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Analysis of Ambient Air Quality of Jalna City (MS) using AQI, India

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Abstract: The ambient air quality of Jalna city has been evaluated by means of air quality index (AQI). For one year period ambient air concentrations of air pollutants viz. SO_2, NOx, RSPM and NRSPM were monitored at residential and industrial sites to determine AQI. The monthly, seasonal and annual AQI values determined at both residential and industrial sites pointed out the overall air quality during the study period was comparable with slight variation. The air quality at residential site was a little inferior than industrial site. Factors like strict government rules, efficient exhaust gas treatments, proper disposal of waste also facilitated in dropping air pollution levels. Annual mean concentrations of SO_2 and NOx evaluated at residential as well as industrial site were observed within the permissible limits of Indian National Ambient Air Quality standards (NAAQS). While annual mean concentrations RSPM and NRSPM at both sites violated norms. The annual AQI values 257 for residential and 224 for industrial were observed due to higher RSPM indicates poor category of air quality.

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

I. INTRODUCTION

Air is one of the most essential constituent of our environment. Humans require on an average 12 kg air everyday which is 12 to 15 times more food consumed daily. Any change in composition of air adversely affects living system including human life causing air pollution. Environmental pollution is increasing at scary rate gradually and environment monitoring agencies indicated the harmful effects of over pollution. Various activities responsible for the destruction of nature are over population, urbanization[1], automobiles[2], scarce public facilities[3], emission and industrialization[4-6]. All such factors are tremendously declining human health, resources and climatic[7-10]. From different air pollutants sulphur dioxide, nitrogen oxides and particulate matter are primary pollutants found by environment protection agency. Quantity of air pollutants in particular area depends on factors like sources of pollution-local and distant, conditions of the area-meteorological and topographical, spatial and temporal variations[11-14]. Correct knowledge of air pollutants, their concentrations, variations and field data are necessary for proper management of these issues[15,16] otherwise it would hinder environment planning activities. Most countries including India started ambient air quality programs to know air quality by preparing statistics on air pollutant concentrations in ambient air[17]. To manage this crisis EPA started Air Quality Index (AQI) which mathematically links concentration of various pollutants and provide a single quantity indicating the air quality of particular place based on air quality index rating scale[18-21]. In Bikaner particulate matter concentration found high in winter and low in monsoon[22]. In Vapi city which is moderately polluted city PM_{10} was found to be vital pollutant[23]. Compiled data for 2013-2014 for 72 AAQM stations collected by MPCB showed moderate to below air quality[24]. In extension of our previous work[25-27] the present paper explores monthly, annual and seasonal variations in ambient air quality on selected monitoring sites residential (IMA hall) and industrial (Krishidhan seeds) of Jalna city for the year 2018 using air quality index (AQI).

II. MATERIALS AND METHODS

Study area: Jalna district is roughly situated in the central part of Maharashtra state and in northern part 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 has an area of 7612 km^2 which is about 2.47% of total area of Maharashtra in India. The district has subtropical climate with bulk rainfall from the southwest monsoon from June to September. The average rainfall of the district is about 650 to 750 mm. The district during drought has rainfall as low as 400 to 450 mm. After rainy season winter extends up to February during which the minimum temperature drops to 9° to 10°C and maximum temperature reaches upto 30-35°C. After winter hot summer extends up to June. The maximum day temperature reaches to 42-45°C in summer[28-29]. Jalna is industrially famous for seed and steel industries. The industrial development of Jalna is broadly based on Engineering, Plastic and Agriculture. At present six industrial areas are under Maharashtra Industrial Development Corporation (MIDC), Jalna containing pulses mills, 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 automobiles are the key causes of air pollution in the city[30, 31].

A. *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 2018 from industrial and residential sites. 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 operating the equipment for 24 hours period. Particulate pollutants i.e. RSPM and NRSPM samples were collected by regulating air with flow rate between 1.1-1.2 m^3/min up to 8 hours. The air inside the sampler passed in two stages through a combination of cyclone separator and filter. The cyclone separator gathers 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 (Whatmann GF/A, 203x254mm). Gravimetrically the concentration of RSPM and NRSPM were determined by standard method, CPCB 2011[32].

