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ASSESSMENT OF SO_2 CONCENTRATION IN AMBIENT AIR AND ITS IMPACT ON HUMAN HEALTH IN THE CITY OF GWALIOR, INDIA

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Abstract: Gwalior is a historical and major city in the Indian state of Madhya Pradesh. It is located south of Delhi the capital city of India, and 423 kilometers north of Bhopal, the state capital. Gwalior is being called as The Heart of Incredible India. Gwalior is surrounded by industrial and commercial zones of neighboring districts (Malanpur – Bhind, Banmor – Morena) on all three main directions. Rapid increase in urbanization with vehicle congestion has increased enormously on the roads of Gwalior city. As a result of this, gaseous pollutants (SOx, NOx) and Respirable and suspended particulate matter pollutants are continuously increasing in the ambient air of Gwalior city. Levels of SO_2 were monitored at 4 locations of Gwalior city by using high volume air sampler (Envirotech APM 415 and 411). The average ambient air concentration of SO_2 was found below the permissible limits of NAAQS of CPCB at all the sites. Comparatively somewhat higher concentration of SO_2 was observed during these months. A health survey was also carried out which demonstrated that symptoms were developed such as sneezing, sore throat, shortness of breath, wheezing, chest tightness, skin irritation, nausea etc. 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). The main objectives of this study are to investigate the state of vehicular emission in Gwalior and to investigate the impact of vehicular emission on people.
Keywords: Ambient Air; Gwalior City; Health Impact; SO_2 Concentration.
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INTRODUCTION

Urbanization in India is more rapid around the major cities in India. Population growth has been accelerated in cities due to migration of rural population. Increase in industrial activities, population both endemic and floating and vehicular population etc. has led to a rapid increase in environmental problems, increasing air pollution. The vehicle fleets in our country are old and poorly maintained roads are narrow and the number of two stroke engines, thus increasing the significance of motor vehicles as a pollutants source (Pandey, et.al., 1998; Khioyangbam, 2010). Gaseous pollutants can be classified into organic and inorganic type based on their chemical compositions. The most important oxide emitted by pollution sources is sulphur dioxide. It is a colorless, nonflammable and non-explosive gas (Rao, 1993; Senthilnathan, 2003-a). Sulphur dioxide (SO_2) is formed when fuel containing sulfur is burned. Sulfur is prevalent in raw materials such as crude oil, coal, and ore that contain common metals like aluminum, copper, zinc, lead etc. Air pollution adversely affects human health (U.S. EPA, 2011a; WHO, 2006; COMEAP, 2010). The emission of pollutants into the atmosphere is an inherent by-product of combustion processes. Sulphur dioxide (SO_2) reacts with other gases in the atmosphere to form sulphates that can cause harm to human health. Effects of sulphur dioxide (SO_2) include respiratory illness, visibility impairment, acid rain and aesthetic damage. Sulfur oxides are emitted in significant quantities from thermal power plants, smelting process of sulfide ores to produce copper, lead and zinc and also from petroleum refining processes. The diesel driven vehicles are specific source of sulfur dioxide generated during combustion process. Sulfate particles, can be transported over long distances and deposited far from the sources. Sulphur dioxide (SO_2) can result in respiratory illness, particularly in children and the elderly, and it can also aggravate existing heart and lung diseases.

Human exposure to air pollution is believed to cause severe health effects, especially in urban areas where pollution levels are often high. The classic example is the severe London smog (smoke and fog) episode in 1952 where the mortality rate in the city increased dramatically (Wilkins, 1954). However, health effects may also be significant when they cannot be detected as easily as in connection with such a severe episode. Studies of long-term exposure to air pollution suggest an increased risk of chronic respiratory illness (Schwartz, 1994; Pope et al. 1995; Dockery and Pope, 1994) and of developing various types of cancer (Hemminki and Pershagen 1994; Knox and Gilman, 1997; Nyberg et al., 2000). In an apparently worst case scenario carried out on the WHO data sets, (Kunzll et al., 2000) found that 6% of deaths in Austria, France, and Switzerland might be associated with exposure of the population to particulate air pollution. Many factors influence human health, and a good assessment of human exposure is crucial for a proper determination of possible links between air pollution and health. A discussion on how to carry out assessments of human exposure to air pollution can be found in Hertel et al., 2001). Vehicle emissions significantly pollute air and require control (Karlsson, 2004). With increasing concern for air toxics and climate modification caused by exhaust emissions, the need for tighter control increases in importance. There is therefore a great need for studies involving emission factors and impact. In recent years, there has been considerable research on vehicle emissions and fumes (Bailey, 1995; Lilley 2000; Marshall et al., 2003; Ababio, 2003; Cadle et al., 1997, 2000-2004).

