is found minimum in the region. This high positive correlation indicates that with the increase of solar flux, the Ozone concentration should increae and vice-versa.

The calculated correlation coefficients between Ozone concentration and UV flux or 10.7cm radio flux during the season spring are insignificant. Thus it may be concluded that the Ozone destruction in Arctic Barrow is independent of solar parameters, as it was in the case of Antarctica.

(3) The mid-latitude stations "Bucharest" in Northern hemisphere and "Lauder" in Southern hemisphere are considered for analysis. A significant amount of Ozone loss has been observed for both the stations.

It is known that solar UV radiation is responsible for Ozone formation and some quantity of Ozone destruction, observed solar UV flux data are available for Nov.'78 to Oct.'84. To derive long period solar UV flux data for assessing its role on the atmospheric Ozone depletion, a regression analysis has been made between relative sunspot number and solar U.V. flux. The correlation coefficient between sunspot number and UV flux is highly positive and definitely significant at 5% level. A linear equation for solar UV flux has been obtained from the regression analysis. By using the equation, the monthly values of solar UV flux for the period 1987 to 1997 are computed and compared with NOAA-9 satellite daily Solar UV flux which are within 1 to 2%.

The correlation coefficients between the Ozone concentration at "Bucharest" or "Lauder" and analytically extrapolated solar UV data are calculated and observed, that most of the correlation coefficients are in significant and they are not at the 5% level, which indicate that the solar parameter is not responsible for the Ozone depletion in mid latitude stations for both the hemispheres. It is concluded that the O_3 depletion during the season

Autumn and spring for both the hemispheres are independent of solar parameters, as it was in the case of Antarctica and Arctica.

So it may be summerised on available information that the possible causes of Ozone decrease in the mid-latitude geographical belt may be due to the increased sulfate aerosol in upper atmosphere due to the volcanic eruption of Mountain "Pinatubo", Man-made pollutanits NOx, CLOx, BrOx which have the potential to decrease atmospheric Ozone. Other cause of Ozone decrease may be the transpotation of Ozone depleted air from polar regions.

However, the observation made by WMO (1998) shows that the declining rate of stratospheric Ozone at mid latitudes of both the hemispheres has slowed. The projected value of loss made in WMO (1994) are greater than actually occured.

(4) The station Dumdum in West Bengal, India, has been chosen which is near tropic of cancer to study the Ozone variation around Dumdum. From the study of the available data it may be said that the Ozone concentration is minimum during late Autumn to early winter for the period 1979 to 1998. A net loss of O_3 concentration of 5.04% is found during the period 1979 to 1996.

The correlation coefficients between Ozone concentration and gross U.V flux or components of solar U.V. flux are calculated for the period 1979 to 1984 (as the observed Nimbus 7, U.V satellite data are available for Nov'78 to Oct.'84). It is found that the correlation coefficient between monthly mean O_3 concentration and monthly mean value of basic component of U.V. flux is positive and significant at 5% level during late autumn to early winter. The correlation coefficient between monthly mean value of O_3 concentration and monthly mean value of gross U.V. flux is positive and significant at 5% level during Autumn but insignificant during late autumn to early winter.

Correlation coefficient between monthly mean value of gross U.V. flux and yearly mean value of gross U.V. flux is also positive and significant at 5% level during late autumn to early winter. Other correlation coefficients are positive and significant at 5% level during late autumn to early winter except the correlation coefficient between monthly mean value of O_3 concentration and yearly mean value of O_3 concentration.

As the observed UV flux data from the Nimbus 7 satellite are available for Nov.'78 to Oct.'84, so for more critical analysis the analytically extrapoplated solar UV flux for the period 1987 to 1997 (eleven years span, i.e. one solar cycle) have been used in addition, the correlation coefficients between the value of Ozone concentration and analytically extrapolated solar UV flux for the period 1987 to 1997 are highly positive and significant at 5% level during late autumn to early winter.

If solar U.V. radiation would have been responsible for this tropical O_3 deficit, then the correlation coefficients during the period late autumn to early winter should have been highly negative and significant.

Thus it may be concluded that the tropical O_3 deficit at Indian station Dumdum (West Bengal) is independent of known solar parameters. The possible cause of this O_3deficit may be due to the increased content of HOx, ClOx, NOx, BrOx and due to the transportation of Ozone by the stratospheric wind and may be due to the factors not considered in the present work.

(5) "Jalpaiguri" is located in the sub-Himalayan region at 26.32°N, 88.46°E. From the NASA, TOMS overpass files it is possible to retrieve, total column Ozone value for any location. Since December 1997 the Ozone data are available for this particular location. To study the impact of Ozone variation on environment at Jalpaiguri, the meteorological data have been made available from the Director, Meteorology office, Jalpaiguri.

The correlation coefficients are calculated between daily Ozone concentration and daily minimum temperature or daily maximum temperature or daily rain fall. It is observed from the correlation table that the correlation coefficient between daily Ozone concentration and daily minimum temperature is found to be maximum and negative (-0.49) in the winter month of December and it is significant at 5% level.

