Global Journal of Science Frontier Research: H
Environment & Earth Science
Volume 14 Issue 6 Version 1.0 Year 2014
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Correlation of Various Gaseous Pollutants with Meteorological Parameter (Temperature, Relative Humidity and Rainfall)

By R. K. Srivastava, Shampa Sarkar & Gufran Beig

Govt. Model Science College (Autonomous), India

Abstract- In the atmosphere many gaseous pollutants like CO, O_3, NO_X and CH_4 are present fluctuates with the atmospheric temperature, relative humidity (RH) and rainfall. The annual average observation of the year 2013 is presented in this paper, which shows the entire monthly average from January to December. Correlation of carbon monoxide (CO), ozone (O_3) and oxides of nitrogen (NO_X) has shown negative correlation with temperature, relative humidity and rainfall. In addition to this, methane (CH_4) also shows negative correlation with temperature and positive correlation with relative humidity and rainfall. The major fluctuation of temperature and RH was observed in the month of May (increased) whereas, in the month of August rainfall was more fluctuated (decreased).

Keywords: atmospheric temperature, relative humidity, rainfall, positive and negative correlation.

GJSFR-H Classification : FOR Code: 969999p

CORRELATIONOFVARIOUSGASEOUSPOLLUTANTSWITHMETEOROLOGICALPARAMETERTEMPERATURERELATIVEHUMIDITYANDRAINFALL

Correlation of Various Gaseous Pollutants with Meteorological Parameter (Temperature, Relative Humidity and Rainfall)

R. K. Srivastava [α], Shampa Sarkar [σ] & Gufran Beig [ρ]

Abstract- In the atmosphere many gaseous pollutants like CO, O_3, NO_X and CH_4 are present fluctuates with the atmospheric temperature, relative humidity (RH) and rainfall. The annual average observation of the year 2013 is presented in this paper, which shows the entire monthly average from January to December. Correlation of carbon monoxide (CO), ozone (O_3) and oxides of nitrogen (NO_X) has shown negative correlation with temperature, relative humidity and rainfall. In addition to this, methane (CH_4) also shows negative correlation with temperature and positive correlation with relative humidity and rainfall. The major fluctuation of temperature and RH was observed in the month of May (increased) whereas, in the month of August rainfall was more fluctuated (decreased).

Keywords: atmospheric temperature, relative humidity, rainfall, positive and negative correlation.

I. Introduction

The atmosphere is the body of gas that surrounds a planet. It acts as a bunch of all vital physical, chemical and biological properties which processes together at the same time. The major appropriate percentile of various gaseous components i.e. Nitrogen (78.09%), Oxygen (20.95%), Argon (0.93%), Carbon dioxide (0.039%) and traces amounts of neon, helium, methane, krypton, hydrogen, nitrous oxide, xenon, ozone, iodine, carbon monoxide, and ammonia are well known. The degree of balanced air decreases due to rapid and developing industrializations or urbanization. The major factors affects atmospheric quality is topography, climatic conditions and physical-chemical properties of pollutants.

Today, the discussion is going about gaseous pollutants whose fluctuation can directly or inversely affect the air quality. The primary pollutant (CO, CH_4 and NO_X) is quite less precarious than the secondary pollutants (O_3 and VOC_S). This pollutant needs to maintain their standards with the index which has made to observe its stable presence in air. Pollutants maintain their concentration with respect to the physical parameters. Temperature and rainfall are the two parameters which affect the concentration of gaseous pollutant mostly. Fluctuation of atmospheric temperature and rainfall can balance the seasonal cycle. Previously, it has noticed that the rise in temperature increased the concentration of gaseous pollutants.

Stathopoulou et. al. (2008) has observed the *impact of temperature on tropospheric ozone concentration levels in urban environments* of Athens. In the 3 monitoring stations ozone has recorded from 1996-1997 whereas continuous monitoring of temperature has recorded in 23 stations. They show linear correlation and temporal variation between ozone concentration and air temperature. Furthermore, neural arrangement it found that temperature is predominant parameters which affect the ozone concentration.

Bhardwaj (2012) analyzed wavelet and correlation of different parameters of air pollution using "*Haar Wavelet technique"* in Delhi, India. Parameters like Carbon Monoxide (CO), Nitrogen Oxide (NO), Nitrogen Dioxide (NO_2), Ozone (O_3) and Sulphur Dioxide (SO_2) were analyzed by taking hourly average. As per observation, it was found that Ozone has negative correlation with all the pollutant parameters.

Beig and Brasseur (2006) noticed the *influence of anthropogenic emissions on tropospheric ozone and its precursors over the Indian tropical region during monsoon.* During 1990s, in geographical region of India rapid human activities which include industrial and economic growth are responsible for the change in tropospheric ozone and its precursors. To study the impacts of emission in 1990-2000 a chemistry transport model (MOZART) showed maximum variation 5-10 ppbv in ozone concentration. The maximum increase in concentration of CO and NO_X i.e. 10-18% and 20-50% was observed in the boundary layer. Changes in NOx concentrations were larger than in the case of CO, and perturbations were less uniformly distributed near the surface.