Air pollution is recognized as a major contributor to several respiratory problems. Diseases of the lungs and the airways are often manifested by one or more symptoms that can be easily recognized. Thus, the presence of a particular symptom or a group of symptoms can confirm the presence of an underlying disease in the upper or lower airways. This has been utilized by several epidemiological studies in which the prevalence of respiratory symptoms has been assessed in order to get an insight into the occurrence of a disease in the airways and the lungs. In view of this, prevalence of upper and lower respiratory symptoms among residents of Gwalior City was assessed through questionnaire survey. Questionnaires are the most commonly used subjective instrument of measurement in respiratory epidemiology. They represent a convenient tool of investigating large sample population owing to low cost, easy to use by the investigator, and good compliance of the subjects (Liard and Neukirch, 2000). Data was collected along the four sections of Gwalior city namely Thatipure, Railway Station, Gola Ka Mandir and Kampoo in Madhya Pradesh. Gwalior is a historical and major city in the Indian state of Madhya Pradesh with a population of 2,032,036 of which male and female were 1,090,327 and 941,709 respectively. In 2001 census, Gwalior had a population of 1,632,109 of which males were 883,317 and remaining 748,792 were females. Males constitute 53% of the population and females 47%. Gwalior has an average literacy rate of 76.65%, higher than the national average of 74%, male literacy is 84.70%, and female literacy is 67.38%. In Gwalior, 12.86% of the population is under 6 years of age.

Gwalior is located at 26.22ºN 78.18ºE in northern Madhya Pradesh 300 km (186 miles) from Delhi. It has an average elevation of 197 meters (646 feet). Most part of it comes under Bundelkhand area. Gwalior has a sub-tropical climate with hot summers from late March to early July, the humid monsoon season from late June to early October, and a cool dry winter from early November to late February. Gwalior occupies a strategic location in the Grid region of India, and the city and its fortress have served as the center of several of historic northern Indian kingdoms. It is famous for its fort which has changed hands many times. From the Tomaras in the 8th century, it passed to the Mughals, then the Marathas under the Scindias (1754). Gwalior is surrounded by industrial and commercial zones of neighboring districts (Malanpur – Bhind, Banmor – Morena) on all three main directions. These industries and vehicles spreading harmful exhaust emissions daily into the city and thereby causing pollution.

EXPERIMENTAL

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 (Senthilnathan, 2005a, 2006). 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 this sampling criterion, four sampling stations, Thatipur, Railway Station, Gola Ka Mandir and Kampoo of Gwalior City were selected for present study. Kampoo comes in the residential zone, Thatipure chosen as in the commercial area and Railway Station and Gola Ka Mandir find were in the heavy traffic street. 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). Sulphur dioxide content in the ambient air was measured by the modified West and Gaeke method (West and Gaeke, 1956). The samples of sulfur dioxide (SO_2) were collected in glass impingers using a solution of 0.04M sodium tetrachloromercurate at an average flow rate of 1 liter per minute (LPM), resulting in the formation of dischlorosulphitomercurate complex. The sampling has been carried out for the duration of 24 hours at regular intervals of 4 hours at each site on monthly basis for a period of 5 months i.e. December 2013 to April 2014. 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. The main interference is due to the oxides of nitrogen which can be prevented by adding sulphamic acid, which acts as a reducing agent and converts some of the oxygenated nitrogen species to nitrogen gas. Ozone also acts as an interfering agent which can be eliminated by aging the sample prior to analysis. Trace metals also acts as an interfering agent, interference from trace metals can be prevented by adding EDTA (disodium salt) to the unexposed absorbing solution. For analysis, the exposed sample is treated with sulphamic acid, formaldehyde and acid bleached Pararosaniline containing hydrochloric acid. Pararosaniline, formaldehyde and bisulfite anion react to form violet red colored Pararosaniline methyl sulphonic acid, which was analyzed spectrophotometrically with the help of Systronic UV-VIS Double Beam Spectrophotometer - 2101 (Tripathy and Panigrahi, 2001). The average data have been statistically analyzed.

The research focused on congested areas of Gwalior city where heavy vehicular emissions are common. The sample areas were densely populated. They were observed both in the day and night. A common characteristic of these areas is the presence of heavy flow of transportation where the heavy combustion of fossil fuel from the internal combustion chambers exists. The sample areas are Thatipur, Railway

Station, Gola Ka Mandir and Kampoo of Gwalior City. In these study areas, concentration of pollutant sulphur oxide in the atmosphere is high. In this investigation, effects of emission on the health of the people living in the sampled location were assessed. In determining the health effects in the samples location, questionnaires were prepared and administered on 100 selected individuals each who live or work in the study areas. A total of 400 questionnaires were distributed. 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.

