A Study of Ambient Air Quality Status in Jaipur City (Rajasthan, India), Using Air Quality Index

Anand Kumar [a *], Dr. Ashish Garg [a] and Prof. Upender Pandel [b]

(a) Department of Chemistry, University of Rajasthan, Jaipur-302004, India.
(b) Department of Metallurgical Engineering, Malviya National Institute of Technology, Jaipur-302017, India.
(*) Corresponding author, E mail- anandkumarchoudhary.2010@rediffmail.com

Abstract: In this paper an attempt has been made to express the ambient air quality of Jaipur city in the form of Air Quality Index (AQI). The data of air pollutants were collected from twelve sites in residential, industrial and commercial areas of the city. The survey was carried out to evaluate Suspended Particulate Matter (SPM), Respirable Suspended Particulate Matter (RSPM), sulphur dioxide (SO_2) and oxides of nitrogen (NOx) by sampling for a period of 24 hours in winter season of the year, 2009-2010. Pollutants concentrations were used to calculate the Air Quality Index .The results show that SPM, RSPM levels at all the selected sites excluding residential area of Tilak Nagar, exceeds the prescribed limits as stipulated by Central Pollution Control Board (CPCB) New Delhi, India. Apart from this, the SO_2 and NOx levels in residential, industrial and commercial areas remain under prescribed limits of CPCB. One site showed AQI values above 100, representing severe air pollution, five sites showed AQI values between 76 to 100, representing heavy air pollution, other five sites showed moderate air pollution and one site showed light air pollution.

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1. Introduction

In Indian cities the ambient atmospheric conditions have generally deteriorated due to lack of awareness about the impacts of urbanization and industrial development. From the studies conducted in different cities of India it can be generalized that there is a significant variation in the pollution level in different areas of a city with reference to its location, time, period for sampling and climate conditions during sampling. Air pollution in sites located in or near industrial or busy commercial areas have a relatively higher pollution levels than the sites in residential areas. Besides this, reports show that the levels of air pollutants in the cities vary with climatic conditions and are highest in winter season.

In many Indian cities the average levels of SO_2 and NO_x pollution have been contained and approximate the Indian air quality standard in many areas but the concentration of suspended particulate matter (SPM) and PM_{10} (RSPM) generally exceeds the Indian air quality guideline. The air borne particles have a direct impact on human health. Although the particles with median diameters higher than 10 µm are stopped in the upper areas of the respiratory system, particles of median diameters less than 10 µm (PM_{10}) can migrate to the lungs and those with diameters less than 2.5 µm can reach bronchial alveolus and may be retained for a long period. The suspended air particulates can cause respiratory problems as asthma, respiratory allergies (Healy et al., 2007) and other health hazards depending on their physicochemical properties.

The present study deals with the effect of industrialization, urbanization and automobile emission on ambient air quality of Jaipur city. The two major sources for emitting air pollutants in Jaipur city are transport vehicles and industrial units. This problem has been aggravated by extensive urbanization of the city and an increase in the number of transport vehicles. In the present study it was therefore thought useful to access the ambient air quality of Jaipur city in the form of Air Quality Index in the winter season of the year, 2009-2010.

2. Materials and Methods

2.1. Study area

Jaipur City is referred as Pink city of Rajasthan (India) which was founded in year 1727 AD by Maharaja Swai Jai Singh. Jaipur (Figure 1) is located on 26° 55' north latitude and 75° 49' east longitude covering an area of 200.4 km^2 with a population of 23, 24,319 (according to 2001 census) and has a hot semi-arid climate. The winter months of November to February are mild and pleasant, with average temperatures ranging from 15°-18°c (59°-64°f) and with little or no humidity. There are however occasional cold waves that lead to temperatures near freezing.

The objective of the study was to monitor the ambient air quality of some sites in the residential,

industrial and commercial areas of the city to express the ambient air quality of Jaipur city in the form of Air Quality Index. Samples from twelve monitoring sites were collected in the winter season and details of the monitoring sites are given in Table-1.

