DOI: Received: 15-05-2019 Accepted: 12-12-2019

Indian J.Sci.Res. 10 (2): 45-53, 2020 Original Research Article ISSN: 0976-2876 (Print)
ISSN: 2250-0138 (Online)

AMBIENT AIR QUALITY ASSESSMENT OF JALNA CITY (MS), INDIA

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ABSTRACT

The ambient air quality of Jalna city has been evaluated using air quality index (AQI). Air pollutants concentration- SO_2, NOx, RSPM and NRSPM were assessed at residential and industrial sites for one-year period. The monthly, seasonal and annual AQI values determined at both residential and industrial sites for a year. Results suggest better air quality at residential sits than industrial. Government regulations, efficient treatments in plants, proper waste disposal helped in pollution reduction. Annual mean concentrations of SO_2 and NOx found within the permissible limits of Indian National Ambient Air Quality standards (NAAQS), while RSPM and NRSPM concentrations violated at both sites. The annual AQI values 127.79 and 88.50 were recorded for residential and industrial site respectively due to higher RSPM.

KEYWORDS: Air Quality Index (AQI), RSPM-Respirable Suspended Particulate Matter, NRSPM- Non Respirable Suspended Particulate Matter, Gaseous pollutants-SO_2, NOx

Environmental pollution is increasing at alarming rate as shown by monitoring agencies and climate change. Over population, scarce public facilities (Tashiro and Taniyama, 2002), urbanization (Atash, 2007), automobile emissions (Baladauf *et al.*, 2009) and industrialization (Harison and Yin, 2000) (Kim *et al.*, 2002) (Sharek et al., 2007) detoriates the climate. Human health, assets and environment (Hrdlickova *et al.*, 2008) (Gupta et al., 2003) (Celis *et al.*, 2004) (Zhang *et al.*, 2007) are spoiled by these factors. Sulphur dioxide, nitrogen oxides and particulate matter are key pollutants indicated by environment protection agency. Factors like pollution sources-local and distant, meteorological and topographical conditions, variations-spatial and temporal (Franchini and Mannucci, 2007) (Allen *et al.*, 2009) (Gomiscek *et al.*, 2004) (Rao *et al.*, 2009) affects amount of pollutants in a particular area. Many countries along with India set air quality monitoring programs to judge air quality (Bishnoi *et al.*, 2009). For proper management of environment issues (Suess, 1979) (Titta *et al.*, 2002) knowledge of air pollutants, concentrations, variations and field data are necessary, otherwise may affect planning. EPA initiated Air Quality Index (AQI) which gives quality of air based on rating scale (Ott and Jr. Hunt, 1976) (Ott and Thom, 1976) (USEPA, 2014) (Ontario, 2013). In Bikaner city, India higher particulate matter found during winters than monsoon (Charan and Sahel, 2014). PM_{10} was a key pollutant in moderately polluted Vapi city in India (Sarella and Khanbete, 2015). 72 AAQM stations compiled data for 2013-14 showed moderate to below quality of air (AQSM, 2013-2014). In continuation of earlier work (Aher *et al.*, 2014) (Aher *et al.*, 2014) (Dobhal et al., 2016) the current paper realizes air quality of residential (IMA hall) and industrial (Krishidhan Seeds) sites of Jalna city from January to December 2016 using AQI.

MATERIALS AND METHODS

Study Area

Jalna district is in central part of Maharashtra state and on northern direction of Marathwada region, India with north latitudes 19°1¹ to 23°3¹ and 75°4¹ to 76°4¹ east longitudes, having an area of 7612 km^2. District has subtropical climate with bulk rainfall of 650-750mm from southwest monsoon between June to September. During drought rainfall reduces to 400 to 450 mm. After monsoon in winter minimum temperature falls to 9°- 10°C and maximum goes to 30-35°C. In summer maximum day temperature reaches to 42-45°C (Rajajoseph *et al.*, 2014) (Erika *et al.*, 2015).

Industrially Jalna is famous for Seeds, Steel along with other areas Engineering, Plastic and Agriculture. City is having six industrial areas under MIDC having industries of pulses, oil mills, refineries, steel re-rolling, plastics, tiles, cement pipes, fertilizers, insecticides, pesticides and the co-operative sugar factories. These industries along with automobiles are the key air polluting factors in the city (Harison and Yin, 2000) (UNCSD, 2001).