RESULTS AND DISCUSSION

Levels of Sulphur dioxide (SO_2) from ambient air of Gwalior City has been monitored from December 2013 to April 2014 using high volume air sampler (Envirotech APM 415 and 411). Sulphur dioxide content in the ambient air was measured by the modified West and Gaeke method (West and Gaeke, 1956). Table 1 shows the National Ambient Air Quality Standards (NAAQS) for Sulphur dioxide (SO_2). The summarized data of average concentration of sulphur dioxide (SO_2) of commercial area (Thatipur), heavy traffic streets (Railway station and Gola ka Mandir) and residential area (Kampoo) have been depicted in Table 2.

Table 1. The National Ambient Air Quality Standards (NAAQS)

Pollutant	Time Weighted average	Concentration in ambient air			Method of measurement
		Industrial Area	Residential Rural & others	Sensitive Area	
Sulphur Dioxide (SO_2)	Annual Average*	80 µg/m³	60 µg/m³	15 µg/m³	Improved West and Geake method
	24 hours**	120 µg/m³	80 µg/m³	30µg/m³	

* Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.

** 24 hourly or 8 hourly or 1 hourly monitored values, as applicable, shall be compiled with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

Table 2. Average concentration (µg/m³) of Sulphur dioxide (SO_2) at different locations of Gwalior City

Location		Thatipur	Railway Station	Gola Ka Mandir	Kampoo	Mean	Standard Deviation
Type of Area		Commercial	Heavy Traffic Street	Heavy Traffic Street	Residential		
Dece-mber	Min	7.2	7.6	8.4	6.0	14.025	± 1.362
	Max	20.0	20.8	21.6	17.6		
	24 hours Average	13.9	14.6	15.4	12.2		
Janua=	Min	8.0	8.0	8.8	6.4	14.150	± 1.279

ry	Max	21.2	21.6	21.2	18.4		
	24 hours Average	14.0	15.0	15.2	12.4		
Febru-ary	Min	7.2	8.8	9.2	6.4	14.700	± 1.421
	Max	22.0	23.2	22.0	18.8		
	24 hours Average	14.2	15.3	16.3	13.0		
March	Min	6.4	7.2	7.6	4.8	13.050	± 1.399
	Max	20.0	20.4	20.4	17.2		
	24 hours Average	12.8	13.8	14.4	11.2		
April	Min	5.6	6.4	7.6	4.4	12.175	± 1.605
	Max	18.4	19.2	19.2	17.2		
	24 hours Average	11.6	13.1	13.8	10.2		
Mean		13.300	14.360	15.020	11.800		
Standard Deviation		± 1.095	± 0.092	± 0.960	± 1.105		

The average concentration of sulphur dioxide during these months was recorded 14.025, 14.150, 14.700, 13.050 and 12.175 µg/m³ respectively is given in Table 2 and graphically represented in figure 1 and 2.