2.2 Air sampling

The air samples were collected during the winter season (15th Nov. to 15th Feb.), the period in which the concentration of air pollutants is generally higher. A 24 hours sampling for two successive days from each site was conducted between15th Nov. to 14th Dec. The sampling method adopted was repeated for the periods 16th Dec. to 14th Jan and 17th Jan to 15th Feb. and from each of the study site three samples were collected.

2.3 Monitoring and Analysis

Air pollutants (SPM, RSPM, SO_2 and NOx) monitoring data for site 1 to 12 was measured with the help of Respirable Dust Sampler (RDS, APM model 451, from Envirotech instruments Pvt. Ltd., New Delhi) for SPM, RSPM monitoring and SO_2 analyzer (API model 100A), NO_X analyzer (API model 200A) for monitoring of SO_2 and NOx respectively. RDS first separates the coarser particles from the air stream before filtering it on the 0.5 micron pore size filter allowing a measurement of both SPM and RSPM. SO_2 analyzer is based upon the well-proven technology from the measurement of fluorescence of SO_2 due to absorption of UV energy. SO_2 absorbs in the 190nm-230nm region with accessories for removing interferences. NOx analyzer is designed to measure the concentration of NO, NOx and by calculation NO_2.The instrument measures the light intensity of the chemiluminescent gas phase reaction of NO and O_3. AQI is then calculated with the pollutant concentration values.

2.4 Air Quality Index

The Air Quality Index (AQI) is a measure of the ratio of the pollutant concentration to the status of ambient air in places. Indices of air pollution or air quality have been used for about 30 years.

The following computation was used to derive the Air Quality Index of the sites under consideration.

$AQI = 1/4[SPM/ sSPM + RSPM/ sRSPM + SO_2/ sSO_2 + NO_x/ sNOx] \times 100$

Where sSPM, sRSPM, sSO_2 and sNOx represent the ambient air quality standards as prescribed by the CPCB, for suspended particulate matter, respirable suspended particulate matter, sulphur dioxide and nitrogen oxides respectively and SPM, RSPM, SO_2 and NOx represents the actual values of the pollutants obtained on sampling.

The ambient Air Quality Index is an index for reporting the day to day air quality. It gives details about the cleanliness of ambient air to what extent ambient air is polluted. Already Environmental Protection Agency (EPA) is using the AQI for the following five major pollutants regulated by clean air viz. Ground level ozone, particulate matter, carbon monoxide, sulphur dioxide and nitrogen oxide. For each of these pollutants EPA has set National Ambient Air Quality Standards (NAAQS) to protest against harmful health effects.

After compiling the results, the concentration of each pollutant was converted in to an AQI. The pollutant with the highest AQI number became the overall AQI for a particulate location. The higher the AQI value, greater is the level of air pollution and greater the damage of health.

The AQI scale was divided in to five categories, each category describes the range of air quality and its associated potential health effects. The index uses health based descriptions to provide meaningful information to the public. The five levels of AQI are depicted in Table 2.

3. Results and Discussion

The present study indicates the air pollution of Jaipur City using air quality index (AQI) at twelve monitoring sites. The results show that suspended particulate matter (SPM) concentration in the study area is varied between a maximum of 854.33µg/m^3 and a minimum of 79.81µg/m^3. Respirable suspended particulate matter (RSPM) in the study area ranges between a maximum of 340.85µg/m^3 and a minimum of 46.64µg/m^3. This exceeds the CPCB prescribed values except Tilak Nagar. Sulphur dioxide in the study areas ranges between the minimum of 11.67µg/m^3 and a maximum of 39.76µg/m^3. Oxides of nitrogen in the study area range between a maximum of 61.86µg/m^3 and a minimum of 16.55µg/m^3. The values of Air Quality Index for the ambient air quality of the sampling sites calculated from the data obtained is given in Table 3 and graphically represented in Figure 2. The Air Quality Index values in the study areas vary between a maximum of 102.71 and a minimum of 52.04. An estimation of the average values at the locations shows that Air Quality Index values corresponds to moderate pollution in the residential areas and heavy pollution in the commercial and industrial areas.

