IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 10, Issue 12 Ver. II (Dec. 2016), PP 93-98
www.iosrjournals.org

Comparative Study of Ambient Air Quality Using Air Quality Index in Residential Areas of Jodhpur City

Nitish Kumar Rai
(M.E. scholar, Deptt. of Civil Engineering, MBM Engineering College / J. N. V. University, Jodhpur City, India

Abstract: *This study reports about the ambient air quality in Jodhpur City, Rajasthan using Air Quality Index(AQI). 24-hourly concentration of five major pollutants have been considered viz. Particulate Matter of 10µ size (PM_{10}), Particulate Matter of 2.5µ size ($PM_{2.5}$), Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2) and Carbon Monoxide (CO), for the month of March in 2016 at two different locations in Jodhpur City (Kudi Housing Board, Sector-3 and Jalori Gate Residential area). AQIs were calculated as per the norms given by Central Pollution Control Board (Govt. of India). Results show the varying percentage of AQIs. SO_2, NO_2 and CO were lying in good to satisfactory zone while PM_{10} and $PM_{2.5}$were lying in moderate to poor zone. Thus, it can be seen that primary pollutant is Particulate Matter in residential areas of Jodhpur.*
Keywords: *Ambient Air Quality, Air Quality Index, Sulphur Dioxide, Nitrogen Dioxide, Jodhpur City,*

I. Introduction

Jodhpur is the second largest city of Rajasthan, having a population of 13.2 million people spread over an area of 624.5 km^2 is the most polluted city of Rajasthan as per latest study. Climate of Jodhpur is generally hot and semi-arid in nature. This city covers about 11.6% of arid area of state. There are around 21200 registered industries in Jodhpur and growing year by year. There is also a huge vehicular load on this city which contributes largely to air pollution. As per Jodhpur census 2011, total numbers of vehicles registered were 636141 in different categories. Due to recent technological advancement, there has been enormous increase in vehicular and industrial activities leading to rapid growth in air pollution. Numbers of pollutants are emitted in ambient air due to anthropogenic activities which primarily includes PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO. These pollutants play significant role in affecting air quality of ambient air. Generally residential areas observe lesser pollution level as compared to industrial and commercial area but still some pollutants dominates in residential areas too and affecting its air quality. Considering all these issues, an attempt was made to measure the ambient air quality in two residential areas of Jodhpur viz. residential area of Jalori Gate which was very closure to Jalori Gate commercial area and another Kudi Housing Board, Sector-3 which was situated far from commercial area. Method adopted here to calculate AQI is taken from specifications given by Central Pollution Control Board, New Delhi (Ministry of environment, Forest & Climate Change). This AQI scheme is based on an overall scheme which transforms the weighed values of individual air pollution related parameters into a single number or set of numbers. It is very useful in indicating day to day variation of ambient air quality.

II. Material And Method

Monitoring in Jodhpur city was carried out at different locations viz. residential colony of Jalori gate and another at Kudi Housing Board, Sector-3 using Respirable Dust Sampler (for measurement of $PM_{10)}$, Fine Particulate Sampler ($PM_{2.5}$), Gaseous Sampling attachment (for SO_2 and NO_2) and CO meter (for measuring Carbon Monoxide). These residential were sampled for initial three weeks of March at different days. Samples collected for monitoring were analyzed for different parameters prescribed by Central Pollution Control Board, New Delhi. Particulate matter i.e., PM_{10} and $PM_{2.5}$ were estimated using a procedure Cyclonic Flow Technique and Gravimetric Method, in which air is drawn through pre-weighed GF/A filter papers at a flow rate of 1 m^3/min on 8 hourly basis for 24 hours. Gaseous pollutants i.e., SO_2 and NO_2 were collected through gaseous sampling attachment on 4 hourly basis for 24 hours at the rate of 1L/min. These gaseous samples were further analyzed by EPA-Modified West and Gaeke Method. Concentrations of these pollutants were measured in microgram per cubic meter i.e., µg/m^3. Carbon monoxide was measured using a Portable Carbon Monoxide meter which directly gives concentration of CO in ambient air on pressing its monitoring switch.

III. Equations

All the formulas used for calculation of different parameters are taken from the manual of Central Pollution Control Board.

