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Study on the Variation of Gaseous Pollutants at the city Jabalpur

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Abstract- Gaseous pollutants have now become an atmospheric component. The reason behind this is the presence of all gaseous pollutants like CO, O_3, NO_2 and CH_4 in the atmosphere in varied levels. The rapid industrial and economic activities and the use of poor technologies in the developing countries cause discharge of these gases which lead to air pollution. The site of Jabalpur is residential in nature but the presences of these gaseous pollutants are noticeable. The study of the comparative presence of these gases in the three years 2012, 2013 and 2014 infers that CO concentration was higher in the year 2014 (0.35ppm), in the other hand O_3 and NO_2 concentration was greater in the year 2013 (55 ppb and 11.45 ppb) whereas the concentration of CH_4 was higher in the year 2012 (2603ppb).

Index Terms- Gaseous pollutants, Carbon Monoxide (CO), Ozone (O_3), Nitrogen Dioxide (NO_2), Methane (CH_4)

I. Introduction

Our atmosphere is made up of many components; which are chemical, physical, gaseous as well as biological. All the components are inter-dependent. Thus the equilibrium of environment is dependent on the physical parameters of each of the gases and the resulting impact on account of the mixture. All the meteorological parameters affect the concentration of pollutants existing in air in gaseous or particulate forms. The gaseous components compose the atmosphere. These may convert to air pollutants due to anthropogenic activities exceeding their level of concentration in the air at local levels.

Today, developing countries in their efforts to match the economy of the developed nations are adopting technological methodologies which are not optimal and scientifically up to date due to the lack of technological and scientific progress. The gaseous pollutants Ozone (O_3), Carbon Monoxide (CO), Nitrogen Dioxide (NO_2) and Methane (CH_4) are the major pollutants. These pollutants can be found in any of the developing countries because of the emissions from the industries and due to rapid pollution from vehicles and traffic jams.

Ozone concentration in atmosphere is on account of natural as well as by human activities. Production of other gaseous pollutants also happens through secondary processes on account of reaction with other chemicals or gaseous components in presence of sunlight, CO, CH_4 and NO_2.

The concentration level of O_3, CO, NO_2 and CH_4 may fluctuate diurnally and seasonally. These physical variations in the ambient air occur due to fluctuation in meteorological parameters. Thus, concentration of the gaseous pollutants and meteorological parameters are correlated. Many studies have already proven that, without the intrusion of any meteorological parameters the correlation cannot be accurate. **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 been recorded between 1996-1997 where continuous monitoring of temperature has been recorded in 23 stations. They show linear correlation and temporal variation between ozone concentration and air temperature. Further, neural arrangement showed that temperature is a predominant parameter which affects the ozone concentration.

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 been acknowledged by **Ping et.al. (2013).** The monitoring of surface ozone concentration and the correlation between ozone precursors compounds some meteorological factors have 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 exceeded during mid-night to early morning and was low during noon. 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 NO_X 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.

Analysis of Diurnal and Seasonal Behavior of Surface Ozone and Its Precursors (NOx) at a Semi-Arid Rural Site in Southern India was given by **Reddy et.al. (2012)**. In the selected site of Anantapur- surface O_3, NO, NO_2 and NOx. The O_3 concentration was highest monthly mean in April (56.1 ± 9.9 ppbv) and lowest in August (28.5 ± 7.4) ppbv. Seasonal variation in ozone concentration was highest in summer (70.2 ± 6.9 ppbv) whereas lowest in season (20.0 ± 4.7 ppbv). Other than this, higher NOx shows in winter (12.8 ± 0.8 ppbv) while lower in the monsoon season (3.7 ± 0.5 ppbv). The concentration of ozone shows positive correlation with temperature, and a negative correlation with both wind speed and relative humidity. In contrast, NOx shows positive correlation with humidity and wind speed, in addition, negative correlation with temperature.

Mansouri et.al. (2011) has studied on **the ambient concentrations of air quality parameters (O_3, SO_2, CO and PM10) in different months in Shiraz city, Iran.** The monthly variation investigation has been done for ozone, sulphur dioxide, carbon monoxide and particulate matter in Shiraz city. Data of the selected air pollutants are continuously monitored from the two stations during 2006-2009. As a result, mean monthly concentration of CO and PM_{10} was higher concentration in summer season rather than cold .