Naja et. al. (2003) has observed the *diurnal and seasonal variabilities in surface ozone at a high altitude site Mt Abu (24.6°N, 72.7°E, 1680m asl) in India* by measuring surface ozone, CO and oxides of nitrogen in 1993-2000. The lower oxygen mixing ratio was observed throughout the year happened due to change during

Author α σ: Environmental Research Laboratory, P.G. Department of Environmental Science, Govt. Model Science College (Autonomous), NAAC RE-Accredited – 'A' Grade, College With Potential For Excellence, UGC, Jabalpur (M.P.) India.
e-mail: srivastavaratna@yahoo.co.in
Author ρ: Senior Scientist-F and Programme Director, Indian Institute of Tropical Meteorology (IITM) Dr. Homi Bhabha Road, Pashan, Pune-Maharashtra, India.

seasonal variation. Some meteorological parameters are responsible for the seasonal and diurnal variations. Different air samples have been analyzed for the presence of CH_4, CO and oxides of nitrogen. As a result, the average of 90 ppbv of ozone mixing ratio was found there.

The *ozone air quality and radiative forcing consequences of change in ozone precursor emissions* has studied by *West et.al. (2007).* Emissions of ozone precursors both air quality and climates has affected. To reduce NO_X, NMVOCS, CO and CH_4 concentration of surface ozone sensitivity (O_3^{srf}) and net radiative forcing of climate (RF_{net}) has estimated. The NO_x reduction increases CH_4, causes long term ozone increases. Decrease in CH_4 emissions caused the greatest RF_{net} decrease per unit reduction in O_3^{srf}, while NO_X reduction increased RF_{net}.

Multivariate methods for ground-level ozone modeling have studied by *Özbay (2011).* Multivariate statistical methods used to study tropospheric ground level ozone concentration and different meteorological parameters like PM10, SO_2, NO, NO_2, CO, O_3, CH_4, NMHC, temperature, rainfall, humidity, pressure, wind direction, wind speed and solar radiation. Bivariate correlation analysis investigated ozone data and other variable. The parameter CH_4, NMHC, NO_2 were shown negative correlation with ozone whereas highest positive correlation with temperature.

An emissions-based view of climate forcing by methane and tropospheric ozone has been studied by *Shindell et. al (2005*). Increased methane and tropospheric ozone precursor emission can simulate the atmospheric composition by a coupled chemistry-aerosol-climate model. The global annual average composition response to all emission changes is within 10% of the sum of the responses to individual emissions quantity. And methane emissions have enforced by double the precursors rather than ozone.

Correlation analysis on variation characteristics of surface ozone concentration and its precursor compounds in Chongqing has acknowledged by *Ping et. al. (2013).* The monitoring of surface ozone concentration and the correlation between ozone precursors compounds some meteorological factors shown positive correlation with solar radiation. VOCs (volatile organic compounds) were basically consistent with the variation of the ozone results. At the same time, there was a good negative correlation with NOx.

In between November 2009 to December 2011 an *observational study of surface O_3, NOx, CH_4 and Total NMHCs at Kannur, India* was done by *Nishanth et. al. (2014).* It was found that the surface O_3 concentration was higher in afternoon and declined at night. NOx concentration was exceeded during mid-night to early morning and low during noontime. The diurnal variations of mixing ratios for NOx and O_3 were anti-correlated. In December, the monthly average of CH_4 concentration was maximum (2.26 ± 0.44 ppmv) whereas in August it was minimum (0.43 ± 0.19 ppmv). The concentration of CH4 was similar to NOX which generally obtained in the early morning.

Jayamurugan et.al. (2013) has studied on the *influence of temperature, relative humidity and seasonal variability on ambient air quality in a coastal urban area* with respect to meteorological parameters. At North Chennai, during monsoon, post-monsoon, summer and pre-monsoon seasons (2010-11), SO2 and NOx were shown negative correlation in summer while positive correlation during post-monsoon season with temperature. In addition to this, RSPM and SPM had positive correlation with temperature in all the seasons except post-monsoon one. The influence of temperature on gaseous pollutants (SO2 & NOx) was effective in summer than other seasons, due to higher temperature range.

II. Significance of The Study

The selected site Pachpedi of Jabalpur is full of greenery. Observation of its air quality at a regular interval can generate useful data for prediction and further studies.

III. Material and Methodology

In the Environmental research laboratory various ambient air quality analyzers for detection of the ambient air quality are installed. The instrument *Ambient Air Quality Monitoring System (AAQMS)* was manufactured by Ecotech Australia. It consists of assembly of many transducers and analyzers employing various instrumentation techniques. These are:

a) *Ec9830 Carbon Monoxide Analyzer (Co)*

Carbon monoxide absorbs infrared radiations (IR) at wavelengths near 4.7 microns; therefore, the presence and the amount of CO can be determined by the amount of absorption of the IR. The absorption spectrum between the measured gas and other gases present in the sample is analyzed to determine the concentration of Carbon Monoxide.

b) *Carbon Monoxide (CO) Analyzer - NDIR Gas Filter Correlation Technique*

The EC9830 analyzer operates by measuring CO absorption of IR radiation at highly specific wavelengths near 4.7 microns. The broad infrared radiation (IR) that is absorbed by the CO is within the 5-meter folded path-length. The gas filter correlation wheel facilitates rejection of interference and the narrow band pass filter ensures measuring only the CO sensitive IR wavelengths. The CO content of the sample is continuously measured from a user-supplied air stream of which the instrument extracts 1 SLPM (standard liter per minute) of sample. The reference cell contains 100% CO and the measurement cell contains 100% Nitrogen (N_2).

i. *Principle of Operation*

- Non-dispersive IR gas filters correlation.
- Single channel differential measurement.
- Reference from sealed cell with CO.
- Measurement with sealed cell with N_2.
- Rotating wheel provides time sequential measurements.