1.1 Equations for the calculation of PM_{10}

Volume of air sampled i.e., V=QT
Where,

V = Volume of air sampled, in m^3
Q = Average flow rate, in m^3/min.
T = Total sampling time, in minute

Calculation of PM_{10} in ambient air (in µg/m^3) = $\frac{(W_2 - W_1) \times 10^6}{V}$

Where,

PM_{10} = Mass concentration of particulate matter less than 10 µm diameter
W_1 = Initial weight of filter paper in gram
W_2 = Final weight of filter paper in gram
V = Volume of air sampled in m^3
10^6 = Conversion Factor

1.2 Equations for the calculation of $PM_{2.5}$

Mass of fine particulate matter collected on filter is given by, $M_{2.5} = (M_f - M_i) \times 10^3$

Where,

$M_{2.5}$ = Total mass of fine particulate collected during sampling period
M_f = Final mass of conditioned filter after sample collection (mg)
M_i = Initial mass of conditioned filter after sample collection (mg)
10^3 = Unit conversion factor for milligrams (mg) to micrograms (µg)

Total sample value V is calculated by, $V = Q_{avg} \times t \times 10^{-3}$ (m^3)

Where,

Q_{avg} = average flow rate over the entire duration of sampling period (L/min)
t = duration of sampling period (min)

Hence, mass concentration of $PM_{2.5}$ is given by, $PM_{2.5} = \frac{M_{2.5}}{V}$

Where symbols have their usual meaning

1.3 Equations for calculation SO_2

Sulphhur Dioxide is calculated by a procedure known as EPA-Modified West and Gaeke Method

Concentration of SO_2 (µg/m^3) = $\frac{(A - A_o) \times 10^3 \times B}{V_n} \times D$

Where,

A = Sample absorbance
A_o = Reagent blank absorbance
B = Calibration factor, µg/absorbance unit
D = Dilution factor for 30 min and 1 hour sample
= 1 (if 1 hour sample) and, = 10 (if 8 hour sample or more)
V_n = Sample corrected to 25°C and 760 mm of Hg and is given by,

$$= V \times \frac{P}{60} \times \frac{298}{(t + 273)}$$

Where,

V = Volume of air at 25°C and 760 mm of Hg
P = Barometric pressure, mm of Hg
T = temperature of air sampled, °C

1.4 Equations for calculation of NO_2

Calculate the volume of air drawn for sample, $V_a(m^3) = \frac{f_i + f_f}{2} \times (t_f - t_i) \times 60 \times 10^{-3}$

Where,

f_i = Air flow rate before sampling, liter per minute
f_f = Air flow rate before sampling, liter per minute
t_i = Initial time in hours

t_f = Final time in hours
10^{-3} = Conversion of liter to m^3
60 = Conversion of hours into minute

NO_2 concentration is calculated by, $NO_2(\mu g/m^3) = \dfrac{NO_2 \times D \times V_s}{0.82 \times V_A \times V_t}$

Where,

NO_2 (μg/ml) = NO_2 concentration in analyze sample
V_s = Final volume of air sampling solution, ml
0.82 = Sampling efficiency
V_a = Volume of air sample, ml
V_t = Volume of sample taken, ml

1.5 Calculation of Carbon Monoxide

CO meter gives reading in ppm and 1 ppm of CO = 1.145 mg/m^3
Hence, 0.40 ppm of CO = 0.40 x 1.145 = 0.458 mg/m^3

1.6 Sub-Index calculation

This index is so deigned that any three of the parameters i.e., PM_{10}, $PM_{2.5}$, SO_2, NO_2, CO, O_3, Pb, NH_3, BaP, C_6H_6, As and Ni is sufficient to calculate the AQI of ambient air. This method involves formation of sub-indices and their aggregation for sub-indices.
The sub-index (I_p) for a given pollutant concentration (C_p) is calculated as,

$$I_P = \left[\left\{ \frac{I_{HI} - I_{LO}}{B_{HI} - B_{LO}} \right\} \times (C_P - B_{LO}) \right] + I_{LO}$$

Where,

B_{HI} = Breakpoint concentration greater than or equal to given concentration
B_{LO}= Breakpoint concentration smaller than or equal to given concentration
I_{HI}= AQI value corresponding to B_{HI}
I_{LO}= AQI value corresponding to B_{LO}, subtract one from I_{LO} if I_{LO} is greater than 50
C_p= Pollutant concentration

Finally, AQI = Max (I_p) (where, p = 1, 2, 3,………denotes n pollutants)

IV. Figures and Tables

Breakpoint concentration for pollutants is given below.