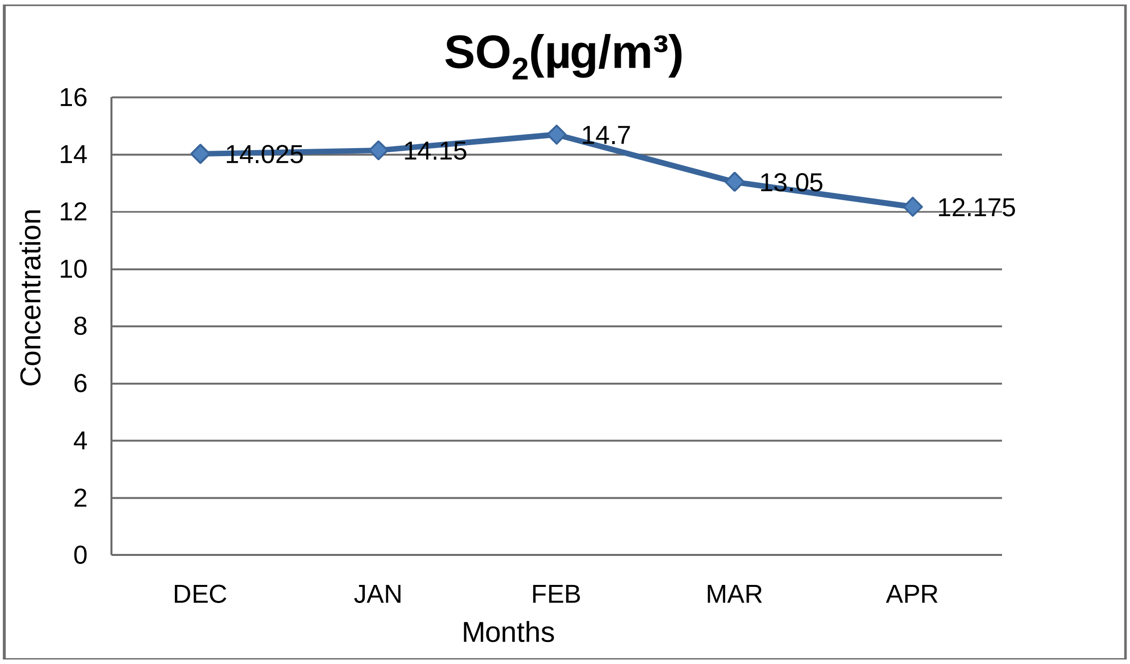
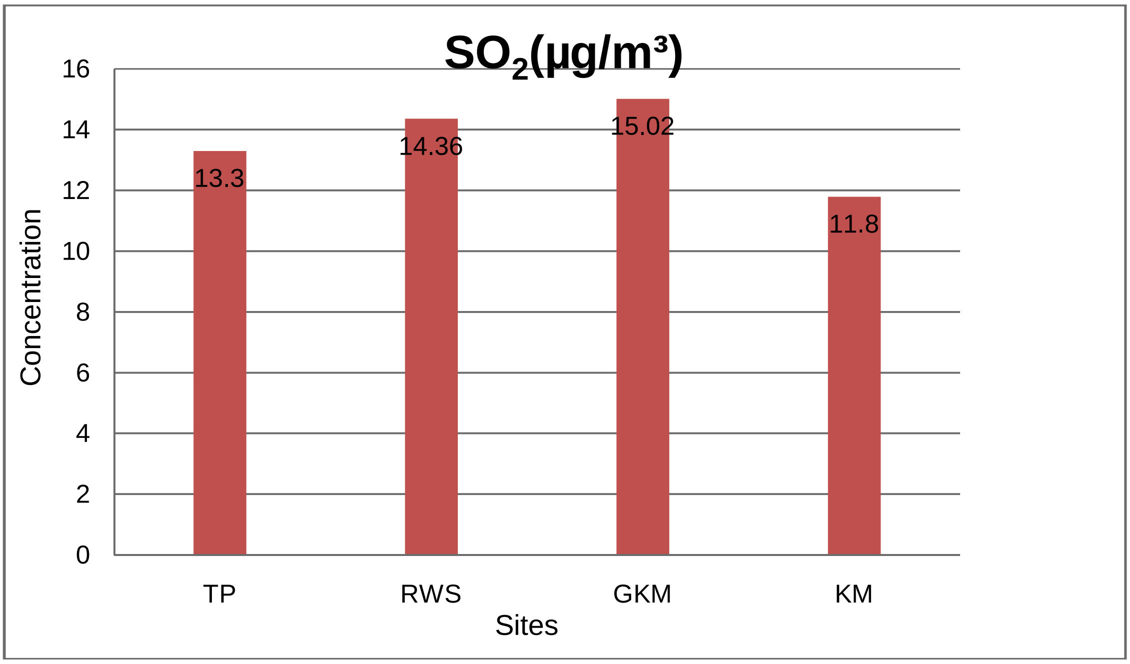


Figure 1. Monthly variation of SO_2 (µg/m³) for the City of Gwalior



Key: TP-Thatipur, RWS-Railway Station, GKM-Gola Ka Mandir, KM-Kampoo.

Figure 2. Site wise variation of SO_2 (µg/m³) for the City of Gwalior

Table 3. Effects of automobile emissions on the respondents at Thatipur, Railway Station, Gola Ka Mandir, and Kampoo

	Number of people affected by:						
Respondent	**Sneezing (T,R,G,K)**	**Sore Throat (T,R,G,K)**	**Shortness of Breath (T,R,G,K)**	**Wheezing (T,R,G,K)**	**Chest Tightness (T,R,G,K)**	**Skin irritation (T,R,G,K)**	**Nausea (T,R,G,K)**
Driver (private/personal)	(2,7,8,2)	(2,8,5,1)	(1,6,5,0)	(1,1,1,0)	(1,4,3,1)	(1,6,3,2)	(1,7,5,0)
Conductor	(0,4,7,1)	(1,3,4,1)	(1,5,4,0)	(1,0,1,0)	(1,4,5,0)	(2,4,5,2)	(2,5,6,1)
Commuter	(1,4,4,1)	(1,5,4,1)	(2,6,4,0)	(1,0,0,0)	(1,7,6,0)	(1,2,2,1)	(1,5,6,1)
Traders	(4,3,3,0)	(3,4,2,1)	(3,1,2,0)	(1,0,0,1)	(1,0,0,0)	(2,0,0,1)	(2,0,0,0)
Student	(4,6,6,1)	(3,5,3,0)	(3,1,2,2)	(0,0,0,0)	(3,1,1,2)	(2,1,2,1)	(1,0,1,0)
Office workers	(2,1,2,0)	(1,1,3,1)	(2,1,0,1)	(0,0,0,1)	(1,0,2,1)	(1,0,0,1)	(1,0,0,1)
Market women	(3,1,1,0)	(1,2,2,1)	(2,1,0,0)	(0,0,1,0)	(2,0,1,1)	(2,0,1,0)	(1,0,0,0)
Street hawkers	(1,2,1,0)	(1,1,1,1)	(1,1,0,1)	(0,0,0,0)	(1,0,2,0)	(2,1,1,1)	(2,0,0,0)
Residents	(1,1,1,1)	(1,0,2,1)	(1,1,1,1)	(0,0,1,0)	(2,0,1,2)	(2,0,1,1)	(1,0,1,1)
Total	(18,29,34,6)	(14,29,26,8)	(16,23,18,5)	(4,1,4,2)	(13,16,21,7)	(15,14,15,10)	(12,17,19,4)