B. *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 coloured solutions absorbance was noted at 530 nm by spectrophotometer. Sulphate ions formed its concentration in absorbent was found 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 calorimetrically by reacting nitrile ion with phosphoric acid, sulphanilamide and N-(1-naphthyl)-ethylenediamine dihydrochloride (NEDA) and measuring the absorbance of the highly coloured azo-dye at 540nm[34,35].

C. *Air Quality Index (AQI)*

AQI is single number which illustrates overall ambient air quality grade based on actual measured concentration of criteria pollutants and its prescribed standard permissible concentration[36, 37].
For analyzing and representing uniform air quality status AQI is key existing tool.
Equation for Calculation of AQI is

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

Where, AQI= air quality index
n = number of criteria pollutants
APC= Actual pollutant concentration
SPC= Standard pollutant concentration (CPCB 2011)

Table.1 Indian 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

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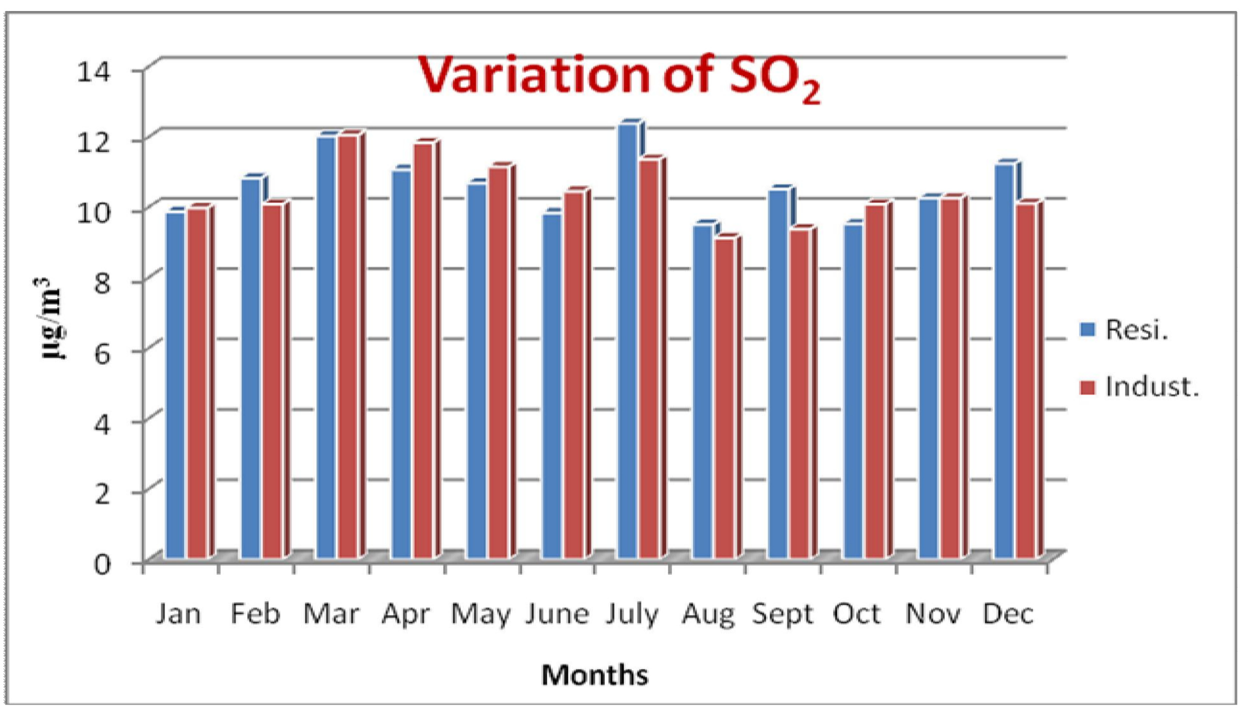
Table.2 Rating Scale of Air Quality Index (AQI) values

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 ($\mu gm/m^3$) at residential and industrial sites