The results of air quality monitoring show that the pollution concentrations were highly variable at different sampling sites. This is expected as the extent of air pollutants in a site depend on the active mobile and stationary pollutant emitting sources and is influenced by meteorological factors. Particulate pollutants concentration exceeded the permissible standards in all sites except in Tilak Nagar, a residential zone with controlled emission from transport vehicles. The concentration of gaseous pollutants was observed to be within permissible limits in all the sites.

Table 1. Site description

S.NO.	SITES	LOCATION	ACTIVITIES
	RESIDENTIAL		
1.	Tilak Nagar	Near Shivaji Park	No Regular traffic, few vehicles
2.	Vidyadhar Nagar	Near Sikar Road	Regular traffic due to 2,3,4 wheelers & buses
3.	Transport Nagar	Near Agra Highway	Four wheelers, trucks buses are plying.
4.	Vaishali Nagar	Near Prestige Tower	Average traffic due to 2,3,4 wheelers & buses
5.	Mansarovar	Near Kaveri Path	Four wheelers, buses are plying
	INDUSTRIAL		
6.	Vishvakarma Industrial Area (VKIA)	Road no.16	Industrial activity zone, low traffic, generally operation related to industries nearby carried out.
7.	Malviya Nagar Industrial Area (MNIA)	Near I.L. office	
8.	Jhotwara Industrial Area	Near Oswal Cables Ltd.	
	COMMERCIAL		
9.	Govt.Hostel Circle	Near K.S. Motors Ltd.	Heavy traffic due to 2,3,4 wheelers & buses
10.	Ajmeri Gate	Near Golecha Mall	
11.	Sahkar Circle	Near Inox Cinema Hall	
12.	Chandpole	Near Hanuman Mandir	

Table 2. Index values of air quality index calculation

Index value	Remarks
0-25	Clean air
26-50	Light air pollution
51-75	Moderate air pollution
76-100	Heavy air pollution
Above 100	Severe air pollution

(Source: Rao and Rao, 1989)

Table 3. Air quality index at selected sampling sites

S.NO.	Zone	Station	AQI	Remarks (pollution)
	RESIDENTIAL			
1.		Tilak Nagar	52.04	Light
2.		Vidyadhar Nagar	73.28	Moderate
3.		Transport Nagar	77.21	Heavy
4.		Vaishali Nagar	59.67	Moderate
5.		Mansarovar	61.03	Moderate
	INDUSTRIAL			
6.		VKIA	91.35	Heavy
7.		MNIA	74.44	Moderate
8.		Jhotwara Industrial Area	73.32	Moderate
	COMMERCIAL			
9.		Govt. Hostel Circle	82.59	Heavy
10.		Ajmeri Gate	84.07	Heavy
11.		Sahkar Circle	86.83	Heavy
12.		Chandpole	102.71	Severe