c) *Ec9810 Ozone Analyzer (O_3)*

The ozone analyzer determines ozone concentrations by measuring the amount of ultraviolet light that the ozone absorbs. Ozone exhibits strong absorption in the ultraviolet spectrum around 250 nanometers (nm). The EC9810 ozone analyzer exploits this absorption feature to accurately measure ozone concentrations to less than 0.5 ppb. A stream switched, single beam photometer serves as the basis for the EC 9810. The ultraviolet light is detected by a photodiode that only responds to ultraviolet energy. The photodiode converts ultraviolet light to electrical signal that is proportional to ultraviolet light detected.

d) *EC9841 Nitrogen Oxides Analyzer (NO_X)*

The EC9841 analyzer uses gas-phase chemiluminescence detection to perform continuous analysis of nitric oxide (NO), total oxides of nitrogen (NO_X), and nitrogen dioxide (NO_2). The EC9841 design represents an advance in nitrogen oxides analysis technology achieved primarily by using adaptive microprocessor control of a single measurements channel. The instrument consists of a pneumatic system, an NO_2 to NO converter (Molygon), a reaction cell, detector (PMT), and processing electronics. The analysis for NO by chemiluminescence detector is the best direct technique. The operation is based on the chemiluminescence of activated molecular nitrogen dioxide species produced by the reaction between in an evacuated reaction cell. The NO reacts with O_3 to form the activated NO_2 species in accordance to the reaction mechanism shown below:

$$NO \longrightarrow O_3$$

$$NO + O \longrightarrow NO_2 + O_2 + hv \ (1200nm)$$

The chemiluminescence reaction is between O_3 and NO only. In order to measure the NOx (NO + NO_2) component of the sample the NO_2 must be reduced to NO prior to its entry to the reaction cell. This process is accomplished by the Molycon catalytic converter.

i. *NO_2 Converter*

The NO_2 concentration is derived by subtracting the NO signal from the NOx. To obtain accurate and stable results, the converter must operate at above 96% (US EPA) and (95% Australian standard) efficiency. The Molybdenum converter will operate at nearly 100% efficiency for in excess of 8000 ppm-hours. Maximum conversion at 99% efficiency is 7 ppm NO_2. For higher NO_2 levels a stainless steel converter that operates at 650 °C is required.

e) *Gc Alpha 115 Methane/Tnmhc*

i. *Dimensions*

The instrument is built for a 19” rack. It is advised to reserve an extra-space of 1 standard HU (at a bottom and on a top) for the instrument ventilation and to mount the arrangement on a rail.

ii. *Gas fittings*

Pressure regulators must be of gas chromatographic quality i.e. must be dust free and should not absorb or emit hydrocarbons.

iii. *Gases needed for Alpha 115*

It is use of a combination of hydrogen and zero air generators. The zero air must be equipped with a catalytic methane scrubber.

FID detector needs hydrogen flame to generate a signal. For this purpose hydrogen and clean air are needed. Zero air is also used as carrier gas in a column.

- *The Study Area*

Jabalpur is one of the major centers of Madhya Pradesh in India and is famous for its green belt. Geographically, it is located at *23.17°N 79.95°E*. It has an average elevation of 411 meters (1348 ft).

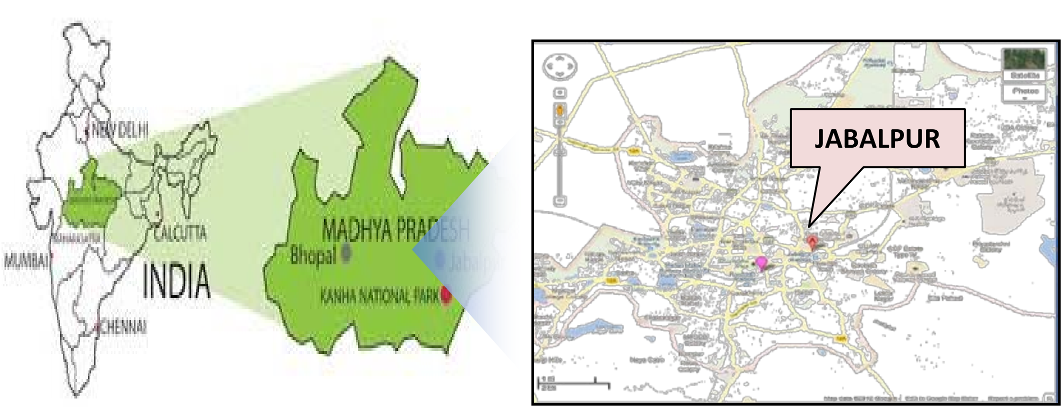

Diagram: Location pointed “Jabalpur”

Topographically, the city is surrounded by low, rocky, and barren hillocks. Jabalpur has got a humid sub-tropical climatic condition all over the year. The average temperature can rise till 45° C during summer which stretches from late March to June. The city experiences monsoon season in between June and early October with an average yearly precipitation of around 1386 mm, winter sets in during late November and stretches till early March. Average temperature in winter can fall down to as low as 7° C.

CLIMATE DATA FOR JABALPUR													
MONTH	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temp. Avg. high °C (°F)	26.5 (79.7)	28.8 (83.8)	34.3 (93.7)	38.7 (101.7)	44.4 (111.9)	36.2 (97.2)	30.3 (86.5)	28.2 (82.8)	30.9 (87.6)	32.4 (90.3)	29.7 (85.5)	26.9 (80.4)	32.28 (90.10)
Temp. Avg. low °C (°F)	6.0 (42.8)	11.4 (52.5)	16.2 (61.2)	21.2 (70.2)	24.4 (75.9)	24.1 (75.4)	22.6 (72.7)	21.9 (71.4)	21.1 (70.0)	18.1 (64.6)	13.9 (57.0)	10.6 (51.1)	17.63 (63.73)
Precipitation mm (inches)	4 (0.16)	3 (0.12)	1 (0.04)	3 (0.12)	11 (0.43)	136 (5.35)	279 (10.98)	360 (14.17)	185 (7.28)	52 (2.05)	21 (0.83)	7 (0.28)	1,062 (41.81)
Avg. precipitation days	0.8	0.8	0.3	0.3	1.8	8.6	15.9	18.3	8.6	3.1	1.4	0.6	60.5
Mean monthly sunshine hours	288.3	274.4	288.3	306.0	325.5	210.0	105.4	80.6	180.0	269.7	273.0	282.1	2,883.3
Source: *HKO*													

