

Study of Air Pollution trends at Lodhi Road, New Delhi through Online Monitoring Equipments

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ABSTRACT: According to a recent WHO report, New Delhi has been classified as having the world's most polluted air among any other city. The city has experienced a large boom in industrialization and urbanization. People have been negligent of their responsibility towards the onset danger of increasing air pollution. Cases of respiratory diseases are at an all-time high and people are suffering from a wide range of ailments, from Asthma to dust allergies. The SAFAR project undertaken by the Indian Meteorological Department under the aegis of IITM, Pune strives to spread awareness among the general public by monitoring air pollution levels and maintaining a visual representation in the form of an Air Quality Index. In the current study, the pollution levels during the months of November and December, because of relatively more residence time of pollutants, of the years 2012 and 2013 are compared to each other. The sampling is done at Lodhi Road in New Delhi, a serene location flanked by Lodhi gardens and other monuments of historical significance. The area is a hub for institutions and corporate offices. Online monitoring equipment supplied by ThermoFisher Scientific was used to measure levels of PM10, PM2.5, NO, NO₂, NO_x, CO, CO₂, O₃. The data thus obtained reveals that pollution levels in 2013 are higher than the previous year's. The levels are well above the acceptable standards and thus, the problem of air pollution is one that needs to be prioritized.

Keywords: Air Quality, Air Pollution, Respiratory diseases, New Delhi, Monitoring

Introduction

Environmental Pollution is considered to be among the most serious problems faced prima facie by a majority of metropolises all across the world. The rapidly increasing population, increased migration coupled with inferior technologies in use by industries and mobile vehicles are the major factors that contribute to the problem of environmental pollution. The rapid phenomenal growth of the population has been a detrimental contributor towards greater industrialization as well as increased urbanization, albeit putting tremendous pressure on the environment.

Table 1. Population characteristics of Delhi, 1951-2001

Year	Population (in millions)	Average annual exponential growth rate	Ratio of population to 1951 population
1951	1.44	7.26	100
1961	2.36	4.96	164
1971	3.65	4.36	254
1981	5.73	4.52	399
1991	8.47	3.85	586
2001	12.82	4.1	890

Source: Census of India, New Delhi, 2001.

Air pollution in such urbanized cities is associated with increased cardiac, pulmonary, neurological and vascular impairments among the populace. The exposure to harmful air pollutants may result in both, chronic and acute health effects. The acute effects are short term health impacts which are immediate and reversible when the pollution source is curbed. Eye irritation, headaches and nausea, if not prolonged, are some acute health effects. Chronic health effects are long term health effects that are not immediate and develop overtime. These are generally irreversible and remain even after the exposure to the pollutant ends. Some chronic effects that the general population may suffer are, decreased lung capacity and lung cancer.

Table 2. Industrial progress in Delhi, 1990-1996

Year	1991	1992	1993	1994	1995	1996	% growth (1991-1996)
Industrial units (in '000)	85	89	93	97	101	126	55.65

Source: Statistical Handbook, NCT of Delhi, 1997.

The Indian Institute of Tropical Meteorology (IITM), Pune, a constituent under the Ministry of Earth Sciences, Government of India, has setup the country's first major initiative named as "System of Air Quality forecasting and Research (SAFAR)". The SAFAR system was tested successfully during the Commonwealth Games 2010 for Delhi and the National Capital Region. The vision of the system is to extend the SAFAR network to all major cities in India and secure a place for the country among top environment-friendly countries of the world.

Table 3. Sources of air pollution, Delhi, 1970-1991

Category	1970-1971	1980-1981	1990-1991
Industrial	56%	40%	29%
Vehicular	23%	42%	63%
Domestic	21%	18%	8%

Source: Central Pollution Control Board, Air Quality Status and Statistics, New Delhi, 1996–1997.

The system provides location-specific near real time information on air quality and 24 hours advance forecast. The weather forecasting system designed by the Indian Meteorology Department, New Delhi complements the SAFAR system. The ultimate objective being an increase in awareness among the general public regarding air quality in the city in advance so that appropriate mitigation action and systematic measures can be adopted in time for the betterment of air quality and related health issues. The SAFAR program was launched by the MOES as a sustainable program aimed at maintaining clean air quality for the duration of the Common Wealth Games- 2010. After the culmination of the CWG-2010, the program was redesigned to collect and process air quality information for the entire city and conduct independent research. The parameters monitored include Ozone (O₃), Oxides of Nitrogen (NO_x), Carbon Monoxide (CO), Suspended Particulate Matters (PM₁₀ /PM_{2.5}), Black Carbon (BC) and Benzene. India is mostly threatened by high levels particulate pollution and ground level ozone, which are widely common in urban scenarios. The ground level ozone causes damage to lung tissues and causes breathing problems for asthmatics and those suffering from chronic lung diseases.

Airborne particles, the main constituents of smoke, haze, and airborne dust; pose significant health risks all across India. The particle size directly influences the potential to cause health problems. Particles of size equal or lesser than 10 micrometres in diameter, denoted as PM₁₀ and PM_{2.5}, are the ones that can significantly affect the heart and lungs of a person as they are too fine to be filtered by the throat and nose. Another volatile organic compound that presents a rapidly increasing risk to Delhi is Benzene, a compound if present in the ambient air, serves as a potential leukaemia-inducing agent.

SAFAR system integrates several complex components like meso-net monitoring network consisting of online air pollution analysers, automatic weather stations, emission inventory, activity data, 3 -D coupled atmospheric chemistry transport models to facilitate forecasting of several major air pollutants like: Ozone, NO_x, CO, PM_{2.5}, PM₁₀, benzene, toluene, xylene and Black Carbon. (<http://safar.tropmet.res.in>)

Table 4. Revised National Ambient Air Quality Standards (MoEF notification G.S.R 826(E), dated 16.11.2009)

