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Research Paper

Evaluation of Ambient Air Quality of Jalna City (MS), India

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ABSTRACT

The ambient air quality of Jalna city has been assessed by using air quality index (AQI). For determining AQI the ambient air concentrations of air pollutants viz. SO_2, NOx, RSPM and NRSPM were monitored at residential and industrial sites for one-year period. The monthly, seasonal and annual AQI values determined at both residential and industrial sites indicated that the overall air quality at residential and industrial sites during the study period was comparable with not too much variations. The air quality at residential site was slightly better than industrial site. Strict government regulations, effective treatments in plants, adequate disposal of waste also helpful in reducing air pollution levels. Annual mean concentrations of SO_2 and NOx determined at residential as well as industrial site were found within the permissible limits of Indian National Ambient Air Quality standards (NAAQS). While RSPM and NRSP Manual mean concentrations at both residential and industrial were violated. The annual AQI values 120 and 126 were recorded for residential and industrial site respectively due to higher RSPM.

Keywords: Ambient air quality (AQI), Gaseous pollutants-SO_2, NOx, Particulate pollutants, RSPM-Respirable Suspended Particulate Matter, NRSPM- Non Respirable Suspended Particulate Matter

INTRODUCTION

Environmental pollution is increasing at frightening rate gradually and environment monitoring agencies pointed out the serious problems which world will face due to over pollution. Various activities responsible for the harm to nature are over population, inadequate public facilities, [1] urbanization, [2] emissions from automobiles [3] and industrialization. [4-6] All these activities are tremendously weakening the health of human beings, assets and to the climatic conditions. [7-10] Amongst various pollutants of air sulphur dioxide, nitrogen oxides and particulate matter are fundamental pollutants identified by environment protection agency. Amount of air pollutants in particular area affected by various factors like sources of pollution-local and distant, conditions of the area-meteorological and topographical, spatial and temporal variations. [11-14] Many countries as well as India established ambient air quality programs to find out quality of air by generating statistics on air pollutant concentrations in ambient air. [15] Proper knowledge of air pollutants, their concentrations, variations and field data are essential for correct management of these issues [16,17] if not, it would obstruct planning activities associated with the environment. To control over this problem

EPA initiated Air Quality Index (AQI) which mathematically links concentration of various pollutants and furnish a single quantity which considers the quality of air of that place depending upon the air quality index rating scale [18-21] In Bikaner particulate matters concentration were observed to be high during winters and low during monsoon season. [22] In Vapi, India which is moderately polluted city PM_{10} was found to be critical pollutant. [23] Compiled data for 2013-2014 for 72 AAQM stations collected by MPCB shows moderate to below air quality. [24] In continuation of our earlier work [25-27] the current paper explores monthly, annual and seasonal trends in ambient air quality on chosen monitoring sites residential (IMA hall) and industrial (Krishidhan seeds) of Jalna city with the help of air quality index (AQI).

MATERIALS AND METHODS

Study area: Jalna district is approximately situated at the central part of Maharashtra state and in northern direction of Marathwada region in India. Jalna district lies between 19°1¹ to 23°3¹ north latitudes and 75°4¹ to 76°4¹ east longitudes. It extends over an area of 7612 km^2 which is 2.47% of total area of Maharashtra state in India. The district has subtropical climate in which the bulk rainfall is received from the southwest monsoon between June to September. The average rainfall of the district ranges between 650 to 750 mm. The district often experiences drought with rainfall recording as low as 400 to 450 mm. The rainy season is followed by winter which last up to February during which the minimum temperature ranges between 9° to 10°C and maximum temperature ranges between 30-35°C. The winter is followed by hot summer which continues up to June. The maximum day temperature ranges between 42-45°C during summer. [28-29]

Jalna is having good industrial background especially famous for seed and steel industries. The industrial development of Jalna is widely based on Engineering, Plastic and Agriculture. At present six industrial areas are under Maharashtra Industrial Development Corporation (MIDC), Jalna accommodating pulses, oil mills, refineries, steel re-rolling, plastics, tiles and cement pipes, fertilizers, insecticides, pesticides and the co-operative sugar factories. These industries and growing numbers of the automobile are the major sources of air pollution in the city. [30,31]

Sampling and analysis of particulate pollutant (RSPM and NRSPM):