The correlation coefficient between daily Ozone concentration and daily maximum temperature is also high and negative (-0.33) in the month of December, but it is maximum and negative (-0.61) in the month of January and it is significant at 5% level, while the correlation coefficient between daily O_3 and daily minimum temperature is also quite considerable and negative (-0.25) in the month of January. On the other hand, the correlation coefficients between daily O_3 concentration and daily rainfall (24 hrs) is found to be maximum and negative (-0.49) in the month of June (early rainy season) which is significant at 5% level, and is also negative for the months of July, August, September.

These anti correlation indicate that further Ozone decrease may cause rise in minimum and maximum temperature in the winter months, heavy rain in the early rainy season in coming decades, resulting in more warm humid climate, shorter winter, water logging and other related natural calamity in the rainy season, with chances of damage of crop. These predictions are based on the available data.

To justify these conclusions, it may be stated that the average temperature of Jalpaiguri has increased with respect to previous decades. Winter has already been shortened. The rainfall distribution pattern has been changed. A climatic change has been noticed at Jalpaiguri. Apart from deforestation, O3 depletion may be one of the potential causes for such changes.

(6) In absence of long period Ozone data of Jalpaiguri, to study the year wise atmospheric Ozone concentration variation, a regression analysis between available Ozone data of Jalpaiguri (available since December 1997) and Ozone data of Dumdum (available since 1979) has been made. The calculated correlation coefficient between a pair of 146 Nos. of sample Ozone data of Jalpaiguri and Dumdum is positive and very high (0.82), which is definitely significant at 5% level.

From the analysis, a linear empirical equation has been obtained. By using this equation, the Ozone value of Jalpaiguri has been derived for the period 1979 to 1999. The derived Ozone data has been compared with the available observed data and it is within 2%. The study for year to year variation shows a loss of 5.35 to 7.76% in winter, 5.78 to 8.5% in summer and 4 to 4.9% in rainy season at Jalpaiguri, these loss may enhance the possibility of climatic change, the risk of cataract, damage of skin, even skin cancer etc. and may cause severe harm to the ecosystem, with the present trend of loss continuing. Also these findings coroborats the earlier findings on climatic impact at Jalpaiguri. Approximate prediction for future Ozone concentration at Jalpaiguri has been made analytically, which shows 31.33% loss of Ozone concentration in the winter of 2200, compared to the present value. It is further observed that the Ozone concentration is minimum in the winter months at Jalpaiguri.

(7) It is observed that the atmospheric Ozone concentration is declining at "Halleybay", "McMurdo" and "Syowa" in Antaractica, at "Barrow" in Arctica, at "Bucharest" in Mid latitude of Northern hemishere, at "Lauder" in Mid Latitude of Southern hemisphere even at Indian station "Dumdum" near tropic and at "Jalpaiguri" in sub-Himalayan region. From critical analysis it is also observed that, though the solar radiation is responsible for atmospheric Ozone formation and some amount of Ozone destruction, but it may not be responsible for Ozone depletion, of such large magnitude.

If solar radiations were only source of production and destruction of Ozone in the stratosphere, the net concentration of Ozone due to the balance between production and destruction by photochemical reaction would vary seasonally without any cumulative loss with years. It may be easily summerised that besides the loss of Ozone by solar U.V. rays and its transport by the stratospheric winds, other chemical processes involving HOx, NOx, ClOx, BrOx and increased presence of sulfate aerosol in atmosphere due to volcanic eruption etc. might have strong contributions in the severe destruction of Ozone in the stratosphere.

(8) The impacts of atmospheric Ozone depletion on earth's environment are found to be most dreaded, which may increase the deleterious solar U.V-B. (wave length between 280 nm to 320 nm) Penetration to the earth surface. The observations made by WMO(1998) shows that the U.V-B penetration to the earth surface increases with the decrease of column Ozone. The satellite observation shows that the largest increase of U.V. occured in the spring at high latitudes during the period 1979-1992. It has the potential to damage biological system, may perturb natural ecosystem and climatic condition. The only beneficial effect of U.V-B radiation on the skin is synthesis of vitamin D_3. This vitamin is very much helpful to the bone system and for other health effect. The formation of Vitamin D_3 in the skin is self-limiting. Too much UV-B radiation does not lead to the formation of too much Vitamin D_3, rather to much of it is very much harmfull to the human health in several ways. It can damage soft biological tissues viz eye cornea, eye lens, ratina, skin, also can damage DNA(Deoxyribonucleic acid, is an essential component of all living things. It contains the genetic code, that determines the overall character and appearance of every organism), which may increase the risk of : Cataract and other eye disorders, sun burn, Photoaging of skin, malignant melanoma and non melanoma skin cancers and other skin problems, viral infections, damage of natural immune system. It may also damage plants and crops resulting in food shortage, CO_2 increase (as it is known that plants accept CO_2 and inlieu of that present O_2 in the atmosphere), which may cause green house trapping, resulting in tropospheric warming etc.

