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Assessing Ambient Air Quality of Kota City, Rajasthan in terms of Air Quality Index

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Abstract— Air pollution is a matter of serious concern for the modern world. With the technological advancements, problem of air pollution has shown its severe impacts on human, animal and plant life. The common man cannot understand the technicalities of air pollutants and their concentrations. To make it simplified, a new concept of air quality index was introduced and different countries of the world have adopted different standards and formula to find out the values of air quality index of a particular place for a specified time period. Such an experiment has been carried out for Kota city, Rajasthan where the air quality was monitored for six months and the air quality index has been worked out and compared with the standards given by the Central Pollution Control Board of India.

Keywords—air quality index, sulfur dioxide, carbon monoxide, particulate matter, oxides of nitrogen

I. INTRODUCTION

Air is an important resource for sustenance of life in addition to land and water. The quality of air is being continuously deteriorating with the developmental activities and technological advancements. In most of the urban areas, level of air pollution is increasing and creating health menace. The government is taking necessary steps to control air pollution and it is expected from the public to assist through community participation. The quality of ambient air is monitored by the governmental agencies as well as other organizations and hence it generates a large amount of data which neither gives a clear picture to the decision makers nor to the common man. The common man is only interested about the quality of air whether it is good or bad without going into much complex technical details of individual air pollutants.

To find out the solution to above problem, the concept of Air Quality Index (AQI) was developed and it is used in many countries of the world with some variations as per their native circumstances. The Central Pollution Control Board (CPCB) of India took the initiative to develop an AQI for Indian cities. AQI is a tool; disseminating information regarding quality of air in qualitative terms (e.g. good, satisfactory and poor) as well as it is associated with likely health impacts.

II. IMPORTANCE OF AIR QUALITY INDEX

An AQI is defined as an overall scheme that transforms weighted values of individual air pollutants (SO_2, CO etc.) into a single number or set of numbers. AQI scale is required for the public and policy makers to take decisions to prevent and minimize air pollution exposure and diseases induced from such exposure. The main purpose of the AQI is to help us understand what ambient air quality means to our health. Ott (1978) has listed out the following six applications of AQI:

1. Helps in resource allocation
2. Ranking of different locations or cities by comparing their AQI values
3. Helps in enforcing and maintaining standards
4. Forecasting of air quality based on changes in air quality

5. To inform public about the state of environment
6. Assists in scientific research

III. STATUS OF AIR QUALITY INDEX IN INDIA

Initially, there were no significant efforts in India to develop and use AQI because the National Ambient Air Quality Proramme started very late i.e.in year 1984. The Ministry of Environment, Forests & Climate Change launched The National Air Quality Index (AQI) in New Delhi in 2014 under the Swachh Bharat Abhiyan. While the earlier measuring index was limited to three indicators, the current measurement index had been made quite comprehensive by the addition of five additional parameters. There are six AQI categories, namely Good, Satisfactory, Moderately polluted, Poor, Very Poor and Severe. The new AQI considers eight pollutants (PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, O_3, NH_3 and Pb) for which short-term (up to 24-hourly averaging period) National Ambient Air Quality Standards are prescribed. Based on the measured ambient concentrations, corresponding standards and likely health impact, a sub-index is calculated for each of the pollutants. The worst sub-index reflects overall AQI. The AQI values and corresponding ambient concentrations (health breakpoints) as well as associated likely health impacts for the identified eight pollutants are as follows:

TABLE I: AQI Category, Pollutants and Health Breakpoints

AQI Category (Range)	PM_{10} (24hr)	$PM_{2.5}$ (24hr)	NO_2 (24hr)	O_3 (8hr)	CO (8hr)	SO_2 (24hr)	NH_3 (24hr)	Pb (24hr)
Good (0-50)	0-50	0-30	0-40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory (51-100)	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	61-90	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
Very poor (301-400)	351-430	121-250	281-400	209-748	17-34	801-1600	1200-1800	3.1-3.5
Severe (401-500)	430+	250+	400+	748+	34+	1600+	1800+	3.5+

(Source: Central Pollution Control Board, National Ambient Air Quality Monitoring, 2015)

TABLE II: AQI and Associated Health Impacts

AQI	Associated Health Impacts
Good (0-50)	Minimal impact
Satisfactory (51-100)	May cause minor breathing discomfort to sensitive people.
Moderately polluted (101–200)	May cause breathing discomfort to people with lung disease such as asthma, and discomfort to people with heart disease, children and older adults.