S.No.	Pollutant	Time Weighted Average	Concentration in ambient air		Methods of measurement
			Industrial Area Residential, Rural & other Areas	Ecologically sensitive area (Notified by Central Govt)	
1	Sulphur Dioxide(SO ₂)	Annual Avg	50.0	20.0	-Improved West and Gaeke method -Ultraviolet fluorescence
		24 hours	80.0	80.0	
2	Oxides of Nitrogen as NO ₂	Annual Avg	40.0	30.0	-Modified Jacob and Hochheise (Sodium Arsenite) -Chemiluminescence
		24 hours	80.0	80.0	
3	Particulate Matter (size less than 10µm)	Annual Avg	60.0	60.0	-Gravimetric -TOEM -Beta attenuation
		24 hours	100.0	100.0	
4	Particulate matter (size less than 2.5 µm)	Annual Avg	40.0	40.0	-Gravimetric -TOEM -Beta attenuation
		24 hours	60.0	60.0	
5	Lead (Pb)	Annual Avg	0.50	0.50	-AAS/ICP method for sampling on EPM2000 or Equivalent Filter paper -ED-XRF using Teflon filter paper
		24 hours	1.0	1.0	
6	Carbon Monoxide (CO)	8 hours	2.0	2.0	-Non Dispersive Infra Red (NDIR) spectroscopy
		1 hour	4.0	4.0	
7	Ozone	8 hours	100.0	100.0	-Photometric -Chemiluminescence -Chemical method
		1 hour	180.0	180.0	
		24 hours	60.0	60.0	
8	Ammonia (NH ₃)	Annual Avg	100.0	100.0	-Chemiluminescence -Indo-Phenol Blue method
		24 hours	400.0	400.0	
9	Benzene	Annual Avg	5.0	5.0	-GC based continuous analyzer -Adsorption/desorption followed by GC analysis
10	Benzo(a)pyrene	Annual Avg	1.0	1.0	-Solvent extraction followed by GC/HPLC extraction
11	Arsenic	Annual Avg	6.0	6.0	AAS/ICP method for sampling on EPM2000 OR Equivalent Filter paper
12	Nickel		20.0	20.0	-AAS/ICP method for sampling on EPM2000 OR Equivalent Filter paper

Materials and Methods

Site Description

New Delhi, the capital of India is spread across a total area of about 1,484 sq. km, which can further be classified as 783 sq. km being rural and 700 sq. km being urban. Among the sizeable portion of around 6 million vehicles registered in the city, a majority uses older combustion engines that are non-compliant with current standards. Moreover, the road stretches have not been able to keep pace with the ever increasing vehicle density. A major cause of concern is the inflow of vehicles from neighbouring states into the capital as it is now a hub of corporate and industrial activities and attracts a large workforce. The city also boasts of a world renowned public transportation system consisting of an intricate network of metro rail and bus services. The average wind speed was recorded to be around 0.8 m/s and average max and min temperatures of around 22°C and 15°C during the months of November and December.

The Lodhi Road in New Delhi is a famous area known for its amalgamation of housing historical monuments as well as various educational, cultural and international institutions. Monuments such as Humayun's Tomb and Safdarjung's Tomb flank the road on the eastern and western ends respectively. The road connects Nizamuddin village to Jor bagh, as planned by Lutyens. A number of institutions such as the Indian Meteorological Department, World Bank, INTACH and Indian Habitat Centre are located in the area. It serves as a hub for offices of large Indian companies.



Figure 1. India Meteorological Department
Source: Google Maps

Parameters analysed/Equipment used/Principle of operation

Particulate Matter 2.5 and 10

Equipment: ThermoFisher FH62C14

Principle: Radiometric particulate mass monitor capable of providing real-time measurements.

The FH62C14 measures the mass concentration of ambient PM₁₀, PM_{2.5}, and PM_{1.0} aerosol in real-time. The FH62C14 monitor incorporates time-averaged measurements of an integral beta attenuation mass sensor.

Source: ThermoFisher Scientific FH62C14 Instruction Manual

NO/NO₂/NO_x

Equipment: ThermoFisher Model 42i Trace Level

Principle: Nitric oxide (NO) and ozone (O₃) react to produce a characteristic luminescence with intensity linearly proportional to the NO concentration. Infrared light emission results when electronically excited NO₂ molecules decay to lower energy states.

The ozonator generates the ozone needed for the chemiluminescent reaction. At the reaction chamber, the ozone reacts with the NO in the sample to produce excited NO₂ molecules. A photomultiplier tube (PMT) housed in a thermoelectric cooler detects the luminescence generated during this reaction. The NO and NO_x concentrations calculated in the NO and NO_x modes are stored in memory. The difference between the concentrations is used to calculate the NO₂ concentration.

ThermoFisher Scientific Model 42i Trace Level Instruction Manual

Ozone

Equipment: Model 49i Primary Standard

Principle: ozone (O₃) molecules absorb UV light at a wavelength of 254 nm. The degree to which the UV light is absorbed is directly related to the ozone concentration as described by the Beer-Lambert Law:

$$\frac{I}{I_0} = e^{-KLC}$$

where:

K = molecular absorption coefficient, 308 cm⁻¹ (at 0°C and 1 atmosphere)

L = length of cell, 38 cm

C = ozone concentration in parts per million (ppm)

I = UV light intensity of sample with ozone (sample gas)

I₀ = UV light intensity of sample without ozone (reference gas)

ThermoFisher Scientific Model 49i Primary Standard Instruction Manual

CO₂

Equipment: Model 410i Optical Filter CO₂ Analyzer

Principle: carbon dioxide (CO₂) absorbs infrared radiation at a wavelength of 4.26 microns.

The Model 410i uses an internally stored calibration curve to accurately linearize the instrument output over any range up to a concentration of either 10,000 ppm (Standard) or 25% (High Level).

Source: ThermoFisher Scientific Model 410i Instruction Manual

CO

Equipment: Model 48i Gas Filter Correlation CO Analyzer

Principle: Carbon monoxide (CO) absorbs infrared radiation at a wavelength of 4.6 microns.

The Model 48i uses an internally stored calibration curve to accurately linearize the instrument output over any range up to a concentration of 10,000 ppm.

Source: ThermoFisher Scientific Model 48i Instruction Manual

Data Analysis and Observations

The daily average concentrations of PM10, PM2.5, NO, NO₂, NO_x, CO, CO₂, O₃ in the months of November 2012 (1-11-2012 to 30-11-2012), December 2012(1-12-2012 to 31-12-2012), November 2013(1-11-2013 to 30-11-2013) and December 2013(1-12-2013 to 31-12-2013) were recorded from the IMD Lodhi Road station.

