Research Paper

ASSESSMENT OF AMBIENT AIR QUALITY STATUS IN URBAN RESIDENTIAL AREAS OF JHANSI CITY AND RURAL RESIDENTIAL AREAS OF ADJOINING VILLAGES OF JHANSI CITY

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ABSTRACT

Urban activities create more pollution in comparison to rural activities. This paper assesses the ambient air quality status in urban residential area of Jhansi city and rural residential area of adjoining village of Jhansi city. Two sites under urban residential area and two cites under rural residential area were selected purposively to spotlight an overview of the total air quality of this region. The air quality was assessed based on measuring four air pollutants namely Suspended Particulate Matter (SPM), Respirable Suspended Particulate Matter (RSPM), Oxides of Nitrogen (NO_x) and Sulphur di oxide (SO_2). In both the areas viz. urban residential and rural residential, the average concentrations of SPM and RSPM exceeded the prescribed limits of Central Pollution Control Board (CPCB) New Delhi. In the urban residential areas the average concentrations of SPM and RSPM were higher than the rural residential areas. Apart from this the SO_2 and NO_x levels in urban residential areas and rural residential areas remain under prescribed limits of CPCB, New Delhi. The average AQI value of urban residential areas was found higher than the rural residential areas. The urban residential area viz. Shivaji nagar and Veerangana nagar were heavily polluted whereas the rural residential area viz. Kochha Bhavar and Lakara were moderately polluted.

KEY WORDS Rural residential area, urban residential area, air quality index, air pollutants

INTRODUCTION

The immediate environment of man comprises of air on which depends all forms of life. Human beings need a continuous supply of air to exist. The requirement for air is relatively constant about 10-20m3 per day (Park 2009). The external air has other compounds and elements along with the already mentioned. Air is rendered impure by a) respiration of man and animals b) decomposition of organic matter, c) combustion of coal, gas, oil etc. d) trade, traffic and manufacturing processes that give off dust, fumes vapors and gases.Urban air pollution due to vehicular emission is a matter of concern because of exposure of large number of people to it. Vehicular emission is responsible for higher level of air pollutants like SPM, RSPM, SO_2, NO_x and other organic and inorganic pollutants including trace metals and their adverse effects on human and environmental health (Caselles et al., 2002; Kaushik et al., 2006; Maitre et al., 2006 ; Curtis et al., 2006; Sharma et al., 2006; Jayaraman, 2007, Barman et al., 2010). Vehicular exhaust is one of the most important sources of fine particles (Nolte et al., 2002; Fang et al., 2005; Barman et al., 2008, Barman et al., 2010).

Vehicular traffic is the main source of particulate air pollution in urban area of Jhansi city. Continuous emission of pollutants from vehicular traffic is a matter of concern because of adverse effects on ambient air quality as well as on the human health. Transportation is the major source of air pollution in urban environment, the other potential sources being industrial operations, combustion of wastes, construction activities and natural contaminants. The vehicle fleets in our country are old and poorly maintained, roads are narrow and the number of two stroke engines is high, thus increasing the significance of motor vehicles as a pollutant source (Pandey, et al., 1998, Khoiyangbam, R. S., 2010). Off late researchers, policy makers and governments has focused their attention on air quality in the urban areas only. Air quality in rural areas remains a neglected issue so far. The common belief is that rural areas are free from air pollution. On the contrary air quality in the rural areas all over the world and particularly in the developing countries may be more polluted than some of the urban areas. Major sources of air pollution in rural area are indiscriminate use of insecticides/pesticides sprays and burning of wheat and paddy straw. The major air pollutants include gases like sulphur dioxide, oxides of nitrogen, suspended particulate matter and respirable suspended particute matter. These air pollutants in the atmosphere have an adverse effect on human life and are contributed by various sources. The direct effect of air pollutants on plants, animals and soil can influence the structure and function of ecosystems, including self regulation ability, thereby affecting the quality of life (WHO 1987). So, it needs to monitor the ambient air quality of urban residential areas of Jhansi City and adjoining rural residential areas of Jhansi City.