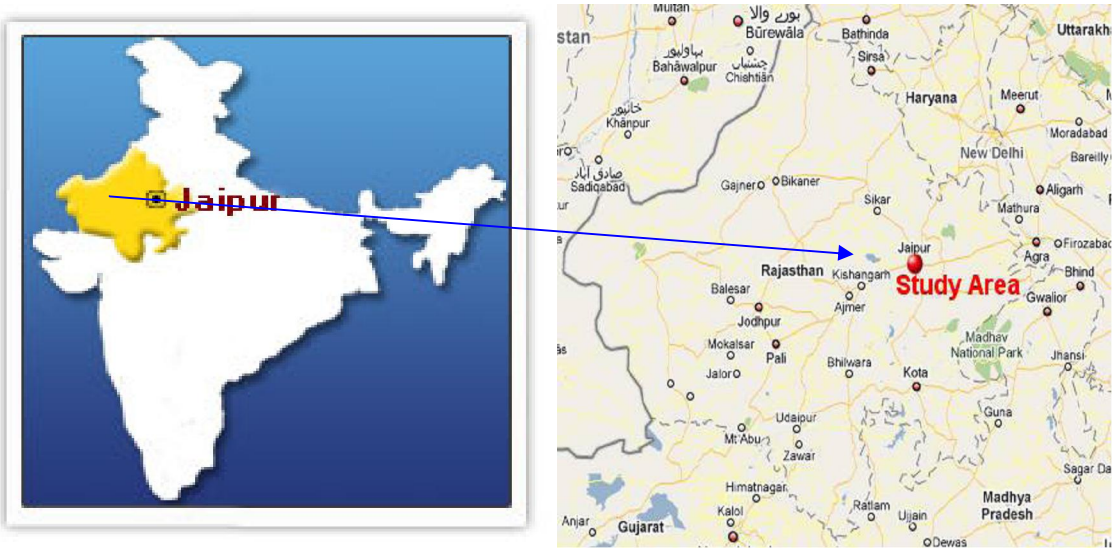

Figure 1. Location of Jaipur City in India

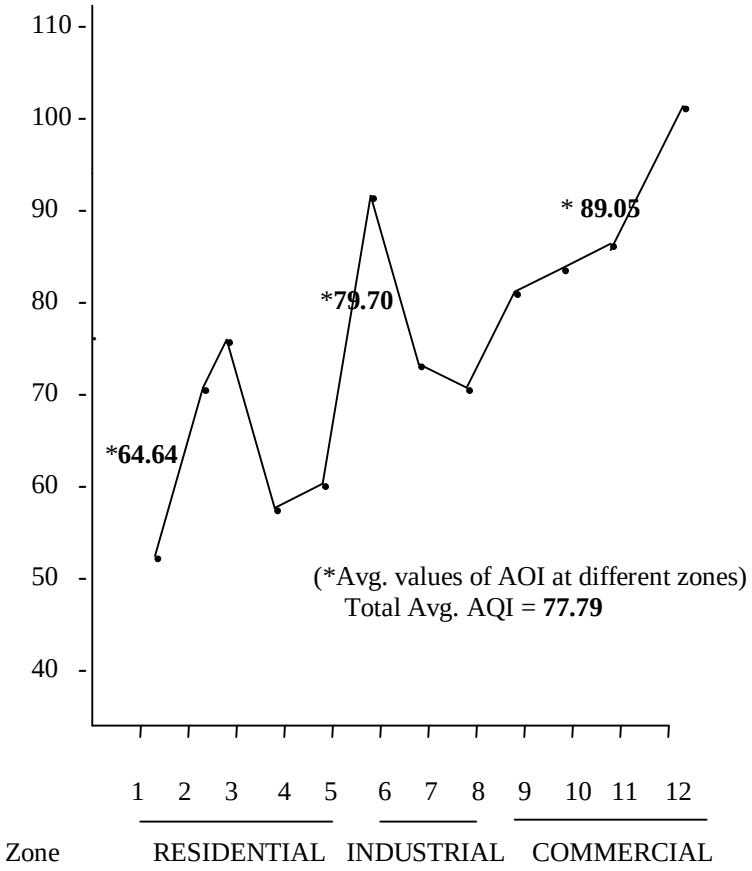

Figure 2. Observed AQI values at selected sampling sites

4. Conclusion

The present study reveals that the concentration of suspended particulate matter exceeded the permissible standards in highly commercial areas, densely populated residential areas, and industrial zones and in the residential areas located near highly commercial or industrial zones. The presence of high concentration particulate pollutants has a significant negative impact on the ambient air quality status of Jaipur city as in terms of Air Quality Index. The main source of the pollutants appears to be vehicular emission as its concentration is highest in the sites located in the busy commercial zones of the city with high transport density.

From the studies it is evident that development and planning of the transport system and social awareness can play a major role in improving the quality of air in the city.

Correspondence to:
Anand Kumar
Department of chemistry, University of Rajasthan
Jaipur 302055, Rajasthan, India
Cellular phone: 09352536810
Email- anandkumarchoudhary.2010@rediffmail.com

Affiliations of authors:
(1) Anand Kumar
Department of Chemistry,
University of Rajasthan,
Jaipur – 302004,
Rajasthan, India.
Email address:
anandkumarchoudhary.2010@rediffmail.com

(2) Dr. Ashish Garg
Department of Chemistry,
University of Rajasthan,
Jaipur – 302004,
Rajasthan, India.
Email address: dr.ashishrenu@rediffmail.com

(3) Prof. Upender Pandel
Department of Metallurgy,

Malviya National Institute of Technology
Jaipur – 302017,
Rajasthan, India.
Email address: upenderpandel@yahoo.in

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