The average concentrations of PM10, PM2.5 were recorded from midnight(00:00) to midnight (00:00) of next day.

The average concentrations of all other pollutants were recorded from sunrise to sunset of each month.

The times at which the monitors were down due to maintenance purposes, N/A is used to denote Non-Availability of data.

The average sunrise and sunset times of the months of November and December of 2012 and 2013 are as follows:

Table 5.

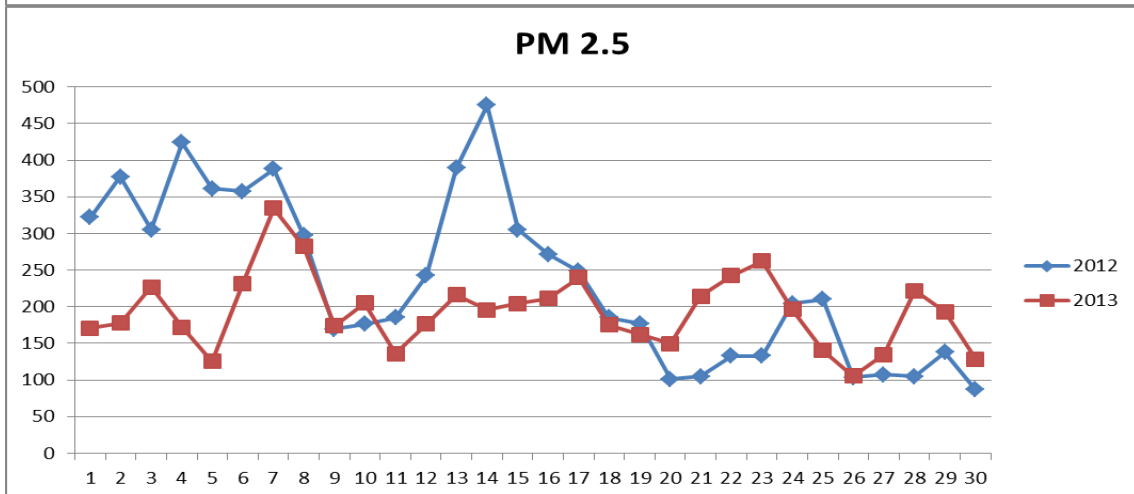
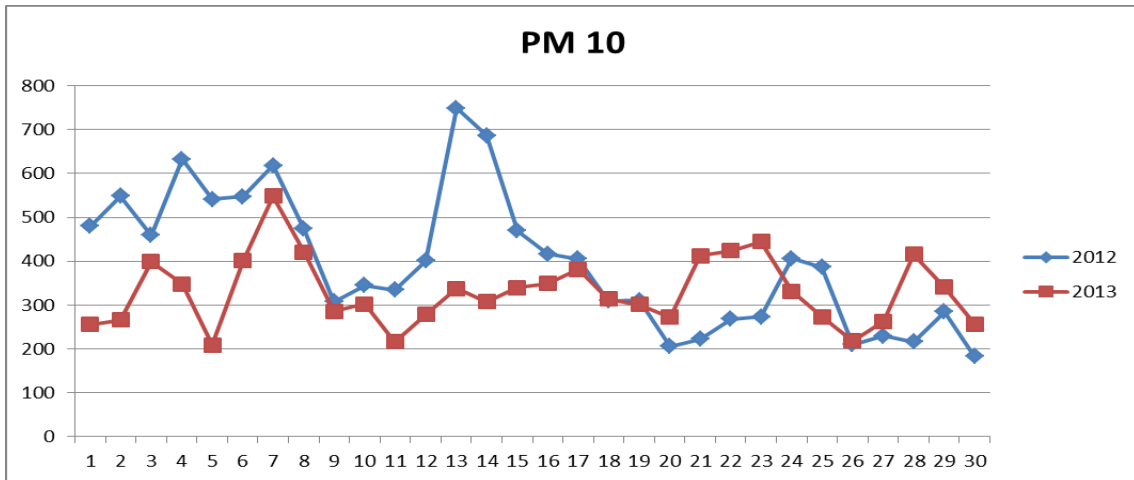
Month - Year	Sunrise time (Average) (Rounded off)	Sunset time (Average) (Rounded off)
November - 2012	7:00	17:00
December - 2012	8:00	17:00
November - 2013	7:00	17:00
December - 2013	8:00	17:00

