Study of Air Quality of Jalna City (MS), India using Air Quality Index (AQI)

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Abstract: Air quality index is used to assess the air quality of Jalna city. Concentrations of air pollutants PM_{10}, $PM_{2.5}$, SO_2, NO_x monitored at residential and industrial sites for an year and used to measure AQI. Overall air quality at both sites studied and compared using monthly and annual AQI values. Air quality at residential site was poorer than industrial site. Government regulations, proper pollutants control in industries, correct waste disposal and awareness helps in minimizing levels of pollutants. As per NAAQS standard annual mean concentrations of SO_2 and NO_x at both sites found within permissible limits, while at both sites annual mean concentrations of PM_{10} and $PM_{2.5}$ deviated from standards. Annual mean AQI value at residential site was 229.75 and at industrial site it was 211.75, both sites AQI falls under poor AQI category as per rating scale. Higher AQI values are due to $PM_{2.5}$ which may affect older adults and children particularly heart and lung disease on prolong exposure and at higher risk.

Keywords: Ambient air quality, Air Quality Index (AQI), Gaseous pollutants- SO_2, NO_x, Particulate pollutants- $PM_{2.5}$ (Respirable suspended particulate matter) and PM_{10} (Non Respirable suspended particulate matter)

I. INTRODUCTION:

Environmental pollution is serious concern due to population, less public facilities [1], urbanization and industrialization [2,4,5,6] and automobile emissions[3]. All these factors declines human health, climate, possessions [7-10]. *SO_2, NO_x, $PM_{2.5}$ and PM_{10}* are key pollutant identified by EPA. Factors like local and distant sources, meteorological and tropical conditions, temporal and spatial variations determine the extent of pollutants at particular place [11-14]. Ambient air quality monitoring stations established to monitor air quality [15]. For proper supervision of pollutants crisis [16,17] their knowledge, concentration variations and obtained data helps in controlling actions. AQI mathematically furnishes a single quantity for deciding the air quality at a place depending on air quality rating scale [18-20]. In extension of our earlier work [21-27] the recent paper examines monthly and annual mean variations at IMA hall (residential site) and Krishidhan seeds (industrial site) of Jalna city using AQI.