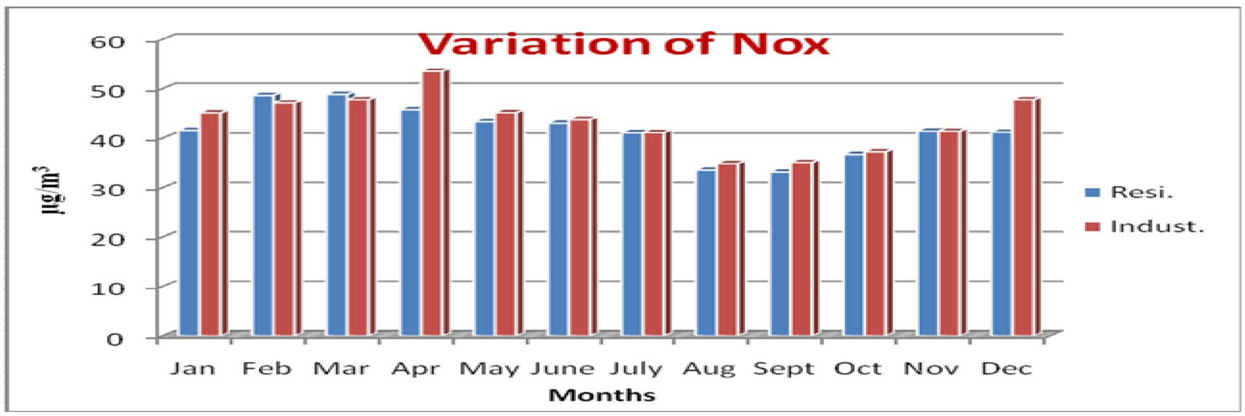
Month	Residential			Industrial		
	Min.	Max.	Avg.	Min.	Max.	Avg.
Jan	8.40	11.34	9.87	7.75	12.21	9.98
Feb	8.95	12.71	10.83	8.97	11.21	10.09
Mar	11.04	13.03	12.03	10.96	13.17	12.06
Apr	9.68	12.46	11.07	9.88	13.79	11.83
May	9.30	12.09	10.69	9.58	12.73	11.15
June	8.69	11.00	9.84	9.42	11.51	10.46
July	10.81	13.96	12.38	10.31	12.42	11.36
Aug	7.58	11.44	9.51	7.51	10.76	9.13
Sept	8.36	12.68	10.52	8.13	10.63	9.38
Oct	7.74	11.33	9.53	8.85	11.33	10.09
Nov	8.67	11.87	10.27	8.67	11.87	10.27
Dec	10.37	12.11	11.24	8.86	11.37	10.11
Average	9.13	12.16	10.64	9.07	11.91	10.49



Graph-1

Table 4. Monthly minimum, maximum and average concentration of NOx (µgm/m^3) at residential and industrial sites.

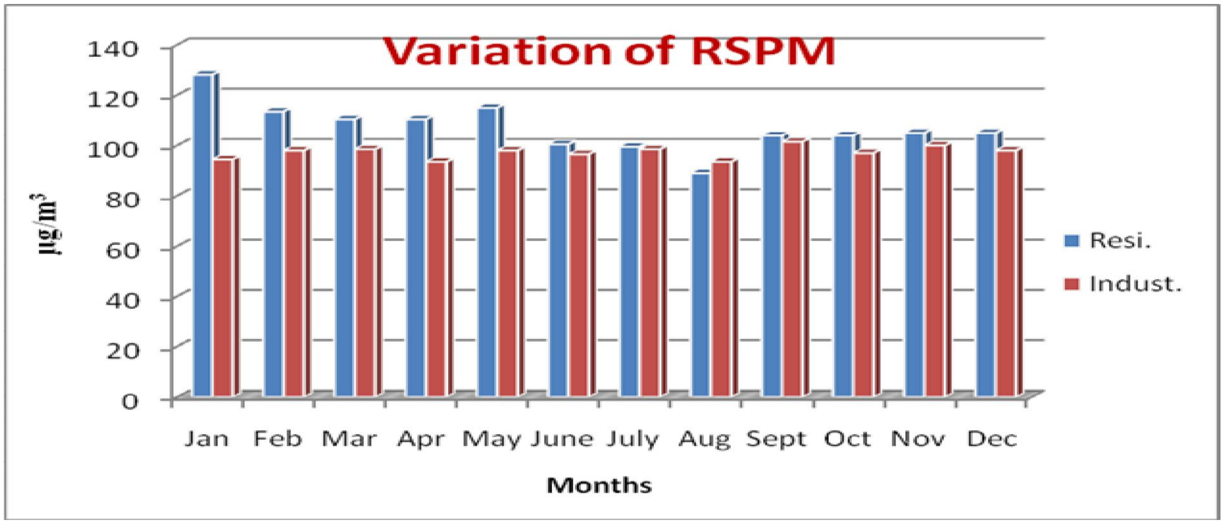
Month	Residential			Industrial		
	Min.	Max.	Avg.	Min.	Max.	Avg.
Jan	35.51	47.64	41.57	39.86	50.27	45.06
Feb	37.25	60.02	48.63	41.93	52.22	47.07
Mar	38.27	59.40	48.83	42.49	53.01	47.75
Apr	38.94	52.49	45.72	46.33	60.60	53.46
May	35.75	50.93	43.34	38.33	51.88	45.10
June	35.46	50.65	43.05	38.15	49.37	43.76
July	38.34	43.86	41.10	36.40	45.86	41.13
Aug	28.09	38.98	33.53	31.27	38.49	34.88
Sept	28.82	37.45	33.13	32.11	38.09	35.10
Oct	33.57	39.91	36.74	33.37	41.20	37.28
Nov	33.69	49.14	41.42	33.69	49.14	41.41
Dec	34.21	48.26	41.23	46.45	49.04	47.74
Average	34.82	48.22	41.52	38.82	48.33	43.57



