CHAPTER - 9

The Subhimalayan Column Ozone Covariation with Meteorological Parameters and its Possible impact on Environment at Jalpaiguri

9.1 Introduction

According to the preceding Chapter - 8, the Ozone concentration value is significantly low in the tropical region and thus the solar ultraviolet penetration is maximum throughout the year. Any further Ozone modification may lead to increase solar U.V. dosage, which may cause serious impact on the environment of the region. In the present chapter the impact of atmospheric ozone change on the environment (mainly on climate) at subhimalayan Jalpaiguri (26.32° N, 88.46° E) has been analysed and perhaps this is the first attempt to work on ozone concentration variation with meteorological parameters at Subhimalayan Jalpaiguri.

The Ozone data of Jalpaiguri has been obtained from the "NASA" internet Website. From the NASA total Ozone mapping spectrometer's overpass file, it is possible to obtain the total column ozone value for any location, at the 1 degree latitude by 1.25 degree longitude resolution of the gridded ozone data. The daily total column ozone data for the period June'98 to May 99 has been obtained for each day, one by one, by inserting day, month, year, Latitude and Longitude in the particular windows. The meteorological data used are daily maximum and minimum temperatures and daily total rainfall for the same period are obtained from the Director Meteorology Office, Jalpaiguri.

Ozone resides in three regions of atmosphere - troposphere (roughly 10% of total ozone content), Stratosphere (roughly 90% of total ozone content), Mesosphere (very small quantity of ozone). The ozone in a column along these three regions of atmosphere is known as column ozone and is measured in Dobson uints. One Dobson unit (D.U.) is defined to be 0.01 mm. thickness at S.T.P. The thickness of the atmospheric Ozone layer reduced to S.T.P. is very small and varying from 1.5 mm. to 4.5 mm. averaging 2.5 mm. This thin ozone layer acts as an atmospheric protective shield, which protects the abiotic and biotic environments of the earth from the deleterious effects of Solar U.V. radiation in the 200 nm to 320 nm wavelength region, and maintain the ecological balance.

It is already established that the stratospheric ozone is created by the photo dissociation of 'O_2' by the Solar U.V. radiation (wavelength <242 nm) at an altitude between about 25 km. and 100 km. Absorption of Solar UV radiation upto about 320 nm. converts the 'O_3' back to 'O_2' and 'O' (Chapman, 1930). So the U.V radiation is responsible for creation as well as destruction of atmospheric ozone. The resultant concentration of ozone depends, at any time, on the rate of production and the rate of loss or destruction.

In the troposphere ozone is created by interaction of UV radiation with automobile and other exhaust fumes; ozone also occurs in some industrial emissions. In the troposphere ozone is a toxic constituent of photochemical smog (Last, 1993).

The global ozone assessment has shown that ozone is declining everywhere throughout the world (WMO report No. 25, 1991 and WMO bull No. 41, 1992). Decrease in atmospheric ozone concentration allows enhanced solar UV radiation (mainly UV - B, wavelength range 280 nm to 320 nm) which is very much harmful to the biosphere as well as ecosystem. This harmful UV radiation can affect severely plants and crops (Tevini and Teramura, 1989), aquatic life (Smith et. al. 1980, Bakers and Smith, 1982, Worrest 1986, Smith 1989), humans and animals (Taylor 1989, Vanderleun et. al. 1993, Ley et. al. 1989, Nikula et. al. 1992). It can also affect the climatic condition of the earth. The variation in solar UV radiation can influence tropospheric climate (Bates, J.R. 1981).

Observations over the last two decades indicate that O_3 concentration in the lower stratosphere has decreased and that tropospheric O_3 concentration has possibly increased in some regions (Stolarski et. al. 1991, McCormic et. al. 1992 and Logan 1994).

Atmospheric ozone changes can affect tropospheric climate in many ways.

Decrease in stratospheric O_3, reduced solar absorption, more solar energy reaching the earth's surface, resulting in tropospheric warming.

Increase in tropospheric O_3 will result in an increased greenhouse trapping of long wave length radiation resulting in tropospheric warming (Mackay et. al. 1997), which may produce global warming and is expected to influence the ocean current. This may alter the distribution of rainfall; weather disturbances, such as hurricanes might become more severe. The other effect of this 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 their ecosystems. Due to global warming, the temperature of the cities will rise, which may increase the heat related illness (Last, 1993).