71% of the earth's surface is covered by sea water, which contribute one third of the global productivity. Due to stratospheric O_3 depletion, the increased UV-B radiation can have serious effect on these aquatic life. More than half of the world's population live in Asia and about 40% of these depend on fish for animal protein, any increase of UV-B radiation could result in the depletion of fish stock.

It is seen from the existing work that stratospheric Ozone is declining everywhere, which causes enhanced U.V-B penetration on the earth surface and tropospheric Ozone has possibly increased in some region. In the troposphere Ozone is created by the action of solar UV radiation with automobile and other exhaust fumes, Ozone also occurs in some industrial emissions. This tropospheric Ozone concentration can result increased green house trapping of long wave radiation, which may produce global warming and is expected to influence ocean current. This may alter the distribution of rainfall, causing weather disturbances. The other effects of global warming is, rise in sea level, caused by melting of ice and thermal expansion of sea water mass, which may submerge many coastal areas and disturb the ecosystem.

(9) To control atmospheric Ozone depletion, which protects the life and whole ecosystem from the deleterious effects of solar U.V. radiation, the following measures are suggested to be taken immediately :

Restriction should be imposed on the use of the pollutants, in all part of the world mainly – chloro flurocarbon, oxides of Nitrogen and Methyl Bromide and Ultimately the production of these pollutants should be stopped gradually and new substitutes need be invented, which will be economic and environment friendly, such that the new products will not deplete Ozone or it will not pollute environment in other form. Moreover it should have properties to destroy the molecules of the Pollutants which are already in atmosphere.

The Montreal protocol, 1987 which amended and adjusted on 1992 should be implemented without delay. The above mentioned precautions, if taken, shall need further backup in the form of constant monitoring of O_3 status of the atmosphere.

The arrangement of atmospheric Ozone observation should be done more thoroughly and critically. The condition of equatorial and tropical region should not be taken separately from the Polar or Midlatitude region, because the situation is already alarming throughout the earth's atmosphere. But the population wise these region viz. equatorial or tropical are most dense and need very special attention considering the alarming situation and shortage of resources to combat the ill effects of strong U.V. radiation. The environmental Scientists, Engineers and Govt. organisations of this region should be urged to get themselves involved in this issue. There is lack of observational / experimental data on U.V. radiation, Ozone concentration, Meteorological parameters and effects on biological systems. Appropriate authorities of the world and of the region need persue in particularly making the necessary policy and move in this direction keeping in mind the over all importance.

It is to be remembered that the mass population of this region is poor, do not have proper education and awareness of harmfull solar UV related damages, even do not have sufficient food and adequate clothing, mostly outdoor worker and accepting high dosage of UV radiation throughout the day and year after year. Awareness programme should start without delay. Finally the population growth should be controlled, as rise in population leads to more industrial activities and deforestation, resulting in greater damage to the natural ecological system on our planet, which may also lead to change in atmospheric Ozone concentration.

11.3 Future Scope of Work

It is observed that atmospheric Ozone concentration is low in the equatorial / tropical region in comparison with polar regions. Though atmospheric Ozone is formed mainly near these regions at the high altitude. Obviously the deleterious solar U.V. ray penetration thus maximum throughout the year. The biological system and the abiotic environment of these region are exposed to high dosage of U.V. radiation every day and year after year. The effect of this high dosage of U.V. radiation on Public health, animal health, micro organism, plants and crops, aquatic life (such as : algae, fresh water fish and other aquatic animal) and on climate (such as: maximum, minimum temperature, humidity, rain fall, etc.) of these region need to be studied thoroughly.

Further the year to year seasonal variations of atmospheric Ozone concentration at the places near equator / tropics need to be studied, as it is observed that the Ozone concentration of Indian Station Dumdum and Jalpaiguri is declining. The places of Himalayan region and the places at tropics and equator or very close to tropic and equator are to be studied. Now these region should get proper attention of the scientists and Govt. organisations, on this dreaded aspect of atmospheric Ozone depletion and its impact on environment, as the situation is already alarming. It should not be under estimated more.

It is found that the deleterious solar U.V. radiation, may increase the severe eye problem, skin problem, viral infection and damage of natural immune system etc. keeping these in mind, the effects on pathogens, which are efficient in water borne diseases are to be studied. As damage of natural immune system may lead to increase the possibilities of infections by such pathogens, which may cause epidemic. On the otherhand the effect of UV radiation, on micro-organism should be studied, so that public health engineers may assess the fate of the water treatment plants and sewage treatment plants, where the biological treatments are done. As it is known from the existing work that the effect of excess U.V.radiation can influence on cell and viruses, some of them may become in active and may lose their ability to reproduce.

Finally the effect of deforestation on Ozone variation in this region is to be studied in detail