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Estimation and Statistical analysis of SO_2 and associated Health risks in Gwalior (India)

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ABSTRACT
The vehicular growth and encroachment may had an important role in environmental pollution of Gwalior. Due to the vehicular emission effects on environment and health is emphasized in Gwalior. In this regards, the use of proper infrastructure and planning should be proposed to predict the pollution level in future. In this regard the study was carried out in Gwalior to access the quality of air with respect to SO_2 and associated health risks. The method used for the determination of SO_2 in the ambient air of Gwalior was (Modified West and Geake method). In this study the Sulphur dioxide from the air stream is absorbed in sodium tetramer curate solution and sampling was done for 8 hours per day and thrice a week. The study, showed the variation in pollution levels during different seasons of a week. Regardless of the season, pollution levels are low during the morning hours, but start increasing during the mid day peak hours till the evening. The average concentration of RSPM during all seasons was observed high, but the data provided the highest concentration during winter and summer. The monsoon months were observed the lowest pollution level. The particles in the air are settled down by the gravity and are removed by the precipitation. Winter was observed as the highest level of particulate pollution because of high humidity and low wind speed. The pollution level was also highest during summer during the peak hours and was also recorded due to temperature inversion.

Key words: SO_2; Air Quality; Chemical methods; Airborne Diseases; Gwalior; India

I. INTRODUCTION

The urban air pollution has increased globally during the last year. According to the World Health Organization (WHO), the increase in the level of pollutants was estimated at around 8% during the year 2008 to 2013. There are about 80% of people who live in urban areas, where the level of pollutants is above the dangerious level. In this regard estimation and monitoring of air pollutants was done and it was observed that the level of pollutants exceed the limits as prescribed by WHO (1). The activities of urbananization and industrializations results in the increase in air pollution which results into serious environmental problem. The quality of air in urban areas is becoming worse due to these activities which causes many both chronic acute problems to human health like heart diseases, lung cancer, asthma, various types of respiratory problems besides affecting the ancient manumants and building materials (2, 3, 4,5). The harmful effects of air pollutants and their associated health risks are studied throught out the world to find out solutions to limit the level of these pollutants (6,7,8) . The various studies conducted in this regard related air pollution to the emission caused by enormous increase in transportation which run on petrol and diesel. The major air pollutants emitted by various anthropogenic activities includes the emissions of dangerous pollutants like oxides of nitrogen and Sulphur, carbon monoxide, volatile organic compounds, and particulate matter which changes the qualitative proportion of air mostly in urban areas (9). In India the major cities that lie close to industries and roadways dominated with traffic, but the level of pollutants varied as it has severely influenced by meteorological factors as well as traffic, size and location of buildings and various land use patterns (10). In this regard it is important to determe exposures of various age groups and major precaution should be taken to limit the exposure of pollutants and their emmision. It is also very impartant to study and understand the causes of these variations prior to the development of interventions and policy recommendation aiming at reduction exposures.

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1.2 Sulphur dioxide

Sulphur dioxide is pungent odour and it is a colorless gas. Naturally sulphur dioxide is produced by volcanoes (67%), manmade sources contributes about 33% of sulphur dioxide pollution, however, which is localized in urban areas. Among manmade sources, fuel combustion i.e., coal combustion is stationary source of SO_2. Industrial and transportation is also responsible for SO_2 pollution.

SO2 absorbs solar radiation in the region of 300 to 400 nm in the lower atmosphere, to produce electronically excited SO2.

SO_2 + hv------------------------->SO_2*

In natural sunlight SO_2 reacts with relative humidity to sulphuric acid (H_2SO_4), which is the main cause of acid rain.

