Evaluation of Ambient Air Pollution: A Case Study of Varanasi, U.P., India

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Abstract- *Man is making rapid strides in science and technology. His eagerness to increase his comfort by utilizing the natural resources resulted rapid industrialization and abnormal urbanization, which consequently witness excessive air pollution. The Varanasi city due to its rapid urban development, various construction projects sanctioned from government and exponential growth in the vehicular usage and fuel consumption resulted poor ambient air quality. On the other hand the decreasing forest cover and existing weather pattern of the city is not favorable for the dispersion of air pollutants. An inventory of air contaminants is the first step towards the control of air pollution. The purpose of the present study was to assess the present air quality status of Varanasi city and to compare the measured values with the recommended threshold limit values. The study has been carried out in 5 major circles of Varanasi. Air samples were collected using a High volume air sampler and analysis was made for SPM, SO_2, and NOx by means of BIS methods. The results showed higher value of all the parameters i.e. SPM, SO_2, and NOx beyond the CPCB limit. The study revealed a significant correlation between SO_2, NOx and SPM.*

Keywords- Industrialization, Ambient air, Threshold, High volume air sampler, Correlation.

I. INTRODUCTION

Air pollution is a one of the alarming environmental problem associated with urban areas. Various monitoring programmes have been undertaken to know the quality of air by creating vast amount of data on concentration of each air pollutant (e.g., SPM, CO, NOx, SO_2, etc.) in different parts of the world. (Biswanath Bishoi, 2009). Varanasi is world famous and one of the most important holy cities of India, famous for Ghat, temples, natural beauty, light and festivals. It gets millions of tourist every month, sometimes just in one day, which increase the number of vehicle of various categories. Varanasi undergo from tremendous increase of population, number of vehicles, narrow roads, parking facility problems, ineffective achievement of laws etc. all these conditions responsible for jam like condition prevalent in almost all the traffic intersections of Varanasi. Moreover there is huge numbers of three wheelers. Most of these three wheelers are carry overload of passengers, poor maintained and conditions besides this they driven by diesel engine. It is estimates that diesel combustion emits 84 g/km of particulates as compared to 11 g/km in CNG (Nylund and Lawson, 2000). Motor automobiles produce a range of particulate matter through the dust produced from brakes, clutch plates, tires and ultimately through the re-suspension of particulates on road surfaces through vehicles–generate turbulence (Watkins, 1991). Over the three decades motor automobiles numbers have been doubling every 10 or fewer year in many Asian countries as against a 2-5% annual growth rate in Canada, the United States, The United Kingdom and the Japan (Faiz et al., 1992). Two wheelers are the most speedily growing type automobile in India. Vehicular pollution contribute about (72%) of the total air pollution load followed by industries (19%) and domestic (9%) in Delhi City (CPCB, 2001). This paper discussed the concentration of pollutants such as sulfur dioxide, oxides of nitrogen and suspended particulate matter (SO_2, NOx and SPM) at selected sites of Varanasi and their correlation analysis.

II. MATERIALS AND METHODS

1. Study area:

Varanasi is an ancient religious city, on the bank of holy river Ganga. Being an important pilgrimage center, thousands of tourists visit the holy city Varanasi from India and abroad. The city is famous for its cultural heritage, music, art, craft and education. Varanasi is a major commercial and industrial center of eastern U.P. Varanasi is in north-eastern part of the country at 25°0' to 25°16' N latitude and 82 5' to 83°1' E longitude. Varanasi has a total area of 78.5 sq km and is under the management of Nagar Nigam.

Total five monitoring sites were selected for present study (Table-1). The first study site Lanka is a residential area of Varanasi near Benaras Hindu University, posses a very high number of motor vehicles throughout the day and night. The site is also surrounded by hospitals and schools. Due to presence of hospitals & colleges this area is very crowded. B.H.U. (Banaras Hindu University) has comparatively very high dense forest and vegetations cover within the premises.