Sampling and Analysis of Particulate Pollutant (RSPM and NRSPM)

Twice a week during January to December 2016 RSPM, NRSPM, SO_2 and NOx samples were collected from both sites using High volume air sampler (model RDS APM 460NL) with attachment APM 411TE (Enviro-tech make) can work for 24 hours. For RSPM

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and NRSPM air flow rate 1.1 to 1.2 m^3/min for 8 hours maintained. The cyclone separator collects bigger particles NRSPM > 10µm size on previously weighed dust collector in first stage, RSPM (size < 10µm) were collected on Whatmann GF/A glass microfiber filter. Using CPCB, 2011 gravimetrically the concentration of RSPM and NRSPM were found.

Gaseous Pollutants (SO_2 and NOx)

SO_2 air samples were absorbed in absorbent solution of potassium tetrachloromercurate (TCM), complex formed dichlorosulphitomercurate was made to react with para rosaniline and methyl sulphonic acid. Spectrophotometer measurs absorbance at 530 nm of formed sulphate ions concentration in absorbent using West and Gaeke Method (IS 5182 part 2:2001); CPCB 2001.

Nitrogen dioxide from air bubbled through a solution of sodium hydroxide and sodium arsenite. Nitrile ion produced was treated with phosphoric acid, sulphanilamide and N-(1-naphthyl)-ethylenediamine dihydrochloride (NEDA) and measuring the absorbance of the highly coloured azo-dye at 540nm (Jacob and Hochheiser, 1958) (IS 5182-2, 2001).

Air Quality Index (AQI)

AQI is a single number showing actual concentration of criteria pollutants compared to its standard permissible values (Bortnick *et al.*, 2002) (Murena, 2004). AQI guides in analyzing and representing uniform air quality status.

AQI Equation 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 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

AQI rating scale of is as shown below.

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

RESULTS AND DISCUSSION

The concentrations of SO_2, NOx, RSPM and NRSPM monitored at residential and industrial sites have been presented in table 3 and table 4.

Table 3: Monthly minimum, maximum and average concentration of SO_2, NOx, RSPM and SPM (µgm/m^3) at residential site

Month	SO_2 (µg/m^3) Prescribed limit 80 µg/m^3			NOx (µg/m^3) Prescribed limit 80 µg/m^3			RSPM (µg/m^3) Prescribed limit 100 µg/m^3			SPM (µg/m^3) Prescribed limit 200 µg/m^3		
	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.
Jan	9.75	15.95	12.63	27.89	30.21	29.36	87.00	175.00	128.00	370.00	507.00	449.00
Feb	10.41	13.02	12.24	27.48	31.84	30.00	99.00	175.00	124.00	355.00	581.00	503.00
Mar	8.17	15.47	11.58	23.57	30.23	27.84	104.00	159.00	122.00	398.00	618.00	489.00
Apr	10.05	16.69	12.32	26.85	32.37	28.47	108.00	144.00	128.00	394.00	567.00	478.00
May	11.48	16.54	13.35	29.62	34.77	31.81	101.00	147.00	128.00	328.00	476.00	411.00
June	6.43	11.24	9.00	18.59	34.16	27.19	76.00	130.00	110.00	204.00	456.00	368.00
July	9.72	15.06	11.96	25.98	41.48	29.43	75.00	131.00	98.00	186.00	449.00	305.00
Aug	9.32	15.05	11.80	23.63	29.87	27.20	74.00	110.00	97.56	265.00	457.00	366.00
Sept	9.70	13.51	11.38	22.32	31.95	28.17	48.00	113.00	84.00	130.00	339.00	237.00
Oct	3.26	5.21	4.27	15.94	43.49	30.81	109.00	130.00	118.00	291.00	605.00	478.00
Nov	3.92	6.20	5.16	23.20	36.53	30.69	116.00	362.00	208.00	405.00	897.00	720.00
Dec	11.51	15.15	13.84	28.97	39.94	35.72	158.00	248.00	188.00	544.00	871.00	749.00
Average	**8.64**	**13.25**	**10.79**	**25.79**	**33.44**	**29.72**	**96.25**	**168.66**	**127.79**	**322.50**	**568.58**	**462.75**

Table 4: Monthly minimum, maximum and average concentration of SO_2, NOx, RSPM and SPM (µgm/m^3) at industrial site