- *Observation Table*

Basically, Pachpedi of Jabalpur is a less polluted region. While on monitoring the ambient air by AAQMS (Ambient Air Quality Monitoring System) some gaseous pollutants like ozone (O_3), carbon monoxides (CO), methane (CH_4) and oxides of nitrogen (NO_X) have shown its fluctuated concentration. Here, the obtained monthly average data of the year 2013 is shown with the monthly average concentration of ozone, carbon monoxides, methane and oxides of nitrogen of the month January to December in Table 1:

Table 1 : Monthly average of gaseous pollutants of 2013

MONTHLY AVERAGE OF GASEOUS POLLUTANTS (2013)				
MONTH	CO ppm	O_3 ppb	NO_X ppb	CH_4 ppb
JANUARY	0.27	59	14	1327
FEBRUARY	0.18	52	12	2196
MARCH	0.21	62	11	1465
APRIL	0.24	63	11	1388
MAY	0.23	41	13	2005
JUNE	0.19	48	9	1765
JULY	0.17	33	10	2081
AUGUST	0.17	54	10	2407
SEPTEMBER	0.11	53	12	2686
OCTOBER	0.17	48	10	2564
NOVEMBER	0.16	66	14	2651
DECEMBER	0.22	53	10	2598
Annual Average	**0.19**	**53**	**11**	**2094**

As we know already that the various physical parameters are responsible for the variation of the gaseous concentrations. The parameters like temperature, relative humidity and rainfall are observed with its monthly average and obtained its annual fluctuated level graphically of the selected region (Figure 1):

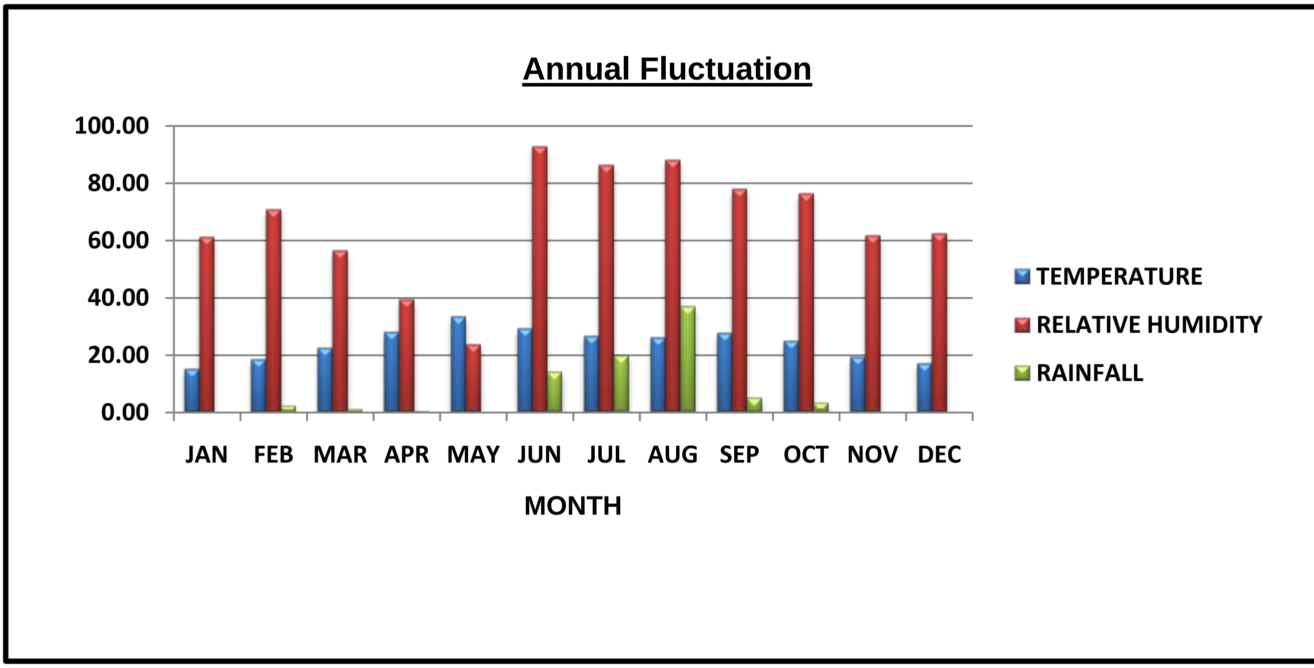

Figure 1 : Graphical presentation of relation between Temperatures, Relative Humidity and Rainfall