II. SIGNIFICANCE OF THE STUDY

The study is significant to gain information about the ambient air quality of the city Jabalpur. The observation has continuously monitored by AAQMS (Ambient Air Quality Monitoring System). In the upcoming years, AAQMS is going to enforce in each cities to aware the population about its importance and necessity.

III. MATERIAL AND METHOD

The Study Area:

Madya Pradesh is generally known as the heart of India. The site 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). Topographically Jabalpur is rich with forests, hills and mountains which contain lots of minerals in it. On the other hand, quality of air is getting deteriorated slowly by increasing industrialization and due to tremendous increase in number of vehicles plying on the roads.

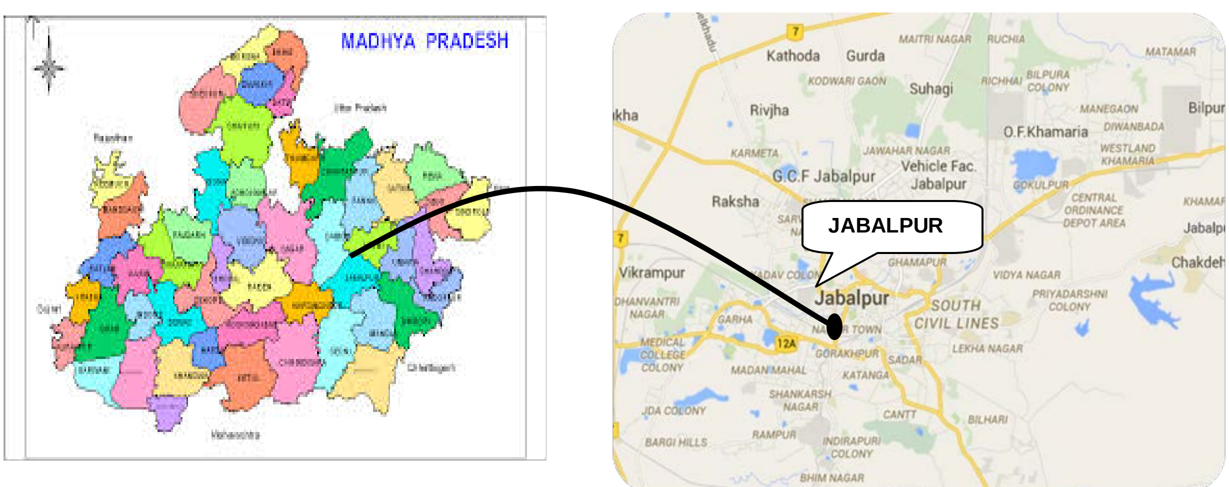

Fig. 1: Location of Jabalpur

Sampling and Investigative method:

The instrument ***Ambient Air Quality Monitoring System (AAQMS)*** was manufactured by ***Ecotech*** Australia. It is systematic, assessment of long term pollutants in the surroundings. ***Ecotech*** established the instrument for environmental monitoring that is WinAQMS (Air Quality Monitoring Station). This WinAQMS has two parts: the client as client and the server. The monitoring system consists of the assembly of many transducers and analyzers employing various instrumentation techniques. These are:

1. 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.

2. 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).

3. 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.

4. 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

$$NO \longrightarrow O_3$$

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:

$$NO + O \longrightarrow NO_2 + O_2 + h\nu \text{ (1200nm)}$$

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.

<u>NO_2 Converter:</u>

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.

5. GC ALPHA 115 Methane/TNMHC:

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.

Gas fittings:

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

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.