MATERIALS & METHODS

Jhansi is one of the important districts of Bundelkhand region which is occupies almost 70,000 km^2 of the central plains in India bounded to the north by the Yamuna River and to the south by the hill of Vindhyan Plateau. Rapidly growing in central India Jhansi district lies between 230 351–261 N and 780-82" E. Climatically Jhansi falls under a semi-arid climate, with two main seasons: monsoon and dry. The monsoon (June-September) brings over 90 % of the annual rainfall. Peak summer (May-June) brings

excessively high temperatures, often exceeding 40^0 C, as the hot dry loo winds sweep in. Indeed, the area is notorious for experiencing droughts in summer. During the winter months (December-February) daytime temperatures are quite pleasant reaching highs between 16.5 and 21^0 C. Air quality in this city is the result of complex interaction between natural and anthropogenic environmental condition (Khoiyangbam, R. S., 2010). For the present study, In urban residential area of Jhansi city, two sites namely Shivaji Nagar and Veerangana Nagar and in rural residential area of adjoining village of Jhansi city, two sites namely Kochha bhavar and Lakara has been selected for ambient air quality monitoring. It was carried out during the month of December-2009 to February-2010. The method for sampling of particulate pollutants is based on the size of the particulates to be sampled (Rao, 1993; senthilnathan, 2003-b). Suspended particulate matter (SPM) and Respirable suspended particulate matter (RSPM) were analyzed using Respirable Dust Sampler (RDS) APM 460 and operated at an average flow rate of 1.0-1.5 m^3 min^{-1}. Pre-weighted glass fibers filter paper (GF/A) of whatman and cup were used as per standard methods. The respirable particulate matter (RSPM) was collected on glass fiber filter paper and suspended particulate matter was collected by gravity settling method. Samples were collected continuously for 48 h every week at 8-hourly intervals. SPM and RSPM were measured using gravimetric method. SO_2 and NO_x were measured with help of RDS APM 460 with gaseous attachment APM 411 by sucking air into appropriate reagent for 48 h every week at 4-hourly intervals and after air monitoring it procured into lab and analysis for the concentration level. SO_2 and NO_x were collected by bubbling the sample in a specific absorbing (Sodium tetrachloromercurate for SO_2 and Sodium hydroxide for NO_x) solution at an average flow rate of 0.2-0.5 min^{-1}. The impinger samples were put in ice boxes immediately after sampling and transferred to a refrigerator until analyzed. The concentration of NO_x was measured with standard method of Modified (Jacob-Hochheiser method, 1958) and SO_2 was measured by modified (West and Geake method, 1956). The instrument was kept at a height of 2 m from the surface of the ground.

Air quality index (AQI):

The air quality index (AQI) is a measure of the ratio of the pollutants concentration to the status of ambient air in places. Indices of air pollutant or air quality have been used for about 25 years (Zlauddin and Siddiqui, 2006; Joshi and Semwal, 2011).

The following computation was used to drive the air quality index of the sites under consideration:

$$AQI = \frac{1}{4} \times (I_{SPM} / S_{SPM} + I_{RSPM} / S_{RSPM} + I_{SO2} / S_{SO2} + I_{NOx} / S_{NOx}) \times 100$$

Where:

I_{SPM}, I_{RSPM}, I_{SO2} and I_{NOX} = Individual values of suspended particulate matter, respirable particulate matter, sulphur dioxide and oxides of nitrogen respectively.

S_{SPM}, S_{RSPM}, S_{SO2} and S_{NOX} = Standards of ambient air quality.

The indices use health based descriptions to provide meaningful information to the public. The five levels of AQI are depicted in Table1.

RESULTS & DISCUSSION

The concentration of the SPM recorded in the study areas ranged between 248.23 to 376.79 µg/m³ (Table 2). Rural residential area has lower values of SPM (250.06 µg/m³) compared to the Urban residential area, that has mean SPM value of 373.48 µg/m³. In urban residential area, pollution sources like diesel powered electric, generator, sugarcane juice stall, telephone tower etc. are more than the rural residential area. The average values of SPM recorded in Shivaji Nagar and Veerangana Nagar was 376.79 and 370.17 µg/m³, respectively. Similarly, the average values of SPM recorded in Kochha Bhavar and Lakara was 251.90 and 248.23 µg/m³, respectively from Figure 1. All these values exceeded the National Ambient Air Quality Standards (NAAQS) prescribed (200 µg/m³) for residential and rural residential by the Central Pollution Control Board (CPCB, 1994), New Delhi from Table 3.