II. MATERIALS AND METHODS:

Study area: Jalna city. Table.1 shows general information about Jalna city

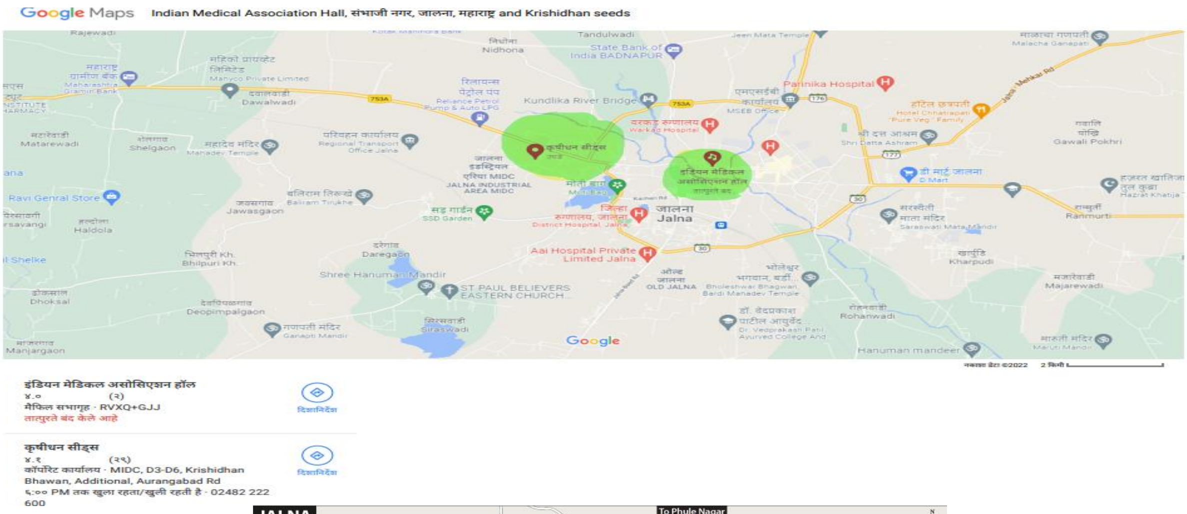
Table 1: Information about Jalna city

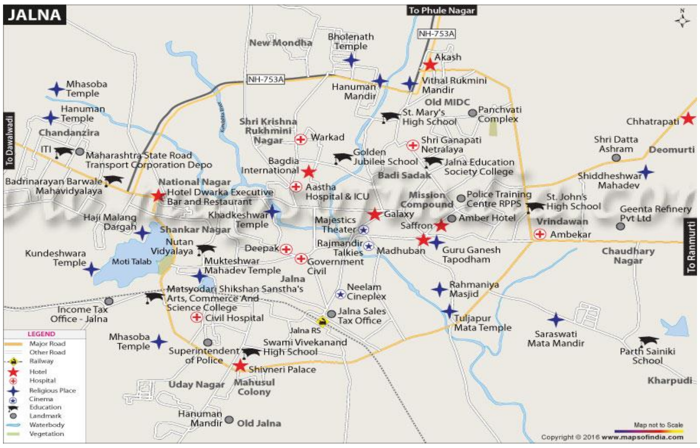
Sr. No.	Information about Jalna city	
01	Situated at	Central part of Maharashtra state and in northern part of Marathwada region in India.
02	Latitudes	between 19°1¹ to 23°3¹ north
03	Longitudes	between 75°4¹ to 76°4¹ east
04	Area	7612 km^2 (about 2.47% of total area of Maharashtra in India).
05	Rainfall	643-825 from the southwest monsoon from June to September
06	Drought	400-450mm rainfall
07	Temperature	minimum 9° to 10°C in winter maximum 42-45°C in summer[28-29]
08	Industries	famous for seed and steel industries
09	Other industries	pulses mills, oil mills, refineries, steel re-rolling, plastics, tiles, cement pipes, fertilizers, insecticides, pesticides and the co-operative sugar factories

Industries, growing numbers of the automobiles, high traffic density, heavy vehicle movement, presence of industrial area in the vicinity, natural dust, constructions, mining works and dust storms, etc are the key causes of air pollution in the city [30, 31]. Table.2 represents the location of sampling stations

Table 2: Location of monitoring stations

Sr. No.	Station Name	Location		
		Latitude	Longitude	Elevation
1	Residential site: IMA Hall	19º84’86.87”N	75º88’92.84”E	503m
2	Industrial site: Krishidhan Seeds Pvt. Ltd.	19º85’04.63”N	75º85’32.35”E	524m





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

Samples of $PM_{2.5}$ (RSPM), PM_{10} (NRSPM), SO_2 and NO_x were collected twice a week during January to December 2019 from both sites.

SO_2: Ambient air samples of SO_2 collected by absorbing it in absorbent solution of potassium tetrachloromercurate (TCM). A stable dichlorosulphitomercurate complex forms which was reacted with para rosaniline and methyl sulphonic acid. Sulphate ions concentration formed in absorbent was measured by absorbance of colour solution at 530nm using spectrophotometer. Modified West and Gaeke Method (IS 5182 part 2:2001); CPCB 2001[33] used for analysis.

NO_x: Ambient NO_x was collected by bubbling known volume of air through sodium hydroxide and sodium arsenite solution. Produced nitrile ions concentration found calorimetrically by reacting nitrile ion with phosphoric acid, sulphanilamide and N-(1-naphthyl)-ethylenediamine dihydrochloride (NEDA). Formed colored azo-dyes absorbance measured at 540 nm [34,35].

$PM_{2.5}$ and PM_{10}: High volume air sampler (model RDS APM 460NL with gaseous sampling attachment APM 411TE (make Enviro-tech India Pvt. Ltd.) run for 24 hours. By drawing air with flow rate between 1.1-1.2 m^3/min for 8 hours maintained to collect RSPM and NRSPM. The air inside the sampler passed through a combination of cyclone separator and filter in two stages. In the first stage the cyclone separator collects bigger particles i.e. non respirable particulate matter-NRSPM (particle size> 10μm) in previously weighed dust collector. In second stage remaining particulate i.e. RSPM (size< 10μm) collected over a previously dried weighed glass microfiber filter (Whatmann GF/A, 203x254mm). Using standard gravimetric method CPCB 2011 [32] concentration of RSPM and NRSPM were determined.

Air Quality Index (AQI): For analyzing and representing overall uniform status of ambient air quality AQI is single number and important tool [33, 34].