Table 2 : Monthly average of Temperature, Relative Humidity and Rainfall of 2013

MONTHLY AVERAGE OF TEMPERATURE, RELATIVE HUMIDITY AND RAINFALL (2013)							
MONTH	TEMPERATURE			RELATIVE HUMIDITY			RAINFALL
	MAX	MIN	Average	MAX	MIN	Average	
JANUARY	23.61	6.63	**15.12**	86.58	35.87	**61.23**	0.00
FEBRUARY	25.76	11.38	**18.57**	90.29	51.14	**70.71**	2.15
MARCH	31.78	13.42	**22.60**	81.10	31.65	**56.37**	1.07
APRIL	37.28	18.92	**28.10**	59.70	19.10	**39.40**	0.46
MAY	42.66	24.38	**33.52**	34.58	12.48	**23.53**	0.00
JUNE	34.35	24.16	**29.25**	80.43	58.70	**92.76**	14.08
JULY	29.80	23.72	**26.76**	92.90	79.74	**86.32**	19.80
AUGUST	28.82	23.43	**26.13**	94.61	81.55	**88.08**	36.93
SEPTEMBER	31.62	23.72	**27.67**	91.20	64.80	**78.00**	5.01
OCTOBER	29.65	20.24	**24.95**	90.77	61.87	**76.32**	3.35
NOVEMBER	28.10	10.85	**19.48**	90.23	33.30	**61.77**	0.00
DECEMBER	25.72	8.62	**17.17**	90.06	34.74	**62.40**	0.00
Annual Average	31.41	18.44	**24.11**	81.87	47.08	**66.41**	**6.90**

The correlation of ozone (O_3), carbon monoxides (CO), methane (CH_4) and oxides of nitrogen (NO_X) with temperature, relative humidity and rainfall has been presented and with graphically representation it has cleared with respect to annual averages (Table 3):

Table 3 : Annual Correlation of CO, O_3, NO_X and CH_4 with Temperature, Relative Humidity and Rainfall

ANNUAL CORRELATION (2013)									
	TEMPERATURE			RELATIVE HUMIDITY			RAINFALL		
	R	R^2	CORRELATION	R	R^2	CORRELATION	R	R^2	CORRELATION
CO	-0.222	0.049	Negative	-0.590	0.348	Negative	-0.345	0.119	Negative
O_3	-0.479	0.229	Negative	-0.237	0.056	Negative	-0.344	0.118	Negative
NO_X	-0.323	0.104	Negative	-0.534	0.286	Negative	-0.520	0.271	Negative
CH_4	-0.034	0.001	Negative	0.338	0.114	Positive	0.163	0.027	Positive

Where, R= correlation, R2= coefficient of determination

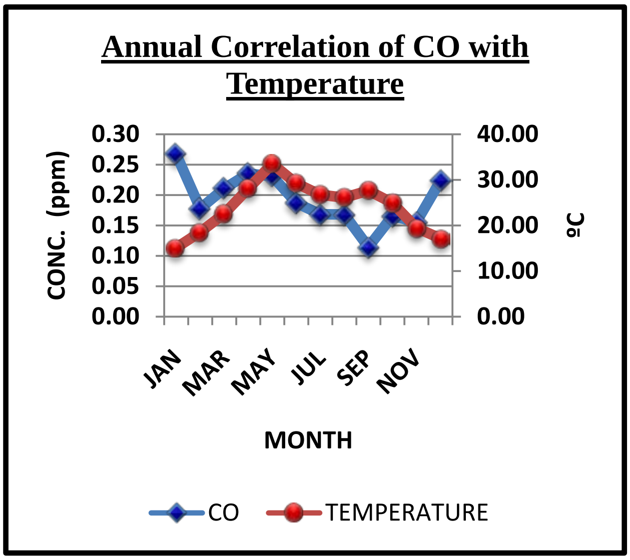

Figure 2(a) : Correlation of CO with Temp.
r^2= 0.049 (Negative Correlation)

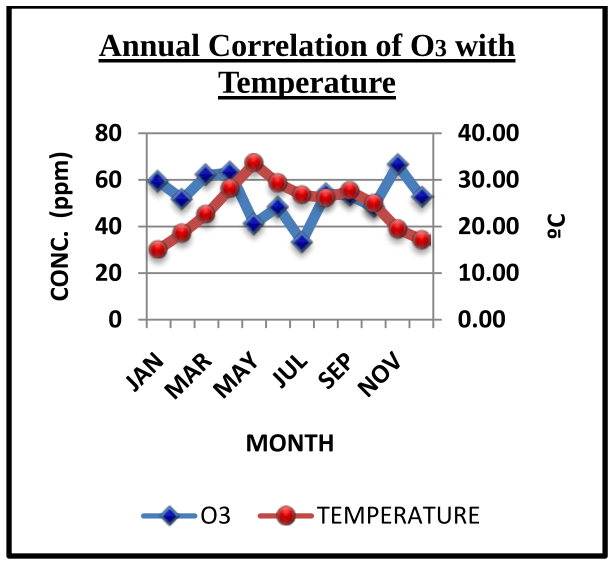

Figure 2(b) : Correlation of O3 with Temp.
r^2=.0 229 (Negative Correlation)

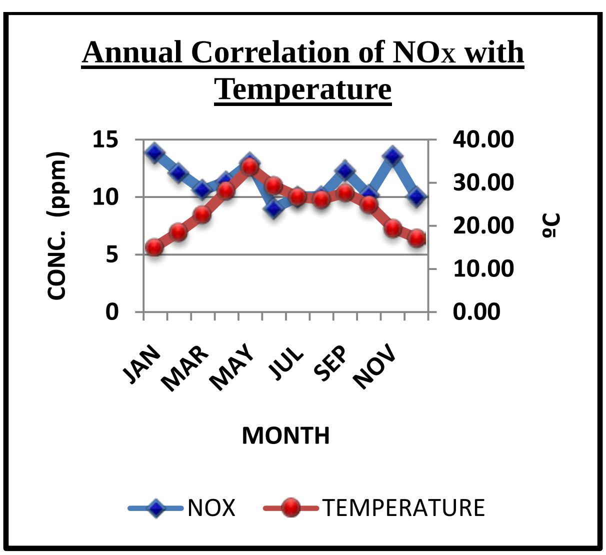

Figure 2(c): Correlation of NOX with Temp.
r^2= 0.104 (Negative Correlation)