The samples of RSPM, NRSPM, SO_2 and NOx were collected twice a week during January to December 2017 from industrial and residential site. For collecting samples High volume air sampler (model RDS APM 460NL with gaseous sampling attachment APM 411TE (make Enviro-tech India Pvt. Ltd.) was used by running the equipment for a period of 24 hours. Particulate pollutants i.e. RSPM and NRSPM samples were collected by drawing air with a flow rate 1.1 to 1.2 m^3/min for 8 hours. The air inside the sampler passed through a combination of cyclone separator and filter in two stages. The cyclone separator collects bigger particles i.e. non respirable particulate matter (NRSPM) (particle size> 10µm) in previously weighed dust collector in first stage, while remaining particulate i.e. RSPM (size< 10µm) were collected over a previously dried weighed glass microfiber filter (Whatman GF/A, 203x254mm).Gravimetrically the concentration of RSPM and NRSPM were calculated using standard method, CPCB 2011. [32]

Gaseous pollutants (SO_2 and NOx):

The ambient air samples for SO_2 were collected by absorbing SO_2 from known volume of air in absorbent solution of potassium tetrachloromercurate (TCM). A stable dichlorosulphitomercurate complex formed was made to react with para rosaniline and methyl sulphonic acid. The colour solution absorbance was measured at 530 nm by spectrophotometersulphate ions concentration formed in absorbent was determined by using modified West and

Gaeke Method (IS 5182 part 2:2001); CPCB 2001. [33]

Ambient nitrogen dioxide was collected by bubbling known volume of air through a solution of sodium hydroxide and sodium arsenite. The nitrile ion concentration produced during sampling were found colourimetrically by treating nitrile ion with phosphoric acid, sulphanilamide and N-(1-naphthyl)-ethylenediaminedihydrochloride (NEDA) and measuring the absorbance of the highly coloured azo-dye at 540nm. [34,35]

Air Quality Index (AQI):

AQI is single number which shows overall ambient air quality status based on actual measured concentration of criteria pollutants and its prescribed standard permissible concentration. [36,37]

For analyzing and representing uniform status of air quality AQI is an important available tool.

Equation for Calculation of AQI is

$$AQI = (\frac{100}{n})\sum_{k=1}^{n}(\frac{APC_k}{SPC_k})$$

Where, AQI= air quality index

n = number of criteria pollutants

APC= Actual pollutant concentration

SPC= Standard pollutant concentration (CPCB 2011)

Table.1Indian National Ambient Air quality standard

Sr.No.	Pollutant	Time weighted Average	Air Quality Standard concentration in Ambient air	
			Industrial, residential, rural and other area	Ecologically sensitive area (notified by central Govt.)
1	SO_2 µgm/m^3	Annual 24 hours	50 80	20 80
2	NO_2 µgm/m^3	Annual 24 hours	40 80	30 80
3	PM_{10} µgm/m^3	Annual 24 hours	60 100	60 100
4	$PM_{2.5}$ µgm/m^3	Annual 24 hours	40 60	40 60

The rating scale of AQI is as shown

Table 2. Rating Scale of Air Quality Index (AQI) values

AQI value	AQI Category
0-50	Good
51-100	Satisfactory
101-200	Moderately polluted
201-300	Poor
301-400	Very poor
>401	Severe

Table 3. Monthly minimum, maximum and average concentration of SO_2 (µgm/m^3) at residential and industrial sites

Month	Residential			Industrial		
	Min.	Max.	Avg.	Min.	Max.	Avg.
Jan	7.02	15.84	12.26	12.72	14.88	13.77
Feb	10.80	16.36	13.80	11.01	14.47	12.94
Mar	7.85	17.49	13.27	8.70	16.03	12.25
Apr	9.11	19.30	12.90	9.45	19.30	12.90
May	10.66	13.46	12.25	9.48	18.26	12.72
June	4.14	11.87	8.00	4.56	10.43	8.09
July	4.70	10.65	7.13	10.46	11.36	10.96
Aug	6.43	9.82	8.14	4.80	11.08	9.26
Sept	8.34	11.23	9.56	9.55	11.72	10.57
Oct	7.98	13.12	11.17	10.22	14.35	11.80
Nov	10.79	14.15	14.00	11.51	16.45	13.20
Dec	10.87	18.00	14.43	9.95	15.00	11.50
Average	8.22	14.27	11.40	9.34	14.40	11.70