Table 1: Index Values of air quality index calculation

Index Value	Remarks
Between 10-25	Clean air
Between 26-50	Light air pollution
Between 51-75	Moderate air pollution
Between 76-100	Heavy air pollution
Above 100	Severe air pollution

(Source: Rao and Rao, 1989)

Table 2: Concentration of SPM and RSPM in urban residential and rural residential areas

Sampling Area	Sampling sites	SPM		RSPM	
		Average	Range	Average	Range
Urban Residential	Shivaji nagar	376.79	351.45 – 403.56	174.01	152.35 – 194.6
	Veerangana nagar	370.17	345.44 – 394.68	172.53	151.69 – 192.45
Rural Residential	Kochha Bhavar	251.90	230.46 – 261.45	119.56	110.25 – 131.25
	Lakara	248.23	227.85 – 267.89	116.72	105.45 – 129.46

Figure 1: Showing the average concentration of SPM in urban residential areas (Shivaji nagar and Veerangana nagar) and rural residential areas (Kochha bhavar and Lakara)

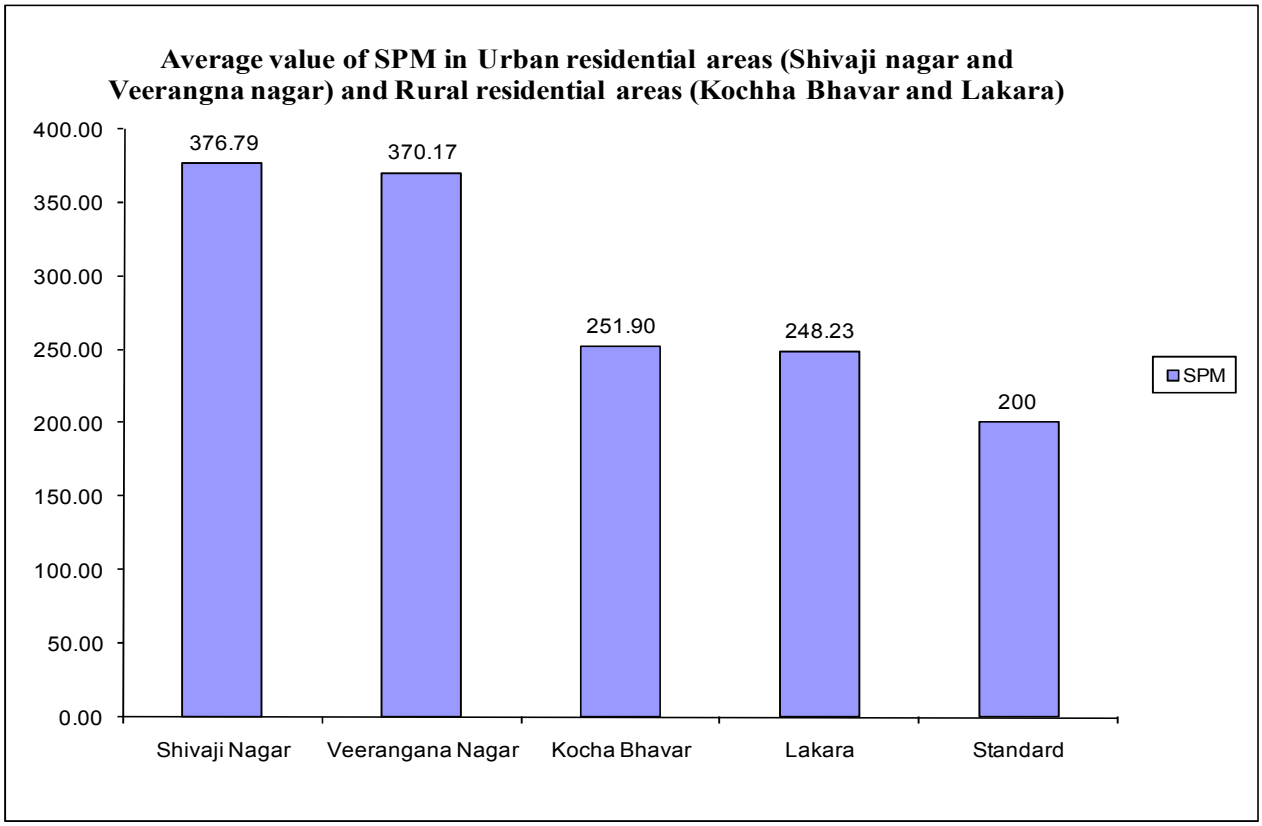


Figure 2: Showing the average concentration of RSPM in urban residential areas (Shivaji nagar and Veerangana nagar) and rural residential areas (Kochha bhavar and Lakara)

