Research Journal of Chemical and Environmental Sciences
Res J. Chem. Environ. Sci. Vol 4 [3] June 2016: 79-87
Online ISSN 2321-1040
CODEN: RJCEA2 [USA]

Website: www.aelsindia.com/rjces.htm

ORIGINAL ARTICLE

Assessment of Ambient Air Quality with Special Reference to NO_x and its Health Impacts on Local Population in Gwalior City, Madhya Pradesh, India

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ABSTRACT
The present study deals with the quantitative effect of vehicular emission on ambient air quality during November 2013 to April 2014 in urban area of Gwalior city. In this study, NO_x was estimated at 4 representative locations (Thatipur, Railway Station, Gola Ka Mandir and Kampoo) in urban areas and its health impacts were assessed. The 24 hr average concentration of NO_x was found to be 20.16 µg/m³ at Thatipur, 21.10 µg/m³ at Railway Station, 22.47µg/m³ at Gola Ka Mandir and 17.47 µg/m³ at Kampoo, respectively. The 24 hr mean of NO_x at each location were found to be lower than prescribed limit of National Ambient Air Quality Standard (NAAQS). These results indicated that ambient air quality in the urban area is affected adversely due to emission and accumulation of NO_x. These pollutants may pose detrimental effect on human health. A health survey was also carried out which demonstrated that symptoms were developed such as eye and skin irritation, coughing, shortness of breath, headache, fatigue, nose and throat irritation etc.
Keywords: *Ambient Air; Air Quality Index, Health Impacts, NO_x Concentration,*

Received 21.03.2016 Accepted 25.05.2016

INTRODUCTION

Air pollution in India has increased rapidly because of intensive population growth, increase in the numbers of vehicles, use of fuels with poor environmental performance, badly mentioned transportation systems, poor land use pattern, industrialization, and above all, ineffective environmental regulations [1]. Urban areas exhibit both the highest level of pollution and largest target of impact on human health. The World Health Organisation estimates that about two million people die prematurely every year as a result of air pollution, while many more suffer from breathing ailments, heart disease, lung infections and even cancer [2]. The two sources of air pollutants ubiquitous in most urban areas are transportation and fuel combustion by stationary sources, including industrial heating [3]. However , motor vehicle emissions, seems to be the dominant source of air pollutants especially in areas with high traffic densities and industrial activities [4]. The worst levels of pollution are seen in such urban cities as are densely populated with a low standard of living [5, 6].

A study in Hong Kong [7] reported NO_2 levels in 11 traffic tunnels in the city. Very high concentrations of NO_2 were found. It is not clear how these levels of NO_2 affect human health since vehicles usually pass theses tunnels in minutes. Emerging air quality issues are primarily associated with road transport with increase in vehicle emissions projected despite proposed national mitigation measures. Although air quality limits for nitrogen dioxide and ozone are infrequently exceeded within cities, increasing trends in concentration are apparent [8, 9]. Volatile organic compound released from fuel filling stations, and nitrogen oxide and hydrocarbon releases from major airports further highlight the air quality implications of transportation infrastructure development.

Sharing the seasonal pattern with several other air pollutants, NO_2 level is usually higher in the winter than in the summer. Many studies showed that NO_2 concentration decreased drastically with increasing distance downwind from traffic [10, 11]. In a Canadian study [10], the authors found that wind and the logarithm of distance from a major highway under study may serve as surrogates for traffic NO_2 exposure, which needed further validation. In this Canadian study, the NO_2 levels ranged from 11.9 to 29.3 ppb. Investigation conducted at schools near Northern California freeways [11] found highest NO_2 levels (24–30 ppb) in schools downwind and close to freeways.