Graph-2

Table 5. Monthly minimum, maximum and average concentration of RSPM (µgm/m^3) at residential and industrial sites.

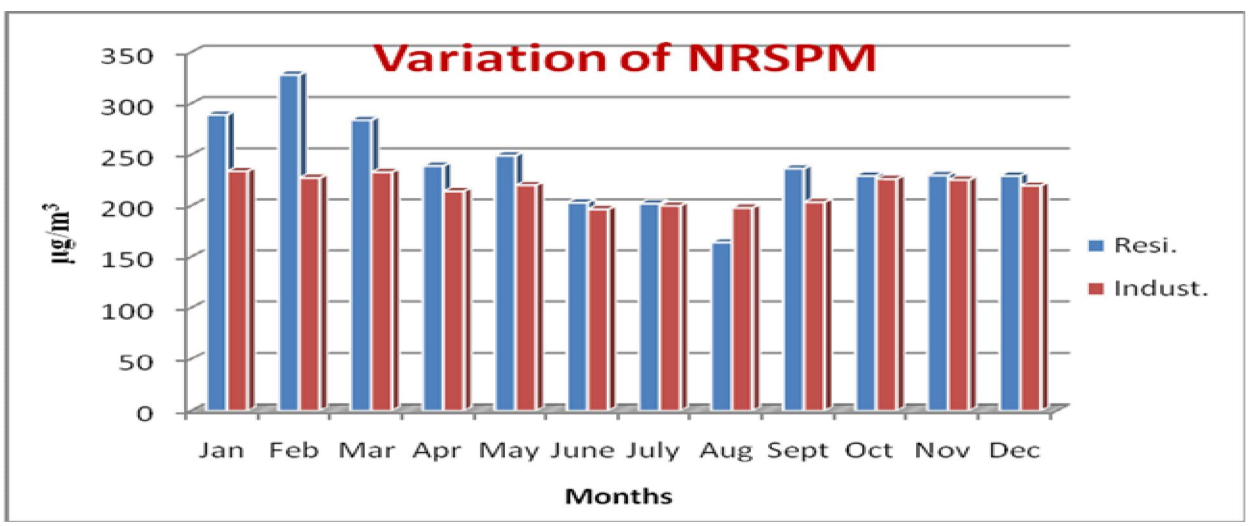
Month	Residential			Industrial		
	Min.	Max.	Avg.	Min.	Max.	Avg.
Jan	115	141	128	89	100	94.50
Feb	104	123	113.50	86	110	98
Mar	103	118	110.50	91	106	98.50
Apr	104	117	110.50	83	104	93.50
May	103	127	115	91	105	98
June	84	117	100.50	90	103	96.50
July	81	118	99.50	91	106	98.50
Aug	61	117	89	82	105	93.50
Sept	96	111	104	97	106	101.50
Oct	94	114	104	94	100	97
Nov	98	112	105	93	107	100
Dec	98	112	105	93	103	98
Average	95.08	118.91	107	90	104.58	97.29