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.3 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	50	20

		24 hours	80	80
2	NO_x µgm/m³	Annual 24 hours	40 80	30 80
3	PM_{10} µgm/m³	Annual 24 hours	60 100	60 100
4	$PM_{2.5}$ µgm/m³	Annual 24 hours	40 60	40 60

Table.4 gives the breakpoint concentration of various pollutants. These breakpoint concentrations are used to calculate the sub index of each pollutants and value of highest sub index is called AQI.

Table.4 Breakpoints for AQI Scale 0-500 (Units: µgm/m³ unless mentioned otherwise)

AQI Category (Range)	**PM_{10} 24-hr**	**$PM_{2.5}$ 24-hr**	**SO_2 24-hr**	**NO_x 24-hr**
Good (0-50)	0-50	0-30	0-40	0-40
Satisfactory (51-100)	51-100	31-60	41-80	41-80
Moderately polluted (101-200)	101-250	61-90	81-380	81-180
Poor (201-300)	251-350	91-120	381-800	181-280
Very poor (301-400)	351-430	121-250	801-1600	281-400
Severe >401	430+	250+	1600+	400+

IV. RESULTS AND DISCUSSION:

Month wise minimum, maximum and average concentration of SO_2, NO_x, $PM_{2.5}$, PM_{10} (µgm/m³) and AQI monitored at both residential and industrial sites are represented in table 5. Variation of SO_2, NO_x, $PM_{2.5}$, PM_{10} (µgm/m³) and AQI at residential and industrial sites is represented graphically in graph 1, 2, 3, 4 and 5 respectively.

Table.5.Minimum, maximum and average concentration variation of SO_2, NO_2, $PM_{2.5}$, PM_{10} (µgm/m³) and AQI at residential and industrial sites.

Site	Pollutants	Variation (µg/m³)	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Residential	SO_2	Min. Max. Average	9.51 12.20 10.85	9.61 11.44 10.52	8.60 10.91 9.75	8.92 11.23 10.07	9.09 10.94 10.01	8.85 11.14 9.99	8.57 10.95 9.76	8.24 11.29 9.76	9.38 10.95 10.16	9.03 10.56 9.79	9.29 10.51 9.90	8.47 10.84 9.65
	NO_2	Min Max Average	36.18 50.51 43.34	37.90 49.95 43.92	33.24 46.52 39.88	34.29 40.62 37.46	32.73 41.78 37.25	33.61 42.25 37.93	35.55 41.06 38.30	35.02 44.20 39.61	34.31 44.78 39.54	34.30 42.19 38.24	34.14 43.48 38.81	35.97 48.14 42.05
	$PM_{2.5}$	Min. Max. Average	98 118 108	99 110 104.5	97 105 101	99 106 102.5	89 103 96	83 105 94	85 120 102.5	83 103 93	84 100 92	88 99 93.5	91 109 100	94 106 100
	PM_{10}	Min. Max. Average	219 237 228	221 246 233	224 241 232	227 292 259.5	228 283 255.5	212 263 237.5	202 245 223.5	196 248 222	203 244 223.5	214 240 227	222 264 243	233 248 240.5
	AQI	Min. Max. Average	227 293 260	230 267 248	223 250 237	230 253 242	197 243 220	177 250 213	183 300 242	177 243 210	180 233 207	193 230 212	203 263 233	213 253 233
Site	Pollutants	Variation (µg/m³)	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Industrial	SO_2	Min. Max. Average	9.17 11.55 10.36	9.41 12.05 10.73	9.69 11.03 10.36	8.88 10.76 9.82	9.0 10.73 9.86	9.77 11.0 10.38	9.28 10.91 10.09	9.67 11.23 10.45	9.29 11.06 10.17	9.02 11.38 10.2	9.48 11.36 10.42	8.99 10.72 9.85
	NO_2	Min. Max. Average	35.59 48.41 42	38.36 50.33	34.82 52.23	34.36 45.03	32.81 47.92	44.24 40.12	33.56 43.84 38.7	35.02 44.27	35.27 44.56	36.7 47.24 41.97	35.36 43.48	37.05 43.7 40.37