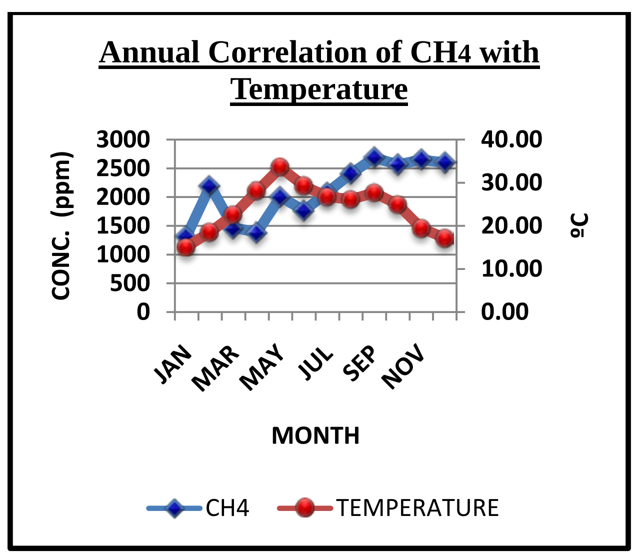

Figure 2(d) : Correlation of CH4 with Temp.
r^2= 0.001 (Negative Correlation)

Figure 2: Correlation of Temperature with carbon monoxides (CO), ozone (O_3), methane (CH_4) and oxides of nitrogen (NO_X) -

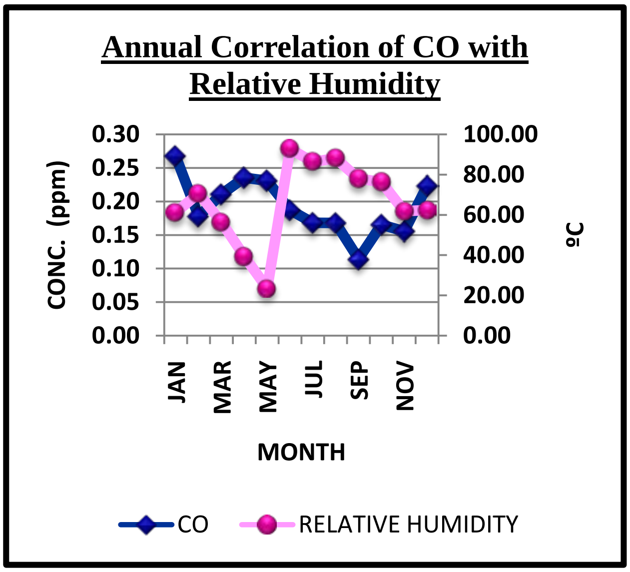

Figure 3 (a) : Correlation of CO with RH
r^2= 0.348 (Negative Correlation)

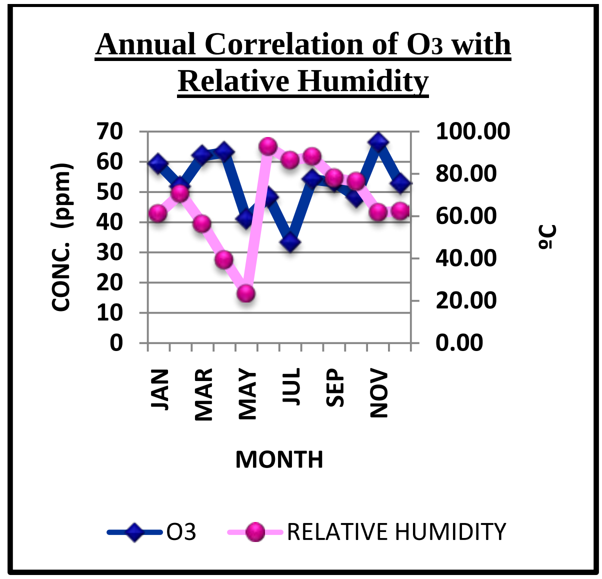

Figure 3 (b) : Correlation of O3 with RH
r^2= 0.056 (Negative Correlation)

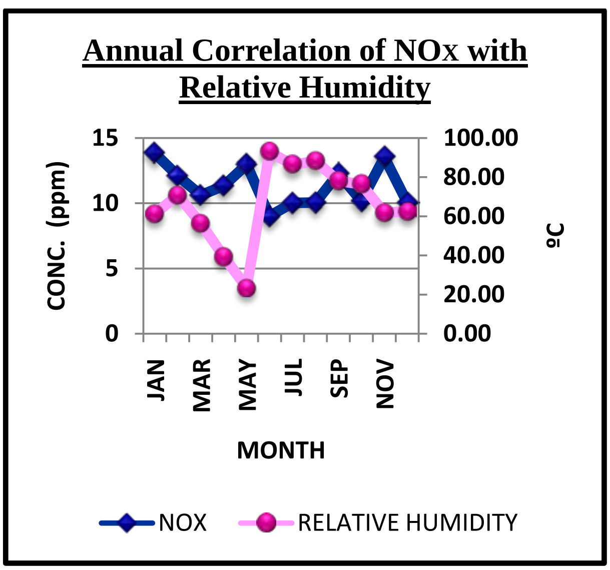

Figure 3 (c) : Correlation of NO_x with RH
r^2= 0.286 (Negative Correlation)