Month	SO_2 (µg/m^3) Prescribed limit 80 µg/m^3			NOx (µg/m^3) Prescribed limit 80 µg/m^3			RSPM (µg/m^3) Prescribed limit 100 µg/m^3			SPM (µg/m^3) Prescribed limit 200 µg/m^3		
	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.
Jan	9.73	15.74	11.71	28.70	34.34	31.62	87.00	97.00	93.00	166.00	344.00	227.00
Feb	11.07	13.43	11.93	27.09	31.16	29.41	91.00	101.00	94.00	213.00	248.00	232.00
Mar	11.68	14.59	13.52	28.75	36.61	13.52	89.00	98.00	95.00	203.00	297.00	241.00
Apr	12.31	14.72	13.44	28.74	38.21	32.81	84.00	96.00	92.00	244.00	503.00	374.00
May	9.83	13.39	11.49	29.35	34.41	31.24	77.00	96.00	89.00	267.00	434.00	356.00
June	6.31	13.34	9.25	24.35	29.56	26.61	68.00	93.00	82.00	189.00	413.00	288.00
July	9.73	16.32	12.63	23.80	35.57	27.48	72.00	96.00	89.00	157.00	253.00	200.00
Aug	10.25	14.00	12.06	23.08	31.99	28.62	65.00	95.00	83.00	236.00	333.00	275.00
Sept	9.25	14.06	11.70	22.32	33.67	27.66	67.00	96.00	78.00	197.00	341.00	258.00
Oct	11.78	13.76	12.91	28.48	31.68	30.81	81.00	95.00	91.00	200.00	363.00	289.00
Nov	5.47	10.24	8.37	32.98	41.94	37.24	74.00	96.00	87.00	117.00	186.00	164.00
Dec	11.99	15.52	13.70	26.64	44.57	35.53	82.00	94.00	89.00	168.00	227.00	200.00
Average	**9.95**	**14.09**	**11.89**	**27.02**	**35.30**	**29.37**	**78.08**	**96.08**	**88.50**	**196.41**	**328.50**	**258.66**

Sulphur Dioxide (SO_2)

The monthly minimum, maximum, and average concentrations at residential site were varied between 3.26-11.51 µg/m^3, 5.21-16.69 µg/m^3 and 4.27-13.84 µg/m^3 respectively. The highest concentration of SO_2 (16.69 µg/m^3) at residential site was recorded in the month of April followed by May (16.54µg/m^3). The lowest concentration of SO_2 (3.26 µg/m^3) was observed in month October at residential site. The monthly minimum, maximum and average concentrations at industrial sites were varied between 5.47-12.31µg/m^3, 10.24-16.32µg/m^3 and 8.37-13.70µg/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 (16.32µg/m^3) in the month of July followed by (15.74µg/m^3) in January while 5.47µg/m^3 was reported

lowest in month of November. Monthly mean variation of SO_2 at both sites is as shown in Graph-1.

The seasonal trend in concentration of SO_2 was as shown in table 5.

Table 5: 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	8.17	16.69	12.37	9.83	14.72	12.60
	NOx	23.57	34.77	29.53	27.09	38.21	26.75
	RSPM	99.00	175.00	125.50	77.00	101.00	92.50
	SPM	328.00	618.00	470.25	203.00	503.00	300.75
	AQI			**125.50**			**92.50**
Monsoon	SO_2	6.43	15.06	11.04	6.31	16.32	11.41
	NOx	18.59	34.16	28.00	22.32	35.57	27.59
	RSPM	48.00	131.00	97.39	65.00	96.00	83.00
	SPM	130.00	457.00	319.00	157.00	413.00	255.25
	AQI			**97.39**			**83.00**
Winter	SO_2	3.26	15.95	8.98	5.47	15.74	11.67
	NOx	15.94	43.49	31.65	26.64	44.57	33.80
	RSPM	87.00	362.00	160.50	74.00	97.00	90.00
	SPM	291.00	897.00	599.00	117.00	363.00	220.00
	AQI			**160.50**			**90.00**

The highest seasonal concentration of SO_2 at residential site was observed in summer (16.69µg/m^3) followed by winter (15.95µg/m^3). The least concentration of SO_2 at residential site was observed in winter season (3.26 µg/m^3). Industrial site recorded highest concentration of SO_2 in monsoon (16.32 µg/m^3) followed by winter (15.74 µg/m^3) and lowest was reported in winter season (5.47 µg/m^3). Seasonal mean variation of SO_2 is as shown in Graph 5.