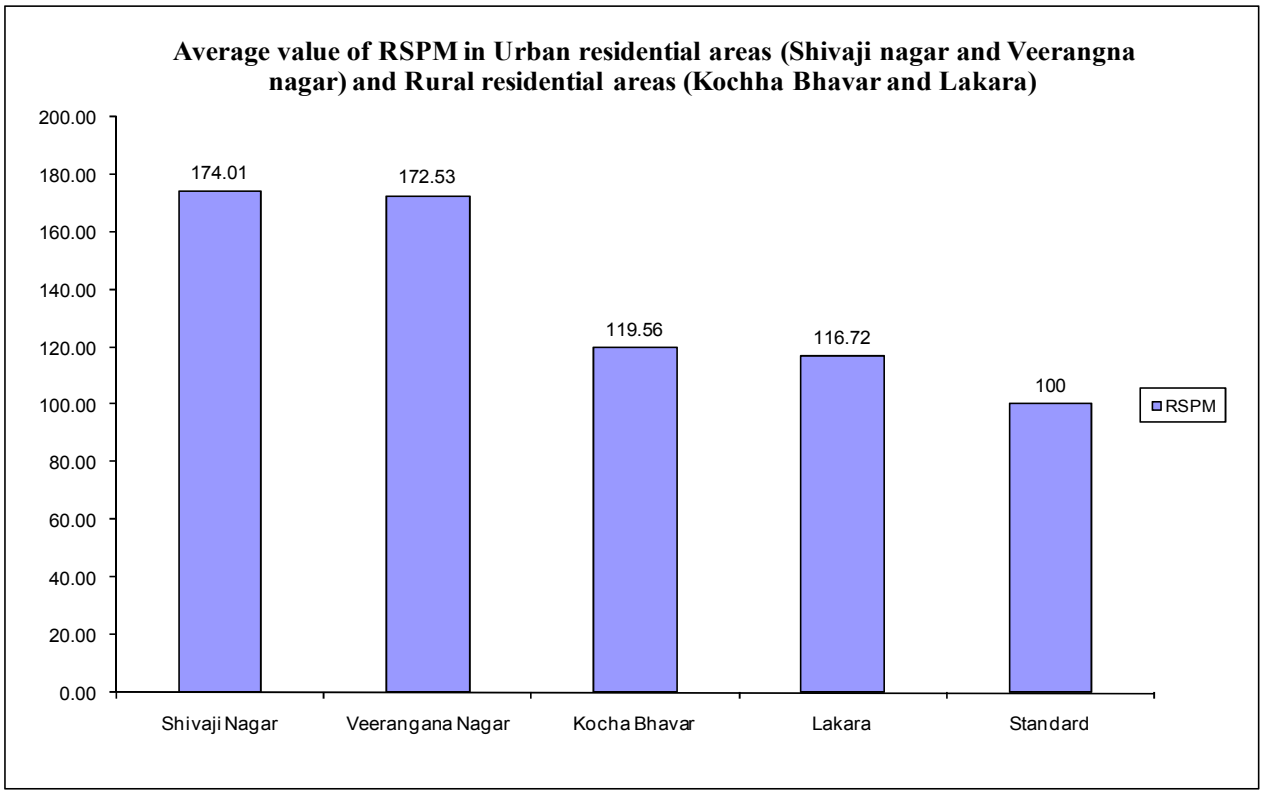


Table 3: National ambient air quality standard of central pollution Control board (CPCB, 1994)