II. STUDY AREA

Gwalior, the city of Madhya Pradesh is know as the heart of india is located 319 kms south of Delhi. The area of Gwalior is approximately 780km2. The population of Gwalior is found to be around 1,901,981 with density 5,478 per km. As per the reports of WHO, the city Gwalior is found to be among the top four cities with adverse air quality. Gwalior has been reported as the most polluted cities in India not Delhi as per the WHO reports. A report of WHO has revealed Gwalior is the most polluted city in India in terms of air pollution. The city Gwalior leaves Delhi behind in the year 2016 which is considered as the most polluted city (11). It has been shown that in India only one city features in the list is Gwalior. For Gwalior the level of PM10 are 329 micrograms/cubic meter and PM2.5 are found to be 176 micrograms/cubic meter. WHO prescribed safe limits PM10 and PM2.5 are 10 micrograms/cubic meter and 20 micrograms/cubic meter respectively. The prescribed limit for the India on the other hand is 20 micrograms/cubic meter and 60 micrograms/cubic meter.

III. MATERIAL AND METHODS

3.1 Measurements methods

The materials and Standard Chemical method has been used for the estimation of air pollutant NO_2 and study of its impact on human health is done. The sampling was carried out in locations of higher risks, depending upon the objective of measurement campaign and was kept at an altitude depending upon the type of study region (road ways, industrial, residual areas, etc.). In this present study air pollutant samples were collected at an interval of 8 hours. For 8 hours sampling 10ml of absorbing solution (stock solution) was taken in imp ringers and flow rate was maintained at 0.5 to 1 liter per minute (11pm). Handy air Sampler (HS-7A) was used to collect SO_2 and estimation has been done spectrophotometrically by Systronic 108 UV visible spectrophotometer. The method used for the determination of SO_2 in the ambient air of Gwalior was West anmd Gaek method (12). Sulphur dioxide from the air stream is absorbed in sodium tetramer curate solution. It forms a stable dichlorosulphitomercurate. The amount of sulphur dioxide is then estimated by the colour produced when p-rosaniline hydrochloride is added to the solution. The colour is estimated than reading from spectrophotometer for which a calibration curve has already been prepared.

3.2 Health Survey and Site Description

The health survey was carried out in hospitals and clinics across the selected three stations taken as residential area (Thatipur), Commercial area (Maharaja Bada), and D.D Nagar lie in the vicinity of Industrial area Malanpur within the city of Gwalior (M.P.) India. The survey was conducted through face-to-face interviews at each stations with patients suffering from various diseases. The admission involving patients with respiratory problems, Asthma and bronchitis was taken to investigate the problems associated with the level of SO_2.

3.3 Statistical analysis

The Pearson correlation is applied to know the degree of association among the variables. The Pearson correlation among all the monitored parameters is calculated by using the following formula

$$r = \sum_{i=1}^{x}(xi - x)(y - \bar{y})/(n - 1)SxSy$$

Where X and Y are two variables, with means X and Y respectively with standard Deviations SX and SY

The Regression analysis was carried. Multiple linear regression analysis was carried out essentially out between various parameters carried out to assess the impact of air Quality on human health by using the formula.

$$\mathbf{Y = a + bX_1 + cX_2 + dX_3 + \epsilon}$$

Where:

Y – Dependent variable

X_1, X_2, and X3 – independent (explanatory) variables

ϵ – residual (error)

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IV. RESULTS AND DISCUSSIONS

4.1 Air Quality Index Calculations at Sampling Stations

The vast amount of data that have been generated through air quality monitoring program is complex for meaningful interpretation of the data and needs extensive statistical analysis as well as computational efforts. Air Quality Index, is a very valuable tool in the interpretation of data. But it may result in loss of some scientific interpretation. In this research the AQIs was been used by various agencies have been adopted is examined (13).

The air quality of the study area was estimated from the air quality index. The air quality index was calculated from the observed seasonal average concentration of SO_2 as per the formula

$AQI=1/4\ (ISO_2/SSO_2) \times 100$

Where:

ISO_2= Individual values SO_2

SSO_2= Standard Values

AQI values are then routed to the corresponding health effects of concerned air pollutants in the study area. It is the numerical rank that reflects the influence of overall air quality parameters that can be helpful in many ways for the awareness of the general public about the health impacts of air pollutants and guide them for systematic planning for future strategies (14).