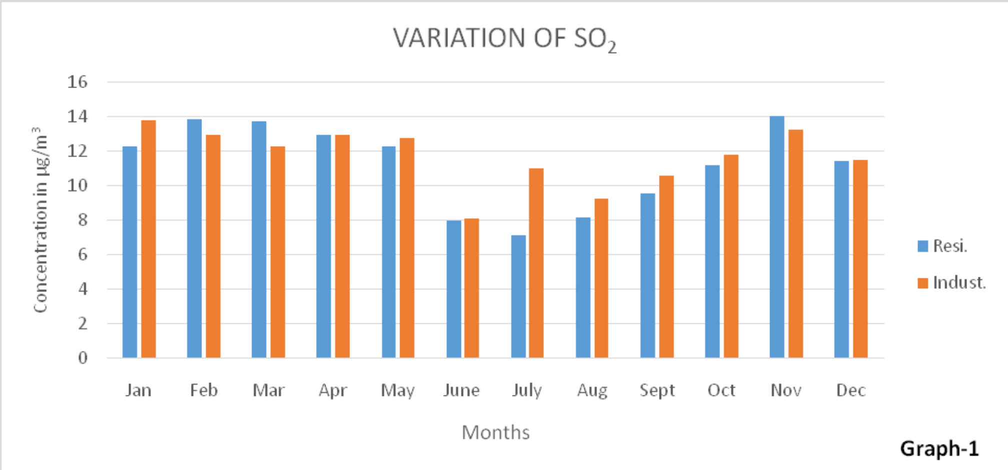


Table 4. Monthly minimum, maximum and average concentration of NOx (µgm/m³) at residential and industrial sites.

Month	Residential			Industrial		
	Min.	Max.	Avg.	Min.	Max.	Avg.
Jan	21.49	45.55	32.06	27.79	39.71	34.31
Feb	27.92	38.91	34.45	25.57	35.77	32.60
Mar	20.86	40.35	31.80	24.08	38.96	31.80
Apr	20.68	38.78	31.05	26.30	38.78	31.05
May	28.29	31.66	31.00	29.77	33.65	31.20
June	14.73	46.62	27.45	19.42	34.17	27.45
July	18.81	29.63	26.29	22.16	34.90	28.08
Aug	23.81	31.59	27.52	16.13	32.69	26.12
Sept	26.13	30.43	28.31	25.35	32.18	28.52
Oct	26.44	32.20	29.58	28.82	32.41	31.00
Nov	20.84	38.10	31.26	28.61	39.68	33.00
Dec	24.76	37.91	29.10	28.74	32.91	31.24
Average	22.89	36.81	29.98	25.20	35.50	30.53

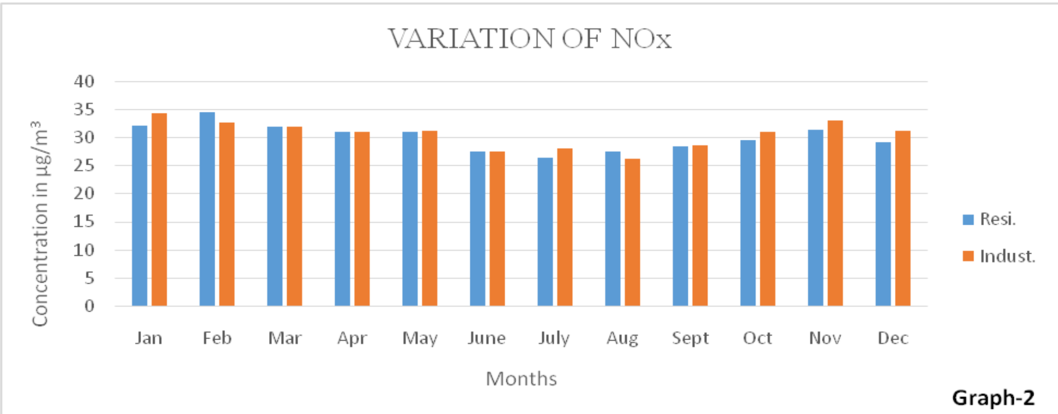


Table 5. Monthly minimum, maximum and average concentration of RSPM (µgm/m³) at residential and industrial sites.