In developing countries, exposure studies on NO_2 usually indicated higher exposure levels than in the developed world.In Tartu, Estonia, ambient level of NO_2 increased by 50% to 100% in several monitoring stations, according to the yearly monitoring data from 1994 to 1999. This increase may have been mainly caused by increasing number of vehicles, poor maintenance of many of these vehicles and narrow streets in the city [12]. In 1998, transport emission accounted for 52% of the total NO_2 emission in the city. Vehicle emissions significantly pollute air and require control [13]. Poor or deteriorating air quality in many cities results from high levels of energy consumption by industry, transport and domestic use [14].
NO_2 is known for its many health risks on the respiratory system of humans. Individuals most sensitive to the emission of NO_2 are those with bronchitis or asthma, infants and children, and the elderly [23]. It causes irritation and airway inflammation of the lungs, increases hospitalization rates, and decreases immunity to respiratory diseases [15]. NO_2 can also cause serious harmful effects on vegetation and the respiratory system of animals. NOx and SO_x are also the two principle precursors for acid rain. Acid rain increases the rate of corrosion of buildings, acidifies water bodies, and decreases visibility [16]. Nitrogen oxides are particularly useful in characterising the chemical aging process of vehicle emissions. During combustion, the nitrogen bound in the fuel is released as a free radical and ultimately reacts with oxygen to form nitrogen dioxide (NO_2) or nitric oxide (NO) [17].
According to current estimates, transportation sources are responsible for about 45 percent of nationwide emissions of the EPA defined pollutants [18]. Highway vehicles, which contribute more than one third of the total nationwide emissions of the six criteria pollutants, are the largest source of transportation related emissions [19]. Emissions of vehicles once present in the atmosphere are pollutants. Pollutants of vehicles are classified into primary and secondary [20, 21] Primary pollutants are simultaneously produced and directly emitted into the atmosphere, such as HC, CO, and NO_x. While, secondary pollutants are formed by physiochemical changes in the atmosphere, such as ozone (O_3) and PAN- peroxyacetyl nitrate- (H_3C-CO-$OONO_2$). Moreover, some vehicles pollutants are both primary and secondary pollutants [22].
The scenario of air pollutants at global is worsening and is becoming a major threat to the health and welfare of people and environment [24-27] that's why this topic of research has been chosen for Gwalior city as it comes under the threatened city for air pollution and data was collected along the four sections of Gwalior city namely Thatipur, Railway Station, Gola Ka Mandir and Kampoo in Madhya Pradesh.

MATERIALS AND METHODS

Study area and sampling

Population of Gwalior is 2,032,036 of which male and female were 1,090,327 and 941,709 respectively. Gwalior is located at 26.22ºN 78.18ºE in northern Madhya Pradesh 300 km (186 miles) from Delhi.
Sampling of the specific sites of the Gwalior city was done for the status examine of ambient air quality. It is very important to know that the various factors related to it and depends on the location of sampling station, size of the site sampling, duration and rate of sampling [28, 29]. The location of sampling station should be in the free atmosphere without interferences from stagnant spaces or from large buildings and so on. It should be located at a minimum height of 1.5 m but not exceeding 15 m from the ground level. Based on sampling criterion, four sampling stations, Thatipur (TP), Railway Station (RWS), Gola Ka Mandir (GKM) and Kampoo (KP) of Gwalior City were selected for present study. The research focused on congested areas of Gwalior city where heavy vehicular emissions are common. The sampled areas were densely populated and observed both in day and night. Common characteristics of these areas were the presence of heavy flow of transportation where the heavy combustion of fossil fuel from the internal combustion chambers exists. In these study areas, concentration of pollutant nitrogen oxide in the atmosphere was high. In this investigation, effects of emission on the health of the people living in the sampled location were assessed.