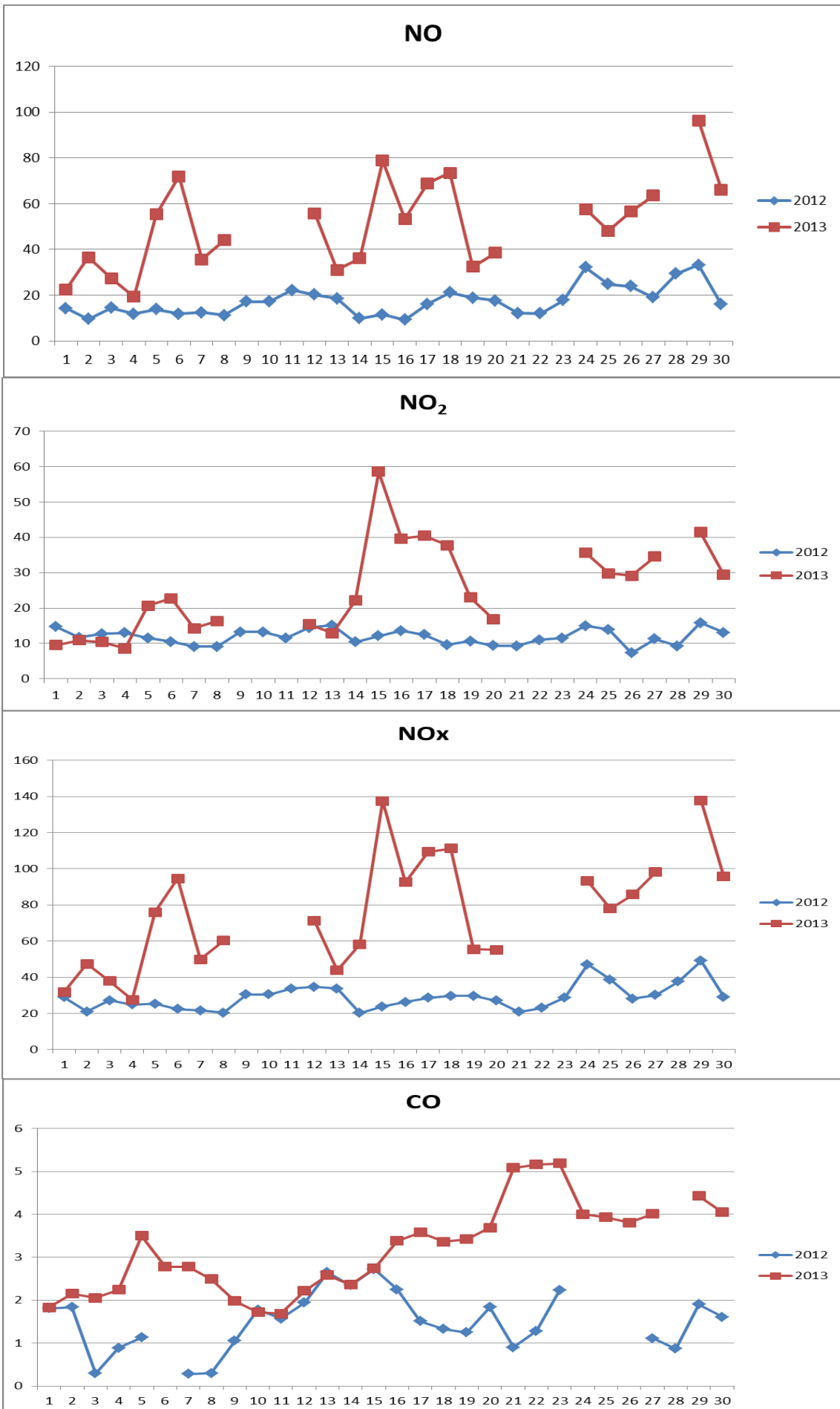
Table 6. November - 2012

Date	PM10 (ug/m ³)	PM2.5 (ug/m ³)	NO (ppb)	NO ₂ (ppb)	NO _x (ppb)	CO (ppm)	CO ₂ (ppm)	O ₃ (ppb)
01-11-2012	480.39	321.96	14.25	14.69	28.94	1.81	159.76	85.73
02-11-2012	548.32	377.26	9.63	11.63	21.00	1.84	121.81	57.61
03-11-2012	459.02	305.26	14.44	12.68	27.13	0.29	185.60	N/A
04-11-2012	633.09	423.97	11.87	12.95	24.82	0.89	169.11	N/A
05-11-2012	540.97	360.97	13.81	11.49	25.31	1.13	185.91	8.20
06-11-2012	547.26	357.13	11.93	10.50	22.43	N/A	152.00	10.20
07-11-2012	618.49	387.99	12.49	9.11	21.60	0.28	153.39	32.20
08-11-2012	473.49	297.25	11.23	9.08	20.31	0.30	294.18	23.06
09-11-2012	307.71	169.42	17.26	13.26	30.53	1.05	423.65	26.14
10-11-2012	344.53	176.16	17.22	13.26	30.49	1.78	417.08	12.91
11-11-2012	334.09	185.32	22.18	11.48	33.66	1.57	414.57	16.00
12-11-2012	401.08	242.19	20.22	14.48	34.71	1.94	N/A	20.48
13-11-2012	748.62	388.84	18.64	15.14	33.79	2.65	N/A	36.68
14-11-2012	686.71	474.89	9.83	10.42	20.26	2.35	449.37	46.19
15-11-2012	469.08	305.19	11.61	12.11	23.71	2.72	393.62	43.82
16-11-2012	416.76	271.31	9.22	13.58	26.31	2.25	402.97	38.37
17-11-2012	405.09	248.29	16.11	12.41	28.53	1.51	388.78	43.70
18-11-2012	309.99	185.12	21.12	9.58	29.61	1.33	372.19	37.97
19-11-2012	311.09	176.82	18.94	10.66	29.61	1.25	333.63	35.78
20-11-2012	205.89	100.77	17.59	9.38	26.97	1.84	337.81	34.93
21-11-2012	221.99	104.51	12.09	9.25	20.87	0.90	355.85	41.14
22-11-2012	268.42	132.80	12.08	10.96	23.04	1.28	367.63	36.31
23-11-2012	272.82	132.88	17.79	11.54	28.72	2.23	399.83	34.86
24-11-2012	406.50	204.45	32.09	14.96	47.05	N/A	465.49	25.32
25-11-2012	386.44	210.01	24.86	13.89	38.76	N/A	441.10	25.12
26-11-2012	209.42	103.33	23.88	7.28	28.18	N/A	439.44	18.16
27-11-2012	229.54	106.99	19.04	11.26	30.13	1.11	455.97	27.86
28-11-2012	215.88	104.60	29.42	9.27	37.55	0.87	444.03	30.30
29-11-2012	284.80	137.48	33.22	15.86	49.10	1.90	504.01	21.99
30-11-2012	183.17	86.87	15.94	13.07	29.02	1.61	455.04	21.02