Key: T-Thatipur, R-Railway Station, G-Gola Ka Mandir, K-Kampoo

Table 4. Distribution of the respondents in the study areas

Respondent	**Thatipur**		**Railway Station**		**Gola Ka Mandir**		**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 5. Effects of the automobile emission on the respondents in the study area

No. of respondents affected					
Complaint	**Thatipur**	**Railway Station**	**Gola Ka Mandir**	**Kampoo**	**Total**
Sneezing	18	29	34	6	87(21.7%)
Sore Throat	14	29	26	8	77(19.2%)
Shortness of Breath	16	23	18	5	62(15.5%)
Wheezing	4	1	4	2	11(2.7%)
Chest Tightness	13	16	21	7	57(14.2%)
Skin irritation	15	14	15	10	54(13.5%)
Nausea	12	17	19	4	52(13.0%)

Average concentration of sulphur dioxide (SO_2) at residential area Kampoo was found 11.800 µg/m³ which is less as compared to other sites and also the health effects are rear in this area this may be due to the fact that this area is not so congested and the fleet of traffic is found less in this area. At commercial area Thatipur average concentration of sulphur dioxide (SO_2) was found 13.300 µg/m³ which is lower that of Railway Station and Gola Ka Mandir and higher than Kampoo may be due to the fact that this area is highly congested as compared to other sites because it is the commercial area of Gwalior and also traffic is found less as compared to Railway Station and Gola Ka Mandir but higher that of Kampoo. Similarly average concentration of sulphur dioxide (SO_2) at heavy traffic streets along Railway Station and Gola Ka Mandir were found 14.360 and 15.020 µg/m³ respectively, Railway Station and Gola Ka Mandir showed the highest concentration of sulphur dioxide (SO_2) as compared to other sites may be due to the fact that these locations are highly congested and the heavy fleet of traffic is found in these areas. The average ambient air concentration of sulphur dioxide (SO_2) was found below the permissible limits of NAAQS of CPCB at all the sites. Comparatively somewhat higher concentration of sulphur dioxide (SO_2) was observed during these months. Figure 1 and 2 shows the monthly and site wise variation for the concentration of sulphur dioxide (SO_2) in Gwalior City. 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. Table 3 and 4 shows the details of selected respondents for the survey. Table 5 shows the results of the responses from the questionnaires administered on the respondents.

The respondents in Thatipur were mainly affected by sneezing and skin irritation. 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, are not frequently serviced. They operate almost 15 hours a day. Wheezing is rare in all areas, but traders in Thatipure showed the highest complaints. Shortness of breath and skin irritation is mainly shown by the tempo drivers and other respondents in Thatipure; 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. Therefore after assimilating different kinds of emissions for a large number of hours, they suffer mainly from sneezing, shortness of breath and skin irritation. The percentage of respondents affected by sneezing, sore throat 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 privet cars are more common in these areas. The effects of these emissions are noticeable during the day as well as in night on the people, because these vehicles ply round the clock. It is observed that majority of the Tempos and buses lying in these areas are not well maintained therefore, the more poisonous coexists from exhaust pipes due to worn rings, leakages from the mufflers, etc. Shortness of breath is very common in these areas. This is due to the fact that the Tempos, buses, trains plying in these areas are usually overloaded which gives no room for more air spaces inside the vehicles in these areas, therefore, there is no more spaces for the rapid diffusion of the emission from the vehicles. The health effects in Kampoo were found rear this may be due to the fact that this area is not so congested and the fleet of traffic is found less in this area. The respondents (mainly drivers) were mainly affected by skin irritation, this may be due to the fact that the spent most of their time with their vehicles which are not well maintained. Figure 3 shows the variation of effects among the respondents.