Graph-3

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

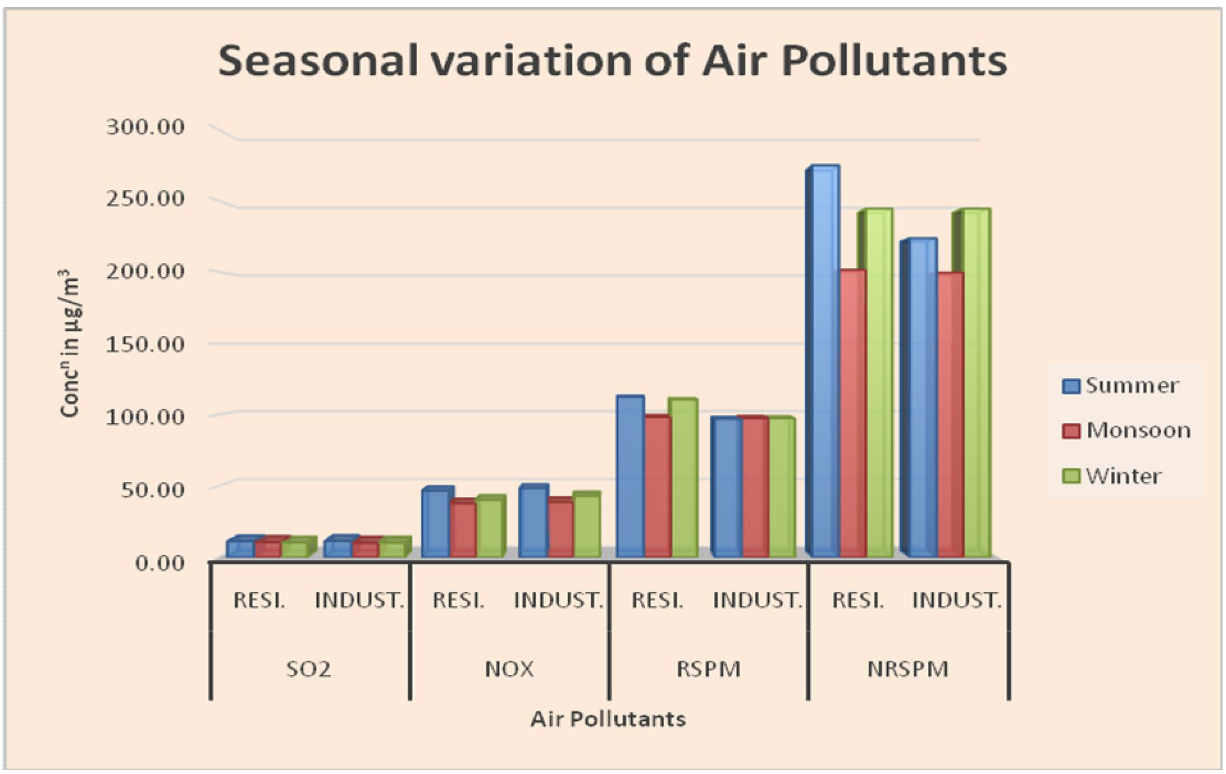
Month	Residential			Industrial		
	Min.	Max.	Avg.	Min.	Max.	Avg.
Jan	228	350	289	187	282	234
Feb	287	368	327.50	197	258	227.50
Mar	256	312	284	200	266	233
Apr	201	277	239	188	240	214
May	219	279	249	197	242	220
June	151	255	203	161	232	196.50
July	173	231	202	164	236	200
Aug	92	236	164	143	253	198
Sept	205	268	236.50	158	249	203.50
Oct	219	240	229.50	210	243	226.50
Nov	212	248	230	207	244	225.50
Dec	217	242	229.50	202	237	219.50
Average	205	275.5	240.25	184.5	248.5	216.50