The purpose of this Chapter is to study the covariation of daily total column ozone concentration with the daily meteorological parameters at Jalpaiguri (India) and to investigate the effects on environment.

Much work has been reported on ozone concentration in Antarctica (Farman et. al. 1985, Stolarski et. al. 1991, Logan 1994, Midya et. al. 1996) and Arctica (Schoeberl et. al. 1990, Manney et. al. 1996, Dessler et. al. 1998, Maitra et. al. - in press). But not many work, have been reported on Tropical/Equatorial region (Ilyas 1986, Maitra et.al. 1999) and perhaps this is the first attempt to work on ozone concentration variation with meteorological parameters and its impact on environment in subhimalayan region centering Jalpaiguri.

The meteorological data used are daily maximum and minimum temperatures, and daily total rainfall for the period June'98 and May'99 and are obtained from the Director, Meteorology Office, Jalpaiguri. The daily total column ozone data for the same period are obtained from the Internet Website : http://jwocky.gsfc.nasa.gov for each day for the latitude 26.32° N and Longitude 88.46° E, where the Jalpaiguri is actually situated. The meteorological data and the ozone data of Jalpaiguri are tabulated in chapter 1, Page 31 & 75 to 80.

9.2. Analysis, Discussion and Conclusions

9.2.1 Analysis :

i) From the daily total column ozone value, and daily maximum and minimum temperatures and daily total rainfall, the correlation coefficients are calculated for each month by using the statistical equation - 2.2.1.1.

Correlation Coefficient
$$r = \frac{N\,\Sigma xy - (\Sigma x)(\Sigma y)}{[N(\Sigma x^2)-(\Sigma x)^2]^{1/2}\;[N(\Sigma y^2)-(\Sigma y)^2]^{1/2}}$$

where 'x' is the daily value of meteorological parameters (minimum temperature or maximum temperature or daily total rainfall), 'y' is the daily value of total column ozone at Jalpaiguri, 'N' is the number of days for which the value of total column ozone are available for a month.

The calculated correlation coefficients are shwon in Table - 9.3.1

ii) From the daily value of total column ozone the monthly mean values are calculated to study the variation of column ozone.

9.2.2. Correlation of Total Column Ozone Concentration at Sub-himalayan Station Jalpaiguri with Various Meteorological Parameters :

From the correlation table 9.3.1 the correlation coefficient between daily mean atmospheric O_3 concentration and daily minimum temperature is found to be maximum and negative (-0.49) in the month of December and it is significant at 5% level. The correlation coefficient between daily mean atmospheric O_3 concentration and daily maximum temperature is also high and negative (-0.33) in the month of December but maximum and negative (-0.61) in the month of January and it is significant at 5% level, while the correlation coefficient between daily mean atmospheric O_3 concentration and daily minimum temperature is also quite considerable and negative (-0.25) in the month of January. On the other hand, the correlation coefficient between daily mean atmospheric O_3 concentration and daily rainfall (24 hrs.) is found to be maximum and negative (-0.49) in the month of June, which is significant at 5% level, it is also negative for the months of July, August, September and May, being positive for the month of October only.

Thus, it may be said that the correlation coefficients of atmospheric ozone concentration with daily minimum temperature, daily maximum temperature and daily rainfall at Jalpaiguri are controlled by their December - January and June values respectively.

The variation of ozone concentration and maximum temperature with respect to days in January'99 at Jalpaiguri are shown in fig,. 9.3.1 and it is seen that the variation of daily ozone concentration and daily maximum temperature at Jalpaiguri are in antiphase, which indicate that, the maximum temperature may increase with the decrease of ozone concentration value at Jalpaiguri in the winter month of January.

The variation of ozone concentration and minimum temperature with respect to days in December'98 at Jalpaiguri are shown in fig. 9.3.2 and it is seen that the variation of daily ozone concentration and daily minimum temperature at Jalpaiguri are in antiphase, which indicate that, the minimum temperature may increase with the decrease of ozone concentration value at Jalpaiguri in the winter month of December.

The variation of ozone concentration and total rainfall (24 hrs.) with respect to days in June'98 at Jalpaiguri are shown in fig. 9.3.3 and it is seen that the variation of daily ozone concentration and daily total rainfall (24 hrs) are in antiphase, which indicate that, any further decrease of ozone concentration value may cause severe rainfall at Jalpaiguri in the monsoon month of June.