				44.36	43.52	39.69	40.36	37.18		39.64	39.91		39.42	
	$PM_{2.5}$	Min. Max. Average	91 105 98	93 100 96.5	89 99 94	90 100 95	91 99 95	80 100 90	75 100 87.5	89 99 94	90 99 94.5	81 99 90	90 99 94.5	87 99 93
	PM_{10}	Min. Max. Average	209 245 227	223 237 230	226 250 238	214 261 237.5	215 277 246	217 277 247	192 261 226.5	212 247 229.5	202 237 219.5	198 237 217.5	224 236 230	218 252 235
	AQI	Min. Max. Average	203 250 227	210 233 222	197 230 213	200 233 217	203 230 217	167 233 200	150 233 192	197 230 213	200 230 215	170 230 200	200 230 215	190 230 210

At residential site SO_2 minimum concentration 8.24µg/m^3 recorded in August and maximum concentration 12.20 µg/m^3 found in the January. Thus the variation range of SO_2 concentration is 8.24-12.20 µg/m^3, while highest average concentration observed 10.85µg/m^3 in January. At industrial site SO_2 minimum concentration 8.88µg/m^3 recorded in April and maximum concentration 12.05 µg/m^3 found in the February. Thus the variation range of SO_2 concentration is 8.88-12.05 µg/m^3, while highest average concentration observed 10.73µg/m^3 in February.

At residential site NO_x minimum concentration 32.73µg/m^3 recorded in May and maximum concentration 50.51µg/m^3 found in the January. Thus the variation range of NO_x concentration is 37.73-50.51µg/m^3, while highest average concentration observed 43.92µg/m^3 in February. At industrial site NO_x minimum concentration 32.81µg/m^3 recorded in May and maximum concentration 52.23µg/m^3 found in the March. Thus the variation range of NO_x concentration is 32.81-52.23µg/m^3, while highest average concentration observed 44.36µg/m^3 in February. Thus average variation of SO_2 and NO_x found higher in January or February which are part of summer season.

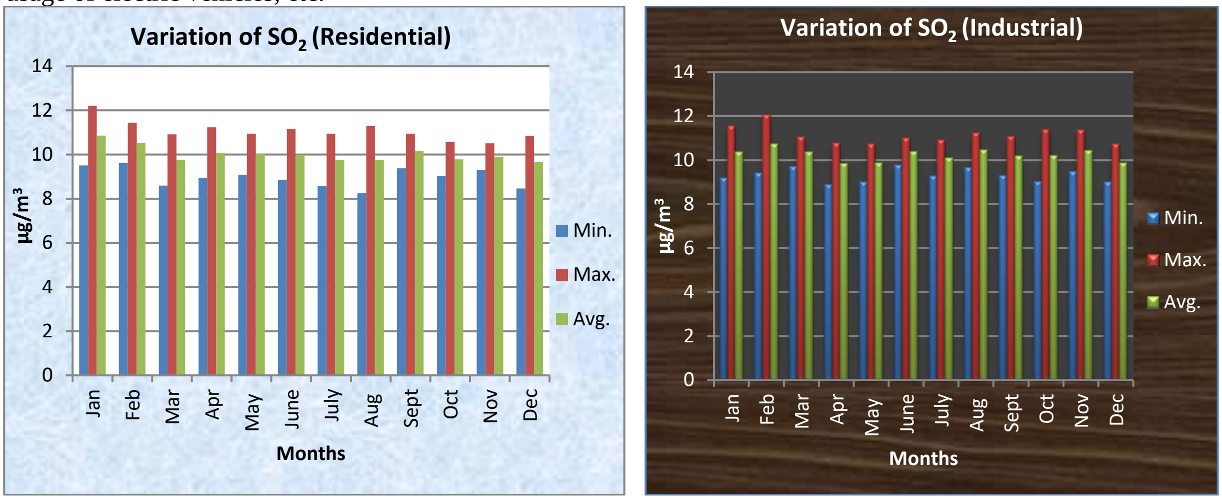
At residential site $PM_{2.5}$ minimum concentration 83µg/m^3 recorded in June and maximum concentration 118 µg/m^3 found in the January. Thus the variation range of $PM_{2.5}$ concentration is 83-118 µg/m^3, while highest average concentration observed 108µg/m^3 in January. At industrial site $PM_{2.5}$ minimum concentration 75µg/m^3 recorded in July and maximum concentration 105 µg/m^3 found in the January. Thus the variation range of $PM_{2.5}$ concentration is 75-105 µg/m^3, while highest average concentration observed 98µg/m^3 in January.