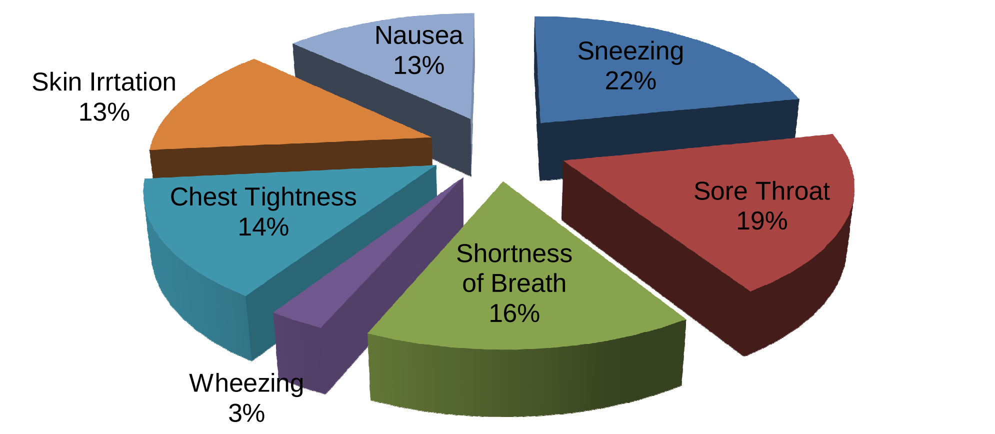


Figure 3. Variation of effects among the respondents

CONCLUSION

The average ambient air concentration of sulphur dioxide (SO_2) was found below the permissible limits of NAAQS of CPCB at all the sites. Comparatively somewhat higher concentration of sulphur dioxide (SO_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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REFERENCES

Ababio, OY. (2003). New school chemistry. African-Feb Publishers Limited, Onitsha, Nigeria, pp. 245-246.

Abbasi, S., Jansson, A., Sellgren, U. and Olofsson, U. (2013). Particle emissions from rail traffic: A literature review. Critical Reviews in Environmental Science and Technology, 43; pp. 2511–2544.

Agrawal R, J. Girija., A. sneh, and Marimuthu P. (2006). Assessing Respiratory Morbidity through Pollution Status and meteorological Condition for Delhi. Air, Water & Soil Pollution, 132; pp. 3-4.

Air quality Status & trends in India, http;//www.whoindia.org/.

Alpopi, C., and Colesca, S.E. (2010). Urban air quality: A comparative study of major European Capitals. Theoritical and Empirical Researches in Urban Management, 6(15); pp. 92-107.

Bailey, PD. (1995). Modeling future vehicle exhaust emission in Europe. Water, Air and Soil Pollution, 85 (4); pp. 1879-1884.

Beecken, J., Mellqvist, J., Salo, K., Ekholm, J., and Jalkanen, J.P. (2014). Airborne emission measurements of SO2 , NOx and particles from individual ships using a sniffer technique, Atmos. Meas. Tech., 7; pp. 1957–1968.

Bert Brunekreef (2007). Health effects of air pollution observed in cohort studies in Europe. Journal of Exposure Science and Environmental Epidemiology, (17); pp. S61-S65.

Bureau of Indian Standard (1969). 5182 Part II, Indian Standard Institute, New Delhi.

Bureau of Indian Standard (1975). 5182 Part VI, Indian Standard Institute, New Delhi.

Cadle SH., Gorse RA Jr., Bailey, BK. and Lawson, DR. (2000). Real-world vehicle emissions: A summary of the ninth coordinating research council on-road vehicle emissions workshop. Journal of the Air and Waste Management Association, 50(2); pp. 278-291.

Cadle, SH., Croes, BE., Minassian, F., Natarajan, M., Tierney, EJ. and Lawson, DR. (2004). Real-world vehicle emissions: A summary of the Thirteenth Coordinating Research Council on-road Vehicle Emissions Workshop. Journal of the Air and Waste Management Association, 54(1); pp. 18-23.

Cadle, SH., Gorse, Jr. RA., Bailey, BK. and Lawson, DR. (2003). Real-world vehicle emissions: A summary of the twelfth Coordinating Research Council on-road vehicle emissions workshop. Journal of the Air and Waste Management Association, 53(2); pp. 152-167.

Cadle, SH., Gorse, RA Jr., Bailey, BK. and Lawson, DR. (2001). Real-world vehicle emissions: A summary of the tenth coordinating research council on-road vehicle emissions workshop. Journal of the Air and Waste Management Association, 51(2); pp. 236-249.

Cadle, SH., Gorse, RJ Jr., Belian, TC. and Lawson, DR. (1997). Real-world vehicle emissions: A summary of the sixth coordinating research council on-road vehicle emission workshop.

Journal of the Air and Waste Management Association, 47(3); pp. 426-438.

Chaursi S., Karwiy A. and Gupta A.D. (2013). Air polution and air quality index of Kinar Gujrat,India inter.J of Enviro. Sc, 25; pp. 62-67.

Chuang, KJ., Chan, CC., Su TC., Lee, CT. and Tang, CS. (2007). The effect of urban air pollution on inflammation, oxidative stress, coagulation, and autonomic dysfunction in young adults. Am J Respir Crit Care Med, 176; pp. 370–376.