The annual mean minimum, maximum and average concentration of SO_2 at residential site obtained was 8.64 µg/m^3, 13.25 µg/m^3 and 10.79 µg/m^3 respectively. While the annual mean minimum, maximum and average concentration of SO_2 at industrial site obtained were 9.95µg/m^3, 14.09µg/m^3 and 11.89 µg/m^3 respectively, which were well below the national ambient air quality standards (NAAQS) specified by the central pollution control board (CPCB, 2009).

Oxides of Nitrogen (NOx)

The monthly minimum, maximum and average concentrations of oxides of nitrogen (NOx) at residential site were ranged from 15.94-29.62 µg/m^3, 25.98-43.49 µg/m^3 and 27.19-35.72 µg/m^3 respectively. The highest monthly concentration was reported in October (43.49 µg/m^3) followed by July (41.48 µg/m^3). While 15.94 µg/m^3 being lowest reported in the October. Thus highest and lowest concentrations of NOx at residential site were recorded in October. The monthly minimum, maximum and average concentrations of oxides of nitrogen (NOx) at industrial site were varied from 22.32-32.98 µg/m^3, 29.56-44.57 µg/m^3 and 13.52-37.24 µg/m^3 respectively. The highest monthly concentration was reported in December (44.57 µg/m^3) followed by November (41.94 µg/m^3). While 22.32 µg/m^3 being lowest reported in the September. Monthly mean variation of NOx is as shown in Graph 2.

Seasonally the highest mean concentration of NOx was observed during winter (43.49 µg/m^3) at residential site and again in winter (44.57 µg/m^3) at industrial site. The lowest concentration of NOx at residential site was observed during winter (15.94 µg/m^3) while at industrial site it was recorded (22.32 µg/m^3) during monsoon. The annual mean concentration of NOx at residential and industrial site was recorded 29.72 µg/m^3 and 29.37 µg/m^3 respectively which were below the NAAQS (CPCB 2009). Seasonal mean concentration 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 (Muschate and Chougale,

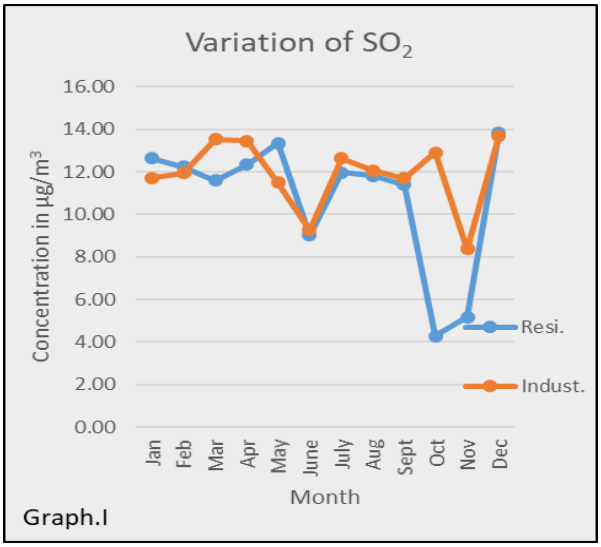
2011). The seasonal concentration pattern of air pollutants is driven by emission characteristics of the dominant sources and meteorological conditions (Gomiscek *et al.*, 2004), similar results reported by other scholars (Bhanarkar *et al.*, 2002) (Kaushik *et al.*, 2006).

Particulate Pollutants

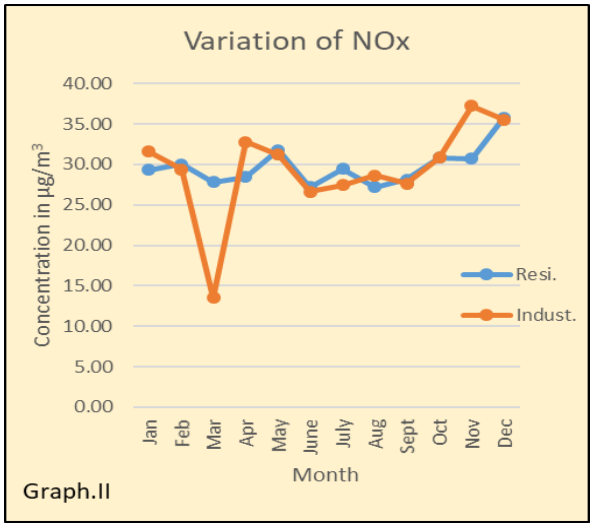
The monthly minimum, maximum and average concentration of RSPM and NRSPM observed at residential and industrial site has been reported in table no. 3 & 4.