Observation Table:

The site for the study is quite dense related to residential area but the place of Jabalpur is also very near to green belt. While on monitoring the ambient air by AAQMS (Ambient Air Quality Monitoring System) of the city, some gaseous pollutants are found like ozone (O_3), carbon monoxides (CO), methane (CH_4) and nitrogen dioxide (NO_2). The observation of gaseous pollutants has been taken from the three consecutive years 2012, 2013 and 2014. Here, the observation tables are showing the annual average of the O_3, CO, NO_2 and CH_4:

Table 1: Annual average of Gaseous Pollutants of the year 2012

MONTH	CO	O3	NO_2	CH4
	ppm	ppb	ppb	ppb
JAN	0.24	44	11.11	2807
FEB	0.20	51	6.83	2744

MAR	0.18	50	6.36	2678
APR	0.33	53	7.14	2684
MAY	0.24	55	6.00	2432
JUN	0.20	53	5.86	2127
JUL	0.18	40	6.22	3097
AUG	0.20	31	8.15	2395
SEP	0.19	37	8.10	2750
OCT	0.20	49	9.10	2639
NOV	0.27	56	14.78	2832
DEC	0.24	57	12.53	2049
Annual Avg.	**0.22**	**47.99**	**8.51**	**2603**

Table 1: Annual average of Gaseous Pollutants of the year 2013

MONTH	**CO**	**O3**	**NO_2**	**CH4**
	ppm	**ppb**	**ppb**	**ppb**
JAN	0.27	59	14	1327
FEB	0.18	52	12	2196
MAR	0.21	62	11	1465
APR	0.24	63	11	1388
MAY	0.23	41	13	2005
JUN	0.19	48	9	1765
JUL	0.17	33	10	2081
AUG	0.17	54	10	2407
SEP	0.11	53	12	2686
OCT	0.17	48	10	2564
NOV	0.16	66	14	2651
DEC	0.22	53	10	2598
Annual Avg.	**0.19**	**53**	**11**	**2094**

Table 3: Annual average of Gaseous Pollutants of the year 2014

MONTH	**CO**	**O3**	**NO_2**	**CH4**
	ppm	**ppb**	**ppb**	**ppb**
JAN	0.29	59	14	3261
FEB	0.33	50	13	3303
MAR	0.28	54	11	3131
APR	0.50	58	11	3276
MAY	0.58	50	11	2186
JUN	0.56	39	10	2318

JUL	0.32	28	9	2140
AUG	0.19	12	9	1626
SEP	0.22	8	8	1830
OCT	0.30	13	10	2198
NOV	0.31	17	10	2516
DEC	0.30	15	10	1623
Annual Avg.	**0.35**	**34**	**10.36**	**2451**

After obtaing the data, it can be easily estimate the maximum concentration of the pollutants annually. The fluctuation in the concentration level may be due to the respective fluctuation of other pollutants. In addition to this, the physical aspects are very much essential factor to counstructing a ambient air. Thus, the comparative representation of all the gaseous pollutants of the three consecutive years (i.e. 2012, 2013 and 2014) in the atmosphere of Jabalpur has been shown here under:

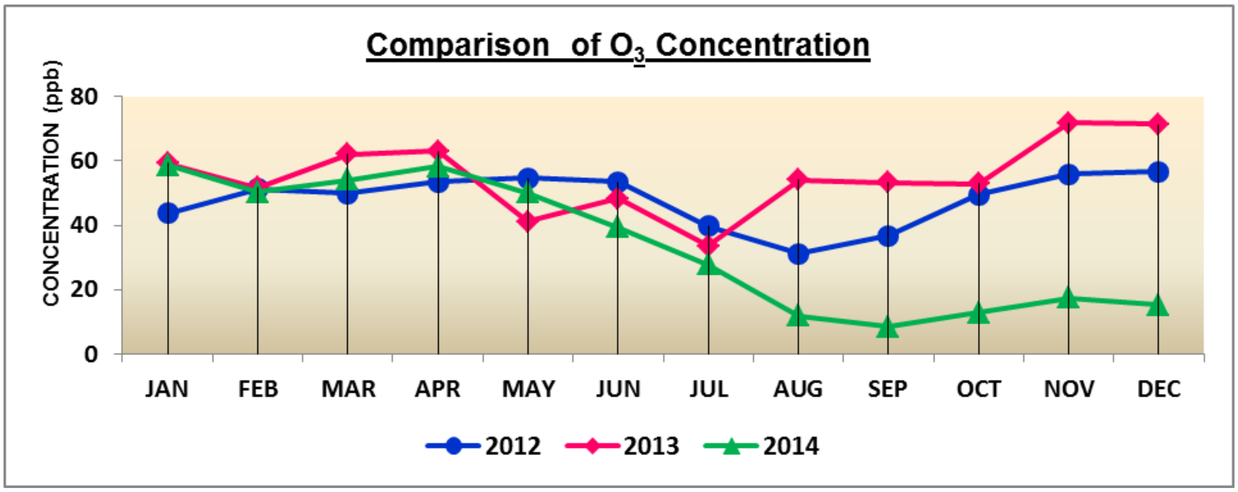

Fig. 1: Comparison of the three year annual average of O_3 concentration

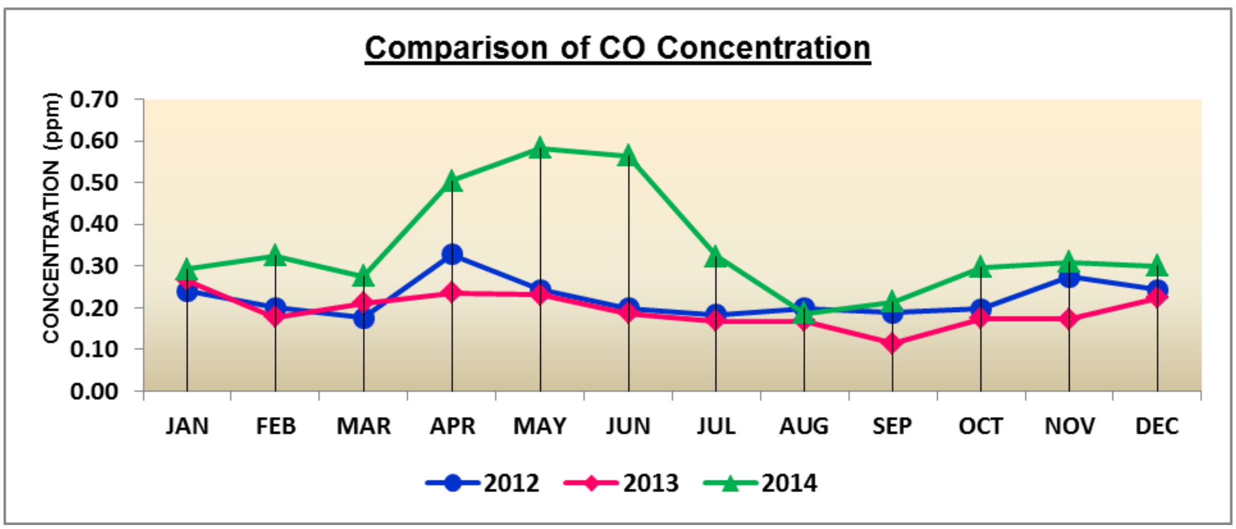

Fig. 2: Comparison of the three year annual average of CO concentration

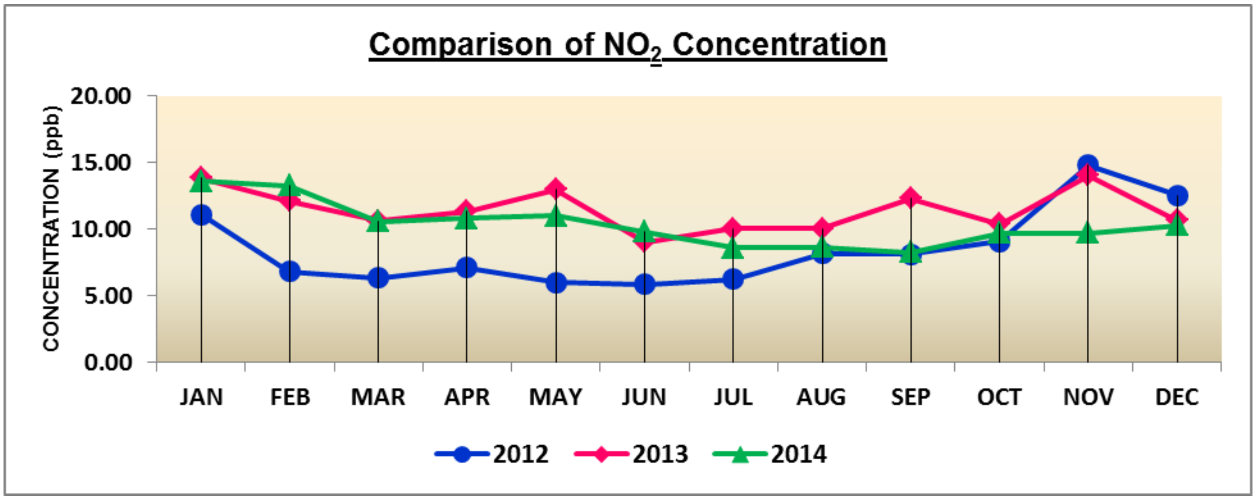

Fig. 3: Comparison of the three year annual average of NO_2 concentration

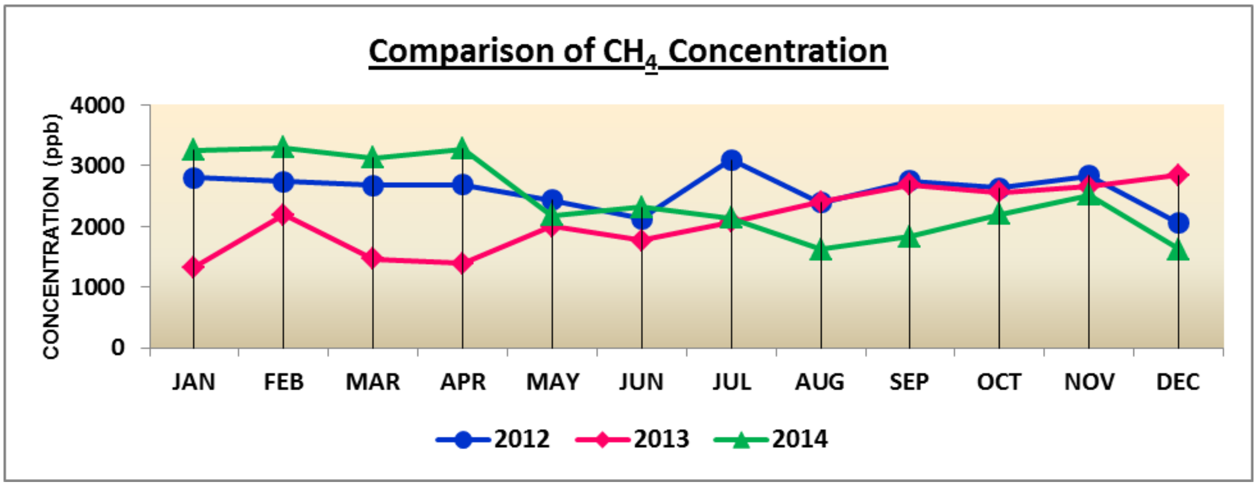

Fig. 4: Comparison of the three year annual average of CH_4 concentration

In the above graphs there has a peak value present which can easily find out and recorded. While on doing further studies or calculations this maximum or minimum levels are must be needs. Because in the study the lowest concentration can figure out the reson behind the fluctuation. While on comparing the level of polltants with respect to its concentration can be effortlessly understood by the figure which pointing the average concentration of air pollutants like CO, O_3, NO_2 and CH_4:

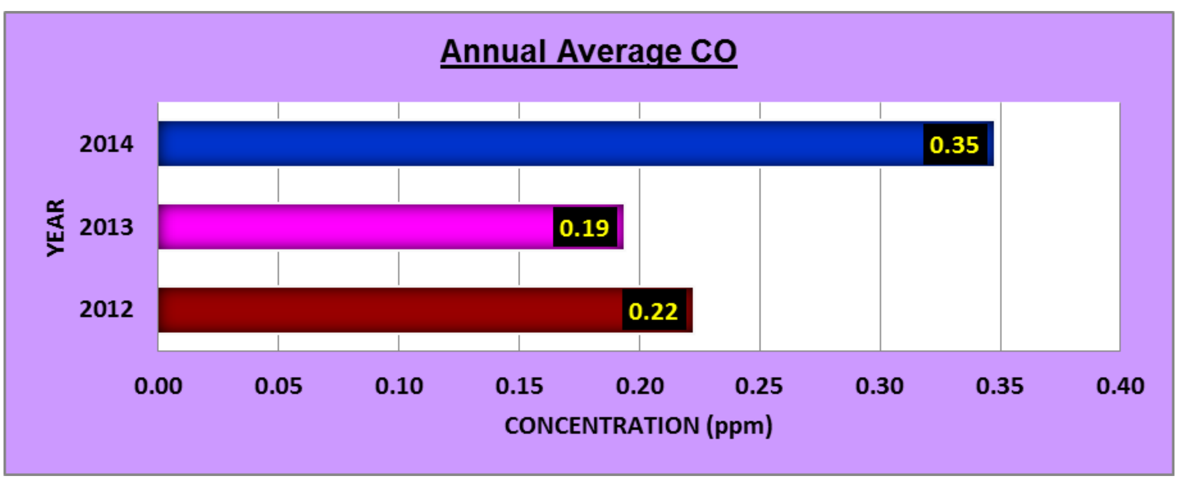

Fig. 5: Three year annual average of CO concentration

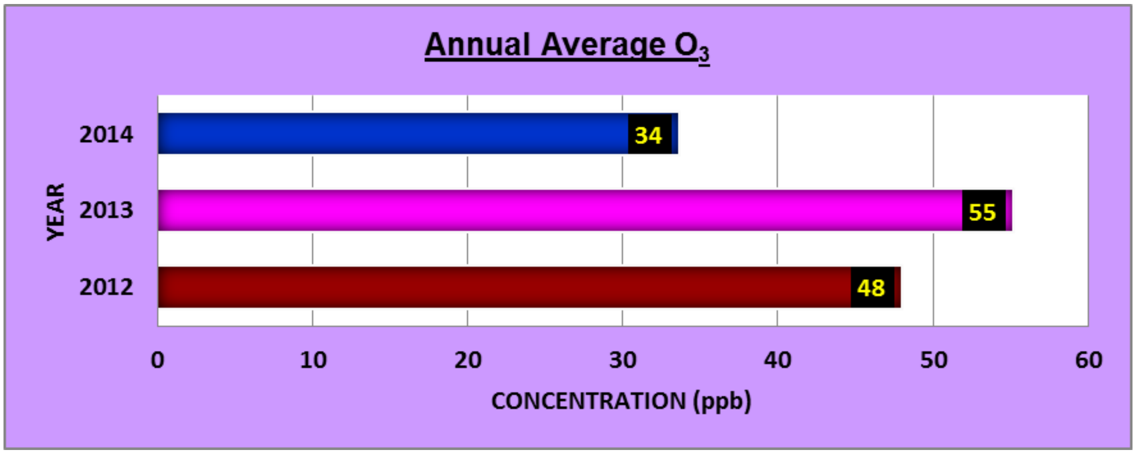

Fig. 6: Three year annual average of O_3 concentration

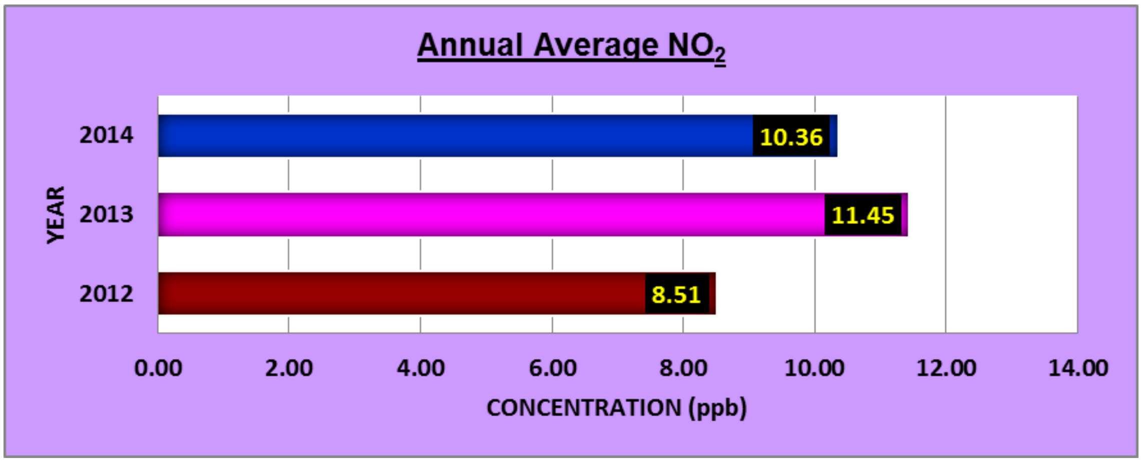

Fig. 7: Three year annual average of NO_2 concentration

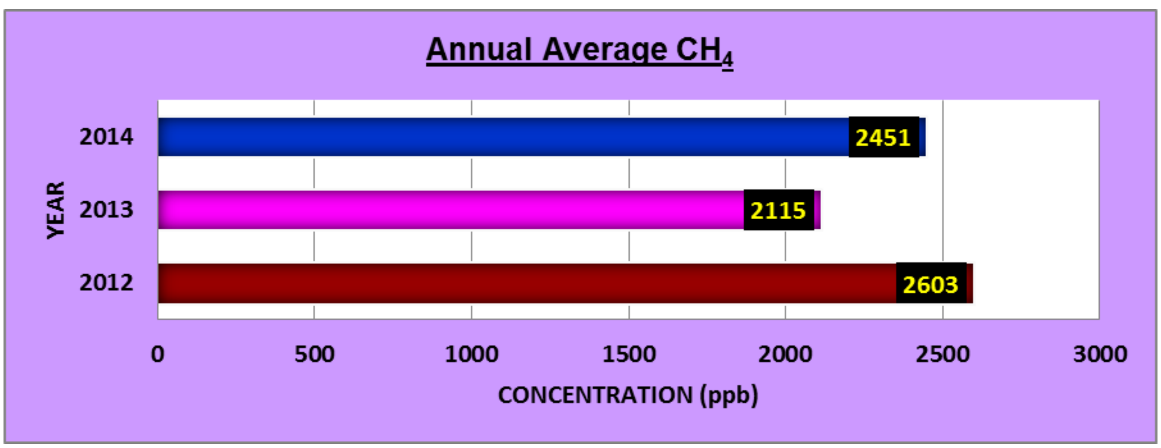

Fig. 8: Three year annual average of CH_4 concentration

IV. RESULT AND DISCUSION

The study provides all the essential information's about the air quality of Jabalpur. Three years i.e. 2012, 2013 and 2014 data shows fluctuation during day and night (diurnal). In addition to this, the annual average performs the climatic condition of the city. In the year 2012, maximum CO, O_3, NO_2 and CH_4 concentration has recorded upto 0.33 ppm (April), 57 ppb (Dec.), 14.78 ppb (Nov.) and 3097 ppb (July) respectively from Table 1. In the 2013, from Table 2: the concentration vary from 0.27 ppm (Jan.), 66ppb (Nov.), 14ppb (Jan. and Nov.) and 2686ppb (Sep.) whereas in 2014, the observation goes towards 0.58ppm (May), 59ppb (Jan.), 14ppm (Jan.) and 3303ppb (Feb.) showing in Table 3.

Incase of annual average concentration, CO was higher (0.35 ppm) in the year 2014 rather than 2012 and 2013 (Fig. 5). Concentration of O_3 and NO_2 is more in 2013 i.e. 55 ppb and

11.58 ppb respectively from Fig. 6 and 7. Whereas, in the year of 2012 methane (CH_4) concentration was increased upto 2603 ppm (Fig. 8). It has been noticed that ozone concentration was higher in afternoon and decreasing at night (Nishanth et.al.). The comparative study of the gaseous pollutants from (Fig. 1, 2, 3 and 4) the three consecutive selected years shown that the fluctuation in concentration may be vary due to the climatic condition and simultaneous because of the fluctuation in concentration of other pollutants.

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