4.2 Air Quality Index (Observed at Sampling Stations)

The maximum AQI value for SO_2 was observed at deen dayal Nager as (27.48µg/cm^3) followed by Maharaja bada as (26.92µg/cm^3). The minimum value was observed as (26.46µg/cm^3) at Thatipur site. The maximum AQI value for SO_2 was observed in summer as (27.48µg/cm^3) followed by winter as (25.87µg/cm^3). The minimum value was observed as (16.92µg/cm^3) in monsoon. The AQI level was generally observed and the results of the study, it can be concluded that the highest value for AQI was observed in the following descending order for Tahtipur, Mahraja Bada and Deen dayal Nager. The maximum concentration values and AQI were observed during the summer and winter and minimum in monsoon and post-monsoon as per (table 1). For the study the average concentration of gaseous pollutant NO_2 and AQI is found to be "Good" and are categorized good as per National Ambient Air Quality standard as per (table 1).

Table 1: Seasonal concentration level (in µg/cm^3) and air quality index of air Pollutants

S.NO.	Season	Parametres	Thatipur		Maharaja Bada		Deendayal Nagar	
			Avg.	AQI	Avg.	AQI	Avg.	AQI
01	Winter	SO2	19.02	23.7	20.7	25.87	22.24	27.8
02	Summer	SO2	21.17	26.46	21.54	26.92	21.99	27.48
03	Monsoon	SO2	16.92	21.15	17.8	22.25	17.33	21.66
04	P-monsoon	SO2	17.9	22.37	19.6	24.5	17.35	21.68

4.3 Statistical Analysis

To generate a proper data of gaseous pollutant SO_2 concentration critical stations are considered for proper monitoring which combines with large types of anthropogenic activities. The study was done to produce data of SO_2 concentration within the Gwalior city. This study employed the statically analysis, which combines with critical sites and observation data was done at specific sites to provide reliable information for future strategies. In this study, the spatial monitoring and sampling resulting accurate information regarding the level of nitrogen dioxide along with meteorological parameters owing to the combined spatial- temporal variation of nitrogen dioxide along with emission sources to the public awareness. This study was employed and was used to generate the information about the increased trend of SO_2 and its associated risk factor. In addition, although the observation was carried out

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at specific points of densely populated areas and critical sites, the city as a whole is considered to be concentrated as polluted. The specific sites were selected with proper monitoring and sampling was done at 15metre height to analyze the impact of pollution on general public. The variation in the SO_2 along with seasonal estimation was done. Therefore, spatial temporal variation of SO2 was estimated and analyzed to yield more accurate results to provide reliable information. The study was carried out to generate the accurate information and easy access to reduce the level SO_2 at the national level, it is necessary to have the access of accurate information on SO_2 concentrations. This study was done along to provide the high accuracy at measurement stations.

4.3.1 SO_2 and Asthma: SO_2 Show positive correlation with Asthma r= -1.000 with significance 0.00 as per table (1). This is due to the fact that the air quality index of SO_2 is below the danger level as prescribed by NAAQS. The mean value was observed as 1.23E-15 and standard deviation as 0.707 (N=3) as per fig. (2).The standard error of SO_2 and Asthma was observed as.597. The value of t for SO_2 and Asthma was observed as 12.292 and -10.062 with tolerance 1.000 as per table (3). The r-square value for asthma is observed as .993 and (F=151.083 and sig. =.052) as per (table 2)

4.3.2 SO_2 and Bronchitis: SO_2 Show negative correlation with Bronchitis r= -.350 with significance 7.27 as per table (1). This is due to the fact that the air quality index of SO_2 is below the danger level as prescribed by NAAQS. The mean value was observed as 2.58E-15 and standard deviation as 0.707 (N=3) as per fig. (3).The standard error of SO_2 and Bronchitis was observed as .431. The value of t for SO_2 and Bronchitis was observed as 9.091 with tolerance 1.000 as per table (3). The r-square value for Bronchitis is observed as 129.10 and (F=82.637 and sig. =.070) as per (table 8)