The second site is Godowlia. It is the main marketing area of Varanasi due to this the crowd of pedestrians can be easily observed. Many temples are situated in nearby area. Therefore vehicular load is not so high. The third site is Pandeypur. It is one of the main squares of the Varanasi in Trans Varuna area. It is the common traffic point from where the vehicles moves towards Azamgarh, Gazipur, Gorakhapur. Therefore pollution level is almost very high, posse's very dense traffic load. The fourth site Sigra is one of the main and busy road of the city, posses a high number of two wheelers, three wheelers and four wheelers vehicles, auto-rickshaws throughout the day. The fifth site is Cantt Railway Station. It is the main junction point of the trains from all over the India and Varanasi bus station is also situated near by this region due to this reason vehicular load in this region is comparatively very high like buses, trucks and many auto-rickshaws.

Table 1. List of study area with their geo-coordinates

Name of study Site	Latitude	Longitude
Lanka	25.3280	83.0275
Godowlia	25.3102	82.9717
Pandeypur	25.3493	82.9934
Sigra	25.3112	82.9891
Cantt. station	25.3176	82.9739

2. Air Monitoring and Analysis:

The ambient air quality such as Suspended Particulate Matter (SPM), Sulphur di oxide (SO_2) and Oxides of nitrogen (NOx) were measured using High Volume Sampler (HVS) (Envirotech APM-415/411) from November 2017 to January 2018 at selected sites of Varanasi, by sucking air into appropriate reagent for 24 hours and after air monitoring it procured into lab and analysis for the concentration level (Jha D. K., 2011). SPM analyzed using gravimetric method. Ambient air allowed to enter into the sampling device HVS through a 20.3 X 25.4 cm filter at an average flow rate of 1.0-1.5 M3 per minute (Chauhan A., 2010) SO_2 and NOx samples collected by bubbling air sample in a specific 30ml absorbing solution (potassium tetra-chloromercurate (TCM) for SO_2 and mixture of sodium hydroxide and sodium arsenite for NOx) at an average flow rate of 1.0-1.5 M3 per minute (Ipeaiyeda et. al, 2018). The impinger samples were put in ice boxes immediately after sampling and transferred to a refrigerator until analyzed. The concentration of NOx was measured with standard method of Modified Jacobs- Hochheiser method (Schmitt et. al. ,2018), SO_2 was measured by Modified West and Geake method (1956) (West, 1956,), SPM and RSPM using filter paper methods. The apparatus was kept at a height of 2 m from the surface of the ground.

3. Statistical analysis:

The mean values and standard deviation of all three air quality parameters i.e. SO_2, NOx and SPM at different study sites of Varanasi, U.P. were calculated using MS Excel 2010. The results were compared with the CPCB air quality standard (Patel and Koshta, 2018). Person's correlation coefficient values (r) were calculated using SPSS software (SPSS Inc., version 10.0) to measure relationship between two variables and also show the degree of dependency of one variable to the other (Tripathi and Vishwakarma, 2015).

III. RESULT AND DISCUSSION

The ambient air samples collected from all five study sites were analyzed and presented in table-2, figure 1 and 2. The results of correlation analysis is tabulated in Table-3 and graphically presented in figure 3.

1. Descriptive statistics

On a global basis, sulfur compounds enter the atmosphere to a very large extent through human activities (Cronan, 2018). The SO_2 value in present study was observed to be highest at Cantt. St. (224.4±26.1 µg/m3) as compared to other sites and it was found to be lowest at Lanka (114.6±12.8 µg/m3). This higher concentration of SO_2 may be due to the increased vehicular load mainly auto-rickshaws in this region in comparison to the other sites (Wang et. al. 2018).

Table 2. Average concentration (µg/m3) of various air pollutants [Mean ± SD]

Air quality Parameters	Name of Study site					Air Quality Standards (CPCB, 2009)
	Lanka	Godowlia	Pandeypur	Sigra	Cantt. St.	
SO_2	114.55 ± 12.83	162.73 ± 25.23	180.40 ± 27.74	195.36 ± 19.21	224.32 ± 26.10	80 µg/m3
NO_x	76.33 ± 12.90	114.09 ± 17.43	128.36 ± 20.07	135.51 ± 16.30	151.27 ± 15.45	80 µg/m3
SPM	851.62 ± 133.56	3868.78 ± 243.19	4242.44 ± 311.10	3747.11 ± 246.42	3570.78 ± 224.10	100 µg/m3