Respirable Suspended Particulate Matter RSPM (≤ PM_{10})

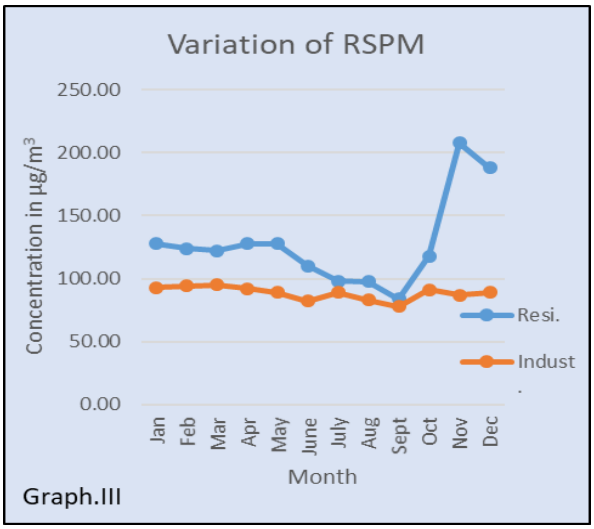
The annual mean concentration of RSPM (≤ PM_{10}) at residential site was found 127.79 µg/m^3, beyond the maximum permissible limits of NAAQS (Table 1). November recorded highest monthly mean RSPM concentration 362 µg/m^3 and the lowest 48 µg/m^3 in September. Seasonally winter recorded highest levels of RSPM 362 µg/m^3 at residential site and at industrial site 101 µg/m^3. RSPM monthly mean concentration varied from 84-208 µg/m^3 at residential site and at industrial site it varied from 78-95 µg/m^{3}as shown in Graph 3. The annual mean RSPM reported at industrial site was 88.5 µg/m^3 which is below the existing NAAQS. Seasonal mean variation of RSPM is as shown in Graph 7.



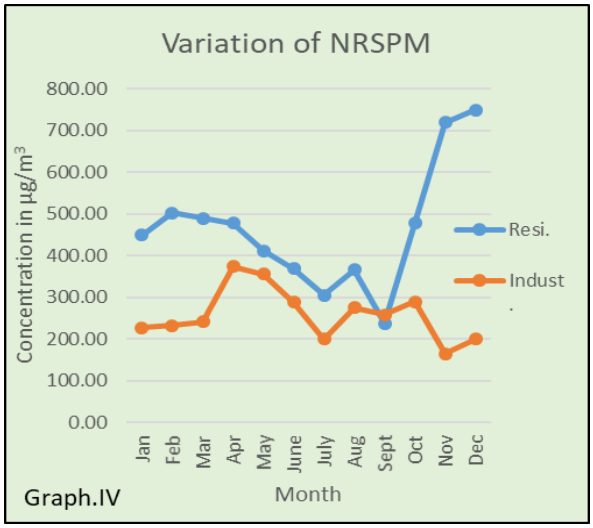
Graph 1: Monthly variation of Concentration of SO_2



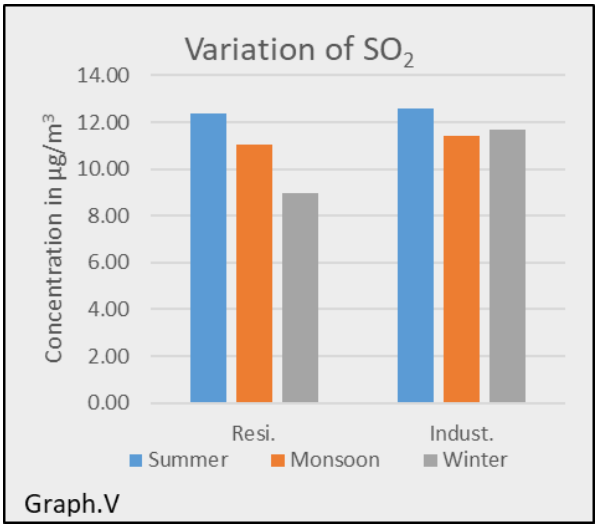
Graph 2: Monthly variation of Concentration of NOx