4.3.3 SO_2 and Respiratory problems: SO_2 Show negative correlation with Respiratory problems r= -.423 with significance .722 as per table (1). This is due to the fact that the air quality index of SO_2 is below the danger level as prescribed by NAAQS. The mean value was observed as 6.58E-15 and standard deviation as 0.707 (N=3) as per fig. (4).The standard error of SO_2 and Respiratory problems was observed as .133. The value of t for SO_2 and Respiratory problems was observed as 33.016 with tolerance 1.000 as per table (3). The r-square value for Respiratory problems is observed as .999 and (F=1.090E and sig. =.019) as per (table 2).

Table 2: Correlation

		SO_2	**Asthma**	**Bronchitis**	**Respiratory problems**
SO_2	Pearson Correlation	1	-1.000^{**}	-.350	-.423
	Sig. (2-tailed)		.	.772	.722
	N	3	2	3	3
Asthma	Pearson Correlation	-1.000^{**}	1	1.000^{**}	1.000^{**}
	Sig. (2-tailed)	.		.	.
	N	2	2	2	2
Bronchitis	Pearson Correlation	-.350	1.000^{**}	1	.997
	Sig. (2-tailed)	.772	.		.050
	N	3	2	3	3
Respiratory problems	Pearson Correlation	-.423	1.000^{**}	.997	1
	Sig. (2-tailed)	.722	.	.050	
	N	3	2	3	3

Correlation is significant at 0.01 level
Correlation is significant at 0.05 level

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Table 3 ANOVA

	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	453.002	1	453.002	151.083	.052
	Residual	2.998	1	2.998		
	Total	456.000	2			
2	Regression	129.104	1	129.104	82.637	.070
	Residual	1.562	1	1.562		
	Total	130.667	2			
3	Regression	162.518	1	162.518	1.090E3	.019
	Residual	.149	1	.149		
	Total	162.667	2			

Predictors: (Constant), SO2 b. Dependent Variable: 1) Asthma, 2) Bronchitis, 3) Respiratory problems

Table 4 Coefficients

S.NO.	Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	**Std. Error**	**Beta**			**Lower Bound**	**Upper Bound**	**Zero-order**	**Partial**	**Part**	**Tolerance**	**VIF**
1	**(Constant)**	-155.228	15.427		-10.062	.063	-351.250	40.795					
	SO_2	7.337	.597	.997	12.292	.052	-.247	14.922	.997	.997	.997	1.000	1.000
2	**(Constant)**	-84.353	11.136		-7.575	.084	-225.850	57.144					
	SO_2	3.917	.431	.994	9.091	.070	-1.558	9.392	.994	.994	.994	1.000	1.000
3	**(Constant)**	-66.007	3.440		-19.187	.033	-109.718	-22.296					
	SO_2	4.395	.133	1.000	33.016	.019	2.703	6.086	1.000	1.000	1.000	1.000	1.000

a. Dependent Variable:
1) Asthma, 2) Bronchitis, 3) Respiratory problems

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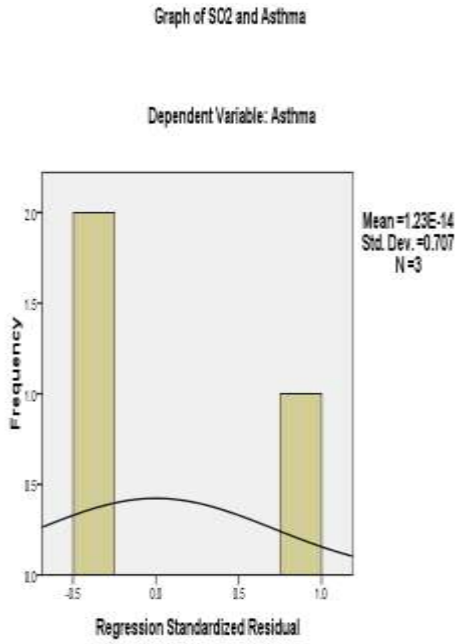