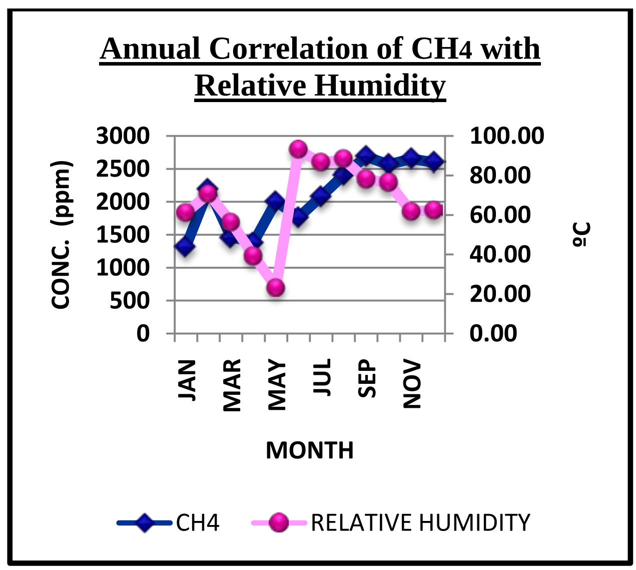

Figure 3 (d) : Correlation of CH_4 with RH
r^2= 0.114 (Positive Correlation)

Figure 3 : Correlation of Relative Humidity (RH) with carbon monoxides (CO), ozone (O_3), methane (CH_4) and oxides of nitrogen (NO_X) -

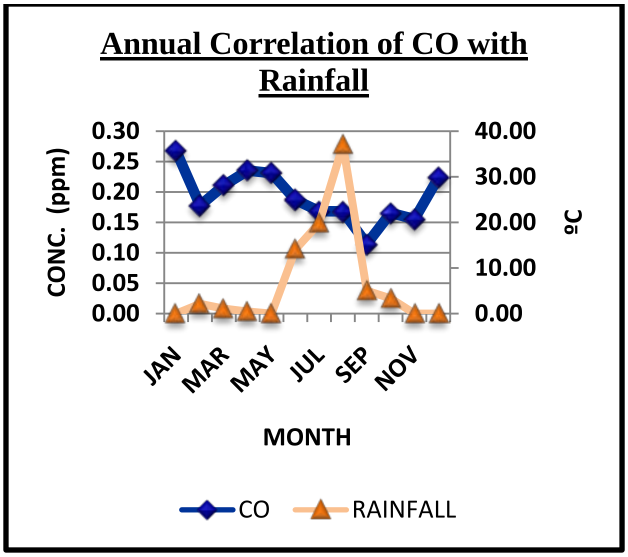

Figure 4(a) : Correlation of CO with Rainfall
$r^2 = 0.119$ (Negative Correlation)

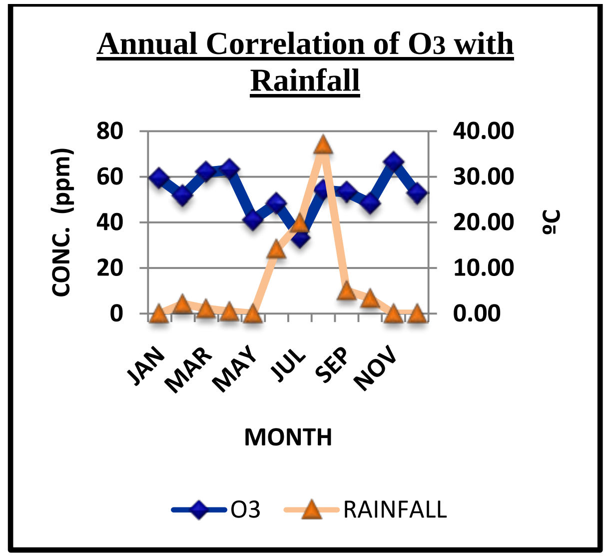

Figure 4(b) : Correlation of O_3 with Rainfall
$r^2 = 0.118$ (Negative Correlation)

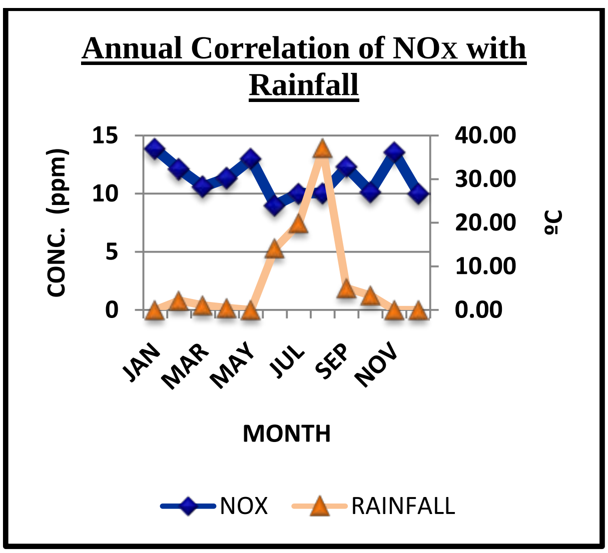

Figure 4(c) : Correlation of NO_X with Rainfall
$r^2 = 0.271$ (Negative Correlation)