High concentration of nitrogen oxides in the ambient air impact both humans and ecosystem badly and also play an important role in tropospheric chemistry. High NOX emissions are mainly observed in polluted regions produced by anthropogenic combustion from industrial, traffic and household activities typically observed in large and densely populated urban areas (Verstraeten et. al., 2017). In present study the highest value of NOx above CPCB standard (80 µg/m3) was observed at Cantt. Station (151.27±26.10 µg/m3), Sigra (135.51±16.30 µg/m3), Pandeypur (128.36±20.07 µg/m3) and Godowlia (114.09±17.43 µg/m3) whereas lowest value below CPCB standard was found at Lanka (76.33±12.90 µg/m3). This may be due to traffic load, fuel quality and cylinder temperature of diesel engine (Johansson et. al., 2009; Shameer and Ramesh, 2017).

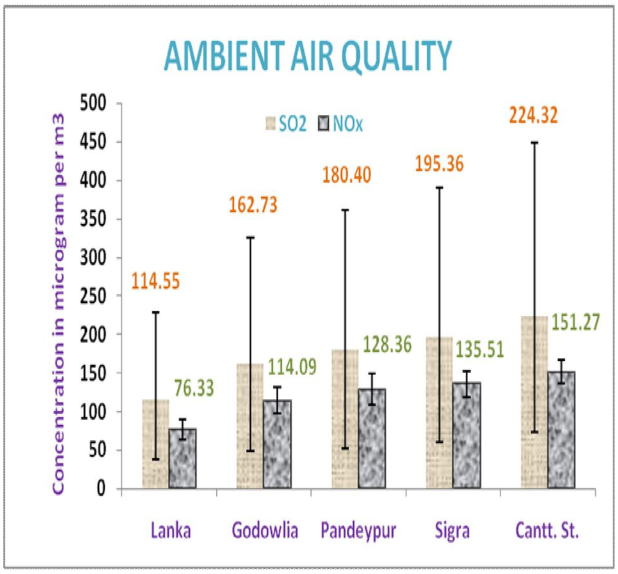

Figure 1. Concentration of SO_2 and NOx in ambient air.

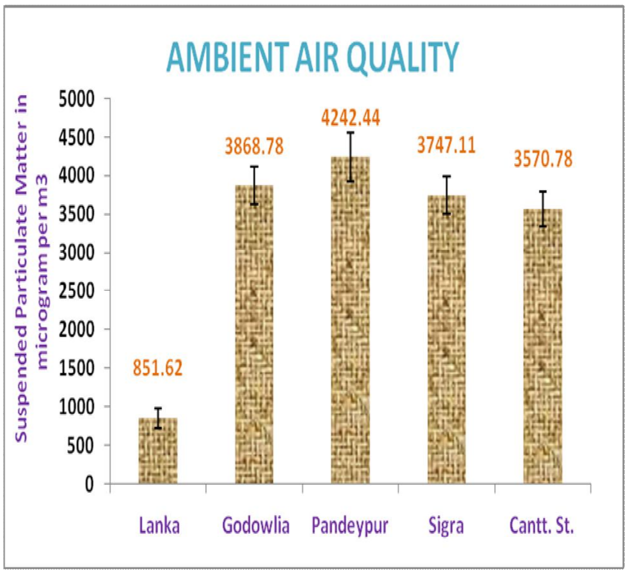

Figure 2. Concentration of SPM in ambient air.

Suspended particulate matter (SPM) refers to particles ranging in size from the smallest to a larger sized particles commonly referred as "dust" and is associated with aesthetic and environmental impacts such as soiling of materials or smothering of vegetation (Monn, 2001). The value of SPM at pandeypur (4242.5±51.1 µg/m3) and godaulia (3868.8±43.2 µg/m3) was found to be high as compared to the standard (100 µg/m3) and it was found to be lowest at lanka (851.6±33.6 µg/m3). Similar result was found in study carry out by O. C. Othman in 2010 (1175 µg/m3) and by many Indian researchers also Sharma, 2005; Nayak and Chowdhury, 2018). Heavy vehicles use in transport system and ongoing civil construction works in urban area can be the important cause of high dust load in ambient air (Pandey, et. al., 2017).