At residential site PM_{10} minimum concentration 196µg/m^3 recorded in August and maximum concentration 292 µg/m^3 found in the April. Thus the variation range of PM_{10} concentration is 196-292 µg/m^3, while highest average concentration observed 259.50µg/m^3 in April. At industrial site PM_{10} minimum concentration 198µg/m^3 recorded in October and maximum concentration 277 µg/m^3 found in the May and June months. Thus the variation range of PM_{10} concentration is 198-277 µg/m^3, while highest average concentration observed 247µg/m^3 in June. Thus average variation of $PM_{2.5}$ and PM_{10} found higher in January, April and June which are part of or extended part of summer season[35]. Thus the general average variation of SO_2, NO_x, $PM_{2.5}$ and PM_{10} found higher in summer season.

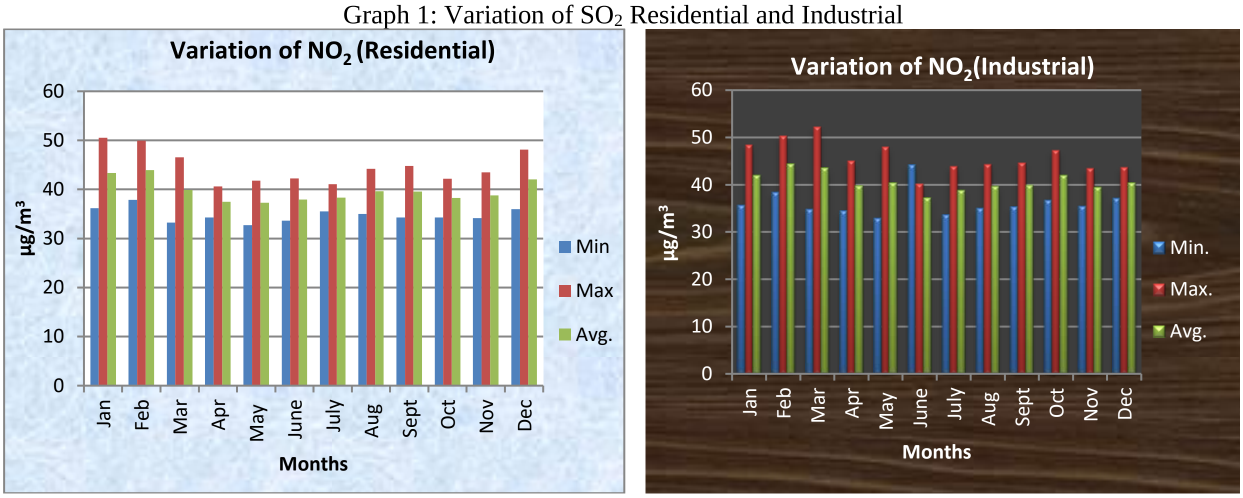
At residential site minimum AQI value 177 recorded in June and August months and maximum AQI 300 found in July. Thus the variation range of AQI is 177-300, while highest average AQI observed 260 in January. At industrial site minimum AQI value 150 recorded in July and maximum AQI 250 found in January. Thus the variation range of AQI is 150-250, while highest average AQI observed 227 in January. Thus average variation of AQI found higher in January which is part of summer season. Annual mean AQI value at residential site was 229.75 and at industrial site it was 211.75, higher value at residential site is associated with meteorological conditions such as wind speed and temperature [36]. Both sites AQI falls under poor AQI category as per rating scale. The combined impact of industrial and vehicular emissions makes the environment toxic [37].

The observations reveal that SO_2 levels were within the prescribed NAAQS during the study period at both the monitoring stations. The reason for low levels of SO_2 may be various measures taken such as reduction of sulphur in diesel, lesser old vehicles, etc. NO_2 levels were also within the prescribed NAAQS during all the monitored location. The reasons for low levels of NO_2 may be various measures taken such as removal of old vehicles, better traffic management, etc. Sulphur dioxide and oxides of nitrogen are the key pollutant contributing to ambient air which is given out by fossil fuel burning, automobiles and industries [38,39]. 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 observations.