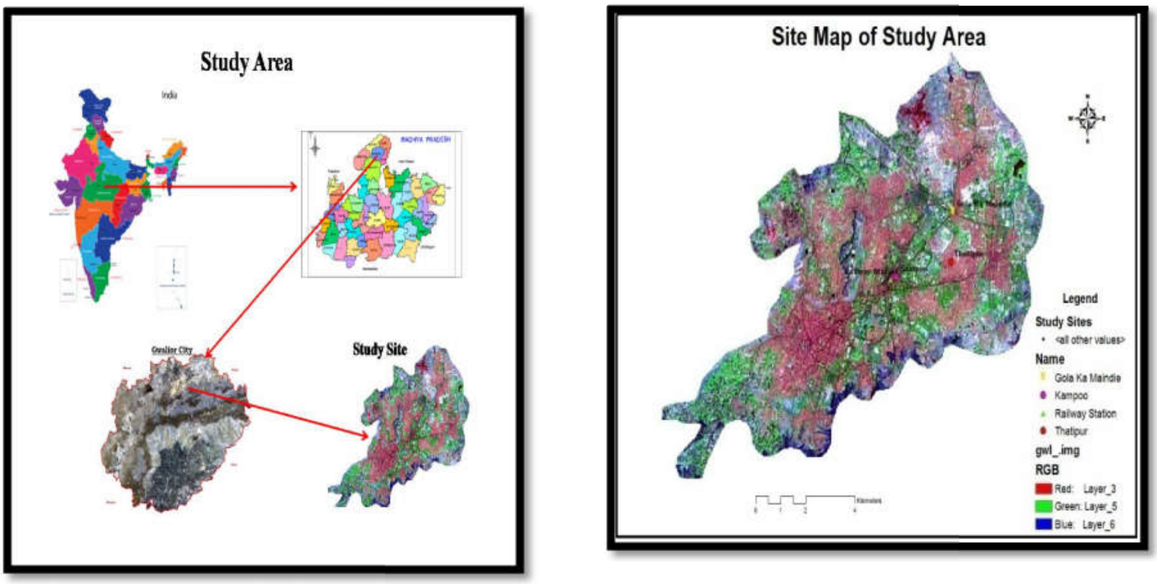

Figure 1: The map of monitoring stations

Questionnaires survey

For determining the health effects in the selected location, questionnaires were prepared and administered on 100 selected individuals each who live or work in the study areas. The data obtained from the questionnaires were analyzed based on the information obtained from them. The questionnaire also sampled people's opinions on what they think should be done to reduce these harmful exhausts.

The sites for questionnaire distribution were selected on the basis, that the area should be located within 1 km radius of the air quality monitoring stations, so that health data of the residents could be analyzed vis-a-vis air quality and also it should represent every section of the people with comparable representations of residents from low, medium and high socio-economic status.

Experimental

The air sampling was carried out in accordance with the standards prescribed by the Bureau of Indian Standards (BIS) (1969, 1975) – BIS 5182, Part II and Part IV, by using high volume air sampler (Envirotech APM 415 and 411) and handy air sampler. The nitrogen dioxide (NO_2) concentrations were determined at the flow rate of above 1 L/min but not more than 2.2 L/min through "Modified Jacobe and Hoshheiser" method (Jacob et.al.,1958). A 30 mL of absorbing solution for high volume sampler and 10 mL absorbing solution for handy air sampler was placed in an impinger and sampled for about 24 hours at an interval of four hours. After sampling the volume of the sample was measured and transferred to a sample storage bottle. A shipping container (Ice box with eutectic cold packs instead of ice) with maintained temperature of 5 ± 5°C was used for transporting the sample from the collection site to the analytical laboratory. Nitrogen oxides (NO_x) as nitrogen dioxide (NO_2) were absorbed in absorbing solution, sodium hydroxide which formed a stable solution of sodium nitrite. The nitrite ion so produced, was determined colorimetrically at wavelength 540 nm by reacting the exposed absorbing reagent with phosphoric acid, sulphanilamide and N (1-naphthyl) ethylenediaminedihydrochloride. The concentration of NO_2 was measured with standard method of Modified Jacob-Hochheiser method [30].

RESULTS AND DISCUSSION

In Gwalior the total number of vehicles registered up to 2014 is 330954. Thus there is a great increase of vehicles on the roads of the city. The increase in the number of vehicles on the roads of Gwalior resulted in an increase in the concentration of air pollution in and around the Gwalior city. Figure 2 show the number of vehicles that has been registered upto 2014 in the city.

