International Journal of Engineering Science Invention
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org ||Volume 6 Issue 12|| December 2017 || PP. 09-12

Air Quality Index Assessment of Industrial Areas of Jodhpur City

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Abstract: *Jodhpur district is centrally situated in Western region of Rajasthan state. In this study four monitoring stations were established to find pollution level in the ambient air of various industrial areas situated around the city. Four industrial areas where samplings were done are Basni industrial area, Boranada industrial area, kankani industrial area and Mandore industrial area. Air Quality Index has been calculated by considering five pollutant parameters i.e. SO_2, NO_2, PM_{10}, $PM_{2.5}$ and CO. Minimum, average and maximum air quality index were calculated for every industrial area. It was found after analysis that air quality index of Basni and Mandore industrial falls under Poor category, while other industrial area falls in Moderate category. In the analysis, it was also observed that PM_{10} and $PM_{2.5}$ were responsible air pollutants for maximum sub-index as well as air quality index. Hence it is the time to plan activities in industrial areas to control air pollution emissions otherwise in future problem may aggravate and create a serious condition.*

Keywords: *Air pollution, AQI, industrial area, PM_{10}, $PM_{2.5}$.*

Date of Submission: 20-11-2017 Date of acceptance: 05-12-2017

I. Introduction

The 'Surya Nagari' Jodhpur is the second largest city of Rajasthan and the gateway of famous 'Thar Desert'. Air pollution of a city mainly depends upon the pollution from industrial areas, pollution from transportation; fuel burning and house hold activities. Pollution due to industrial areas around city significantly affects air quality of city if city lies on the downwind direction.

Air pollution is physical or chemical changes brought about by natural processes or human activities that result in air quality degradation[1]. Air is invariably impure and is always contaminated with gases like CO, NO_2, SO_2, and others (which are poisonous in nature) and finely divided solid and liquid particles and smog. Air becomes polluted due to the presence of the above contaminants. The presence of these contaminants in the air is called air pollution and the materials which pollute the air are called air pollutants[2]. As the population increased, people began to congregate and establish cities. The release of large amounts of smoke and other forms of waste into the air caused an unhealthy condition because the pollutants were released faster than they could be absorbed and dispersed by the atmosphere[3]. "More than 2 million premature deaths each year can be attributed to the effects of urban outdoor air pollution and indoor air pollution .More than half of this disease burden is borne by the populations of developing countries. Heart attacks, respiratory diseases, and lung cancer are all significantly higher in people who breathe dirty air compared to matching groups in cleaner environments[1]. The acute health effect of suspended particulate matter (SPM), even at short term low levels exposure; include increased daily mortality and hospital admission rates for exacerbation of respiratory disease[4]. Living close to busy traffic appears to be associated with elevated risk[5]. The available human clinical results do not establish a mechanistic pathway leading to adverse health impacts for short term NO_2 exposure at present day ambient environment[6].Each day our lungs are directly exposed to more than 7000 liters of air, which contain varying amount of inorganic, organic particles and various types of gases[7]. Hence it is now time to assess the air quality of the area in terms of pollutant concentration. Basni industrial area has mainly textile / timber / Guar gum industrial units. Boranada industrial area has mainly Metal and Wooden Handicrafts industrial units, Mandore industrial area has handicrafts/ oil mills/ Guar gum/ textile / Stone Processing industrial units. Kankani industrial area has mainly handicraft / plastic industrial units[8].

II. Methodology, Observations, Calculations and Analysis

Monitoring was carried out in all the four industrial areas as per central pollution control board (CPCB) of India guidelines. Five pollutants (SO_2, NO_2, PM_{10}, $PM_{2.5}$ and CO) were measured to calculate AQI of a particular area. AQI has been developed and used effectively in many industrialized countries to represent

pollution by a single number. An air quality index is a number to communicate to the public how polluted the air currently is or how polluted it is forecast to become[9]. An air quality index is defined as an overall scheme that transforms the weighed values of individual air pollution related parameters into a single number or set of numbers. The result is a set of rules (i.e. set of equations) that translate parameter values into a more simple form by means of numerical manipulation (Fig. 1).