Poor (201-300)	May cause breathing discomfort to people on prolonged exposure and discomfort to people with heart disease.
Very poor (301-400)	May cause respiratory illness to the people on prolonged exposure. Effect may be more pronounced in people with lung and heart diseases.
Severe (401-500)	May cause respiratory impact even on healthy people and serious health impacts on people with lung/heart disease. The health impacts may be experienced even during light physical activity.

(Source: Central Pollution Control Board, National Ambient Air Quality Monitoring, 2015)

The pollutant with an AQI number suggests the overall AQI of a particular location. Higher AQI value suggests greater level of air pollution and greater damage to health and ecology. The AQI scale is divided into five categories with the type of air quality and potential health effect associated to air quality. Scale ranges from 0 (Good) to 500 (Hazardous).

IV. METHODOLOGY

To find out the AQI, a high volume air sampler was used for monitoring the air quality at ten locations during day and night for a period of 8-hours, along the major roads of Kota and parameters like SPM, SO_2 and NO_X have been worked out as per the standard methods.

FIGURE I: High Volume Air Sampler installed at a location during study

In this study, AQI at various locations in Kota city have been calculated with the following mathematical equation.

$$AQI = 1/3\{(SPM/SPM_{standard}) + (SO_2/SO_{2standard}) + (NO_X/NO_{Xstandard})\} \times 100$$

Where, SPM = Individual values of suspended particulate matter.
$SPM_{standard}$ = Standards of ambient air quality of suspended particulate matter.
SO_2 = Individual Values of sulphur dioxide.
$SO_{2standard}$ = Standards of ambient air quality of sulphur dioxide.
NO_X = Individual values of oxides of nitrogen.
$NO_{Xstandard}$ = Standards of ambient air quality of oxides of nitrogen.

The values in numerator have been found out with the help of high volume air sampler and the values in denominator have been taken from the standard values as per the National Ambient Air Quality Standards in India mentioned in the following table:

TABLE III: National Ambient Air Quality Standards in India

Sr. No.	Type of Area	Time Weighted Average	RSPM ($\mu g/m^3$)	SPM ($\mu g/m^3$)	SO_2 ($\mu g/m^3$)	NO_X ($\mu g/m^3$)
1	Ecologically Sensitive Areas	Annual	40	60	20	30
		24 Hours	60	100	80	80
2	Residential, Industrial and Rural Areas	Annual	40	60	50	40
		24 Hours	60	100	80	80

(Source: NAAQM & Trends-2012, CPCB and MOEF/2014-2015)

V. RESULTS AND DISCUSSION

The average AQI of Kota city has been found as 140 that come under the category of unhealthy for sensitive ones while the average AQI during day is 185 that come under the category of unhealthy and average AQI during night is 95 that come under the category of moderate pollution.

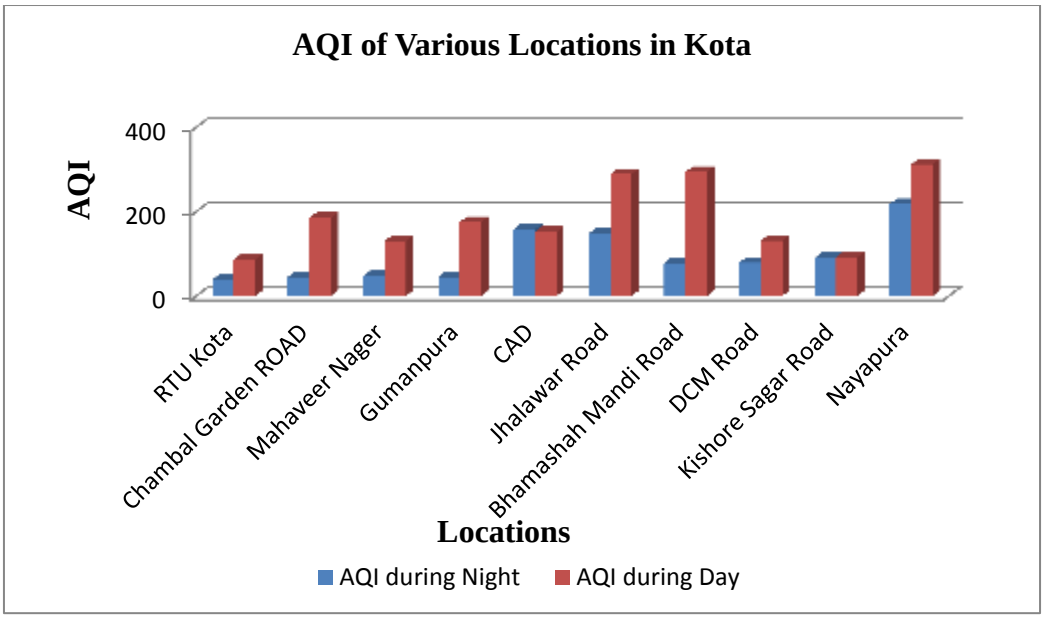
The increase in value of AQI from night to day directly shows the impact of vehicles in polluting the air of Kota. Major pollutants responsible for increased value of AQI in Kota are suspended particulate matter and NO_X that directly signifies the impact of vehicular air pollution in Kota.