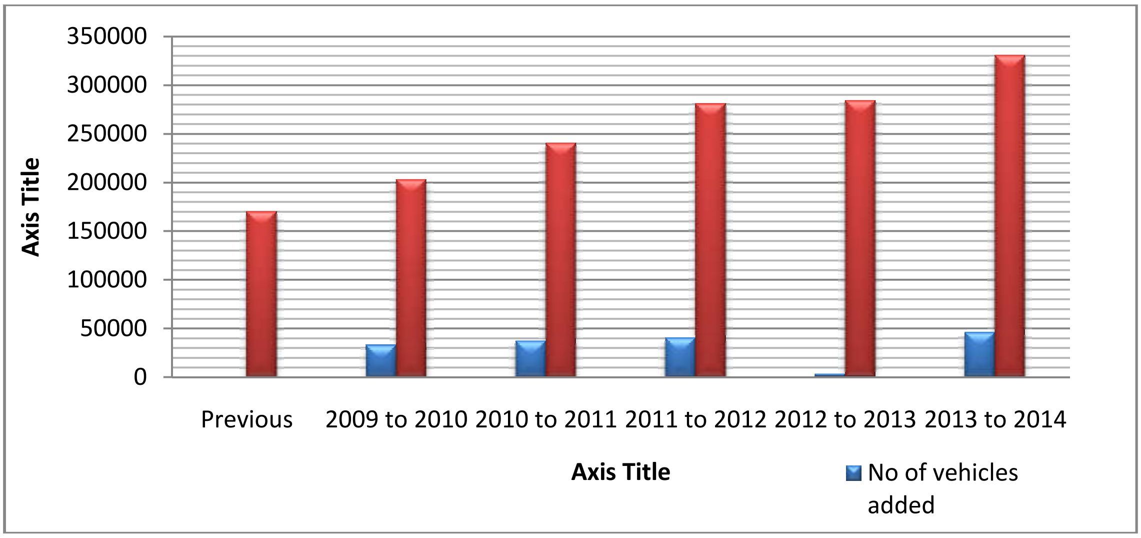

Figure 2: Registered vehicles in Gwalior City

Temperature and its vertical distribution affect the concentration of pollutants through atmospheric stability and by the rate of chemical reaction in the atmosphere. In the present study it has been observed that the months which experienced higher temperatures there was lesser concentrations of NO_x. The months that experienced lower temperatures a reverse trend has been observed in the concentration of NO_x. Monthly minimum, maximum and average temperature from November 2013 to April 2014 (study period) is shown in Figure 3.

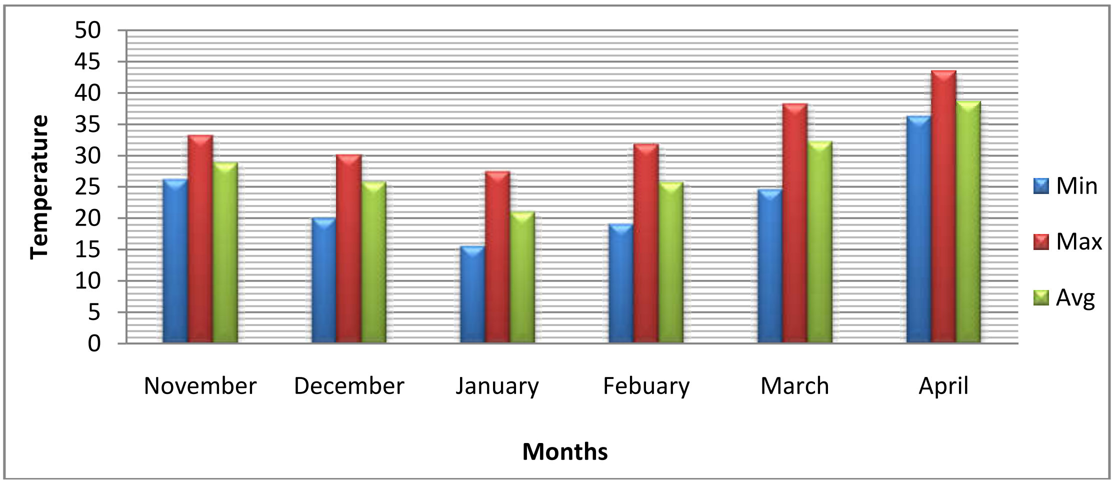

Figure 3: Monthly mean temperatures

After selection of sampling site, monitoring of NO_2,was done. The summarized dataof average concentration of NO_2 at Thatipur, Railway Station, Gola Ka Mandir and Kampoo for the study period have been represented graphically in figure 4. At the Kampoo, the average concentration of NO_2 during these months was 17.47 μg/m^3 with minimum average of 14.2 μg/m^{3}and maximum average of 22.9 μg/m^3. At Thatipur, the average concentration of NO_2 during these months was 20.16 μg/m^3 with minimum average of 17.2 μg/m^{3}and maximum average of 23.1 μg/m^3. At Railway Station, the average concentration of NO_2 was 21.10 μg/m^3 with minimum average of 18.5 μg/m^{3}and maximum average of 24.6 μg/m^3. The average concentration of NO_2 at Gola Ka Mandir during these months was 22.47 μg/m^3 with minimum average of 16.5 μg/m^{3}and maximum average of 25.6 μg/m^3. The concentration of NO_2 has been observed to be always higher in Gola Ka Mandir and Railway Station in comparison to the Thatipur and Kampoo.