Table 1: Breakpoint concentration for pollutants

AQI category	Break point concentrations of CO (mg/m^3) 8 hour	Break point concentrations of NO_2 (μg/m^3) 24 hour	Break point concentrations of PM_{10} (μg/m^3) 24 hour	Break point concentrations of $PM_{2.5}$ (μg/m^3) 24 hour	Break point concentrations of SO_2(μg/m^3) 24 hour
Good	1	40	50	30	40
Satisfactory	2	80	100	60	80
Moderate	10	180	250	90	380
Poor	17	280	350	120	800
Very poor	34	400	430	250	1600
Severe	34+	400+	430+	250+	1600+

Table 2: breakpoint for AQI scale 0-500

(Units: μg/m^3 unless mentioned otherwise)

AQI Category (Range)	PM_{10} 24-hr	$PM_{2.5}$ 24-hr	NO_2 24-hr	O_3 8-hr	CO 8-hr (mg/m^3)	SO_2 24-hr	NH_3 24-hr	Pb 24-hr
Good (0-50)	0-50	0-30	0-40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory (51-200)	51-100	31-60	41-80	51-100	1.1-2.0	41-80	201-400	0.5-1.0
Moderately polluted (101-200)	101-250	61-9-	81-180	101-168	2.1-10	81-380	401-800	1.1-2.0
poor (201-300)	251-350	91-120	181-280	169-208	10-17	381-800	801-1200	2.1-3.0

*One hourly monitoring (for mathematical calculation only)
Observed values of different parameters considered at two different locations are given below.

Table 3: Pollutant concentration at sub index at residential colony of Jalori Gate

Date	Pollutants	Concentration in μg/m^3 (except for CO)	Sub Index	AQI
04/03/2016	PM_{10}	183.67	156	237
	$PM_{2.5}$	101	237	
	SO_2	5.90	7	
	NO_2	34.27	43	
	CO (mg/m^3)	0.44	22	
07/03/2016	PM_{10}	185.33	157	223
	$PM_{2.5}$	96.97	223	
	SO_2	6.15	8	
	NO_2	39.01	49	
	CO (mg/m^3)	0.44	22	
10/03/2016	PM_{10}	178.33	152	273
	$PM_{2.5}$	112	273	
	SO_2	6.10	8	
	NO_2	40.11	50	
	CO (mg/m^3)	0.40	20	
15/03/2016	PM_{10}	192.67	162	199
	$PM_{2.5}$	89.66	199	
	SO_2	5.76	7	
	NO_2	40.59	51	
	CO (mg/m^3)	0.44	22	
16/03/2016	PM_{10}	181	154	194
	$PM_{2.5}$	88.33	194	
	SO_2	6.23	8	
	NO_2	38.60	48	
	CO (mg/m^3)	0.46	23	
18/03/2016	PM_{10}	183	159	251
	$PM_{2.5}$	105.33	251	
	SO_2	6.76	8	
	NO_2	42.47	53	
	CO (mg/m^3)	0.38	19	
19/03/2016	PM_{10}	191.33	161	256
	$PM_{2.5}$	106.67	256	
	SO_2	6.23	8	
	NO_2	39.04	49	
	CO (mg/m^3)	0.49	25	

Table 4: Pollutant concentration at sub index at Kudi Housing Board, Sector-3

Date	Pollutants	Concentration in μg/m^3 (except for CO)	Sub Index	AQI
03/03/2016	PM_{10}	127	118	118
	$PM_{2.5}$	54	90	
	SO_2	4.64	6	
	NO_2	25.16	31	
	CO (mg/m^3)	0.34	17	
06/03/2016	PM_{10}	140.33	127	127
	$PM_{2.5}$	47.67	79	
	SO_2	4.52	6	
	NO_2	26.83	34	
	CO (mg/m^3)	0.39	20	
08/03/2016	PM_{10}	143.67	129	129
	$PM_{2.5}$	55.67	93	
	SO_2	4.28	5	
	NO_2	25.83	32	
	CO (mg/m^3)	0.43	22	
15/03/2016	PM_{10}	135.33	124	124
	$PM_{2.5}$	62.67	109	
	SO_2	4.76	6	
	NO_2	26.62	33	

	CO (mg/m^3)	0.38	19	
18/03/2016	PM_{10}	136	124	124
	$PM_{2.5}$	57	95	
	SO_2	4.49	6	
	NO_2	27.58	34	
	CO (mg/m^3)	0.44	22	
19/03/2016	PM_{10}	144	129	129
	$PM_{2.5}$	61.67	106	
	SO_2	4.03	5	
	NO_2	23.81	30	
	CO (mg/m^3)	0.37	19	
21/03/2016	PM_{10}	134.67	123	123
	$PM_{2.5}$	62.33	108	
	SO_2	4.39	5	
	NO_2	24.95	31	
	CO (mg/m^3)	0.40	20	

Graphs showing different pollutants at both locations are given below.