Table 7. November – 2013

Date	PM10 (ug/m ³)	PM2.5 (ug/m ³)	NO (ppb)	NO ₂ (ppb)	NO _x (ppb)	CO (ppm)	CO ₂ (ppm)	O ₃ (ppb)
01-11-2013	255.26	170.48	22.57	9.47	31.90	1.83	319.71	31.26
02-11-2013	266.15	177.76	36.49	10.93	47.42	2.15	341.49	39.60
03-11-2013	399.32	226.88	27.43	10.42	37.85	2.05	305.28	N/A
04-11-2013	347.88	172.24	19.31	8.57	27.56	2.24	349.72	30.06
05-11-2013	208.42	125.52	55.33	20.63	75.93	3.50	375.90	16.86
06-11-2013	400.59	231.97	71.92	22.71	94.64	2.78	355.87	25.52
07-11-2013	548.49	334.66	35.66	14.23	49.81	2.78	339.98	19.93
08-11-2013	420.49	282.19	44.01	16.36	60.35	2.49	384.88	20.07
09-11-2013	285.31	173.64	N/A	N/A	N/A	1.98	304.34	21.75
10-11-2013	301.88	205.24	N/A	N/A	N/A	1.72	270.85	25.84
11-11-2013	216.15	135.97	N/A	N/A	N/A	1.69	269.75	27.15
12-11-2013	278.80	176.53	55.85	15.40	71.21	2.22	289.68	30.40
13-11-2013	337.24	216.07	31.14	12.85	43.78	2.58	293.06	29.89
14-11-2013	307.39	195.63	36.18	22.09	58.21	2.36	309.80	28.25
15-11-2013	339.67	204.62	78.85	58.60	137.40	2.74	296.00	31.12
16-11-2013	349.05	210.89	53.31	39.64	92.56	3.38	298.54	30.97
17-11-2013	381.21	239.72	68.94	40.44	109.34	3.58	290.20	32.51
18-11-2013	314.11	175.36	73.53	37.72	111.24	3.36	273.64	29.99
19-11-2013	301.77	162.32	32.52	22.96	55.46	3.42	272.75	25.12
20-11-2013	272.09	149.57	38.52	16.73	55.12	3.69	281.57	26.85
21-11-2013	412.01	214.44	N/A	N/A	N/A	5.08	343.23	18.08
22-11-2013	423.79	242.25	N/A	N/A	N/A	5.16	343.68	24.82
23-11-2013	444.69	262.24	N/A	N/A	N/A	5.19	319.99	29.67
24-11-2013	330.99	196.01	57.60	35.65	93.24	4.00	285.78	17.11
25-11-2013	273.59	140.34	48.19	29.79	77.99	3.93	273.73	25.59
26-11-2013	217.83	105.33	56.61	29.12	85.74	3.807	264.68	27.88
27-11-2013	262.46	134.62	63.55	34.57	98.10	4.01	281.81	31.71
28-11-2013	415.03	221.93	N/A	N/A	N/A	N/A	N/A	N/A
29-11-2013	341.09	193.46	96.34	41.48	137.67	4.43	296.23	16.31
30-11-2013	256.31	128.14	66.21	29.39	95.61	4.05	278.19	16.43