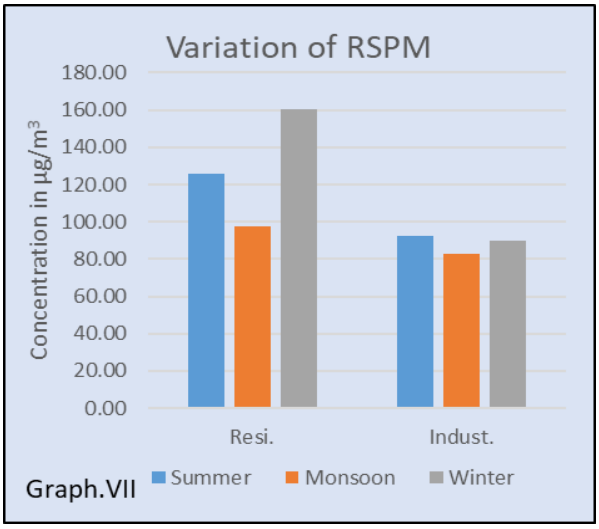
Graph 3: Monthly variation of Concentration of RSPM



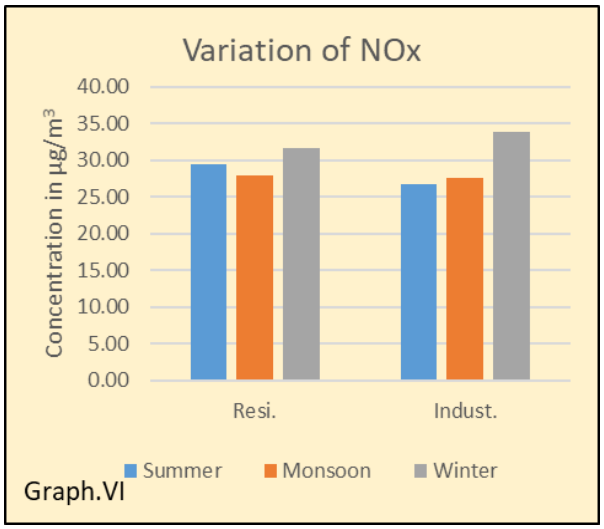
Graph 4: Monthly variation of Concentration of NRSPM



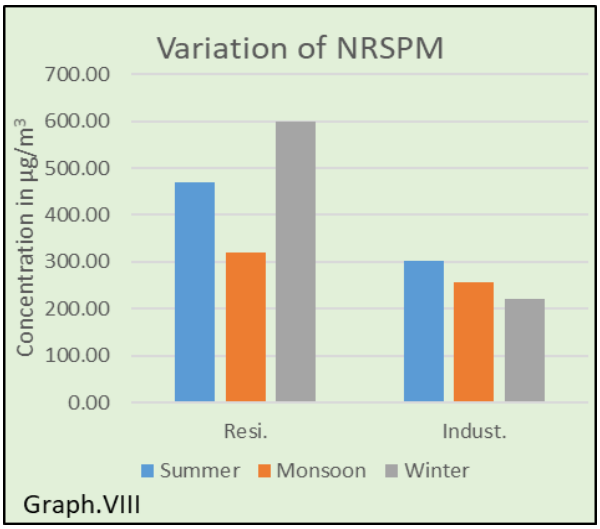
Graph 5: Seasonal variation of Concentration of SO_2