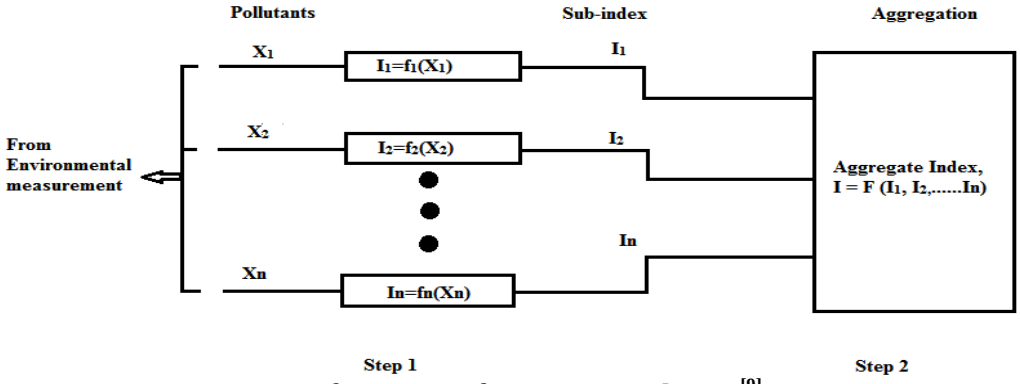

Figure 1: formation of an aggregated AQI [9]

Formation of sub-indices (I_1, I_2.... I_n) for n pollutant variable (X_1, X_2.....X_n) is carried out using sub index functions that are based on air quality standards and health effects. Mathematically;

$$I_i = f(X_i), \qquad i = 1, 2,...,n$$

Sub-index function represents the relationship between pollutant concentration X_i and corresponding sub-index I_i. The general equation for the sub-index (I_i) for a given pollutant concentration (C_p); as based on 'linear segmented principle' is calculated as:

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

Where,
I_{HI} = AQI value corresponding to B_{HI}
I_{LO} = AQI value corresponding to B_{LO}
B_{HI} = Breakpoint concentration greater or equal to given concentration.
B_{LO} = Breakpoint concentration smaller or equal to given concentration
C_p = Pollutant concentration
Each sub-index represents a relationship between pollutant concentrations and health effects[9].

Aggregation of sub-indices, I_i is carried out with some mathematical function to obtain the overall index (I), referred to as AQI. The aggregation function usually is a summation or multiplication operation or simply a maximum operator[9]

$$I = F(I_1, I_2,....., I_n)$$

For the AQI, a maximum operator system is selected in this study:

$$AQI = Max (I1, I2, I3... In)$$

Based on the measured ambient concentrations, corresponding standards and likely health impact, a sub-index is calculated for each of these pollutants. The worst sub-index reflects overall AQI. The AQI is divided in six categories, namely Good, Satisfactory, Moderately polluted, Poor, Very Poor, and Severe. Breakpoint concentrations for various pollutants are given in Table-1[9]. The minimum, average and maximum concentrations of all the five pollutants and locations of four monitoring stations are given in Table -2 to5 and calculated AQI are given in Table-6 to 9.

Table 1: Breakpoints for AQI Scale 0-500 (Units: µg/m^3 unless mentioned otherwise) [9]

AQI Category (Range)	PM_{10} 24-hr	$PM_{2.5}$ 24-hr	NO_2 24-hr	CO 8-hr (mg/m^3)	SO_2 24-hr
Good (0-50)	0-50	0-30	0-40	0-1.0	0-40

Satisfactory (51 - 100)	51-100	31-60	41-80	1.1-2.0	41-80
Moderately polluted (101-200)	101-250	61-9-	81-180	2.1-10	81-380
Poor (201 – 300)	251-350	91-120	181-280	10-17	381-800
Very poor (301 – 400)	351-430	121-250	281-400	17-34	801-1600
Severe (401- 500)	430+	250+	400+	34+	1600+

Table 2: Pollutant Concentration at Basni Industrial Area

Latitude	$26^0$14'15.09" N				
Longitude	73° 0'0.67" E				
Pollutant	SO_2 (µg/m^3)	NO_2 (µg/m^3)	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	CO (mg/m^3)
Minimum Concentration	10.41	21.01	190.67	61.09	0.458
Average Concentration	12.95	26.98	248.96	78.64	0.764
Maximum Concentration	15.75	34.38	308.75	97.39	1.145

Table 3: Pollutant Concentration at Boranada Industrial Area

Latitude	26°10'40.5" N				
Longitude	72°56'1.15" E				
Pollutant	SO_2 (µg/m^3)	NO_2 (µg/m^3)	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	CO (mg/m^3)
Minimum Concentration	5.27	20.06	94.16	45.82	0.00
Average Concentration	7.74	23.76	115.55	57.18	0.572
Maximum Concentration	10.26	27.51	138.45	69.64	1.145