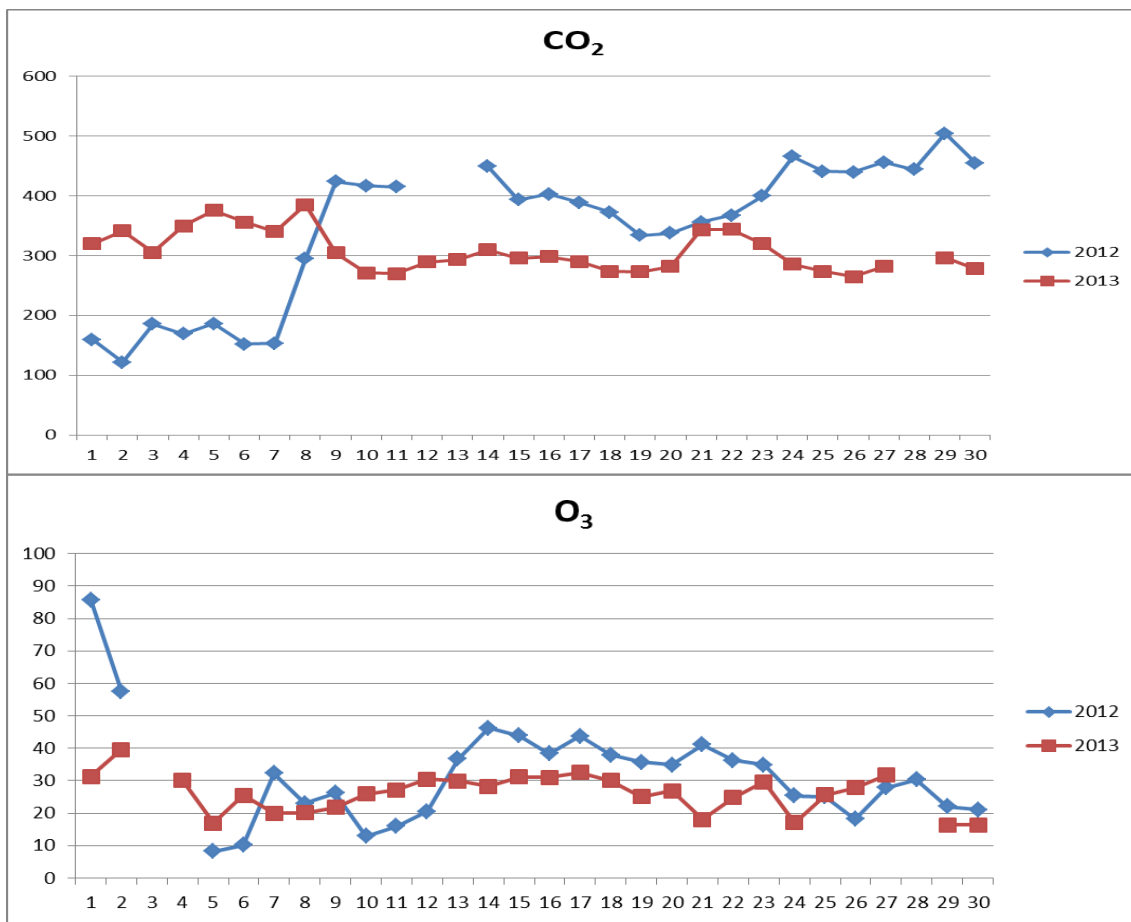


Figure 2. Comparison of data for November 2012 and 2013

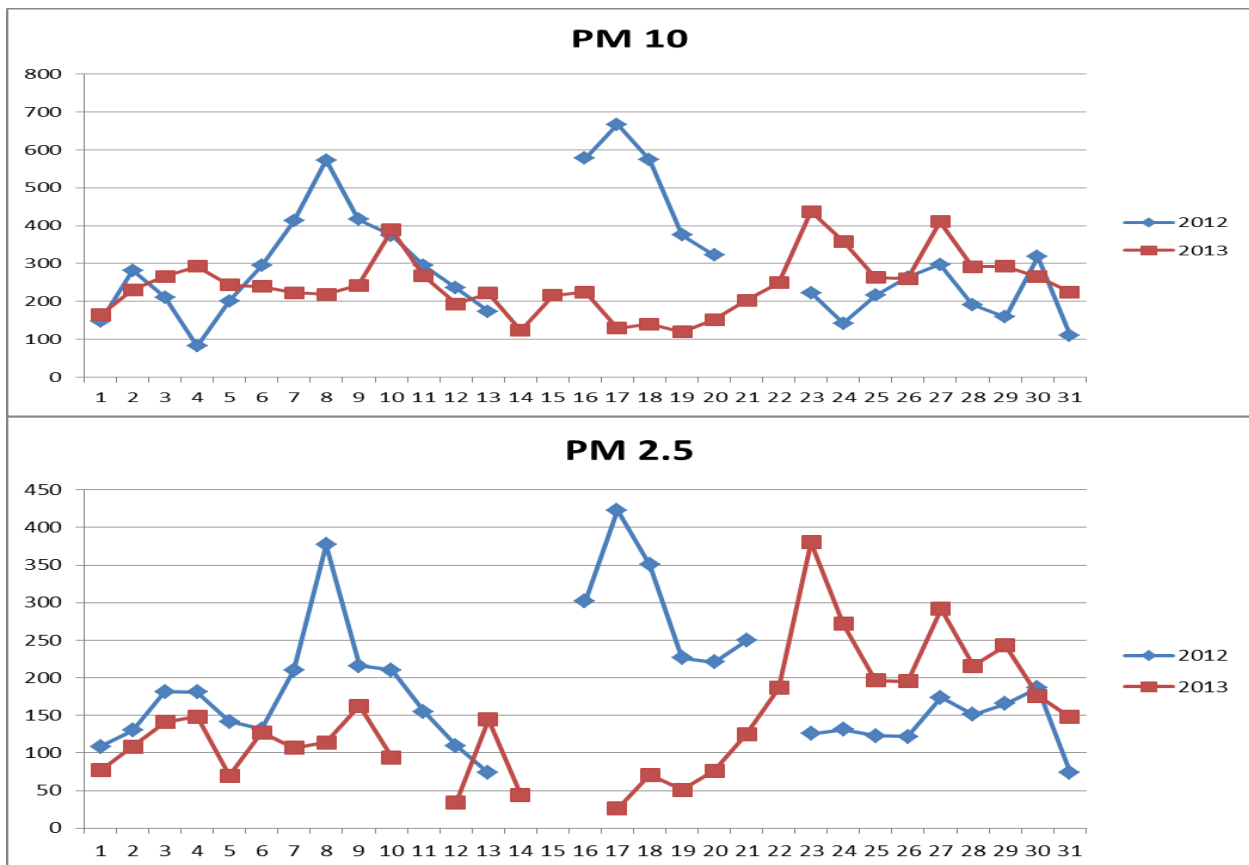
Table 8. December – 2012

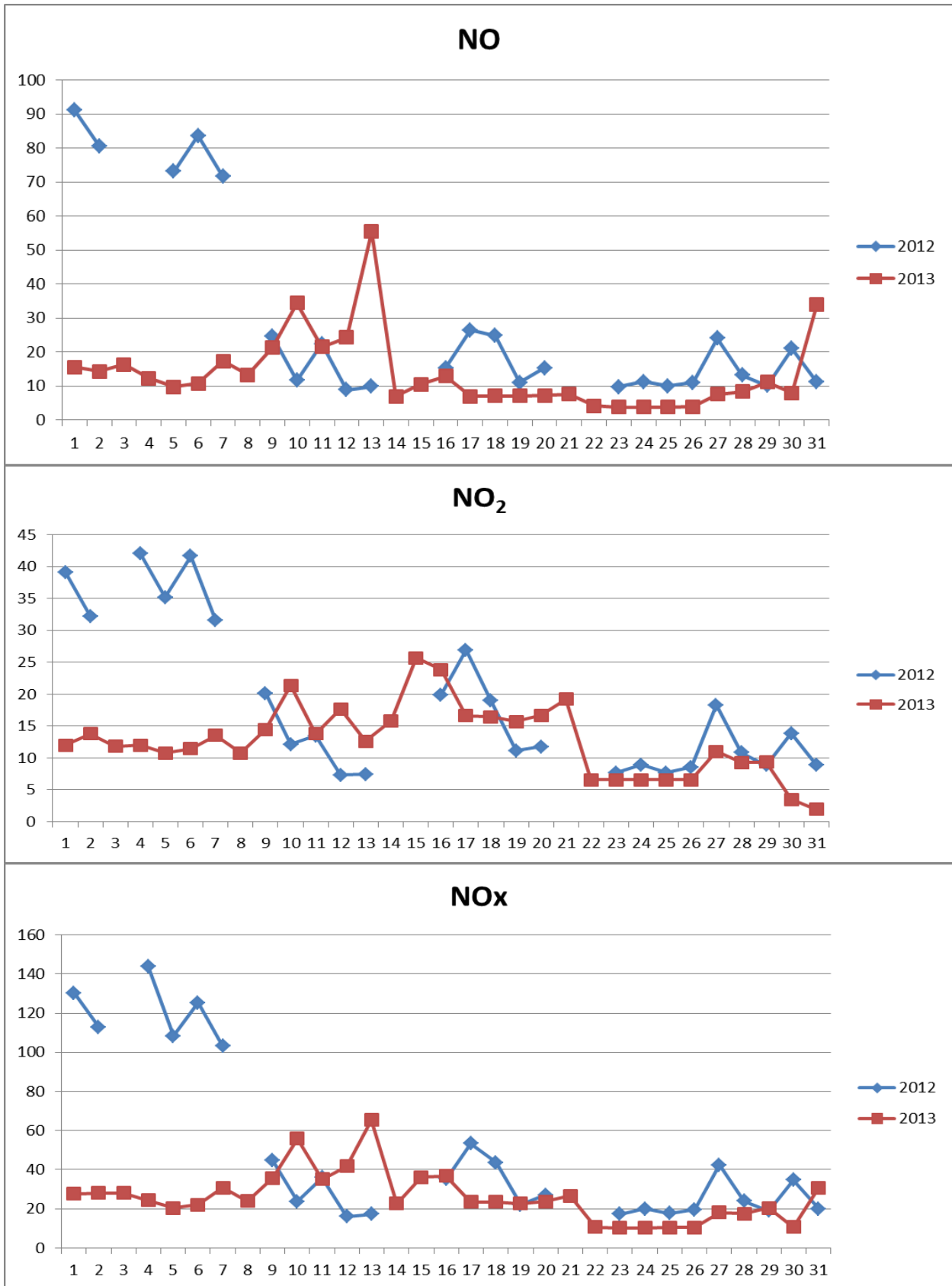
Date	PM10 (ug/m ³)	PM2.5 (ug/m ³)	NO (ppb)	NO ₂ (ppb)	NO _x (ppb)	CO (ppm)	CO ₂ (ppm)	O ₃ (ppb)
01-12-2012	146.91	108.39	91.26	39.14	130.33	4.21	288.19	16.26
02-12-2012	281.45	129.86	80.56	32.22	112.84	4.21	281.57	16.90
03-12-2012	211.07	181.79	N/A	N/A	N/A	5.17	319.98	16.3
04-12-2012	82.25	181.01	N/A	42.12	144.09	4.78	298.17	16.48
05-12-2012	201.17	141.77	73.10	35.20	108.26	4.88	280.83	21.85
06-12-2012	294.74	131.97	83.68	41.68	125.35	4.74	286.97	36.80
07-12-2012	412.25	210.48	71.67	31.55	103.20	5.13	313.81	N/A
08-12-2012	572.40	376.75	N/A	N/A	N/A	N/A	N/A	20.44
09-12-2012	415.93	216.02	24.45	20.13	44.59	5.56	328.77	54.81
10-12-2012	374.12	210.26	11.64	12.11	23.69	4.20	302.16	49.03
11-12-2012	294.67	154.89	22.37	13.49	35.87	1.26	286.68	36.39
12-12-2012	235.19	109.49	8.80	7.30	16.10	2.45	267.27	34.31
13-12-2012	173.57	73.63	9.79	7.45	17.25	2.44	262.29	34.42
14-12-2012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15-12-2012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16-12-2012	577.79	301.50	15.28	19.86	35.14	4.52	338.20	27.87
17-12-2012	666.98	422.93	26.40	26.91	53.29	5.86	367.68	18.79
18-12-2012	573.33	350.53	24.74	18.94	43.69	5.57	336.33	11.5
19-12-2012	375.4	226.34	10.98	11.15	22.13	4.30	298.05	25.48
20-12-2012	321.69	221.05	15.26	11.74	27.00	4.35	296.37	24.40
21-12-2012	N/A	249.492	N/A	N/A	N/A	N/A	N/A	N/A
22-12-2012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
23-12-2012	222.82	125.40	9.64	7.67	17.32	4.15	271.08	37.95
24-12-2012	141.98	131.31	11.17	8.90	20.07	4.53	297.07	N/A
25-12-2012	215.36	123.11	9.96	7.65	17.62	4.71	264.18	N/A
26-12-2012	263.65	121.71	10.99	8.52	19.53	4.28	325.25	N/A
27-12-2012	297.15	173.77	23.94	18.31	42.28	3.28	298.35	28.59
28-12-2012	191.10	151.31	13.13	10.85	23.99	0.90	260.71	47.17
29-12-2012	158.47	165.26	10.03	8.86	18.90	1.05	258.72	54.84
30-12-2012	318.44	186.32	20.93	13.82	34.76	1.48	289.58	44.82
31-12-2012	110.67	74.15	11.06	8.93	20	1.12	269.35	27.19