Month	Residential			Industrial		
	Min.	Max.	Avg.	Min.	Max.	Avg.
Jan	62.00	167.00	121.00	51.00	475.00	206.00
Feb	110.00	182.00	140.00	163.00	222.00	257.00
Mar	73.00	262.00	157.00	60.00	219.00	132.00
Apr	62.00	202.00	162.00	125.00	202.00	162.00
May	85.00	146.00	106.00	77.00	202.00	130.00
June	49.00	185.00	88.00	36.00	141.00	101.00
July	62.00	121.00	91.00	75.00	110.00	95.00
Aug	70.00	130.00	96.00	45.00	114.00	90.00
Sept	48.00	117.00	77.00	40.00	94.00	72.00
Oct	49.00	406.00	134.00	68.00	114.00	89.00
Nov	112.00	201.00	143.00	33.00	120.00	91.00
Dec	101.00	166.00	129.00	76.00	103.00	91.00
Average	73.58	190.40	120.30	70.75	176.30	126.30

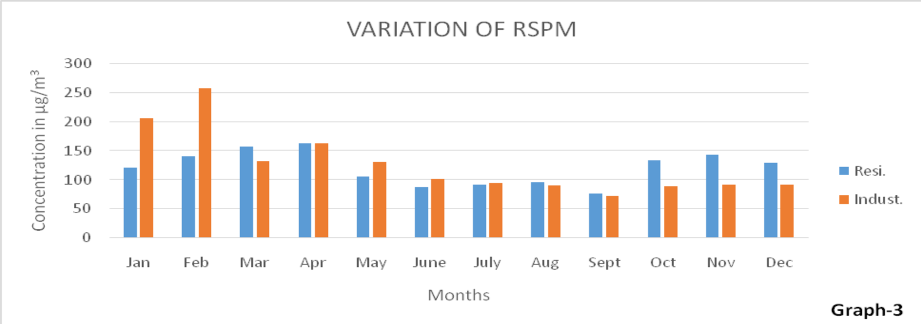


Table 6. Monthly minimum, maximum and average concentration of NRSPM (µgm/m^3) at residential and industrial sites.

Month	Residential			Industrial		
	Min.	Max.	Avg.	Min.	Max.	Avg.
Jan	117.00	523.00	370.00	189.00	424.00	781.00
Feb	339.00	558.00	433.00	375.00	448.00	507.00
Mar	230.00	760.00	441.00	154.00	503.00	313.00
Apr	182.00	504.00	354.00	263.00	504.00	354.00
May	251.00	459.00	342.00	225.00	471.00	347.00
June	108.00	495.00	270.00	88.00	388.00	193.00
July	239.00	368.00	283.00	130.00	205.00	264.00
Aug	193.00	353.00	289.00	116.00	265.00	196.00
Sept	105.00	272.00	180.00	115.00	490.00	220.00
Oct	136.00	692.00	391.00	150.00	326.00	238.00
Nov	364.00	569.00	424.00	69.00	317.00	201.00
Dec	324.00	528.00	398.00	152.00	261.00	209.00
Average	215.60	506.70	347.90	168.30	383.50	318.60