Pollutant	Time Weighted average	Concentration in ambient air			Method of measurement
		Industrial Area	Residential. Rural & other areas,	Sensitive Area	
Sulphur Dioxide (SO2)	Annual Average*	80 mg/m³	60mg/m ³	15 µg/m³	Improved West and Gacke method
	24 hours **	120 µg/m³	80 µg/m³	30µg/m³	Ultraviolet fluorescence
Oxides of Nitrogen as NO2	Annual Average*	80 mg/m³	60mg/m ³	15 µg/m³	Jacob & Hochheiser modified (Na-Arsenite) Method
	24 hours **	120 µg/m³	80 µg/m³	30µg/m³	Gas Phase Chemiluminescence
Suspended Particulate Matter (SPM)	Annual Average*	360 µg/m³	140 µg/m³	70 µg/m³	(Average flow rate not less than 1.1 m ³/minute) Gravemetric Method
	24 hours **	500 µg/m³	200 µg/m³	100 µg/m³	
Respirable Particulate matter (size less than10 um)(RPM)	Annual Average*	120 µg/m³	60 µg/m³	50 µg/m³	
	24 hours **	150mg/m³	100 µg/m³	75 µg/m³	

During the same period of sampling, concentration of the RSPM recorded in the sampling stations ranged between 116.72 to 174.01 µg/m³ (Table 2). Urban residential area found more polluted (173.27 µg/m³) with RSPM compared to the rural residential area (118.14 µg/m³). The values of RSPM in both the residential areas exceeded the NAAQS (100 µg/m³). The average values of RSPM recorded in Shivaji Nagar and Veerangana Nagar was 174.01 and 172.53 µg/m³, respectively. Similarly, the average values of RSPM recorded in Kochha Bhavar and Lakara was 119.56 and 116.72 µg/m³, respectively (Figure 2). All these values exceeded the National Ambient Air Quality Standards prescribed for residential areas by the Central Pollution Control Board (CPCB). The concentration of the SO_2 recorded in the study areas ranged between 13.08 to 18.54 µg/m³ (Table 4). The value of SO_2 in both the residential areas was within the values prescribed (80 µg/m³) by the National Ambient Air Quality Standards for residential areas by the Central Pollution Control Board (CPCB). Urban residential area has higher values of SO_2 (18.54 µg/m³) compared to the Urban residential area, that has mean SO_2 value of 13.12 µg/m³. In urban residential area, pollution sources like diesel powered electric, generator, sugarcane juice stall, telephone tower etc. are more than the rural residential area. The average values of SO_2 recorded in Shivaji Nagar and Veerangana Nagar was 18.54 and 18.54 µg/m³, respectively. Similarly, the average values of SO_2 recorded in Kochha Bhavar and Lakara was 13.15 and 13.08 µg/m³, respectively (Figure 3). All these values was within the National Ambient Air Quality Standards (NAAQS) prescribed (80 µg/m³) for residential and rural residential by the Central Pollution Control Board (CPCB), New Delhi. oxidation of SO_2, usually in the presence of a catalyst such as NO_2, forms $H2SO_4$, and thus acid rain (WHO, 2005). Similarly, the concentration of the NO_x recorded in the study areas ranged between 28.15 to 34.16 µg/m³ (Table 4). The value of NO_x in both the residential areas was within the values prescribed (80 µg/m³) by the National Ambient Air Quality Standards for residential areas by the Central Pollution Control Board (CPCB) (CPCB, 1994). Urban residential area has higher values of NO_x (34.12 µg/m³) compared to the Urban residential area, that has mean NO_x value of 28.19 µg/m³. The average values of NO_x recorded in Shivaji Nagar and Veerangana Nagar was 34.16 and 34.07 µg/m³, respectively. Similarly, the average values of NO_x recorded in Kochha Bhavar and Lakara was 28.15 and 28.23 µg/m³, respectively (Figure-4). All these values was within the National Ambient Air Quality Standards (NAAQS) prescribed (80 µg/m³) for residential and rural residential by the Central Pollution Control Board (CPCB), New Delhi. In a process parallel to that of sulfur dioxide production during fuel combustion, nitrogen in fuels is converted to oxides of nitrogen in the combustion process (WHO, 2010).

Table 4- Concentration of SO_2 and NO_x in urban residential and rural residential areas

Sampling Area	Sampling sites	SO_2		NO_x	
		Average	Range	Average	Range
Urban Residential Area	Shivaji nagar	18.54	9.67 – 22.76	34.16	23.00 – 39.65
	Veerangana nagar	18.54	9.44 – 22.69	34.07	22.00 – 39.46
Rural Residential Area	Kochha Bhavar	13.15	8.65 – 16.46	28.15	19.00 – 35.00
	Lakara	13.08	8.46 – 16.35	28.23	19.45 – 35.62

Figure 3: Showing the average concentration of SO_2 in urban residential areas (Shivaji nagar and Veerangana nagar) and rural residential areas (Kochha bhavar and Lakara)