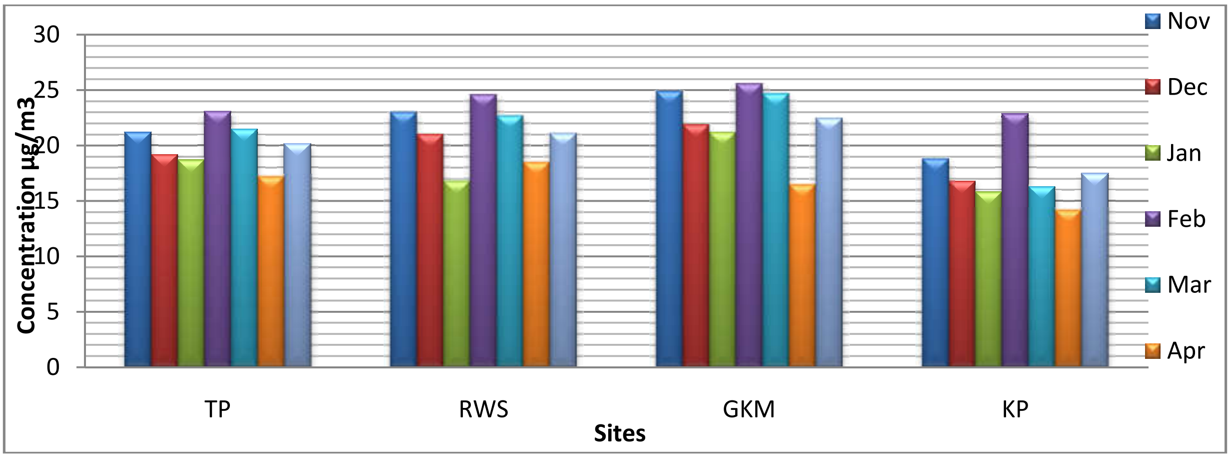

Figure 4: Average concentrations of nitrogen dioxide (NO_x) in ambient air of different locations

From the average data it was concluded that Gola Ka Mandir and Railway Station sampling sites showed higher concentrations of NO_x in all the months as compared to Kampoo and Thatipur sites. The average concentrations of nitrogen dioxide during these months were recorded 21.98±1.30, 19.73±1.13, 18.13±1.19, 25.05±0.65, 21.30±1.80 and 16.60±0.91 µg/m^3 respectively Monthly variation of NO_2 (Figure 5) showed low values during April at all the selected locations. Whereas high values were observed in the months of February.

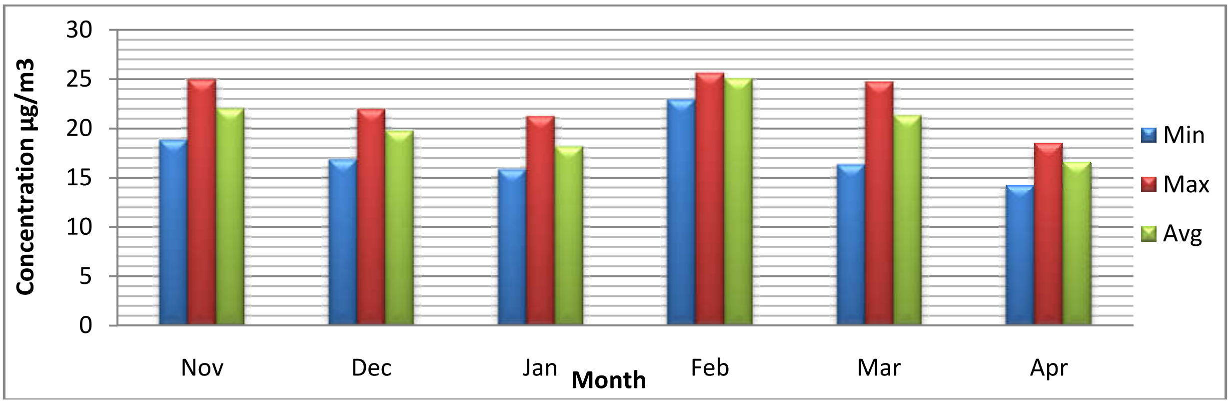

Figure 5: Monthly variations of pollutants

The 24 hour average ambient air concentration of NO_2 was compared with National Ambient Air Quality Standards of Central Pollution Control Board, New Delhi and was found below the permissible limits of NAAQS of CPCB at all the sites. Comparatively somewhat higher concentration of NO_2 was observed during these months as shown in figure 6.

