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Investigation of Air Quality Index of Jalna City (MS), India.

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Abstract: *The current paper investigates study of ambient air quality of Jalna city in which an effort has been made to prepare an account of pollutants (PM_{10}, $PM_{2.5}$, SO_2, NOx) at regional level to know the recent increasing air pollution load in the study area by means of Air Quality index determination. Monitoring stations were set up at two different locations i.e. industrial and residential and samples have been analyzed, subsequently air quality index has been computed. The result reveals that gaseous pollutants such as SO_2 and NOx are within the permissible limits prescribed by National Ambient Air Quality standards (NAAQS) at both the monitoring locations. The calculated AQIs value for SO_2 and NOx falls under good category. $PM_{2.5}$ levels and also PM_{10} levels exceeded the prescribed standards of NAAQS at both the monitoring locations, thus particulate matter is the principal source of air pollution in the study area. The calculated AQI values of PM_{10} and $PM_{2.5}$ falls under moderate and poor categories. The overall AQI was found to fall under poor category owing to $PM_{2.5}$. Thus it is observed that $PM_{2.5}$ and to some extent PM_{10} are responsible pollutants at both these locations of Jalna city. 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.*

Keywords: *Ambient air quality, Air Quality Index (AQI), Gaseous pollutants- SO_2, NOx, Particulate pollutants, RSPM - Respirable Suspended Particulate Matter ($PM_{2.5}$), NRSPM - Non Respirable Suspended Particulate Matter (PM_{10}), Residential area, Industrial area.*

INTRODUCTION:

Air is one of the most vital 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 badly affects living system including human life causing air pollution. Environmental pollution is increasing at a frightening rate steadily and environment monitoring agencies indicated the harmful effects of over pollution. Various activities responsible for the destruction of environment are population explosion, emission and industrialization[1-3], insufficient public facilities[4], automobiles[5] and urbanization[6]. All such factors are immensely declining human health, assets and climate[7-10]. Amongst various air pollutants sulphur dioxide, nitrogen oxides and particulate matter are primary pollutants notified by environment protection agency. Amount 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]. Accurate knowledge of air pollutants, their concentrations, variations and field data are essential for appropriate management of these issues [15,16] if not it would hamper environment planning activities. Majority of countries including India initiated ambient air quality programs to identify air quality by preparing statistics on air pollutant concentrations in ambient air[17]. To handle this crisis EPA started Air Quality Index (AQI) which mathematically relates concentration of various pollutants and offer a single quantity representing the air quality of particular place using air quality index rating scale[18-21]. In Bikaner city particulate matters concentration found high in winter and low in monsoon[22]. In Vapi city which is moderately polluted city PM_{10} was found to be fundamental pollutant[23]. Compiled data for 2013-2014 for 72 AAQM stations collected by MPCB showed moderate to below air quality[24]. In expansion of our previous work[25-27] this paper investigates monthly -April, May and June 2019 variations in ambient air quality of selected monitoring stations residential (IMA hall) and industrial (Krishidhan seeds) of Jalna city by means of air quality index (AQI).

MATERIALS AND METHODS:

Study area: Jalna district is approximately 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 up to 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, growing numbers of the automobiles, high traffic density, heavy vehicle movement, presence of industrial area in the vicinity, natural dust, construction and mining works and dust storms, etc are the main causes of air pollution in the city[30, 31].

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

The samples of RSPM ($PM_{2.5}$), NRSPM (PM_{10}), SO_2 and NOx were collected twice a week during April to June 2019 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].

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 540 nm[34,35].

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

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

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

OBSERVATION AND ANALYSIS:

Table.2 represents the location of sampling stations whereas table.3 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 gives average concentration of $PM_{2.5}$, PM_{10}, SO_2 and NOx (µgm/m^3) at residential and industrial sites. Variations of $PM_{2.5}$, PM_{10}, SO_2 and NOx (µgm/m^3) at residential and industrial sites is represented graphically in graph 1 and 2 respectively. Table.5 indicates the maximum, minimum and average AQI at both the 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