Jhalawar Road and CAD Road have AQI values more than 100 in night that signifies highly polluted locations. Nayapura is under critically polluting location in night having value of AQI as 218 that comes under very unhealthy category. For rest of the locations during night the value of AQI is less than 100 that comes under the moderate and minimal pollution category.

During day, the condition of air become worse as such average AQI of Kota during day is 185 that show that air is very much polluted during the day time except Kishore Sagar Talav Road and Rawatbhata Road that have AQI values 92 and 87. Low value of AQI at Kishore Sagar Talav Road is due to ban on vehicles, low population density and nearby parks, however during morning and evening, people come to the park for walking, jogging, exercise and sightseeing due to famous lake of Kota but vehicles are completely banned during evening hours while at Rawatbhata Road the value of AQI is low because of low population density and exterior end of the city.

AQI is very high during day at Jhalawar Road (289), Bhamashah Mandi Road (294) and Nayapura Road (312) that comes in the category of critically polluted locations in Kota. Nayapura and Jhalawar Roads are severely polluted due to the impact of both heavy and light vehicles while at Bhamashah Mandi Road, both vehicles and small scale industries are responsible for air pollution but share of vehicle pollution is more because it is connecting road to the National Highway and well known Grain Mandi of Rajasthan. During day, at Chambal Garden Road, Mahaveer Nagar Road and Gumanpura Road, the value of AQI is tremendously high with respect to AQI during night because of the main contribution of city vehicles in these locations. These three locations are the interior roads of Kota city and contribution of heavy vehicles is less, only city vehicles are responsible for the pollution during day and night.

The following graph I shows the variations in AQI during day and night for all the selected ten locations of Kota City.



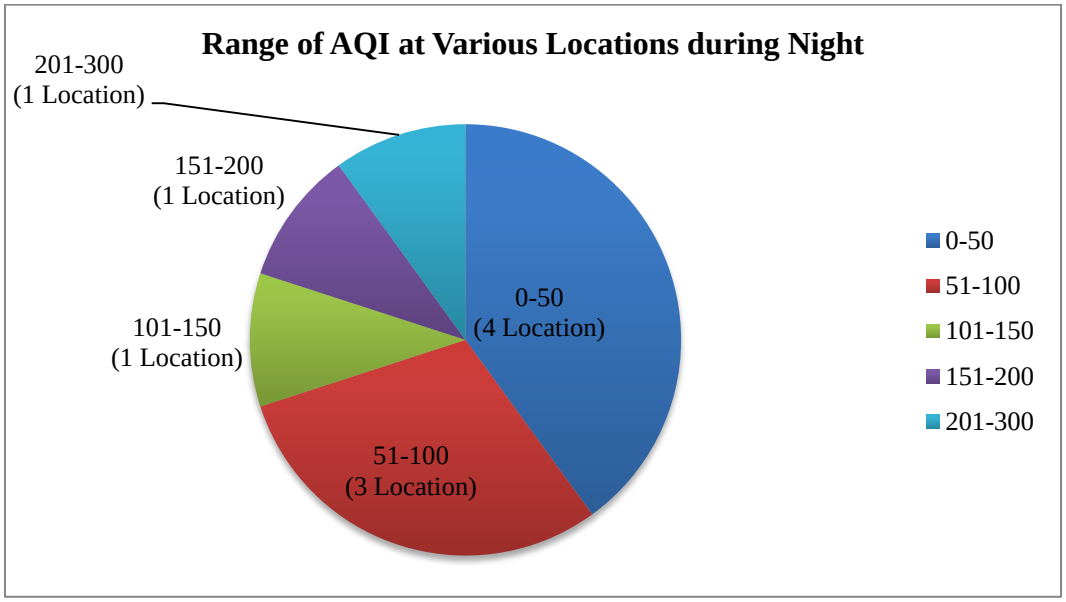
Graph I: Observation of AQI at different Locations

Table IV gives an outline of summary of results obtained during the study regarding concentration of parameters like SPM, SO_2, NO_X and values of AQI calculated with the help of mathematical equation for all the ten locations for day and night.