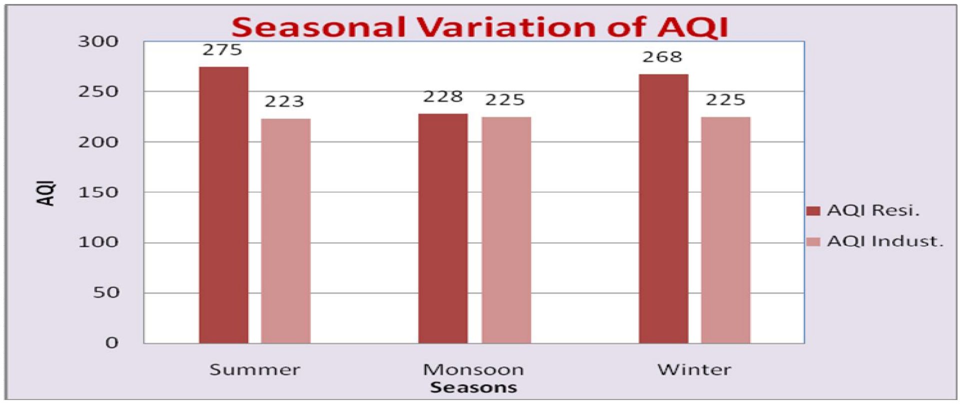
Graph-4

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	8.95	13.03	11.15	8.97	13.79	11.28
	NOx	35.75	60.02	46.63	38.33	60.60	48.34
	RSPM	103.00	127.00	112.37	83.00	110.00	97.00
	NRSPM	201.00	368.00	274.87	188.00	266.00	223.62
	AQI	275			223		
Monsoon	SO_2	7.58	13.96	10.56	7.51	12.42	10.08
	NOx	28.09	50.65	37.70	31.27	49.37	38.71
	RSPM	61.00	118.00	98.25	82.00	106.00	97.50
	NRSPM	92.00	268.00	201.37	143.00	253.00	199.50
	AQI	228			225		
Winter	SO_2	7.74	11.87	10.22	7.75	12.21	10.11
	NOx	33.57	49.14	40.24	33.37	50.27	42.87
	RSPM	94.00	141.00	110.50	89.00	107.00	97.37
	NRSPM	212.00	350.00	244.50	187.00	282.00	226.37
	AQI	268			225		



Graph-5



Graph-6

III. 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.

A. Sulphur dioxide (SO_2)

The monthly minimum, maximum, and average concentrations at residential site were 7.58µg/m^3, 13.96µg/m^{3}and 10.64µg/m^3 respectively. The highest concentration of SO_2 (19.96µg/m^3) at residential site was recorded in the month of July followed by March (13.03µg/m^3). The lowest concentration of SO_2 (7.58µg/m^3) was observed in month August at residential site. The monthly minimum, maximum and average concentrations at industrial sites were 7.51µg/m^3, 13.79µg/m^3 and 10.49g/m^3 respectively. The industrial site generally recorded the lower concentrations of SO_2 compared to the residential site. The SO_2 concentration at industrial site was observed highest (13.79µg/m^3)in the month of April followed by (13.17µg/m^3)in March while 7.51µg/m^3 was reported lowest in month of August. 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 Monsoon (13.96µg/m^3) followed by summer (13.03µg/m^3). The least concentration of SO_2 at residential site was observed in monsoon season (7.58µg/m^3). Unlike to residential site industrial site recorded highest concentration of SO_2 in summer (13.79µg/m^3) followed by Monsoon (12.42µg/m^3) and lowest was reported in Monsoon season (7.51µg/m^3). Seasonal mean variation of SO_2 is as shown in Graph-5.

Mean annual minimum, maximum and average concentration of SO_2 at residential site obtained were 9.13µg/m^3, 12.16µg/m^3 and 10.64µg/m^3 respectively. While mean annual minimum, maximum and average concentration of SO_2 at industrial site obtained were 9.07µg/m^3, 11.91µg/m^3 and 10.49µg/m^3 respectively, which were well below the national ambient air quality standards (NAAQS) stipulated by the central pollution control board (CPCB 2009)[38].