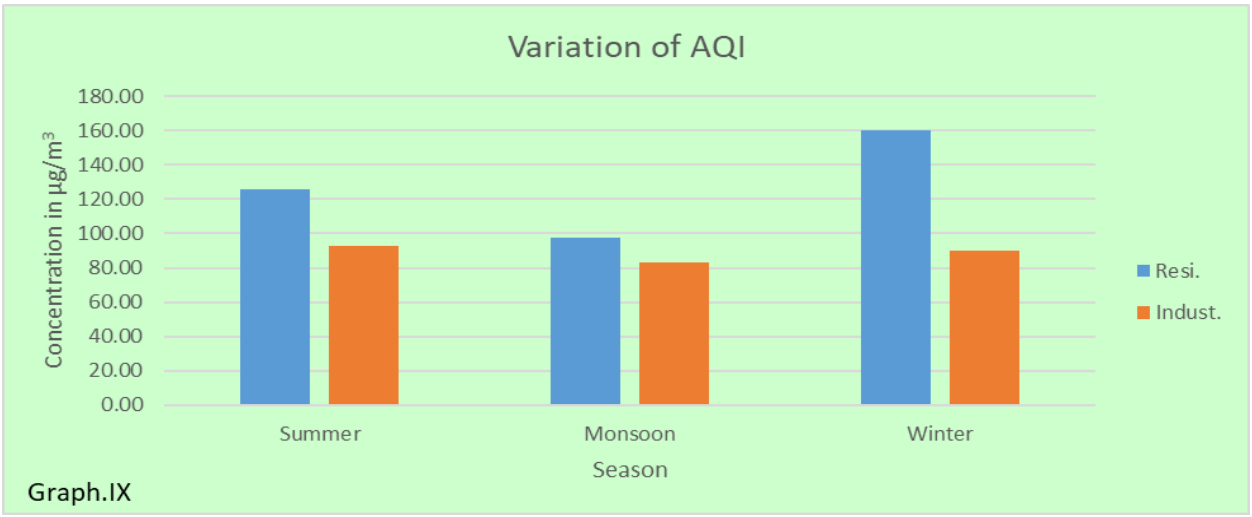
Graph 7: Seasonal variation of Concentration of RSPM



Graph 6: Seasonal variation of Concentration of NOx



Graph 8: Seasonal variation of Concentration of NRSPM



Graph 9: Seasonal variation of AQI

Non Respirable Suspended Particulate Matter (NRSPM) ≥ PM_{10}

NRSPM monthly mean concentration was ranged between 237-749 µg/m^3 and 164-374 µg/m^3 and annual mean concentration were recorded 462.75 µg/m^3 and 258.66 µg/m^3 at residential and industrial site respectively. NRSPM highest monthly mean concentration at residential site was found 749 µg/m^3 in December followed by 720 µg/m^3 in November. At industrial site highest NRSPM concentration 503 µg/m^3 was in April followed by 434 µg/m^3 in May. Lowest NRSPM at residential site was recorded in September 130 µg/m^3 as shown in Graph 4.

Seasonal NRSPM concentrations varied significantly at both the monitoring sites. The highest mean NRSPM levels were recorded in winter as 749 µg/m^3 followed by 720 µg/m^3 again in winter at residential site. While highest mean NRSPM levels were recorded in summer 374 µg/m^3 followed by 356 µg/m^3 again in summer at industrial site. Lowest NRSPM concentration for residential site was recorded in monsoon as 237µg/m^3 and 164 µg/m^3 for industrial site during winter. Seasonal mean variation of NRSPM is as shown in Graph 8. The major contributors of particulate pollutants in ambient air are automobiles and industries (Hrdlickova *et al.*, 2008). The seasonal variation pattern of RSPM and NRSPM concentration can be seen from the values presented in table.V. The variation pattern is caused by the meteorological effects i.e. vertical mixing in summer and frequent inversions in winter (Gomiscek *et al.*, 2004). 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. Seasonal mean variation of AQI is as shown in Graph 9. AQI values for residential site 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 compared to general public. While AQI values for industrial site obtained are between 51 and 100 due to higher particulate matter indicate satisfactory level of pollution as per the rating scale (table 2), which will have less effect even on sensitive group of persons.

CONCLUSION

Analysis of variations of SO_2, NOx, RSPM and NRSPM based on one-year study at Jalna city area-residential and industrial site shown that the particulate pollutants at both sites were found to be higher 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 concentrations violated the prescribed limit more at residential and less at industrial site. Whereas NRSPM concentrations violated the prescribed limit at both sites. The seasonal cycle for SO_2 at both sites showed higher concentration during summer and lower in monsoon. The NOx, RSPM and NRSPM concentration was found to be higher in winter and lower in monsoon at both sites, only NRSPM concentration higher in summer at industrial site. Ambient air quality was found to be better in monsoon season.

ACKNOWLEDGEMENT

Authors are thankful to Director, Maharashtra pollution control board (MPCB), Aurangabad, Badrinarayan Barwale College, Jalna and Enviro-tech lab for their supports like financial, technical, scientific, laboratory, infrastructure, co-operation, guidance and suggestion, also to everyone who helped directly or indirectly for work.

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