COMEAP. (2010). The Mortality Effects of Long-term Exposure to Particulate Air Pollution in the United Kingdom. (A report by the Committee on the Medical Effects of Air Pollutants).

Cooper, O. R. et al., (2010). Nature, 463; pp. 344-348.

Diamond, G. and Parker, M. (2004). Preliminary air quality assessment related to road congestion at Windsor Ambassador Bridge. Ontario: Ministry of Environment.

Dockery, D. W. and Pope, C. A. (1994). Acute respiratory effects of particulate air pollution. Annual Review of Public Health, 1(5); pp. 107–132.

Dubowsky, SD., Suh, H., Schwartz, J., Coull, BA. and Gold, DR. (2006). Diabetes, obesity, and hypertension may enhance associations between air pollution and markers of systemic inflammation. Environ Health Perspect, 114; pp. 992–998.

Francesco Sava and Chris Carlsten (2012). Respiratory Health Effects of Ambient Air Pollution. Clinics in Chest Medicine, 33(4); pp. 759-76.

Gauss, M., Nyiri, A., Semeena, V., Benedictow, A. and Klein, H. (2013), Transboundary air pollution by main pollutants (S, N, O3) and PM in 2011, The Republic of Moldova. MSC-W.

Guidelines for air quality, World health organization publication, Geneva.

Hemminki, K. and Pershagen, G. (1994). Cancer risk of air pollution: Epidemiological evidence. Environmental Health Perspectives, 102(suppl. 4); pp. 187–192.

Hertel, O., Jensen, S. S., Andersen, H. V., Palmgren, F., Wahlin, P., Skov, H., *et al.* (2001). Human exposure to traffic pollution. Experience from Danish studies. Pure and Applied Chemistry, 73(1); pp. 137–145.

Jeremy A. Sarnat., Rachel Golan, et al. (2014). Exposure to traffic pollution, acute inflammation and autonomic response in a panel of car commuters. Environmental Research, 133; pp. 66-76.

Joshi, P.C., Swami, A. and Gangwar, K.K. (2006). Air quality monitoring at two selected traffic junctions in the city of Haridwar. Him. J. Env. Zool, 20(2); pp. 219-221.

Julia, R. Barrett (2013). Small Changes, Big Impact: Exposure to Air Pollution and Reduced Lung Function in Children. Environmental Health Perspectives, 121(11-12); pp. A341-A341.

Just, J. (2011). Impact de pollution sur l’asthme de la petite enfance. Revue Française d'Allergologie, 51(3); pp. 144-147.

Karlsson, HL. (2004). Ammonia, nitrous oxide and hydrogen cyanide emissions from five passenger vehicles. Science of the Total Environment. 334/335; pp. 125-132.

Khoiyangbam, R. S. (2010). Air Quality in School located along the national highway in Jhansi city. Rele. Res. In Scic. and tech, 2(4); pp. 63-68.

Knox, E. G. and Gilman, E. A. (1997). Hazard proximities of childhood cancers in Great Britainfrom1953–1980. Journal of Epidemiology and Community Health, 51; pp. 151 –159.

Kunzli, N. (2014). Effects of near-road and regional air pollution: the challenge of separation. Thorax, 69(6); pp. 503-504.

Kunzll, N., Kalser, R., Medina, S., Studnicka, M., Chanel, O., Filliger, P., *et al.* (2000). Public health impact of outdoor and traffic-related air pollution: A European assessment. The Lancet, 356; pp. 795–801.

Liard, R. and Neukirch, F. (2000). Questionnaires: a major instrument for respiratory epidemiology. Eur Respir Mon, 15; pp.154–166.

Lilley, LC. (2000). A new approach to emissions inventory modeling – Assessing fuel and vehicle impacts on air quality. Advances in Air Pollution, 8; pp. 389-398.

Marshall, JD., Riley, WJ., McKone, TE. and Nazarott, WE. (2003). Intake fraction of primary pollutants: motor vehicle emission in the

South Coast Air Basin. Atmospheric Environment, 37(24); pp. 3455-3468.

Michail Katsoulis, Konstantina Dimakopoulou, Xanthi Pedeli, Dimitrios Trichopoulos, et al. (2014). Long-term exposure to traffic-related air pollution and cardiovascular health in a Greek cohort study. Science of The Total Environment, 490; pp. 934-940.

Molini M. Patel., James W. Quinn., Kyung Hwa Jung., Lori Hoepner., Diurka Diaz., Matthew Perzanowski., Andrew Rundle., Patrick L. Kinney., Frederica P. Perera. and Rachel L. Miller (2011). Traffic density and stationary sources of air pollution associated with wheeze, asthma, and immunoglobulin E from birth to age 5 years among New York City children. Environmental Research, 111(8); pp. 1222-1229.