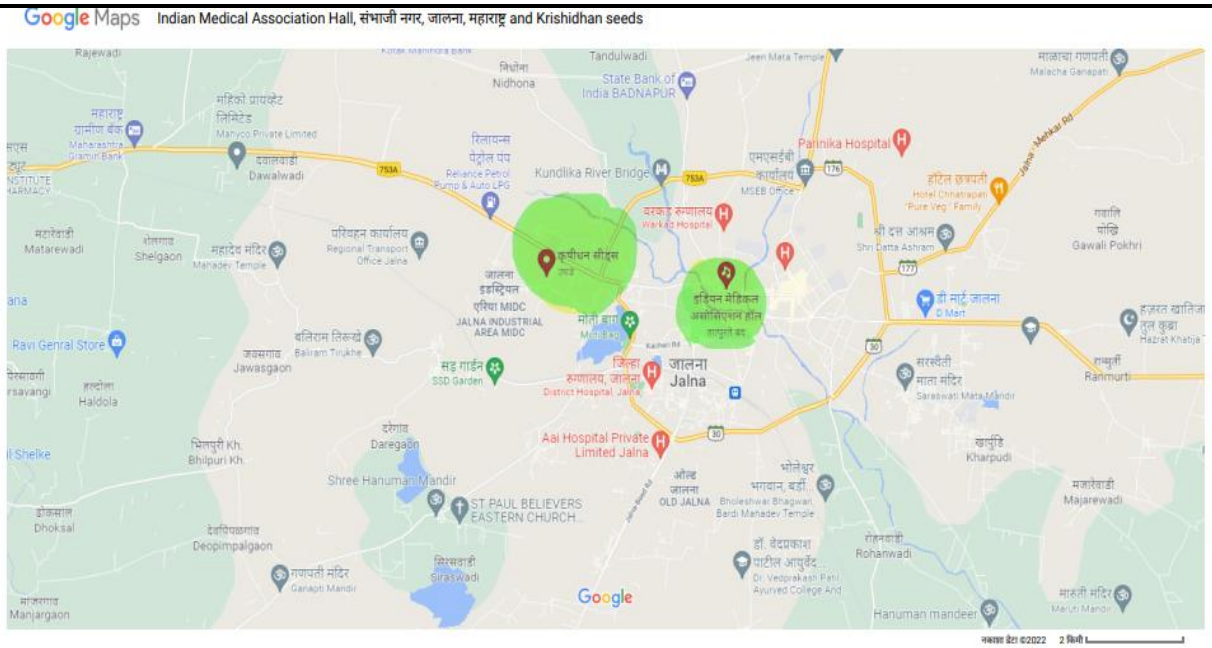

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Table.3 Breakpoints for AQI Scale 0-500 (Units: µgm/m^3 unless mentioned otherwise)

AQI Category (Range)	**PM_{10} 24-hr**	**$PM_{2.5}$ 24-hr**	**SO_2 24-hr**	**NOx 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+

Table.4. Average concentration of $PM_{2.5}$, PM_{10}, SO_2 and NOx (µgm/m^3) at residential and industrial sites during April to June 2019.