Table 9. December – 2013

Comparison of data for December 2012 and 2013

Date	PM10 (ug/m ³)	PM2.5 (ug/m ³)	NO (ppb)	NO ₂ (ppb)	NO _x (ppb)	CO (ppm)	CO ₂ (ppm)	O ₃ (ppb)
01-12-2013	164.94	76.72	15.57	11.98	27.56	1.45	435.54	30.89
02-12-2013	230.95	108.66	14.20	13.81	28.01	1.77	456.86	41.44
03-12-2013	265.63	141.21	16.21	11.79	27.99	1.54	459.59	38.33
04-12-2013	291.98	148.20	12.27	11.97	24.26	0.97	464.75	46.54
05-12-2013	243.11	69.72	9.71	10.77	20.47	1.16	352.93	37.29
06-12-2013	239.14	127.39	10.65	11.42	22.08	1.04	224.96	41.30
07-12-2013	222.54	106.99	17.25	13.54	30.80	1.10	225.92	31.29
08-12-2013	218.83	113.96	13.24	10.77	24.02	1.36	200.19	40.45
09-12-2013	242.12	162.72	21.32	14.47	35.78	1.55	214.75	42.81
10-12-2013	388.89	93.89	34.44	21.38	55.81	2.50	261.32	35.25
11-12-2013	267.11	N/A	21.50	13.78	35.07	2.58	254.23	N/A
12-12-2013	192.70	34.07	24.19	17.64	41.83	2.26	253.29	19.78
13-12-2013	221.35	144.38	55.43	12.6	65.50	2.19	231.50	22.29
14-12-2013	123.25	44.23	6.84	15.8	22.64	1.91	179.12	25.66
15-12-2013	215.64	N/A	10.48	25.66	36.14	2.84	217.29	20.01
16-12-2013	224.43	N/A	12.89	23.83	36.73	2.88	232.59	17.03
17-12-2013	129.22	26.16	6.96	16.63	23.59	2.08	194.18	33.91
18-12-2013	139.77	71.06	7.04	16.46	23.51	2.00	198.78	30.57
19-12-2013	119.89	51.14	7.05	15.69	22.74	2.00	194.02	32.04
20-12-2013	151.46	76.56	7.16	16.66	23.82	2.08	185.62	38.98
21-12-2013	202.69	125.08	7.49	19.22	26.70	2.27	283.63	37.54
22-12-2013	249.56	186.23	4.13	6.57	10.71	2.48	204.91	31.29
23-12-2013	436.91	380.15	3.76	6.57	10.33	3.37	234.47	8.95
24-12-2013	358.15	271.47	3.75	6.57	10.33	3.81	240.98	22.17
25-12-2013	263.16	196.65	3.78	6.58	10.37	3.40	210.74	15.04
26-12-2013	259.99	195.25	3.82	6.57	10.39	2.78	230.01	17.97
27-12-2013	410.77	291.89	7.57	11.01	18.07	3.17	240.04	15.82
28-12-2013	291.14	215.57	8.25	9.30	17.55	2.07	232.00	10.67
29-12-2013	292.25	242.84	11.09	9.36	20.45	1.26	206.90	16.08
30-12-2013	264.50	175.88	7.94	3.49	10.62	1.05	190.95	24.96
31-12-2013	225.04	147.86	33.97	1.92	30.74	1.50	187.89	15.84