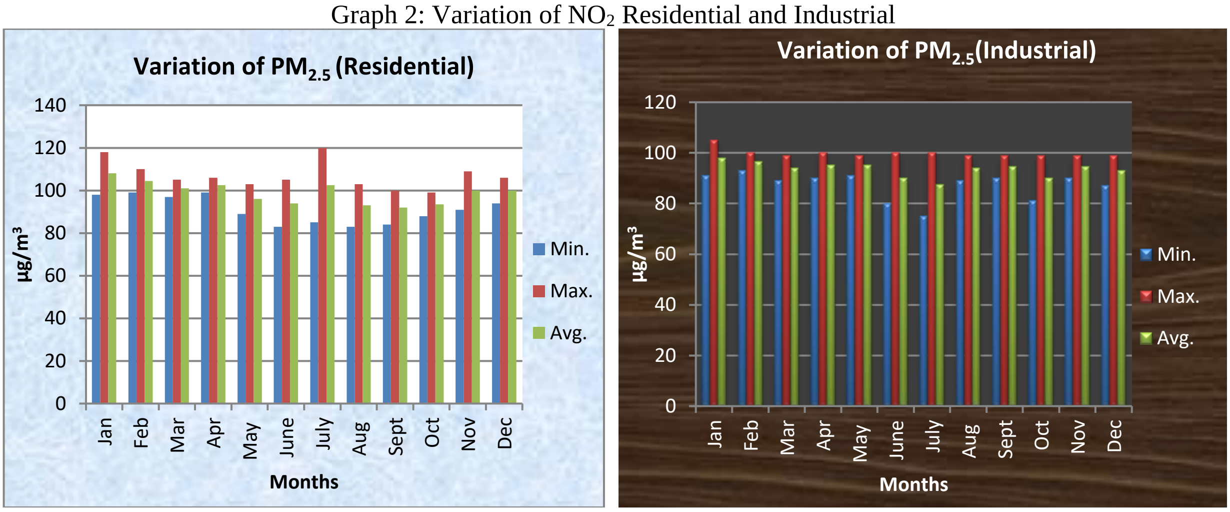
$PM_{2.5}$ levels exceed the prescribed NAAQS and PM_{10} levels also exceeded the prescribed NAAQS at both the monitoring location [43]. The reason for high particulate matter in the study area can be high traffic density, heavy vehicle movement [44], presence of industrial area in the vicinity, natural dust and dust storms, other operations that involve the burning of fuels such as wood, heating oil or coal and burning forest, garbage burning, etc. The major contributors of particulate matter in ambient air are automobiles and industries [7, 40, 41]. 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 [45] compared to general public which is affected to lesser extent. Coarse particles ($PM_{10-2.5}$) can irritate a person's eyes, nose, and throat as indicated by reports of Environment Protection Agency, USA. India faces one of the highest disease burdens from air pollution in world, with an estimated 100% of the population living in areas with $PM_{2.5}$ concentrations above the World Health Organization Guideline (10µg/m^{3}annual average). With development and population growth, increases in ambient air pollution are anticipated. Combined with an aging population and increasing burden of chronic diseases, ambient air pollution will remain a concern for India well into the current century. Air quality measurements make critical contributions to the identification and prioritization of sources and locations of greatest concern, benchmarking against standards and guidelines, and in the evaluation of effectiveness of actions to reduce emissions [46]. The lower level of particulate matter can be achieved by increasing the green belt development in the area and also by better traffic management, reducing usage of particulate matter forming appliances, avoid burning, quit indoor smoking, walk instead of vehicle, using solar energy, regular maintaining vehicle, usage of electric vehicles, etc.



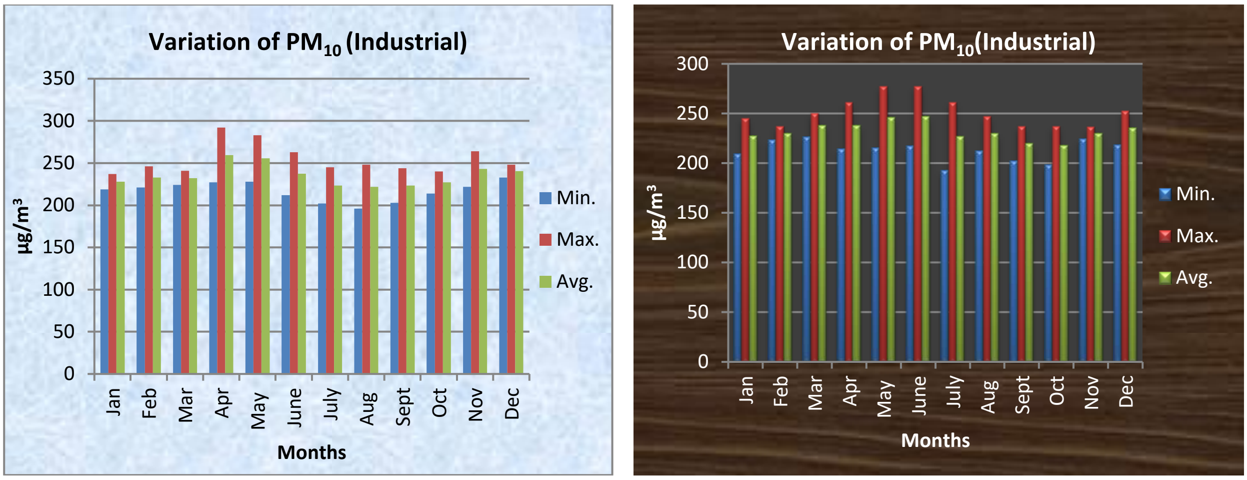
Graph 1: Variation of SO_2 Residential and Industrial