Sr. No.	Industrial-Krishidhan Seeds Pvt. Ltd					Residential-IMA Hall				
	Hrs Date	24 Hrs Avg. (µgm/m^3)				Hrs Date	24 Hrs Avg. (µgm/m^3)			
		$PM_{2.5}$	PM_{10}	SO_2	NOx		$PM_{2.5}$	PM_{10}	SO_2	NOx
1	04/02/2019	100	261	9.16	45.03	04/04/2019	100	227	10.37	38.62
2	04/03/2019	92	222	10.57	42.07	04/05/2019	106	240	11.23	38.70
3	04/09/2019	96	214	10.31	39.57	04/11/2019	99	247	8.92	34.29
4	04/10/2019	90	217	10.76	34.36	04/12/2019	105	292	9.61	40.62
5	04/16/2019	91	226	8.88	35.20	04/18/2019	102	251	9.81	36.65
6	04/17/2019	98	241	10.18	36.57	04/19/2019	99	254	10.77	36.69
7	04/23/2019	96	234	10.35	38.08	04/25/2019	104	241	10.74	34.30
8	04/24/2019	99	227	9.67	35.04	04/26/2019	99	258	9.35	39.13
9	04/30/2019	93	228	9.37	37.83	05/02/2019	94	230	10.49	39.08
10	05/01/2019	95	265	10.36	37.68	05/03/2019	100	235	9.33	36.35
11	05/07/2019	98	244	10.56	43.94	05/09/2019	103	272	10.94	35.39
12	05/08/2019	91	277	9.00	32.81	05/10/2019	89	253	9.50	41.27
13	05/14/2019	95	215	10.73	47.92	05/16/2019	98	271	9.96	32.73
14	05/15/2019	99	247	9.61	46.89	05/17/2019	96	248	9.09	36.13
15	05/21/2019	97	228	9.21	41.63	05/23/2019	100	283	10.24	35.77
16	05/22/2019	98	223	9.96	39.28	05/24/2019	99	262	10.32	41.78
17	05/28/2019	94	225	10.61	37.90	05/30/2019	98	230	9.99	41.29
18	05/29/2019	99	224	9.86	38.80	05/31/2019	100	228	10.80	40.96
19	06/04/2019	95	258	9.77	40.12	06/06/2019	105	260	9.64	37.88
20	06/05/2019	100	277	10.45	37.18	06/07/2019	94	258	9.71	34.97
21	06/11/2019	98	225	10.24	36.16	06/13/2019	99	263	8.85	36.52
22	06/12/2019	91	246	11.00	37.20	06/14/2019	98	258	9.25	35.57
23	06/18/2019	98	232	10.05	34.34	06/20/2019	105	243	9.68	42.25
24	06/19/2019	93	224	10.25	34.24	06/21/2019	90	229	11.05	33.61
25	06/25/2019	80	218	10.44	37.77	06/27/2019	95	212	10.44	37.31
26	06/26/2019	94	217	10.07	34.70	06/28/2019	83	233	11.14	37.29
Average		**95**	**235**	**10.05**	**38.55**		**98**	**249**	**10.05**	**37.51**

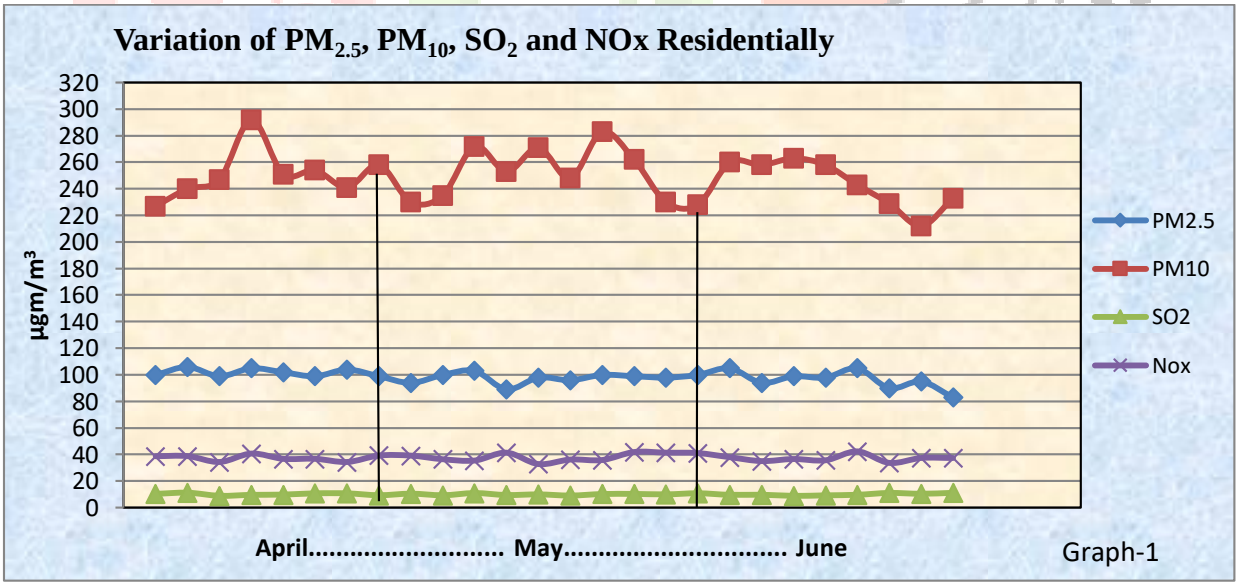
Table 5: Sub Index of Pollutants at different monitoring stations