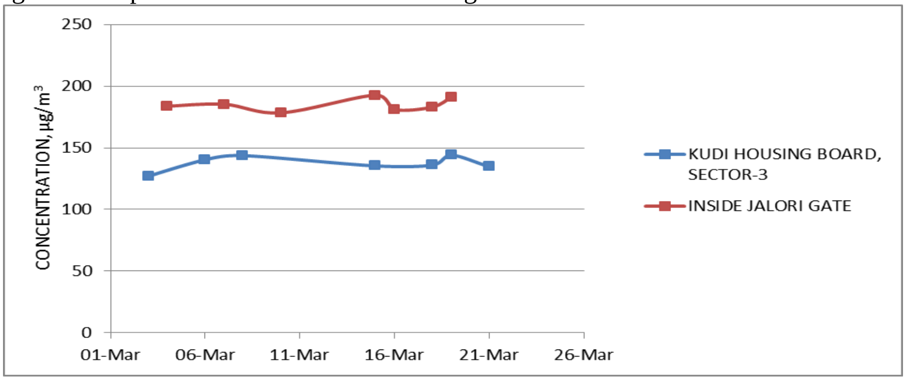

Fig. 1: PM_{10} concentration in ambient air

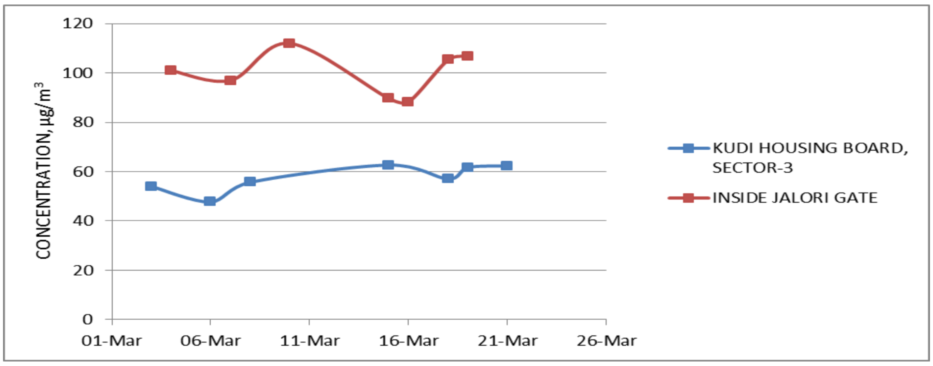

Fig. 2: $PM_{2.5}$ concentration in ambient air

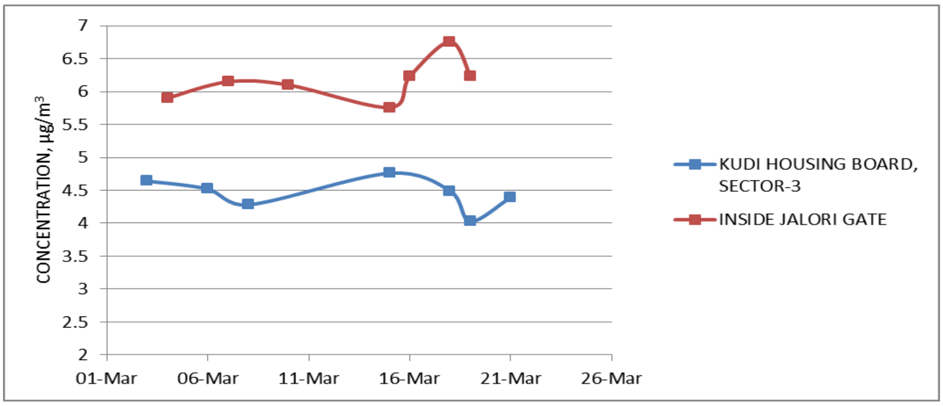

Fig. 3: SO_2 concentration in ambient air

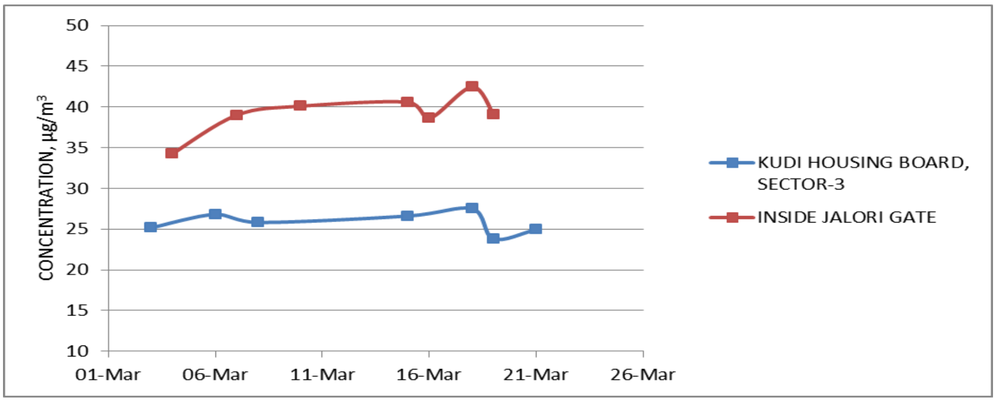

Fig.4 NO_2 concentration in ambient air

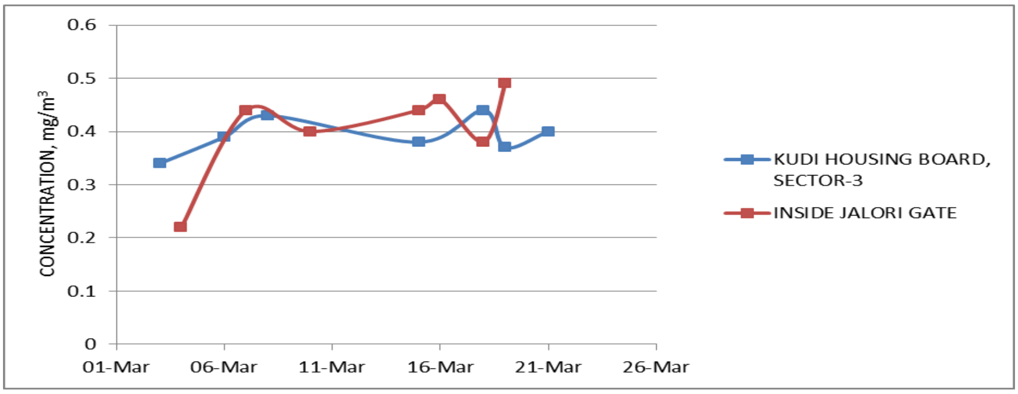

Fig.5: CO concentration in ambient air

V. Conclusion

On analyzing above data, it can be clearly inferred that primary pollutant at residential area of Jalori Gate is $PM_{2.5}$ and at Kudi Housing Board, sector-3 is PM_{10}. Reason behind this difference may be attributed to the locations of monitoring stations. Jalori Gate area was chosen near to heavily populated commercial area where vehicular movement and population density was very high whereas Kudi Housing board area was significant distance away from any major district roads. Overall AQI for Jalori gate area is ranging between 194 273 which falls under the category of moderate to poor ambient air quality and primarily it lies in poor category whereas for Kudi Housing Board Sector-3 area, AQI ranges between 118 to 129 which falls under the category of moderate air quality. Reason behind these pollutants can be basically related to vehicular pollution and light sand storm as Jodhpur zone is an arid zone. This study will help common people in identifying the areas of pollution, especially for those who are suffering with respiratory disease. In the area of poor air quality, people with any kind of breathing should consider reducing prolonged or heavy outdoor work.

References

[1] Central pollution control board, ministry of environment and forest, India, 2014
[2] Gowtham Sarella, Khambete K. Anjali, Ambient air quality analysis using air quality index-a case study of Vapi, 2013-2014
[3] Greenpeace, A status assessment of national air quality index (NAQI) and pollution level assessment for Indian cities, December 2015
[4] Kanchan, Amit Kumar Gorai and Pramila Goyal, A Review on Air Quality Indexing System, June 2015
[5] Lawrence K. Wang, Norman C. Pereira, Yung- Tse Hung, Adavnced air and noise pollution control, 2005
[6] Prakash Mamta, Bassin J.K, Analysis of ambient air quality using air quality index-a case study, 2009
[7] WHO air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide, Global update 2005
[8] National Research Council, Acute exposure guideline levels for selected airborne particles, 2010
[9] en.wikipedia.org/wiki/Air_quality_index
[10] en.wikipedia.org/wiki/jodhpur
[11] WHO Global Urban Ambient Air Pollution Database, 2016