9.2.3. The Possible impact on the environment at Jalpagiuri

It is found from the ozone data set that the daily column ozone concentration is minimum during December'98 - January'99 (i.e. in winter), and correlation coefficient between daily mean column ozone concentration and daily minimum temperature is maximum and negative (-0.49) in December'98; also the correlation coefficient between daily mean column ozone concentration and daily maximum temperature is maximum and negative (-0.61) in January'99 which indicates that further ozone depletion may cause rise in minimum and maximum temperature at Jalpaiguri in coming decades, resulting in more warmer and shorter winter.

On the other hand, the correlation coefficient between daily mean column ozone concentration and daily total rainfall (24 hrs.) is maximum and negative (-0.49) in June'98. It is also quite considerable and negative in July (-0.27), August (-0.34). This indicates that further ozone depletion may cause severe rain at Jalpaiguri in coming decades during monsoon, resulting in water logging and flood in the area, if drainage system is not improved. It may also damage the crop. The flood water may contaminate the drinking water sources and total unhygenic condition may arise. These predictions are based on the analysis of available data.

9.2.4. Discussion

The long period column ozone data set of Jalpaiguri (26.32° N, 88.45° E) is not available. Satellite ozone data only for few months are available on the particular latitude and longitude in the Internet, from where the twelve month daily ozone data are retrieved one by one for each day. Therefore, the yearwise ozone depletion could not be studied at Jalpaiguri. But the ozone data for Dum Dum (22.38° N, 88.28° E) are available since November 1978 in the Internet and in the paper (Maitra et. al 1999) found 5.04 percent ozone deficit at Dum Dum during the period 1979 to 1996. Moreover, global ozone assessment confirmed that O_3 is declining everywhere throughout the world (WMO report 1991, 1992, 1994, 1998). 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. May be one of the reason is deforestation, but ozone depletion factor can not be ruled out. So it may be inferred that ozone concentration is declining at Jalpaiguri also.

9.2.5. Conclusion

About 20 year ago it was realised that certain human activities can lead to significant ozone depletion and it can increase the dosage of harmful UV radiation, resulting in severe impact on earth's environment. Since then the scientists and Govt. organisations of developed countries have involved themselve to work on this issue.

It is clear that in the tropical / equatorial geographical belt the ozone thickness is significantly small and so the solar UV radiation penetration is probably maximum throughout the yaar. The effect of this high dosage of UV radiation that may have on the environment of this region need be studied and the scientists and govt. organisations of this region should be urged themselves involved in this issue. There is lack of observational / experimental data on UV radiation, ozone concentration, and meteorological parameters in this region. Appropriate authorities may make a move in this direction with the realisation of its serious importance.

The possible causes and impacts on environment of ozone depletion have been discussed in the papers (Maitra et. al. 1999, Maitra et. al. - in press) and in the present chapter, an attempt has been made to investigate the impacts on environment around Jalpaiguri.

It may conclude that the ozone depletion may affect seriously the environment at sub-himalayan Jalpaiguri in future if this present trend continues. There are possibilities to have more warm climate. The winter may be shorter. Monsoon may have more rainfall, the rainfall distribution pattern may change, such as there may be more rain in the month of June i.e. in early monsoon compared to the month of July, August, Sept.

To control ozone depletion, restriction need be imposed on the use of the pollutants, mainly chloroflurocarbon and oxides of nitrogen and ultimately the production of these pollutants should be stopped step by step and new substitute should be invented, which will be economic and environment friendly, so that it will not deplete ozone or it will not pollute environment in other form. Moreover it should have prosperities to destroy the molecules of pollutants which are already in atmosphere.

The Montreal Protocol, 1987 which amended and adjusted on 1992 (Copenhagen) should be implemented immediately, for the recovery of the ozone layer (WMO report 37, 1994). Finally the population growth should be controlled, as rise in population leads to increased demand for food, accomodation and other necessities leading to more industrial activities and emissions of different pollutants resulting in greater damage to the natural ecological system on our planet.