Station Name : Industrial site: Krishidhan Seeds Pvt. Ltd.					
Sub Index	Pollutants				AQI
	$PM_{2.5}$	PM_{10}	SO_2	NOx	
Maximum	100	277	11	47.92	277
Minimum	80	214	8.88	32.81	214
Average	95	235	10.29	38.55	235

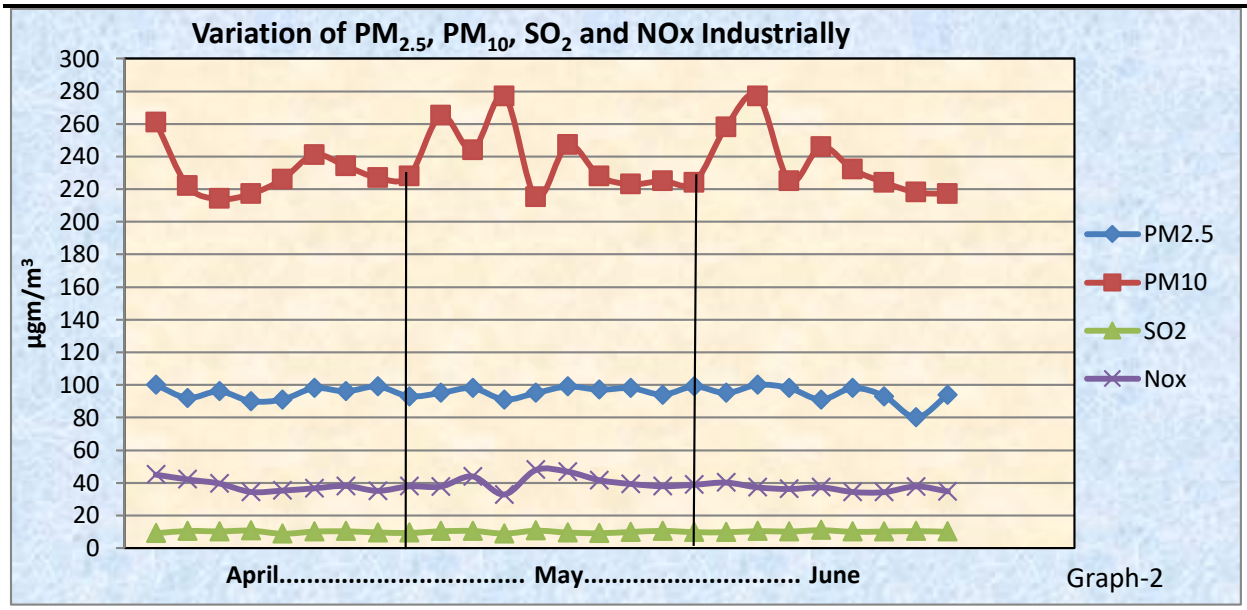
Station Name : Residential site: IMA Hall.					
Sub Index	Pollutants				AQI
	$PM_{2.5}$	PM_{10}	SO_2	NOx	
Maximum	105	292	11.23	42.25	292
Minimum	83	212	8.82	32.73	212
Average	98	249	10.05	37.51	249

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 fossil fuels like diesel, coal, lesser use of 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, tightening of vehicle emission standards etc. Sulphur dioxide and oxides of nitrogen are the main pollutants 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 analogous observations.

$PM_{2.5}$ levels and PM_{10} levels exceeded the prescribed NAAQS at both the monitoring location. The reason for high particulate matter in the study area can be high traffic density, heavy vehicle movement, presence of industrial area in the vicinity, natural dust and dust storms, 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 can experience health effects like heart or lung disease on prolong exposure and at greater risk [43-44] 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. 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, avoiding burning, quitting indoor smoking, walk instead of vehicle, using solar energy, regular maintaining vehicle, etc.



Graph-1



Graph-2

CONCLUSION:

The main air pollution problem in Jalna City is the increasing levels of particulate matter ($PM_{2.5}$ & PM_{10}) concentrations in air. The predominant cause 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 level 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 compared to Industrial site- Krishidhan seeds Pvt. Ltd. is having poor Air Quality index and is comparatively more polluted station among both stations. 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.

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