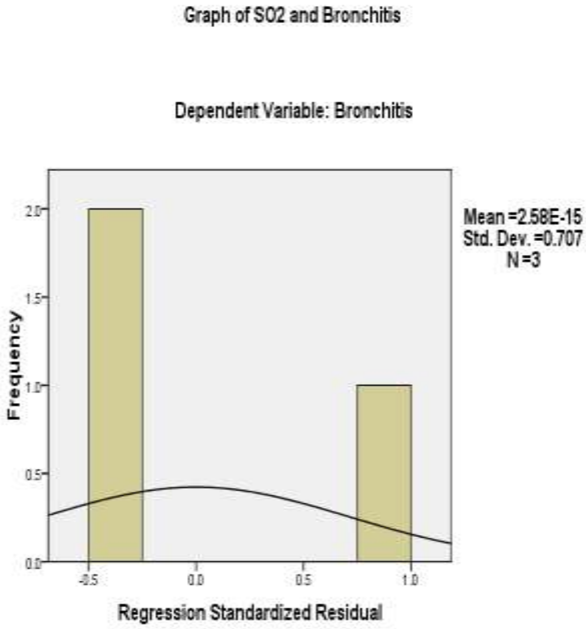

Fig. 2 **Fig. 3**

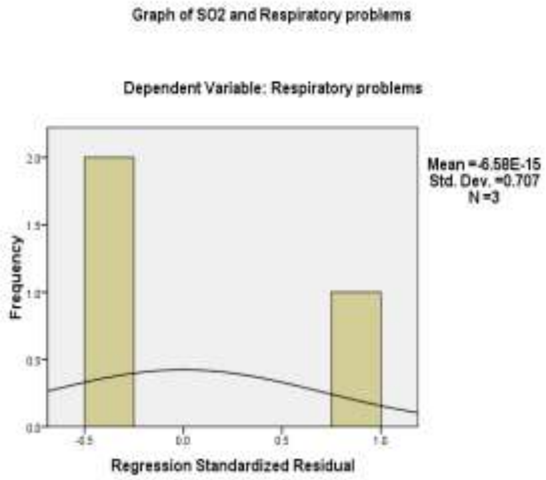

Fig. 4

V. CONCLUSION

In this study it was observed that the level of pollutants was very high in winter and summer as compared to monsoon and post-monsoon periods. It is due to the favorable matereological conditions. The level of air pollutant was observed to vary during differants seasons and stations. It is very impartant to study and understand the causes of these variations prior to the development of interventions and policy recommendation aiming at reduction exposures.The air borne health problems viz respiratory problems, bronchits and asthma are assessed and correlated with with the level of SO_2 at three study Stations of Gwalior city to find out the relation between deteriorating air quality and increasing rate of air borne diseases. It is observed that there is a negative co-relation between the two. The level of air pollutant SO_2 is significantly and negatively correlated with the air borne diseases.

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This may explain that SO_2 does not effect the human health but is increasing and these problems may be due to other pollutants like RSPM which enters deep into the repiratory tract. The results show the concentration and emission of SO_2 and same was compared with the permissible concentration of industrial, residential, and commercial areas as per the standards given by CPCB and major precautions were suggested to reduce the concentration level of SO_2. In this regard awareness programme regarding the main sources of pollution in a particular study area is taking into consideration for practical solution in future.

Abbreviations

WHO: World Health Organization
NAAQS: National Ambient Air Quality Standard
CPCB: Central Pollution Control Board
mm: Milimeter
ug: Microgram
mg/ml: Miligram per litre
ug/g: Microgram per litre
Sdv: Standard Deviation
AQI: Air Quality Index
ThP: Thatipur
MRBD: Mahraja Bada
DDN: Deen Dayal Nagar
R.H: Relative Humidity
NO_2 : Nitrogen dioxide
SO_2 : Sulphur dioxide
R.F: Rainfall
R.A: Respiratory Admissions
R.P: Respiratory Problems
IMD: Indian Meteorological Department
A.P: Air PollutantM.P: Meteorological parameters

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