Table - 9.3.1

Correlation coefficient between ozone concentration and various meteorological parameters.
Station : Jalpaiguri (26.32°N, 88.48°E)

Correlation Coefficient Between	June 1998	July 1998	Aug. 1998	Sept. 1998	Oct. 1998	Nov. 1998	Dec. 1998	Jan. 1999	Feb. 1999	Mar. 1999	Apr. 1999	May 1999
1. Daily mean O_3 concentration and daily minimum temperature at Jalpaiguri.	0.005	-0.28	0.12	-0.06	0.32	0.022	-0.49	-0.25	-0.19	0.22	-0.16	0.19
2. Daily mean atmospheric O_3 concentration and daily maximum temperature at Jalpaiguri.	0.36	-0.05	-0.24	0.02	-0.17	0.3	-0.33	-0.61	0.09	-0.18	-0.07	0.23
3. Daily mean atmospheric O_3 concentration and daily rainfall (24 hrs.) at Jalpaiguri.	-0.49	-0.27	-0.34	-0.08	0.3	*	*	*	*	*	*	-0.04

(* Signifies that due to insufficient rain data, the correlation coefficients are not calculated)

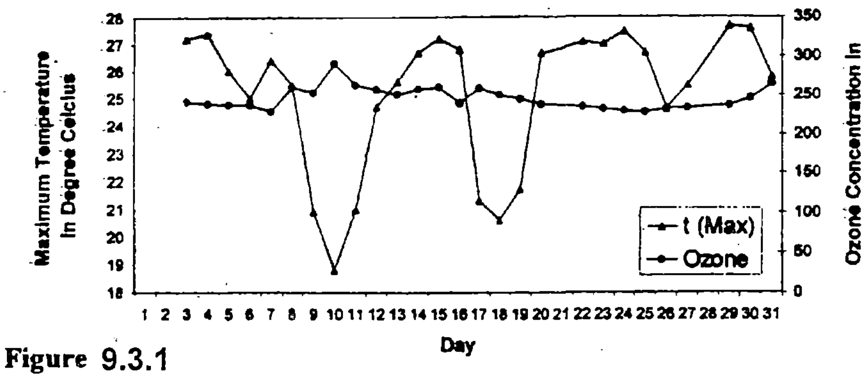

Figure 9.3.1

Variation of Ozone Concentration & Maximum Temperature with respect to Days in January'99 at Jalpaiguri

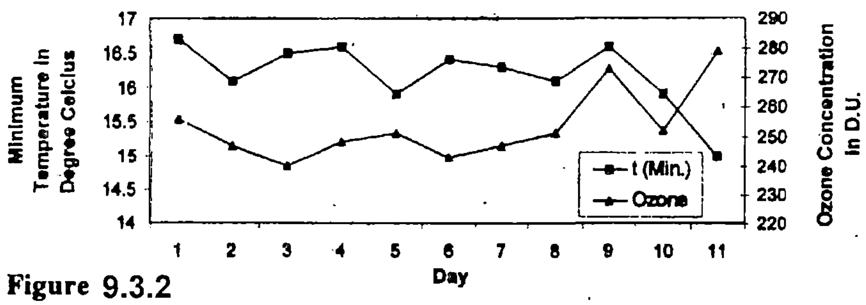

Figure 9.3.2

Variation of Ozone Concentration & Minimum Temperature with respect to Days in December'98 at Jalpaiguri

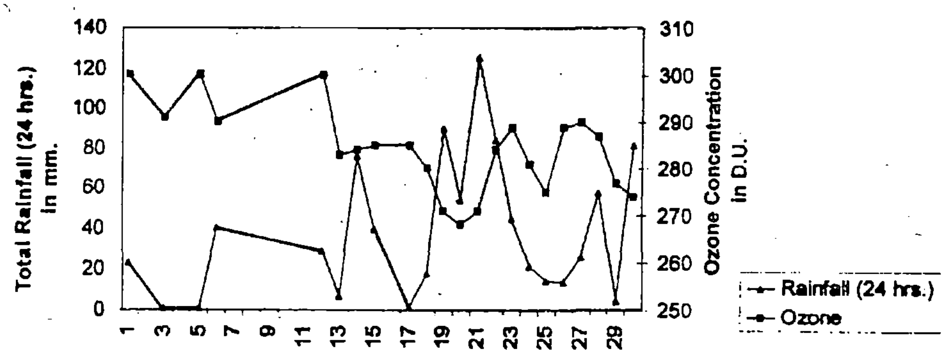

Figure 9.3.3

Variation of Ozone Concentration & Total Rainfall (24 hrs.) with respect to Days in June'98 at Jalpaiguri

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The Sub-Himalayan Column Ozone Covariation with Meteorological Parameters and Its Possible Impact on Environment at Jalpaiguri

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Abstract

An attempt was made to study the covariation of daily column ozone with the daily meteorological parameters such as daily minimum temperature, daily maximum temperature and daily total rainfall at sub-Himalayan Jalpaiguri (26.32°N, 88.46°E). From the correlation coefficients calculated and graphs plotted, it was found that ozone depletion may affect seriously the future environment at sub-Himalayan Jalpaiguri. There are possibilities to have more warmer climate. The winter may be shorter. Monsoon may have more rainfall, resulting in water logging in the vicinity, which may contaminate drinking water sources.