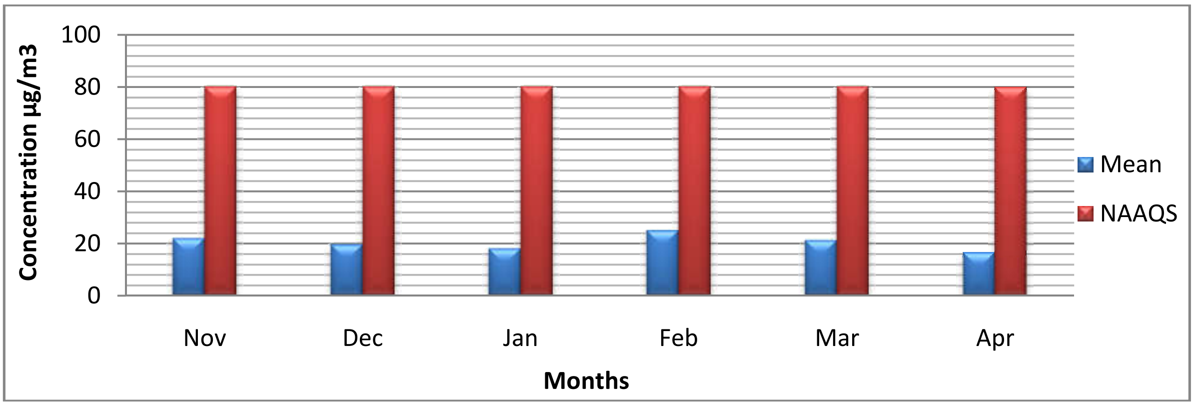

Figure 6: Comparison of NO_2 with respective NAAQS

In the present study, the maximum concentration of NO_2 gas was observed at GolaKaMandir and Railway Station as shown in figure 7. Higher concentration of NO_2 in traffic crossings Railway Station and GolaKaMandir can be attributed to mini-bus stand for passengers, auto-rickshaw stand and parking for four-wheelers in the vicinity. Usage of generators during the frequent power cuts, traffic congestion and slow speed of vehicular traffic due to frequent stopping of public transports to board and de-board the passengers, occurrence of bakery shops and dhabas which uses coal as fuel, narrow and poorly maintained roads, frequent traffic jams and slow speed of the vehicles also contribute for the increase in the concentration of NO_2 which is further aggravated by the presence of high buildings on the sides of the road that often give less scope for the dispersion of air pollutants.

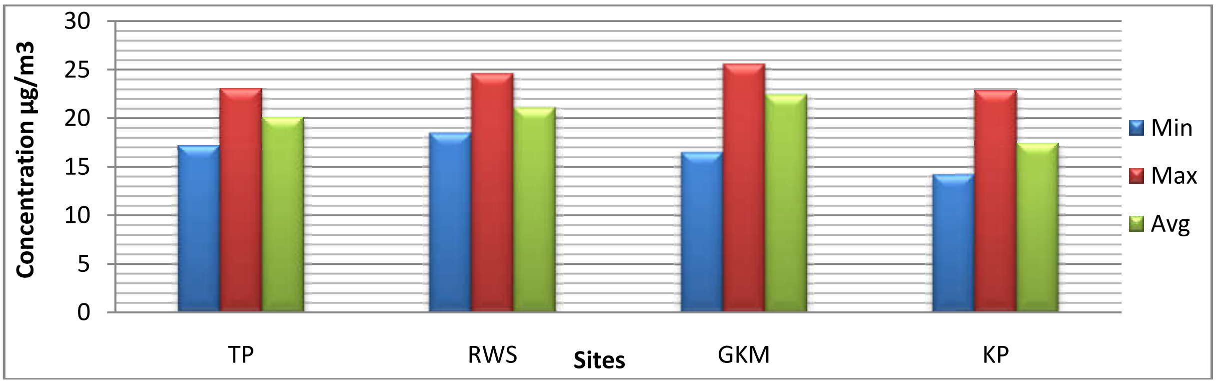

Figure 7: Site wise variation of nitrogen dioxide

In this study, an exposure–response assessment (aged 10 to 60 years) was carried out related to health problems due to vehicular pollution between the months of November-2013 to May-2014 (winter) which demonstrated that symptoms (sneezing, sore throat, shortness of breath, wheezing, chest tightness, skin irritation, nausea etc) were developed.Table1 to 3 shows the details of selected respondents for the survey.

TABLE 1 : The distribution of the respondents in the study area

Respondent	Thatipur		Railway Station		GolaKaMandir		Kampoo		Total
	M	**F**	**M**	**F**	**M**	**F**	**M**	**F**	
Driver (private/personal)	15	4	18	3	21	4	11	1	77
Conductor	11	-	10	-	15	-	7	-	43
Commuter	9	7	12	5	11	5	7	3	59
Traders	17	-	10	-	13	-	5	-	45
Student	15	12	13	10	18	11	12	9	100
Office workers	5	1	3	2	7	1	3	-	22
Market women	-	3	-	1	-	1	-	-	5
Street hawkers	3	-	7	-	4	-	1	-	15
Residents	7	2	3	1	7	5	6	3	34
Total	82	29	76	22	96	27	52	16	400

Key: M: Male, F: Female.