2. Correlation Analysis

Correlation is a simplified statistical tool to establish the relationship between two variables and also show the degree of dependency of one variable to the other (Belkhiri et al., 2010). Summary of correlation matrix ambient air quality parameter is presented in table-3 and regression equation for SO_2 and NOx are given in Figure-3. Correlation analysis reveals linear positive correlation of SPM with SO_2 (r=0.6595) and NOx (0.7087). Similar result was found in a study conducted by P.K. Sharma et. al. at Raniganj, 1990 (Between SPM and SO_2 r=0.749 and of SPM and NOx r=0.699). Similarly positive correlation was found between SO_2 and NOx (r=0.7833). This was the best correlation found in this study. Similar result was found in a study conducted by Dilip Kumar Jha et. al. at Port Blair (r=0.557).

Table 3. Correlation Matrix. of air quality parameters

Air parameter	SPM	SO_2	NOx
SPM	1	-	-
SO_2	0.6596	1	-
NOx	0.7087	0.7833	1

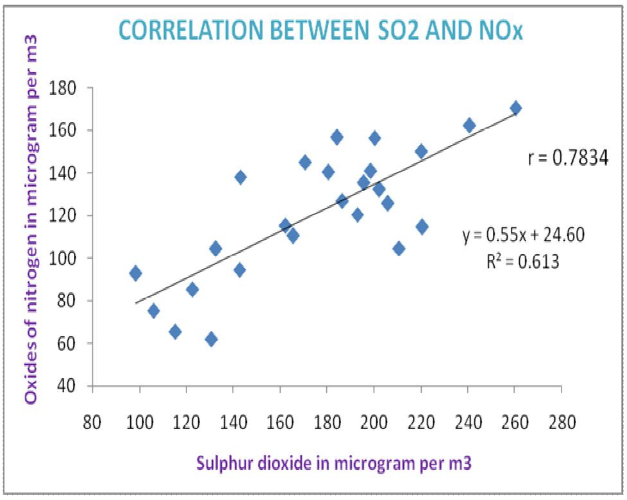

Figure 3. Correlation between SO_2 and NOx.

Regression equation is used in data analysis to find out the relationship between dependent and independent variables. Regression line represents the degree of linear relationship between both the variables (MacKinnon et. al., 2002). Based on the correlation coefficient of determination (r2 =0.613), it was evident that all the variance in the dependent variable (i.e. SO2 concentration) explained by derived regression equation. A significant positive correlation was found between SO_2 and NOx.

IV. CONCLUSION

The present study was aimed to assess the ambient air quality of Varanasi at different sites, identification of key air parameter, which influence the other parameters. Pearson correlation analysis and regression analysis was performed to parameters (NOx, SO_2 and SPM) monitored was found above the limit prescribed by CPCB at all the sites of Varanasi. The average concentration of SO_2 and NOx was observed high at Cantt. Railway station site. The SPM value was found high at Pandeypur site. The result of Pearson correlation analysis identified NOx as a key air parameter, which has significantly influenced the other air parameters i.e. SO_2 and SPM. The study found that there was a gradual increasing trend of ambient air pollutants in Varanasi possibly due to growing cities, increasing traffic, rapid economic development, many constructions and higher levels of energy consumption in Varanasi. The study concludes that there is a need to address the issue of air quality monitoring and adopt suitable control measures.

REFERENCES

[1] Bishoi B., Prakash A., Jain V.K. A Comparative Study of Air Quality Index Based on Factor Analysis and US-EPA Methods for an Urban Environment. Aerosol and Air Quality Research. 2009: 9 (1).

[2] Belkhiri, L., Boudoukha, A. and Mouni, L. A multivariate Statistical Analysis of Groundwater Chemistry Data. Int. J. Environ. Res.,2010: 5(2): 537-544.

[3] CPCB . National ambient air quality statistics of India. Central Pollution Control Board, Parivesh Bhavan, Delhi, India. 2001.

[4] Chauhan A., Pawar M ., Kumar K. and P. C. Joshi. Ambient Air Quality Status in Uttarakhand (India): A Case Study of Haridwar And Dehradun Using Air Quality Index. Journal of American Science. 2010:6(9).