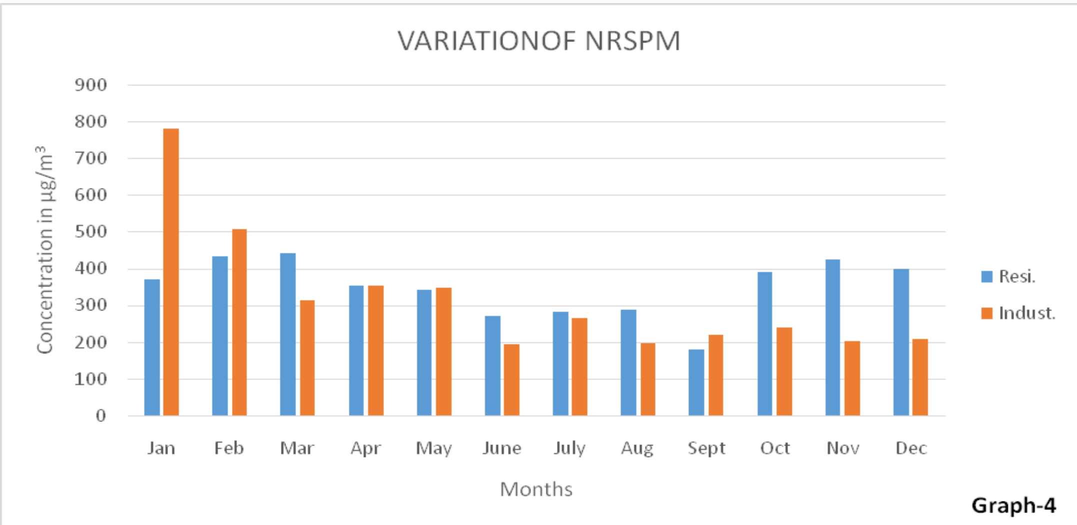


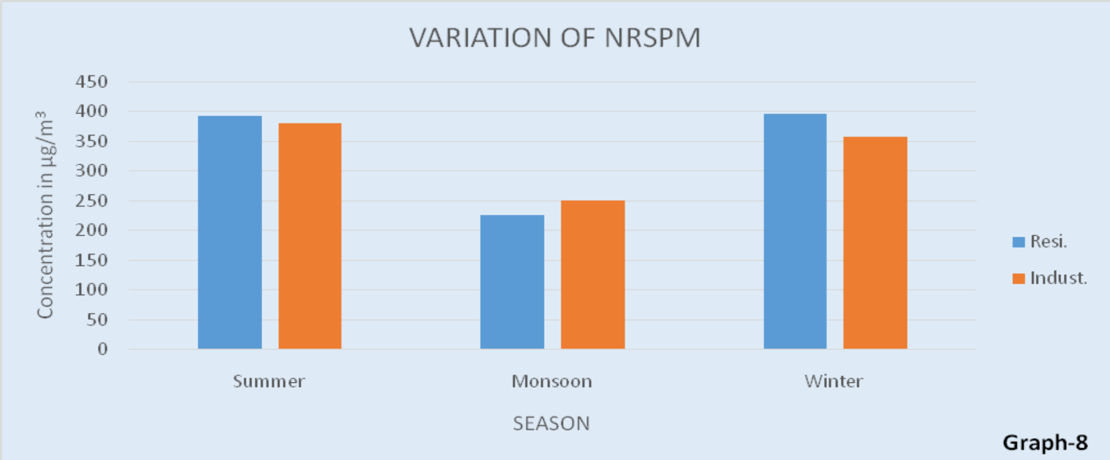
Table 7. Seasonal, Minimum, Maximum and Average concentration of pollutants (µgm/m^3) at residential and industrial sites.

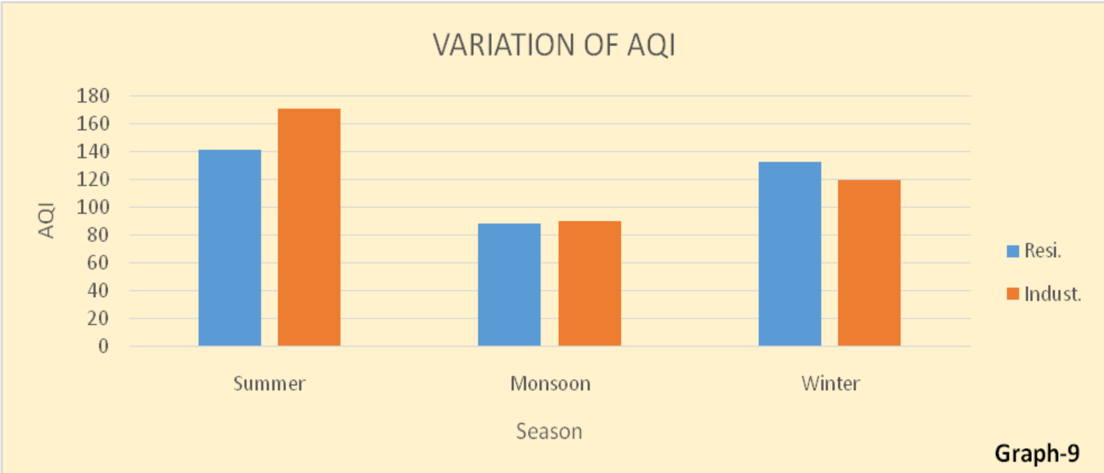
Season	Pollutant	Residential			Industrial		
		Min.	Max.	Avg.	Min.	Max.	Avg.
Summer	SO_2	7.85	9.30	13.05	8.70	19.30	12.70
	NOx	20.68	40.35	37.42	24.08	38.96	31.66
	RSPM	62.00	262.00	141.25	60.00	222.00	170.25
	SPM	182.00	760.00	392.50	154.00	504.00	380.25
	AQI	141.25			170.25		
Monsoon	SO_2	4.14	11.87	8.20	4.56	11.72	9.72
	NOx	14.73	46.62	27.39	16.13	34.90	27.54
	RSPM	48.00	185.00	88.00	36.00	14.10	89.50
	SPM	105.00	495.00	225.50	88.00	490.00	250.00
	AQI	88.00			89.50		
Winter	SO_2	7.02	18.00	12.96	9.95	16.45	12.56
	NOx	20.84	45.55	30.50	27.79	39.71	32.38
	RSPM	49.00	406.00	131.75	33.00	47.50	119.25
	SPM	117.00	692.00	395.75	69.00	424.00	357.25
	AQI	131.75			119.25		