TABLE IV: Summary of Results

S. No.	Location	Status	SPM ($\mu g/m^3$)	SO_2 ($\mu g/m^3$)	NO_X ($\mu g/m^3$)	AQI
1	Rawatbhata Road	Night	103.36	3.03	7.39	39
		Day	253.99	1.25	4.07	87
2	Chambal Garden Road	Night	124.50	0.83	8.46	45
		Day	539.40	1.25	10.16	185
3	Mahaveer Nagar Road	Night	131.79	1.33	6.23	47
		Day	368.51	1.78	16.26	130
4	Gumanpura Road	Night	125.00	1.25	6.60	45
		Day	494.09	5.14	18.54	174
5	C.A.D. Road	Night	464.06	1.25	6.35	158
		Day	448.00	1.25	5.84	152
6	Jhalawar Road	Night	392.27	5.0	37.09	148
		Day	806.25	3.33	45.73	289
7	Bhamashah Mandi Road	Night	217.30	3.30	11.18	78
		Day	868.33	2.50	8.38	294
8	D.C.M. Road	Night	201.12	2.50	25.41	79
		Day	367.16	2.50	18.04	131
9	Kishore Sagar Talav Road	Night	257.11	1.67	8.38	90
		Day	266.66	1.67	6.61	92
10	Nayapura Road	Night	639.20	2.50	10.16	218
		Day	902.84	7.91	19.81	312

(i) AQI at Locations during Night



Graph II: Range of AQI Values at different Locations during Night

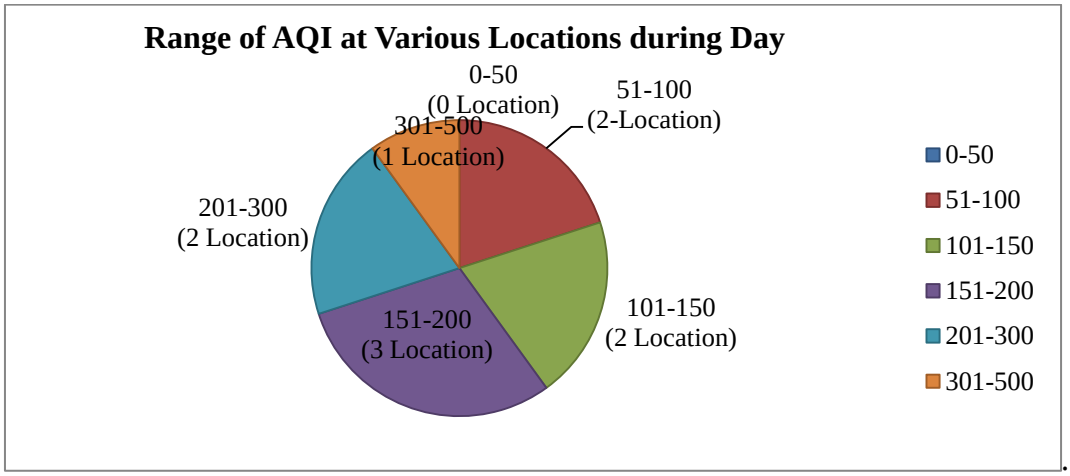
The graph II shows that four locations have AQI in the range of 0-50 that signifies that these four locations Rawatbhata Road, Chambal Garden Road, Mahaveer Nagar Road and Gumanpura Road are in the category of good atmospheric conditions. These four locations have minimum low AQI during night because of minimal interference of heavy traffic during night as all these four locations are interior city locations so, only city vehicles are mainly responsible for pollution and in night, minimum city vehicles move in interior parts of Kota.

Bhamashah Mandi Road, Kishore Sagar Talav Road and DCM Road have AQI value in the range of 51-100 that comes under the category of moderate air pollution. Bhamashah Mandi Road is connecting road to the national highway and vehicles come for loading and unloading grains during night. DCM Road is also a connecting road to the national highway and also comes in interior road of the city so both heavy and city vehicles are responsible for vehicle pollution in night at this location. Kishore Sagar Talav Road is also a connecting road to the national highway road and comes in interior road of city but from evening hours to late night hours there is a ban on traffic on this road so, surrounding pollution due to nearby highway is mostly responsible for the moderate value of AQI.

Jhalawar Road has AQI value of 148 during night that comes under the category of unhealthy for sensitive ones. The high value of AQI at this location is mainly due to heavy vehicles as this road serves as a national highway road of Kota city. CAD Road has AQI value 158 during night that comes under the category of unhealthy. High value of AQI at CAD during night is because of coal dust and flue gases from the stack of Kota Thermal Power Station chimneys. CAD Road is interior in Kota city and during night a few heavy vehicles are moving, so for high value of AQI only light vehicles and plant emission is mainly responsible. However plant emission is mainly responsible for high value of AQI.