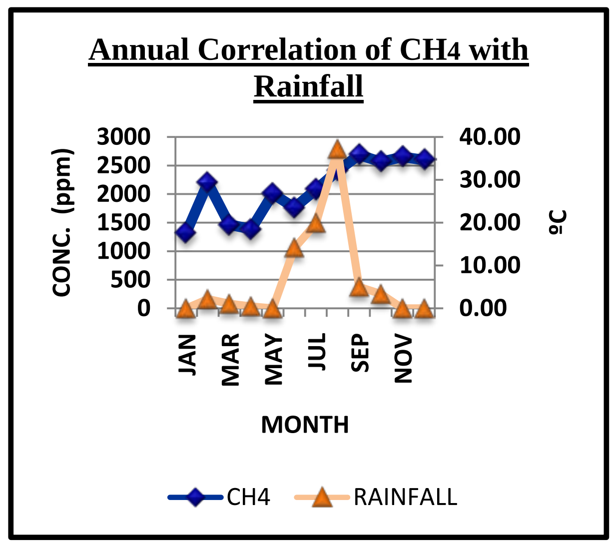

Figure 4(d) : Correlation of CH_4 with Rainfall
$r^2 = 0.027$ (Positive Correlation)

Figure 4 : Correlation of Rainfall with carbon monoxides (CO), ozone (O_3), methane (CH_4) and oxides of nitrogen (NO_X) –

IV. Result and Discussion

As per the obtained result, it has been observed that the meteorological parameters like temperature, relative humidity (RH) and rainfall affect the level of gaseous contents in the atmosphere. Table 1, shows the average value of all the gaseous pollutant while, Table 2: shows all the annual average value of temperature, relative humidity and rainfall. Table 3, represents the correlation of gaseous pollutants with meteorological parameters. Thus, it has cleared that CO has shown negative correlation with Temperature, RH and Rainfall *(R^2=0.049, 0.348 and 0.348)* respectively, in the other hand, O_3 and NO_X also shows negative correlation *(R^2= 0.229, 0.056 and 0.118, R^2= 0.104, 0.286 and 0.271)* respectively. Whereas, CH_4 shows negative correlation with temperature *(R^2= 0.001)* and positive correlation with RH and Rainfall *(R^2= 0.114 and 0.027).* The major fluctuation of temperature and RH has been observed in the month of May whereas; in the month of August, rainfall was more fluctuated. The level of ozone concentration was higher in the urban environments which may be due to solar radiation and pollutants [Stathopoulou et. al. (2008)]. The monthly highest average temperature was observed in the month of May (33.52°C) from (fig. 1), with the moderate level of monthly average of ozone and methane concentration (41 ppb and 2005 ppb) and near to maximum monthly average of CO and NO_X (0.23ppm and 13ppb) respectively. The meteorological parameters, CH_4 and NO_2 were shown to have negative correlation with ozone whereas highest positive correlation was observed with temperature. [Özbay (2011)]. As such in the respective May month, the monthly average temperature was increased in the other hand, the value of monthly average relative humidity and rainfall was declined (23% and NIL) respectively. As per Table 3, the correlation of monthly average ozone concentration with temperature shows negative correlation may be due to the monthly average temperature of entire day and night, whereas generally, the observation has taken out with the average sunshine of the day.

V. Acknowledgement

We express our thanks to Indian Institute of Tropical Meteorology (IITM), Pune to install the Ambient Air Quality Monitoring System (AAQMS) in Environmental Research Laboratory of Government Model Science College (Autonomous) Jabalpur, which helped a lot in the present study.

References Références Referencias

1. Beig, G., Brasseur, G.P. (2006). Influence of anthropogenic emissions on tropospheric ozone and its precursors over the Indian tropical region during a monsoon. *Geophysical Research Letters.* Vol. 33, L07808.
2. Jayamurugan, R., Kumaravel, B., Palanivelraja, S. and Chockalingam, M.P. (2013). Influence of Temperature, Relative Humidity and Seasonal Variability on Ambient Air Quality in a Coastal Urban Area. *International Journal of Atmospheric Sciences.* Vol. 2013, Article ID 264046, 7 pages. http://dx.doi.org/10.1155/2013/264046.
3. Naja, M., Lal, S. and Chand, D. (2003). Diurnal and seasonal variabilities in surface ozone at a high altitude site Mt Abu (24.6ºN, 72.7ºE, 1680m asl) in India. *Atmospheric Environment.* Vol. 37, pp. 4205-4215.
4. Nishanth, T., Praseed, K.M., Satheesh Kumar, M.K., Valsaraj, K. T. (2014). Observational Study of Surface O3, NOx, CH4 and Total NMHCs at Kannur, India. *Aerosol and Air Quality Research*. Vol. 14, pp. 1074–1088. doi: 10.4209/aaqr.2012.11.0323.
5. Özbay, Bilge., Keskin, Gülşen Aydın., Doğruparmak, Şenay Çetin., Ayberk, Savaş., (2011). Multivariate methods for ground-level ozone modeling. *Atmospheric Research.* Vol. 102, pp. 57–65.
6. R. Bhardwaj (2012). Wavelet & Correlation Analysis of Air Pollution Parameters Using Haar Wavelet (Level 3). *International Journal of Thermal Technologies.* Vol.2, No.2, June. ISSN 2277 – 4114.
7. Shindell, D.T., Faluvegi, G., Bell, N. and Schmidt, G.A. (2005). An emissions-based view of climate forcing by methane and tropospheric ozone. *Geophysical Research Letters*. Vol. 32, Issue 4.
8. Stathopoulou, E., Mihalakakou, G., Santamouris,, M. and Bagiorgas, H.S., (2008). On the impact of temperature on tropospheric ozone concentration levels in urban environments. *Journal Earth System Science*. Vol. 117, pp. 227-236.
9. West, J.J., Fiore, A. M., Naik, V., Horowitz, L.W., Schwarzkopf, M. D. and Mauzerall, D,L. (2007) . Ozone air quality and radiative forcing consequences of change in ozone precursor emissions. *Geophysical Research Letters.* Vol. 34, Issue 6.