Graph-5

Graph-6

Graph-7





RESULTS AND DISCUSSION

The monthly minimum, maximum, and average concentrations of SO_2 and NOx monitored at residential and industrial sites have been presented in table 3 and table 4.

Sulphur dioxide (SO_2): The monthly minimum, maximum, and average concentrations at residential site were varied between 4.14 -10.87 µg/m^3, 9.82 -19.30 µg/m^{3}and 7.13 -14.43 µg/m^3 respectively. The highest concentration of SO_2 (19.13 µg/m^3) at residential site was recorded in the month of April followed by December (18.0µg/m^3). The lowest concentration of SO_2 (4.14µg/m^3) was observed in month June at residential site. The monthly minimum, maximum and average concentrations at industrial sites were varied between 4.56-12.72µg/m^3, 10.43-19.30µg/m^3 and 8.09-13.77µg/m^3 respectively. The industrial site generally recorded the higher concentrations of SO_2 compared to the residential site. The SO_2 concentration at industrial site was observed highest (19.30µg/m^3)in the month of April followed by (18.26µg/m^3) may while 4.56µg/m^3 was reported lowest in month of June. Monthly mean variation of $SO_2$is as shown in Graph-1.

The seasonal trend in concentration of SO_2 was observed during the study (table 7). The highest seasonal concentration of SO_2 at residential site was observed in summer (19.30µg/m^3) followed by winter (18.30µg/m^3). The least concentration of SO_2 at residential site was observed in monsoon season (4.24 µg/m^3). Similar to residential site industrial site recorded highest concentration of SO_2 in summer (19.30 µg/m^3) followed by winter (16.45 µg/m^3) and lowest was reported in monsoon season (11.72 µg/m^3). Seasonal mean variation of SO_2 is as shown in Graph-5.

(as shown in Graph-5). The annual minimum, maximum and average concentration of SO_2 at residential site obtained were 8.22 µg/m^3, 14.27 µg/m^3 and 11.40 µg/m^3 respectively. While the annual minimum, maximum and average concentration of SO_2 at industrial site obtained were 9.34 µg/m^3, 14.40 µg/m^3 and 11.78 µg/m^3 respectively. Which were well below the national ambient air quality standards (NAAQS) stipulated by the central pollution control board (CPCB 2009). [38]

Oxides of Nitrogen (NOx):

The monthly minimum, maximum and average concentrations of oxides of nitrogen (NOx) at residential site were varied from 14.73-28.29 µg/m^3, 29.63-46.62 µg/m^3 and 26.29-34.45 µg/m^3 respectively. The highest monthly concentration was reported in June (46.62 µg/m^3) followed by January (45.55 µg/m^3). While 14.73 µg/m^3 being lowest reported in the June. The monthly minimum, maximum and average concentrations of oxides of nitrogen (NOx) at industrial site were varied from 16.13-29.17 µg/m^3, 32.18-39.71 µg/m^3 and 26.12-34.31µg/m^3 respectively. The highest monthly concentration was reported in January (39.71 µg/m^3) followed by November (39.68 µg/m^3). While 16.13 µg/m^3 being lowest reported in the August. Monthly mean variation of NOx is as shown in Graph-2).

Seasonally the highest mean concentration was observed during monsoon (46.62 µg/m^3) at residential site and during winter (39.71 µg/m^3) at industrial site. The lowest concentration of NOx at residential site was observed during monsoon (14.73 µg/m^3) while at industrial site it was recorded (16.13 µg/m^3) during monsoon. The annual mean concentration of NOx at residential and industrial site was recorded 29.98 µg/m^3 and 30.53 µg/m^3 respectively which were found below the NAAQS (CPCB 2009).Seasonal mean variation of NOx is as shown in Graph-6.