Nayapura Road has AQI value 218 that comes in the very unhealthy category. The high value of AQI at this location during night is due to heavy and light vehicles as Nayapura Road serves as a national highway road for vehicles to come in Kota city along with the presence of state roadways and bus stand make it highly polluted even in night.

(ii) AQI at Locations during Day



Graph III: Range of AQI Values at different Locations during Day

The graph III shows that air pollution in Kota city during day time is too high with average AQI as 185 that come under the category for unhealthy atmosphere. The main reason for high AQI is the presence of suspended particulate matter and NO_X. No single location having AQI in the range of 0-50 shows highly pollution in Kota city during daytime.

Two locations Rawatbhata Road and Kishore Sagar Road have AQI in the range of 51-100 that comes under the category of moderate air pollution. These locations show moderate value of AQI because of less populated, less vehicle density and high greenery area. Rawatbhata Road is an exterior end of Kota city, vehicles move to Rawatbhata side only along with vehicles coming to colleges at Rawatbhata Road are majorly responsible for pollution of air during day while at Kishore Sagar Talav, vehicles move to nearby connecting highway road is responsible for deterioration of air, as such there is a ban on vehicles on that road during evening hours.

Mahaveer Nagar Road and DCM Road have AQI in the range of 101-150 that comes under the category of unhealthy for sensitive ones. Mahaveer Nagar has high air pollution only due to light vehicles of Kota city; as such no heavy traffic at this location is present while at DCM road both heavy and light vehicles are responsible for high value of AQI during day.

Gumanpura, Chambal Garden and CAD Road have AQI in the range of 151-200 that come under the category of unhealthy atmosphere. The higher value of AQI for Gumanpura during day is mainly due to congestion of vehicles, high population density and small road widths while at CAD both vehicles as well as fly ash from the stack of chimneys are responsible for high value of AQI during day.

Chambal Garden Road has high AQI during day time due to various types of parks and temples along the road side which increase the frequency of vehicles as people come from morning to evening to visit parks and temples.

Two locations having AQI in the range of 201-300 are Bhamashah Mandi Road and Jhalawar Road that come under the category of very unhealthy atmosphere. Bhamashah Mandi has high value of AQI due to both vehicles and small scale Industry (mainly stone crusher industry) while Jhalawar Road has high value of AQI due to high frequency of heavy and light vehicles during day.

Nayapura Road is the most critically polluted location in Kota with AQI value 312 that comes under the category of hazardous atmosphere that directly increases the risk of premature death on long-term exposure and lung and heart diseases on short-term exposure. Both heavy and light motor vehicles are responsible for high value of AQI at this location during night. Nayapura serves as entrance road to national highway in Kota with both State and local roadways bus stand.

VI. CONCLUSION

An attempt has been made in this study to monitor air quality on major roads of Kota by setting up sampling stations at 10 locations and monitoring is done during day and night for a period

of 8-hours with the help of high volume air sampler for three parameters SPM, SO_2 and NO_X. Based on these three parameters, air quality index is found out. The average AQI of Kota is 140 that come under the unhealthy category for sensitive ones while average AQI during day is 185 that come in unhealthy category. Average AQI during night is 95 that come in moderate region. Higher value of AQI in Kota is due to SPM, NO_X and SO_2; however SPM and NO_X are more dominant than SO_2.

VII. RECOMMENDATIONS AND SUGGESTIONS

Based on the results of monitoring air quality and values of air quality index, the following steps should be taken up by the government (regulating agency) and also by the public as no rule or implementation is successful without the active participation and compliance by the public:

- There should be proper control and regulation of traffic in the congested areas of the city.
- There is a need for strict vigilance and no-tolerance to visible polluting vehicles, industries, open burning and construction activities.
- The sources of air pollution should be identified and actions be taken for reducing emissions from such sources.
- The people should maintain their vehicles properly by way of getting Pollution Under Control (PUC) certificates, replacing car air filter, maintaining right tires pressure etc. and following lane discipline and speed limits, avoiding prolong idling and turning off engines at red traffic signals.
- In addition, at places of very poor AQI values, people should avoid traveling and using private vehicles and instead use public transport or carpooling.
- The uses of diesel vehicles and generators should be minimized. Use of CNG driven vehicles be encouraged.
- People, especially those suffering from heart diseases and asthma, may consider avoiding undue exposures.

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