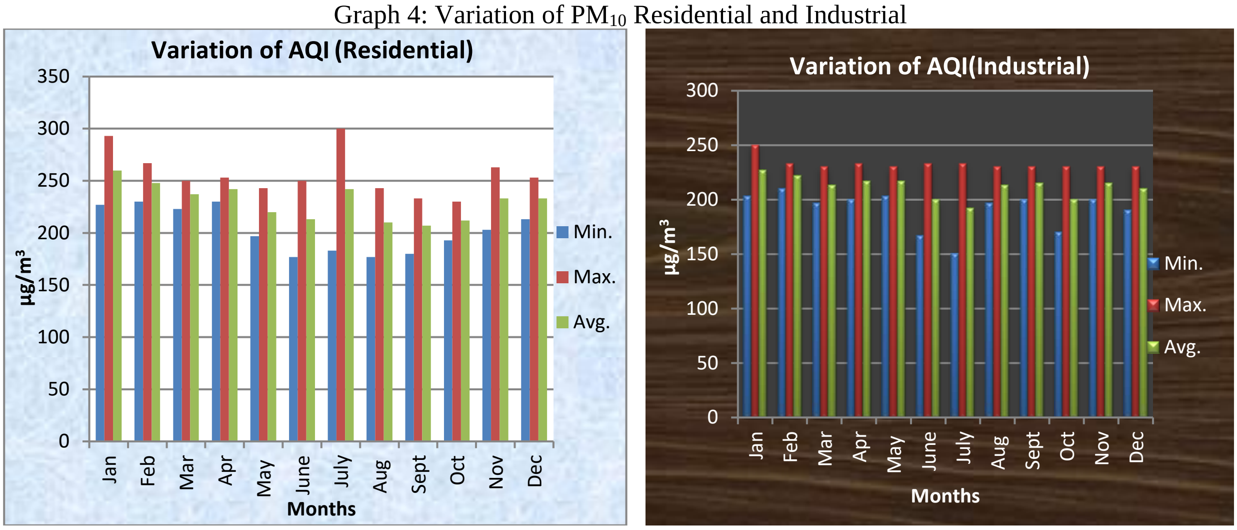
Graph 2: Variation of NO_2 Residential and Industrial



Graph 3: Variation of $PM_{2.5}$ Residential and Industrial



Graph 4: Variation of PM_{10} Residential and Industrial



Graph 5: Variation of AQI Residential and Industrial

V. CONCLUSION:

The main air pollution problem in Jalna City is the increasing level of particulate matter ($PM_{2.5}$ & PM_{10}) concentrations in air. The predominant source of air pollution in the study area is the growing number of vehicles, industries, automobiles, construction work, combustion activities, agricultural activities; mining activities and deforestation are major contributors. Particulate matter when inhaled in large quantities lead to development of cardiovascular effects such as cardiac arrhythmias and heart attacks, and respiratory effects such as asthma attacks and bronchitis. The degree of impact is also dependent on the size of the particulate matter. Coarse particles results in adverse effect on lung system while fine particles are deposited in the deeper parts of the lungs. The results reveal that residential site (IMA hall) is having poor air quality index compared to industrial site (Krishidhan Seeds Pvt. Ltd.) and is comparatively more polluted station amongst the two. AQI of both the sampling stations indicates that pollutants concentration in the air of Jalna city is continuously increasing and deteriorating the quality of air. The air quality at both these stations falls under moderately polluted to poor category.

VI. DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

VII. ACKNOWLEDGEMENTS:

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