Table 1 shows the distribution of the respondents in the study area. The sites for questionnaire distribution were selected on the basis, that the area should be located within 1 km radius of the air quality monitoring stations, so that health data of the residents could be analyzed vis-a-vis air quality and also it should represent every section of the people with comparable representations of residents from low, medium and high socio-economic status.

The respondents in Thatipur were mainly affected by eye and skin irritation, coughing and shortness of breath. This may be due to the heavy emissions from Tempos that ply from Thatipur to other parts of Gwalior.These vehicles are mainly powered by diesel fuel and in most cases, were not frequently serviced. They operate almost 15 hours a day. Traders in Thatipur showed the highest complaints of fatigue, eye irritation and coughing,shortness of breath, eye and skin irritation and coughing is mainly shown by the tempo drivers and other respondents in Thatipur; this may be due to the fact that these Tempos are overloaded. Since this is a commercial area of Gwalior, there is the possibility of the respondents staying around this area for the greater part of their day.

TABLE 2: Effects of automobile emissions on the respondents at Thatipur, Railway station, Golakamandir, and Kampoo

Number of people affected by							
Respondent	**Eye and skin irritation (T,R,G,K)**	**Coughing (T,R,G,K)**	**Shortness of Breath (T,R,G,K)**	**Headache (T,R,G,K)**	**Fatigue (T,R,G,K)**	**Dizziness (T,R,G,K)**	**Nose and throat irritation (T,R,G,K)**
Driver (private/personal)	(2,4,6,1)	(2,5,5,1)	(1,6,5,0)	(2,4,5,1)	(2,5,4,1)	(1,3,1,0)	(1,7,5,0)
Conductor	(1,3,5,0)	(1,2,3,0)	(1,5,4,0)	(1,2,3,0)	(1,4,5,0)	(0,4,3,1)	(2,5,6,1)
Commuter	(1,3,5,1)	(1,4,6,1)	(2,6,4,0)	(1,1,2,0)	(1,7,6,0)	(2,4,3,1)	(1,5,6,1)
Traders	(3,1,2,0)	(3,2,2,1)	(3,1,2,0)	(1,0,0,1)	(2,0,0,0)	(2,0,0,1)	(2,0,0,0)
Student	(3,3,5,0)	(5,3,3,1)	(3,1,2,2)	(0,1,2,0)	(3,2,2,2)	(2,1,2,0)	(1,0,1,0)
Office workers	(1,2,1,0)	(1,1,3,1)	(2,1,0,1)	(0,1,0,1)	(1,0,2,1)	(1,2,1,1)	(1,0,0,1)
Market women	(3,1,1,0)	(2,1,2,0)	(2,1,0,0)	(1,0,1,0)	(2,0,1,1)	(2,0,1,0)	(1,0,0,0)
Street hawker	(2,1,0,0)	(1,1,1,1)	(1,1,0,1)	(1,0,1,0)	(1,0,2,0)	(2,1,1,1)	(2,0,0,0)
Residents	(0,1,2,0)	(1,0,2,0)	(1,1,1,1)	(2,1,3,0)	(2,2,3,2)	(1,0,1,1)	(1,0,1,1)
Total	(16,19,27,2)	(17,19,27,6)	(16,23,18,5)	(9,10,17,3)	(15,20,25,7)	(13,15,13,6)	(12,17,19,4)

T= Thathipur, R=Railway Station, G= Gola Ka Mandir, K= Kampoo

TABLE 3: The effects of the automobile emissions on the respondents in the study area.