The major contributors of Sulphur dioxide (SO_2) and oxides of nitrogen (NOx) to ambient air are automobiles and industries. [39] The seasonal concentration pattern of air pollutants is driven by emission characteristics of the dominant sources and meteorological conditions. [13] Researchers [40-42] reported similar results.

Particulate pollutants:

The monthly minimum, maximum and average concentration of RSPM and NRSPM monitored at residential and industrial site has been reported in table No. 5 & 6.

Respirable suspended particulate matter RSPM ($\leq PM_{10}$): The annual mean concentration of RSPM (PM_{10}) at residential site was observed 120.30 µg/m^3 which is above the maximum permissible limits of NAAQS (Table 1). The highest monthly mean concentration 162 µg/m^3 was recorded in the month of April while the lowest 77 µg/m^3 reported during September. Seasonally summer recorded highest levels of PM_{10}141.25 µg/m^3 at residential site and at industrial site 170.25 µg/m^3. The monthly mean concentration of PM_{10} at residential site was varied from 48-406 µg/m^3. While at industrial site it varied from 33-475 µg/m^3. Monthly mean variation of RSPM is as shown in Graph-3. The annual mean reported at industrial site was 126.3 µg/m^3 which violated the existing NAAQS. Seasonal mean variation of RSPM is as shown in Graph-7.

Non Respirable Suspended particulate matter (NRSPM)≥ PM_{10}:

The monthly mean concentration of SPM was ranged between 105-760 µg/m^3 and 69-504 µg/m^3 and annual mean concentration were recorded 347.9 µg/m^3 ad 318.6 µg/m^3 at residential and industrial site respectively. The highest monthly mean concentration at residential site was observed 760 µg/m^3 in March followed by 692 µg/m^3 in October. At industrial site highest NRSPM concentration 504 µg/m^3 was recorded in April followed by 503 µg/m^3 in March. While the lowest NRSPM at residential site was recorded in September 105 µg/m^3. Monthly mean variation of NRSPM is as shown in Graph-4.

Significant seasonal variations in NRSPM concentrations were found at both the monitoring sites. The highest mean NRSPM levels were recorded in winter with 395.75 µg/m^3 followed by 392.5 µg/m^3 in monsoon at residential site. While highest mean NRSPM levels were recorded in summer 380.25 µg/m^3 followed by 357.25 µg/m^3 in winter at industrial site. Lowest NRSPM concentration for both the sites was recorded in monsoon as 225.50 µg/m^{3}for residential and 250 µg/m^3 for industrial. Seasonal mean variation of NRSPM is as shown in Graph-8. The major contributors of particulate pollutants in ambient air are automobiles and industries. [7,43,44] The seasonal variation pattern of RSPM and NRSPM concentration can be seen from the values presented in table 7. The variation pattern is caused by the meteorological effects i.e. vertical mixing in summer and frequent inversions in winter. [13,42,45] The pattern for urban sites are basically similar for both summer and winter suggesting that most important emission sources are seasonally independent for urban areas and are surely traffic emissions and industries. [46] Seasonal mean variation of AQI is as shown in Graph-9AQI values obtained are between 101 and 200 due to higher particulate matter indicate moderate pollution as per the rating scale (table 2). Members of sensitive groups like older adults and children may experience health effects like heart or lung disease on prolong exposure and at greater risk but the general public is affected to a lesser extent.

CONCLUSIONS

Analysis of temporal and spatial variations of SO_2, NOx, RSPM and NRSPM based on one-year study of continuous measurements at Jalna area (residential and industrial site) revealed that the particulate as well as gaseous pollutants concentration at both sites were found to be higher and comparable due to wind flow and location. The annual mean gaseous pollutants measured at residential site were found within the permissible limits of NAAQS, whereas RSPM and NRSPM concentrations violated the prescribed limit at residential and industrial site. The seasonal cycle for SO_2, RSPM and NRSPM at both sites generally showed higher concentration during summer and lower in monsoon. The NOx concentration was found to be higher in summer and lower in monsoon at residential site and higher in winter and lower in monsoon at industrial site.Ambient air quality was found to be better in monsoon season.

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