Ozone resides in three regions of atmosphere-troposphere (roughly 10% of total ozone content), stratosphere (roughly 90% of total ozone content), mesosphere (very small quantity of ozone). The ozone in a column covering an area 10 deg × 5 deg along these three regions of atmosphere is known as column ozone and is measured in Dobson units. One Dobson unit (DU) is defined to be of 0.01 mm thickness at STP. The thickness of the atmospheric ozone layer reduced to STP is small and varied from 1.5 mm to 4.5 mm., averaging 2.5 mm. This thin ozone layer acts as an atmospheric protective shield, which protects the abiotic and biotic environments of the earth from the deleterious effects of solar UV radiation in the 200 nm to 320 nm wavelength region, and maintain the ecological balance.

It is already established that the stratospheric ozone is created by the photo dissociation of O_2 by the solar UV radiation (wavelength <242 nm) at an altitude between about 25 and 100 km. Absorption of solar UV radiation upto about 320 nm converts the O_3 back to O_2 and O (1). So the UV radiation is responsible for creation and destruction of atmospheric ozone. The resultant concentration of ozone depends, at any time, on the rate of production and the rate of loss or destruction. In the troposphere ozone is created by interaction of UV radiation with automobile and other exhaust fumes ; ozone also occurs in some industrial emissions. In the troposphere ozone is a toxic constituent of photochemical smog (2). The global ozone assessment has shown that ozone is declining everywhere throughout the world (3, 4). Decrease in atmospheric ozone concentration allows enhanced solar UV radiation (mainly UV-B, wavelength range 280 to 320 nm.) which is very much harmful to the biosphere and ecosystem. This harmful UV radiation can affect severely plants and crops (5), aquatic life (6—9), humans and animals (10—13). It can also affect the climatic condition of the earth. The variation in solar UV radiation can influence tropospheric climate (14).

Observations over the last two decades indicate that O_3 concentration in the lower stratosphere has decreased and that tropospheric O_3 concentration has possibly increased in some regions (15—17). Atmospheric ozone changes can affect tropospheric climate in many ways : Decrease in stratospheric O_3, reduced solar absorption, more solar energy reaching the earth's surface, resulting in tropospheric warming. Increase in tropospheric O_3 will result in an increased greenhouse trapping of long wave radiation resulting in tropospheric warming (8), which may produce global warming and is expected to influence the ocean current This may alter the distribution of rainfall; weather disturbance, such as hurricanes might become more severe. The other effect of this 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 their ecosystems. Due to global warming, the temperature of the cities will rise, which may increase the heat related illness (2). The purpose of this paper is to study the covariation of daily total column ozone concentration with the daily meteorological parameters at Jalpaiguri (India) and to investigate the effects on environment.

Much work has been reported on ozone concentration in Antarctica (15, 17, 19, 20) and Arctica (21—24). But so far less work has been reported on Tropical/Equatorial region (24, 25) and perhaps this is the first attempt to work on ozone concentration variation with meteorological parameters and its impact on environment in sub-Himalayan region at Jalpaiguri.

(The authors acknowledge with regards Dr McPeters of NASA, USA for providing advice to get the ozone data of Jalpaiguri through the Internet. The authors also acknowledge with thanks Mr M. B. Sarkar and Mr I. Sengupta of Jalpaiguri Meteorology office for providing help to get the meteorological data.)

Methods

In this paper the meteorological data used are daily maximum and minimum temperatures, and daily total rainfall for the period June 1998 and May 1999 and are obtained from the Director, Meteorology Office, Jalpaiguri. The daily total column ozone data for the same period are obtained from the Internet Website : *http : // jwocky.gsfc.nasa.gov.* for each day for the latitude 26.32°N and longitude 88.46°E, where the Jalpaiguri is situated.