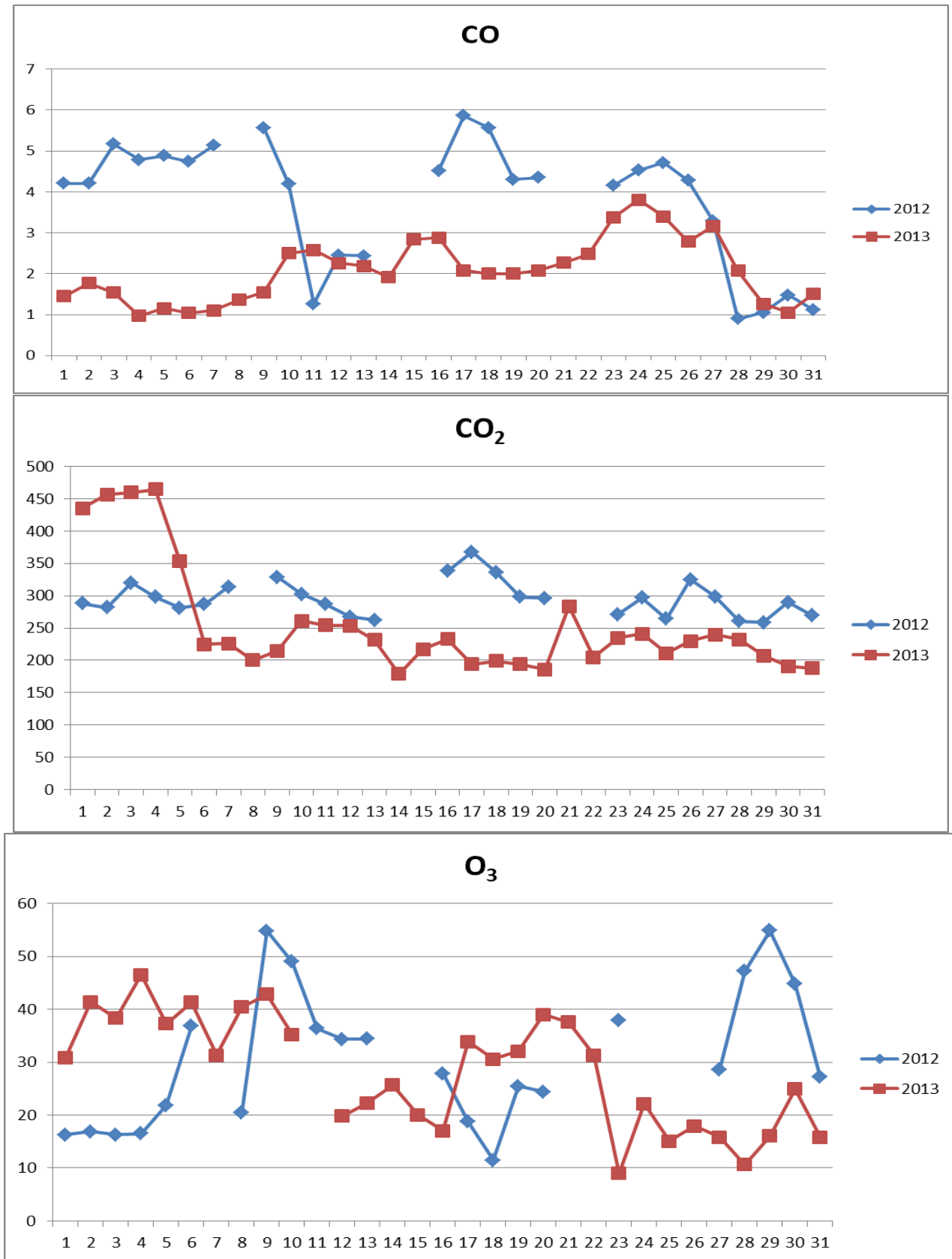


Figure 3.

Results and Conclusion

Through the study of the concentrations of the pollutants in New Delhi for the months of November and December 2012 and 2013, a comparison between the air qualities can be established.

For the month of November in both the years, the PM 10 and PM 2.5 concentrations remained higher in 2012 with levels being as high 748.62 ug/m³ as in the mid-month and dropping to a low of 183.17

ug/m³ as the month progressed. The NO, NO₂ and NO_x levels were more than double in 2013 as compared to 2012 levels. In the middle of the month in 2013, the levels spiked to much higher values and returned to normal gradually. The CO level remained high at an average of around 3 ppm all across the month in the year 2013 while the levels in 2012 remained lower than 2 ppm all across the month. The CO₂ concentration increased over the month in 2012 to 500ppm whereas decreased over the month in 2013 to levels around 300 ppm. The ozone concentrations remained almost identical in both the years over the month at an average concentration of 30 ppb.

For the month of December in the both the years, PM 10 and PM 2.5 levels remained relatively low in 2013 in the range of 200-300 ug/m³. Although some data from 2012 is missing, it can be concluded that concentrations spiked in the middle of the month in 2012 to upwards of 400 ug/m³. The NO, NO₂ and NO_x levels remained almost constant in the year 2013 in the range of 10-20 ppb while spiked to higher values of more than 25 ppb in 2012. Overall, the NO, NO₂, NO_x levels were higher in 2012 than 2013. The CO levels were higher in 2012 than 2013 all over the month with a difference of almost 2 ppm. The CO₂ levels were higher in the starting days of the month in 2013 but dipped as the, month progressed. The 2012 levels remained higher on an average. The ozone levels varied heavily in 2012 with high peaks of maximum 54.84 ppb and also dipping to lower levels of minimum 11.5 ppb across the month. The 2013 levels remained constant on an average at around 30 ppb.

The level of the pollutants recorded is much higher than the acceptable limits. Hence it can be concluded that necessary actions are required to be taken in order to curb this harmful level of pollution. If left unabated, it will lead to serious environmental damage as well as pose a huge risk to health of the general public.

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