B. Oxides of Nitrogen (NOx)

The monthly minimum, maximum and average concentrations of oxides of nitrogen (NOx) at residential site were 28.09µg/m^3, 60.02µg/m^3 and 41.42µg/m^3 respectively. The highest monthly concentration was reported in February (60.02µg/m^3) followed by March (59.40µg/m^3), while 28.09µg/m^3 being lowest reported in the August. The monthly minimum, maximum and average concentrations of oxides of nitrogen (NOx) at industrial site were 31.27µg/m^3, 60.60µg/m^3 and 43.57µg/m^3 respectively. The highest monthly concentration was reported in April (60.60µg/m^3) followed by March (53.01µg/m^3), while 31.27µg/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 Summer (60.02µg/m^3) at residential site and also during Summer (60.60µg/m^3) at industrial site. The lowest concentration of NOx at residential site was observed during Monsoon (28.09µg/m^3) while at industrial site it was recorded (31.27µg/m^3) during monsoon. The annual mean concentration of NOx at residential and industrial site was recorded 41.52µg/m^3 and 43.57µg/m^3 respectively which were found below the NAAQS (CPCB 2009).Seasonal mean variation of NOx is as shown in Graph-5.

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]. Investigators [40-42] reported similar outcome.

C. 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.

1) *Respirable suspended particulate matter RSPM ($\leq PM_{10}$):* The annual mean concentration of RSPM (PM_{10}) at residential site was observed 107µg/m^3 which is above the maximum permissible limits of NAAQS (Table 1). The highest monthly mean concentration 141µg/m^3 was recorded in the month of January while the lowest 61µg/m^3 reported during August. Seasonally Winter recorded highest levels of RSPM 141µg/m^3 at residential site and in Summer at industrial site as 110µg/m^3. The monthly mean concentration of RSPM at residential site was 107µg/m^3. While at industrial site it was 97.29µg/m^3. Monthly mean variation of RSPM is as shown in Graph-3. The annual mean reported at industrial site was 97.29µg/m^3 which violated the existing NAAQS. Seasonal mean variation of RSPM is as shown in Graph-7.
2) *Non Respirable Suspended particulate matter (NRSPM)$\geq PM_{10}$:* The monthly mean concentration of NRSPM was ranged between 92-368µg/m^3 and 143-282 µg/m^3 and annual mean concentration were recorded 240.25µg/m^3 and 216.50µg/m^3 at residential and industrial site respectively. The highest monthly mean concentration at residential site was observed 368µg/m^3 in February followed by 350µg/m^3 in January. At industrial site the highest NRSPM concentration 282µg/m^3 was recorded in January followed by 266µg/m^3 in March, whereas the lowest NRSPM at residential site was recorded in August 92µg/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 summer with 368µg/m^3 followed by 350µg/m^3 in winter at residential site. While highest mean NRSPM levels were recorded in winter 282µg/m^3 followed by 266µg/m^3 in summer at industrial site. Lowest NRSPM concentration for both the sites was recorded in Monsoon as 92µg/$m^3$for residential and 143µg/m^3 for industrial sites. Seasonal mean variation of NRSPM is as shown in Graph-5. Automobiles, emissions from industries[7, 43, 44] along with dust and construction, waste burning are the main contributors of particulate pollutants in ambient air. The seasonal variation pattern of RSPM and NRSPM concentration can be understood from the values presented in table 7. The variation pattern is caused by the meteorological factors like vertical mixing in summer and frequent inversions in winter[13,42,45]. The pattern for urban sites are basically analogous for both summer and winter signifying that most important emission sources are seasonally independent for urban areas and are certainly traffic emissions and industries[46]. Seasonal mean variation of AQI is as shown in Graph-6. AQI values obtained are 257 and 224 at respective sites due to higher particulate matter indicate[47] poor or unhealthy pollution grade as per the rating scale (table 2). Members of sensitive groups such as older adults and children may suffer from health effects like heart or lung disease on prolong exposure and at higher risk compared to general public[48].

IV. CONCLUSIONS

Analysis of temporal and spatial variations of SO_2, NOx, RSPM and NRSPM based on one-year study of constant measurements at Jalna area (residential and industrial site) shown that the particulate as well as gaseous pollutants concentration at both sites were found to be elevated and comparable caused by wind flow directions and location of sites. The annual mean gaseous pollutants measured at residential site were found inside the permissible limits of NAAQS, whereas RSPM and NRSPM concentrations violated the prescribed limit at residential as well as at industrial site. The seasonally for SO_2, NOx, RSPM and NRSPM at both sites generally showed higher concentration during summer, intermediate in winter and lowest in monsoon. Only RSPM showed nearly similar trend seasonally at industrial site. The overall Ambient air quality was found to be better in Monsoon compared to winter and then summer.