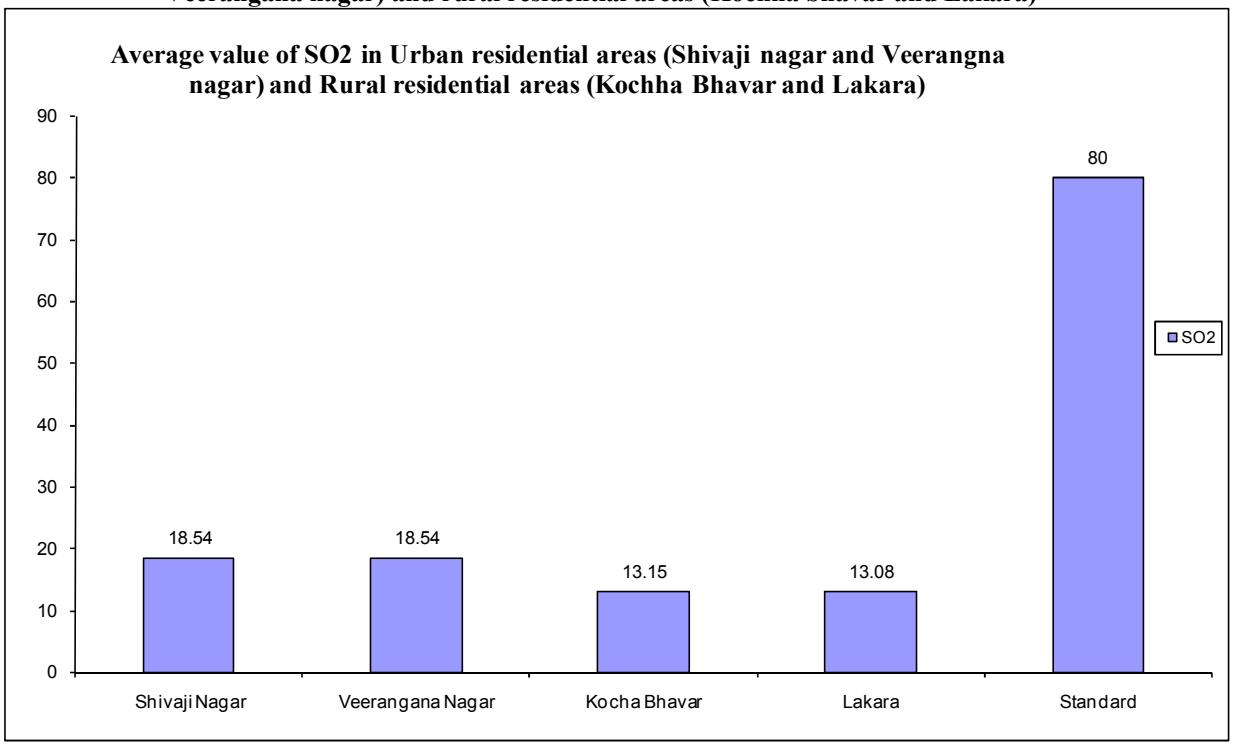
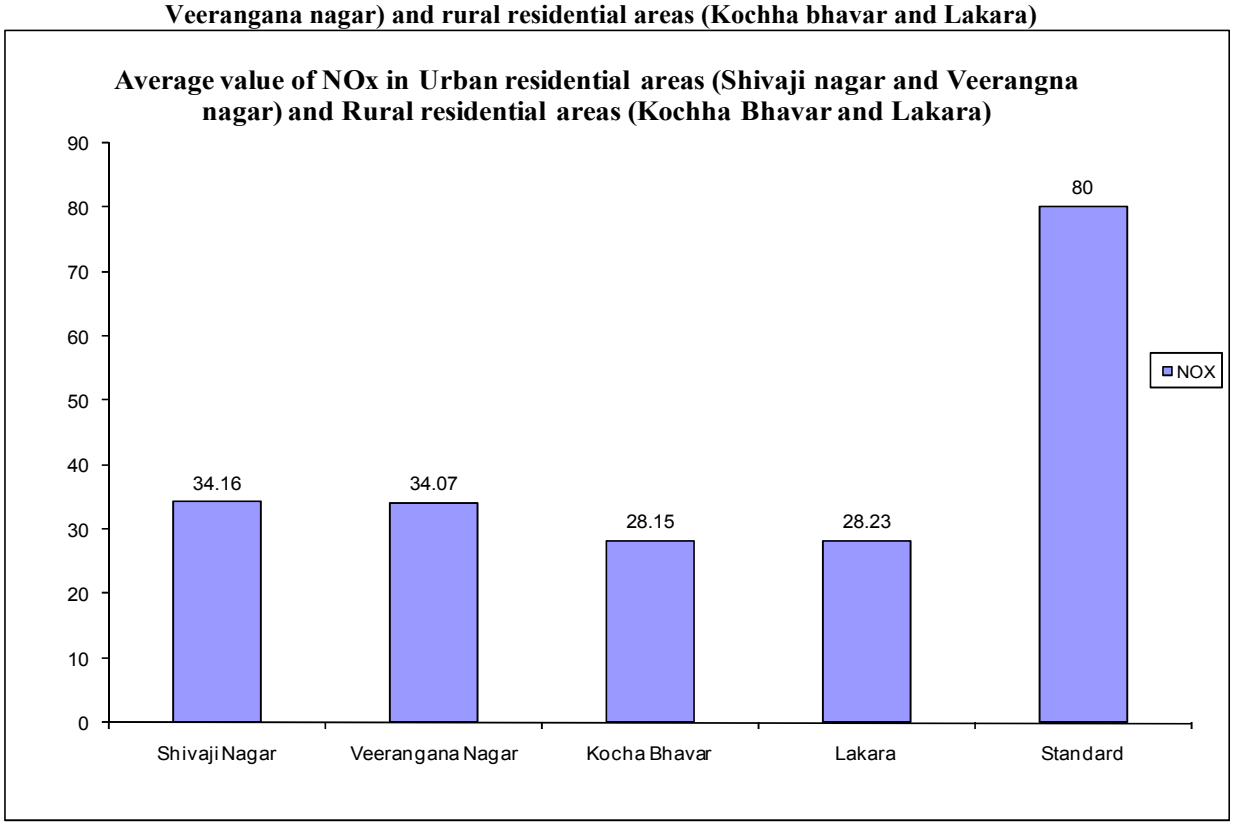