Table 4: Pollutant Concentration at Kankani Industrial Area

Latitude	26°4'46.94" N				
Longitude	73°4'1.02" E				
Pollutant	SO_2 (µg/m^3)	NO_2 (µg/m^3)	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	CO (mg/m^3)
Minimum Concentration	5.75	20.99	97.50	42.23	0.00
Average Concentration	7.90	22.98	114.81	52.68	0.534
Maximum Concentration	10.60	26.26	135.31	67.29	0.916

Table 5: Pollutant Concentration at Mandore Industrial Area

Latitude	26°22'57.69" N				
Longitude	73°4'6.22" E				
Pollutant	SO_2 (µg/m^3)	NO_2 (µg/m^3)	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	CO (mg/m^3)
Minimum Concentration	10.99	28.97	140.77	64.87	0.687
Average Concentration	12.27	30.82	165.02	77.50	1.069
Maximum Concentration	13.49	33.53	201.93	91.56	1.488

Table 6: Calculated AQI for Basni Industrial Area

Pollutant	**Minimum**		**Average**		**Maximum**	
	Sub-index	**AQI**	**Sub-Index**	**AQI**	**Sub-index**	**AQI**
SO_2	13.01	160.45	16.19	199.31	19.69	258.75
NO_2	26.26		33.72		42.98	
PM_{10}	160.45		199.31		258.75	
$PM_{2.5}$	103.63		162.13		224.63	
CO	22.90		38.20		57.25	

Table 7: Calculated AQI for Boranada Industrial Area

Pollutant	**Minimum**		**Average**		**Maximum**	
	Sub-index	**AQI**	**Sub-Index**	**AQI**	**Sub-index**	**AQI**
SO_2	6.59	94.16	9.68	110.37	12.82	132.13
NO_2	25.08		29.70		34.39	
PM_{10}	94.16		110.37		125.63	
$PM_{2.5}$	76.37		95.30		132.13	
CO	0.00		28.30		57.25	

Table 8: Calculated AQI for Kankani Industrial Area

Pollutant	**Minimum**		**Average**		**Maximum**	
	Sub-index	**AQI**	**Sub-Index**	**AQI**	**Sub-index**	**AQI**
SO_2	7.19	97.50	9.80	109.87	13.25	124.30
NO_2	26.24		28.72		32.82	
PM_{10}	97.50		109.87		123.54	
$PM_{2.5}$	70.55		87.80		124.30	
CO	0.00		26.70		45.80	

Table 9: Calculated AQI for Mandore Industrial Area

Pollutant	Minimum		Average		Maximum	
	Sub-index	AQI	Sub-Index	AQI	Sub-index	AQI
SO_2	13.74	127.18	15.34	158.33	16.86	205.20
NO_2	36.21		38.52		41.91	
PM_{10}	127.18		143.35		167.95	
$PM_{2.5}$	116.23		158.33		205.20	
CO	34.35		53.45		74.40	

The maximum sub-index among the entire sub index for a particular case determines the AQI. From the observations and calculated AQI, it is assessed that maximum sub- index is because of either PM_{10} or $PM_{2.5}$. It is assessed that for SO_2 & NO_2 air pollutants air quality category is good. For CO air pollutant also air quality category is good/ satisfactory and for PM_{10} & $PM_{2.5}$ air quality category is Satisfactory, Moderate and Poor at four different monitoring stations for different conditions. It also can be concluded that air quality in industrial area of Jodhpur city is "Moderate Category" when minimum AQI is considered and Poor Category when maximum AQI is considered.

III. Conclusion

Minimum, Average and Maximum AQI calculated in this study for different industrial areas indicates that air quality falls between moderate to poor category. it is concluded that maximum AQI in Basni and Boranada industrial area come under Poor category, while other industrial area come under Moderate category. It is observed that minimum AQI is found during early morning time duration while maximum AQI is found during day time due to movement of heavy vehicles and other related working in industrial area. The present study clearly indicates that particulate matter is the major air pollutant in the study areas. In all the study areas, particulate matter pollutants exceed the permissible standards, but gaseous pollutants are within the permissible limits in industrial areas.

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International Journal of Engineering Science Invention (IJESI) is UGC approved Journal with Sl. No. 3822, Journal no. 43302.

Narendra Katara Air Quality Index Assessment of Industrial Areas of Jodhpur City." International Journal of Engineering Science Invention(IJESI), vol. 6, no. 12, 2017, pp. 09-12.