Analysis. Form the daily total column ozone value, and daily maximum and minimum temperatures and daily total rainfall, the correlation coefficients are calculated for each month by using the statistical equation :

Correlation Coefficient $r=$

$$\frac{N\Sigma xy-(\Sigma x)(\Sigma y)}{[N(\Sigma x^2)-(\Sigma x)^2]^{\frac{1}{2}}[N(\Sigma y^2)-(\Sigma y)^2]^{\frac{1}{2}}}$$

where x is the daily value of meteorological parameters (minimum temperature, maximum temperature or daily total rainfall), y is the daily value of total column ozone at Jalpaiguri, N is the number of days for which the values of total column ozone are available for

Table 1. Correlation coefficient between ozone concentration and various meteorological parameters at Jalpaiguri (26 32°N, 88.46°E). (a) signifies that due to insufficient rain data the correlation coefficients are not calculated.

Correlation Coefficient between	Jun 1998	Jul 1998	Aug 1998	Sep 1998	Oct 1998	Nov 1998	Dec 1998	Jan 1999	Feb 1999	Mar 1999	Apr 1999	May 1999
1. Daily mean atmospheric O3 concentration and daily minimum temperature at Jalpaiguri	0.005	−0.28	0.12	−0.06	0.32	0.022	−0.49	−0.25	−0.19	0.22	−0.16	0.19
2. Daily mean atmospheric O3 concentration and daily maximum temperature at Jalpaiguri	0.36	−0.05	0.24	0.02	−0.17	0.3	−0.33	−0.61	0.09	−0.18	−0.07	0.23
3. Daily mean atmospheric O3 concentration and daily rainfall (24 hrs.) temperature at Jalpaiguri	−0.49	−0.27	−0.34	−0.08	0.3	a	a	a	a	a	a	−0.04

a month.

(ii) From the daily values of total column ozone the monthly mean values are calculated to study the variation of column ozone.

Results

Correlation of Total Column Ozone Concentration at Sub-Himalayan Station Jalpaiguri with Various Meteorological Parameters

From the correlation data (Table 1) the correlation coefficient between daily mean atmospheric O_3 concentration and daily minimum temperature is found to be maximum and negative (—0.49) in December. The correlation coefficient between daily mean atmospheric O_3 concentration and daily maximum temperature is also high and negative (—0.33) in December but maximum and negative (—0.61) in January, while the correlation coefficient between daily mean atmospheric O_3 concentration and daily minimum temperature is also quite considerable and negative (—0.25) in January. On the other hand, the correlation coefficient between daily mean atmospheric O_3 concentration and daily rainfall (24 hours) is found to be maximum and negative (—0.49) in June. It is also negative for July, August, September and May, being positive for October only.

Thus, we may infer that the correlation coefficients of atmospheric ozone concentration with daily minimum temperature, daily maximum temperature and daily rainfall at Jalpaiguri are controlled by their December—January and June values respectively.

The variation of ozone concentration and maximum temperature with respect to days in January 1999 at Jalpaiguri are shown in Figure 1. The variation of ozone concentration and minimum temperature with respect to days in December 1998 at Jalpaiguri are shown in Figure 2. The variation of ozone concen