Figure 4: Showing the average concentration of NO_x in urban residential areas (Shivaji nagar and Veerangana nagar) and rural residential areas (Kochha bhavar and Lakara)



Air Quality Index (AQI)

The categorization of ambient air quality with respect to the AQI is presented in Table 2. The average AQI value of urban residential areas was found higher than the rural residential areas (Table 5). On the basis of AQI, it can be seen that the urban residential area viz. Shivaji nagar and Veerangana Nagar were heavily polluted (AQI 100-125) whereas the rural residential area viz. Kochha Bhavar and Lakara were moderately polluted (AQI 50-75). In order to protect human health, property and environment from the adverse effects of air pollution, the National ambient air quality standards have been set by the central pollution control board. At all the monitoring sites, SPM and RSPM concentrations exceeded the permissible limits specified by CPCB while SO2 and NOX were within the standard specified by CPCB.

Table 5- AQI at Urban residential area and rural residential area

Sampling Area	Sampling sites	SPM	RSPM	SO_2	NO_x	AQI	Ambient air quality
Urban Residential Area	Shivaji Nagar	376.79	152.35	18.54	34.16	101.66	Heavily polluted
	Veerangana Nagar	370.17	172.53	18.54	34.07	105.84	Heavily polluted
Rural Residential Area	Kochha Bhavar	251.90	119.56	13.15	28.15	74.28	Moderately polluted
	Lakara	248.23	116.72	13.08	28.23	73.12	Moderately polluted

Urgent action is required to remediate the pollution problem. The problems associated with air pollution in Jhansi city and adjoining rural areas are mostly due to the large number of privately owned motor vehicles, vehicles of obsolete two stroke technologies, road congestion, poor public transit system, bad maintenance etc. Over the years there has been a dramatic increase in the number of vehicles particularly the two wheelers. Joshi et al., 2006; Chauhan and Joshi, 2010; Chauhan and Pawar, 2010 found that the concentration of gaseous pollutants viz SOx and NOx was under the permissible limits as per CPCB while the concentration of particulate pollutants (SPM and PM10) was higher the permissible limits as per CPCB in Haridwar city.

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