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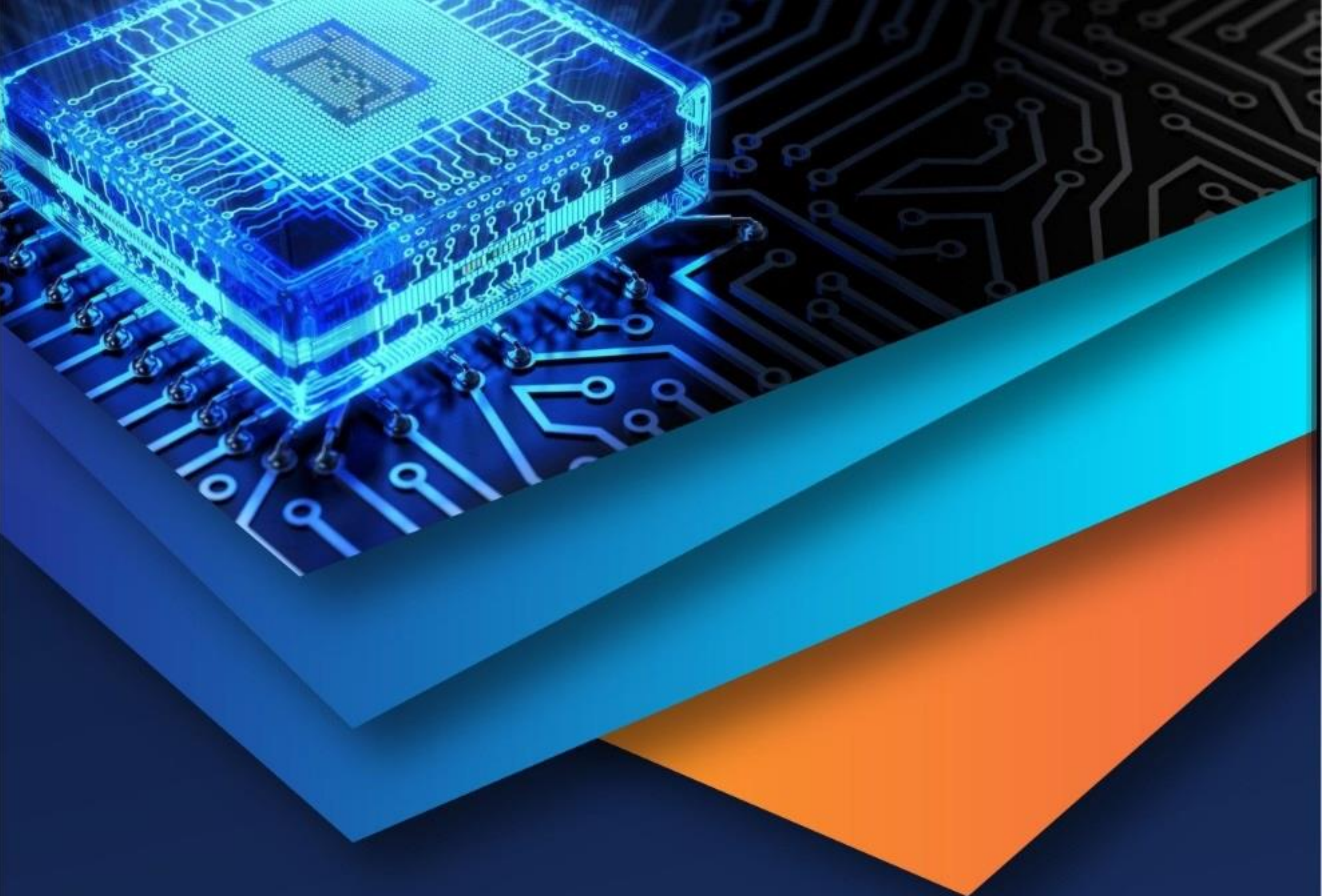

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