Nyberg, F., Gustavsson, P., Jarup, L., Bellander, T., Berglind, N., Jakobsson, R., *et al.* (2000). Urban air pollution and lung cancer in Stockholm. Epidemiology, 11(5); pp. 487–495.

Official Website of Gwalior (http://www.gwalior.nic.in/).

Pandey, A. Kumar., Pal, A., Singh, N. and Yunus, M. (1995). Status of ambient air quality in Lucknow city. Indian Journal of Environmental Protection, 19(3); pp. 181-184.

Pope, C. A., Thun, M. J., Namboodiri, M. M., Dockery, D. W., Evans, J. S., Speizer, F. E., *et al.* (1995). Particulate air pollution as a predictor of mortality in a prospective study of us adults. American Journal of Respiratory and Critical Care Medicine, 151; pp. 669–674.

Pope, C. and Arden III. (2004). Air Pollution and Health — Good News and Bad. New England Journal of Medicine, 351(11); pp. 1132-1134.

Pope, CA. and Dockery, DW. (2006). Health effects of fine particulate air pollution: lines that connect. J Air Waste Manag Assoc, 56; pp. 709–742.

Rao, C.S. (1993). Air Pollution, Wiley Eastern, New Delhi.

Rao, MN. and Rao, HVN. (2000). Air Pollution. Tata Mc Graw Hill Publishing company ltd.

Rochelle S. Green., Brian Malig., Gayle C. Windham., Laura Fenster., Bart Ostro. and Shanna Swan (2009). Residential Exposure to Traffic and Spontaneous Abortion. Environmental Health Perspectives 117(12); pp. 1939-1944.

Satellite map of Gwalior Junction and nearby railway stations (http://indiarailinfo.com/station/map/740).

Schwartz, J. (1994). Air pollution and daily mortality: A review and meta analysis. Environmental Research, 64; pp. 36 –52.

Senthilnathan, T. and Rajan, R.D. (2003-a). PM-10 concentration in the ambient air in Chennai city. Journal of the Institute of Engineers (India), 83; pp. 34-35.

Steven M. Lee and Mark W. Frampton (2010). Traffic-Related Urban Air Pollution. In: Occupational and Environmental Lung Diseases. John Wiley & Sons, Ltd, pp. 421-443.

Stockman, J.A. (2006). The Effect of Air Pollution on Lung Development From 10 to 18 Years of Age. Yearbook of Pediatrics, pp. 43-45.

Thomas Gotschi., Joachim Heinrich., Jordi Sunyer. and Nino Kunzli (2008). Long-Term Effects of Ambient Air Pollution on Lung Function. Epidemiology, 19(5); pp. 690-701.

Tripathy, A.K., and Panigrahi, G.P. (2000), Assessment of air pollution due to SPM, SO2, NOx at IRE Ltd., Oscom Environment. Indian Journal of Environmental Protection, 20(12); pp. 901-905.

Tripathy, A.K., and Panigrahi, G.P. (2001). Air quality index and its variation in coastal belt of Ganjam district. Indian Journal of Environmental Protection, 21(3); pp. 206-209.

U.S. EPA. (2011-a). The Benefits and Costs of the Clean Air Act: 1990 to 2020. Final Report of U.S. Environmental Protection Agency Office of Air and Radiation, pp. 5-10.

Under Construction Website of Gwalior city (http://www.gwaliorcity.com/).

Urman, R., McConnell, R., Islam, T., Avol, E. L., Lurmann, F. W., Vora, H., Linn, W. S., Rappaport, E. B., Gilliland, F. D. and Gauderman, W. J. (2014). Associations of children's lung function with ambient air pollution: joint effects of regional and near-roadway pollutants. Thorax, 69(6); pp. 540-547.

West, P. W. and Gaeke, G. C. (1956). Fixation of SOx as a sulfatomecurate (II) and subsequent colorimetric estimation. Analyst Chem, 28; pp. 1816-1819.

Wilkins, E. T. (1954). Air pollution and the London fog of December, 1952. Journal - Royal Sanitary Institute, 74(1); pp. 1–21.

William Rea and Kalpana Patel. (2014). Pediatrics In: Reversibility of Chronic Disease and Hypersensitivity. CRC Press, 2; pp. 555-690.

World Health Organization, (2012). IARC: Diesel engine exhaust carcinogenic, Press Release No. 213, http://www.iarc.fr/en/media–centre/pr/2012/pdfs/pr213_E.pdf, accessed in 2013.

Zhao, W. C., Cheng, J. P., Yu, Z. Y., Tang, Q. L., Cheng, F., Yin, Y. W., Wang W. H. (2013). Levels, seasonal variations, and health risks assessment of ambient air pollutants in the residential areas. International Journal of Environmental Science and Technology, 10(3); pp. 487- 494.

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