No. of respondents affected					
Complaint	**Thatipur**	**Railway Station**	**Gola Ka Mandir**	**Kampoo**	**Total**
Eye and skin irritation	16	19	27	2	64(16.0%)
Coughing	17	19	27	6	69(17.2%)
Shortness of Breath	16	23	18	5	62(15.5%)
Headache	9	10	17	3	39(9.7%)
Fatigue	15	20	25	7	67(16.7%)
Dizziness	13	15	13	6	47(11.7%)
Nose and throat irritation	12	17	19	4	52(13.0%)

Therefore after assimilating different kinds of emissions for a large number of hours, they suffer mainly from fatigue, coughing, shortness of breath and eye and skin irritation. The percentage of respondents affected by fatigue, dizziness, coughing, headache and shortness of breath was the highest in Railway Station and Gola Ka Mandir. This may be due to the fact that Tempos, Buses, Trucks, Trains and private cars were more common in these areas. The effects of these emissions were noticeable during the day as well as in night on the people [20], because these vehicles fly round the clock. It is observed that majority of the Tempos and buses lying in these areas were not well maintained therefore, the more poisonous coexists from exhaust pipes due to worn rings, leakages from the mufflers, etc. Shortness of breath was very common in these areas. This was due to the fact that the Tempos, buses, trains plying in these areas were usually overloaded which gives no room for more air spaces inside the vehicles in these areas, therefore, there was no more spaces for the rapid diffusion of the emission from the vehicles [20. The health effects in Kampoo were found rear this may be due to the fact that this area was not so congested and the fleet of traffic is found less in this area. The respondents (mainly drivers) were mainly affected by eye and skin irritation, headache and fatigue this may be due to the fact that the spent most of their time with their vehicles which were not well maintained. Figure 8 showed the variation of effects among the respondents.

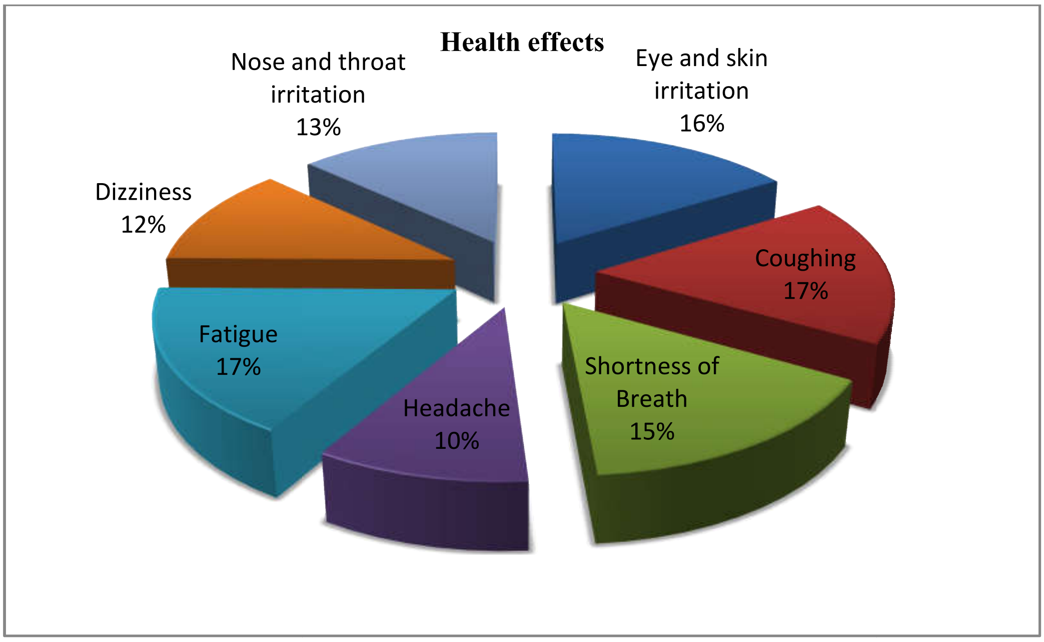

Figure 8: The variation of diseases among the respondents.

CONCLUSIONS

The average ambient air concentration of nitrogen dioxide (NO_2) was found below the permissible limits of NAAQS of CPCB india at all the sites. Comparatively somewhat higher concentration of nitrogen dioxide (NO_2) was observed during these months and it was closely associated with increased health effects. Much is being done to control, monitor and rectify damage done by pollutants. The problems are diverse and some are only being recognized but it is important to keep a close control over pollutants so that we can maintain the environment in an acceptable condition for future generations. We need to take pollution issue seriously because ignorance is certainly not the proper way to go. The stakes are really high and world needs to wake up and start acting right now because environmental issues are constantly growing in both number and size.

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CITE THIS ARTICLE

Harendra K. Sharma, Ishfaq Ahmad Tantry and Nimisha Jadon. Assessment of Ambient Air Quality with Special Reference to NO_x and its Health Impacts on Local Population in Gwalior City, Madhya Pradesh, India. Res. J. Chem. Env. Sci. Vol 4 [3] June 2016. 79-87