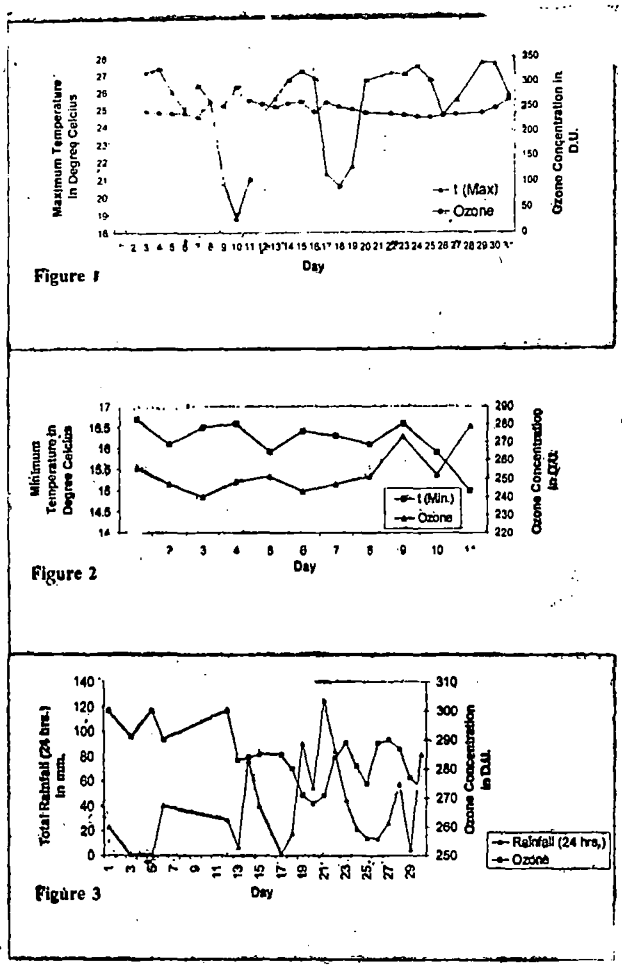

Figure 1. The sub-Himalayan column ozone covariation with meteorological parameters at Jalpaiguri, West Bengal, India. (1) Variation of ozone concentration and maximum temperature during January 1999 ; (2) variation of ozone concentration and minimum temperature during December 1998 ; (3) variation of ozone concentration and total rainfall during June 1998.

tration and total rainfall (24 hours) with respect to days in June 1998 at Jalpaiguri are shown in Figure 3.

The Possible Impact on the Environment at Jalpaiguri

It is found from the ozone data set that the daily column ozone concentration is minimum during December 1998—January 1999 (winter), and correlation coefficient between daily mean column ozone concentration and daily minimum temperature is maximum and negative (-0.49) in December 1998 ; also the correlation coefficient between daily mean column ozone concentration and daily maximum temperature is maximum and negative (-0.61) in January 1999 indicates that further ozone depletion may cause rise in minimum and maximum temperature at Jalpaiguri in coming decades, resulting in more warmer and shorter winter.

On the other hand, the correlation coefficient between daily mean column ozone concentration and daily total rainfall (24 hours) is maximum and negative (-0.49) in June 1998. It is also quite considerable and negative in July (-0.27) and August (-0.34). This indicates that further ozone depletion may cause severe rain at Jalpaiguri in coming decades during monsoon, resulting in water logging and flood in the area, if drainage system is not improved. It may also damage the crop. The flood water may contaminate the drinking water sources and total unhygenic condition may arise. These predictions are based on the available data.

Discussion

The long period column ozone data set of Jalpaiguri (26.32°N, 88.46°E) are not available Sattelite ozone data only for few months are avilable on the particular latitude and longitude in the Internet, from where the twelve month daily ozone data are retrieved one by one for each day, Therefore, the yearwise ozone depletion could not be studied at Jalpaiguri. But the ozone data for Dum Dum (22.38°N, 88.28°E) are available since 1978 in the Internet and in our other paper (24) we found 5.04% ozone depletion at Dum Dum during the period 1979 to 1996. Moreover global ozone assessment confirmed that O_3 is declining everywhere throughout the world (3, 4). So it may be inferred that ozone concentration is declining at Jalpaiguri also. 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. May be one of the reason is deforestation, but ozone depletion factor cannot be ruled out.

Conclusion

About 20 years ago it was realised that certain human activities can lead to significant ozone depletion and it can increase the dosage of harmful UV radiation, resulting in severe impact on earth's environment. Since then the scientists and government organizations of developed countries have involved them to work on this issue.

It is clear that in the tropical/equatorial geographical belt the ozone layer thickness is significantly small and obviously the solar UV radiation penetration is thus maximum throughout the year. The effect of this high dosage of UV radiation may have on the environment of this region need to be studied and the scientists and government organizations of this region should be largely involved in this issue. There is lack of observational/experimental data on UV radiation, ozone concentration, and meteorological parameters in this region.

Thus we may conclude that the ozone depletion may affect seriously the environment at sub-imalayan Jalpaiguri in future. To control ozone depletion, restriction should be imposed on the use of the pollutants, mainly, chloroflurocarbon and oxides of nitrogen and ultimately the production of these pollutants should be stopped step by step and new substitute should be invented, which will be economic and environment friendly, such that it will not deplete ozone or it will not pollute environment in other form, Moreover itshould have properties to destroy the molecules of pollutants which are already in atmosphere.

The Montreal protocol, 1987 which amended and adjusted on 1992 (Copenhagen) should be implimented immediately, for the recovery of the ozone layer (26). Finally the population growth should be controlled, as rise in population leads to increased demand for food, acommodation and other necessities leading to more industrial activities and deforestation resulting in greater damage to the natural ecological system.

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