[5] Cronan, C. S. (2018). Atmospheric Deposition. In Ecosystem Biogeochemistry (pp. 73-85). Springer, Cham.

[6] Faiz, A., Weaver, C., Sinha, K., Walsh, M. and Carbajo, J. Air pollution from motor vehicles: Issues and options for developing countries. The World Bank, Washington, DC. 1992.

[7] Jha D.K., Sabesan M., Das A., Vinithkumar N.V., Kirubagaran R. Evaluation of Interpolation Technique for Air Quality Parameters in Port Blair, India. Universal Journal of Environmental Research and Technology.2011: 1(3). 301-310.

[8] Ipeaiyeda, A. R., Lasisi, T. I., Amana, S. B., & Adegboyega, D. A. (2018). Gaseous air pollutants emissions from ota industrial estate in Ogun state, Nigeria. Ife Journal of Science, 20(1), 145-154.

[9] Johansson, C., Norman, M., & Burman, L. (2009). Road traffic emission factors for heavy metals. Atmospheric Environment, 43(31), 4681-4688.

[10] Monn, C. (2001). Exposure assessment of air pollutants: a review on spatial heterogeneity and indoor/outdoor/personal exposure to suspended particulate matter, nitrogen dioxide and ozone. Atmospheric environment, 35(1), 1-32.

[11] MacKinnon, D. P., Lockwood, C. M., Hoffman, J. M., West, S. G., & Sheets, V. (2002). A comparison of methods to test mediation and other intervening variable effects. Psychological methods, 7(1), 83.

[12] Nylund, N.O. and Lawson, A. Exhaust emissions from natural gas vehicles. Helsinki: International Association of Natural Gas Vehicles, VTT Energy. 2000.

[13] Nayak, T., & Chowdhury, I. R. (2018). Health Damages from Air Pollution: Evidence from Open Cast Coal Mining Region of Odisha, India. Ecology, 1(1).

[14] Othman O. C. Roadside Levels of Ambient Air Pollutants: SO2, NO2, NO, CO and SPM in Dar es Salaam City. Tanzania Journal of Natural and Applied Sciences (TaJONAS). 2010: 1(2).

[15] Pandey, M., Pandey, A. K., Mishra, A., & Tripathi, B. D. (2017). Speciation of carcinogenic and non-carcinogenic metals in respirable suspended particulate matter (PM10) in Varanasi, India. Urban Climate, 19, 141-154.

[16] Patel, M., & Koshta, M. K. (2018). Assessment of Total

Suspended Particles and Particulate Matter in different sites of Jabalpur City. Assessment, 5(03).

[17] Sharma P.K. and Singh G. Assessment Of Ambient Air Quality in Tilaboni,Nakrakonda and Jhanjra Blok of Raniganj Coalfield, Indian J. Environmental Protection. 1990: 10(2).

[18] Sharma, R., Pervez, Y. and Pervez, S. Seasonal evaluation and spatial variability of suspended particulate matter in the vicinity of a large coal-fired power station in India-a case study. Environmental Monitoring and Assessment 2005: 102, 1-13.

[19] Shameer, P. M., & Ramesh, K. (2017). Experimental evaluation on performance, combustion behavior and influence of in-cylinder temperature on NOx emission in a DI diesel engine using thermal imager for various alternate fuel blends. Energy, 118, 1334-1344.

[20] Schmitt, K., Tarantik, K. R., Pannek, C., & Wöllenstein, J. (2018). Colorimetric Materials for Fire Gas Detection—A Review. Chemosensors, 6(2), 14.

[21] Tripathi, S. K., & Vishwakarma, S. K. (2015). Physico-chemical and statistical evaluation of bore well water in two villages of Varanasi (Up), India. Int J Sci Res Environ Sci, 3(9), 314-321.

[22] Verstraeten, W. W., Folkert Boersma, K., Douros, J., Williams, J. E., Eskes, H. H., & Delcloo, A. (2017, April). Top-down NOX emissions over European cities from LOTOS-EUROS simulated and OMI observed tropospheric NO2 columns using the Exponentially Modified Gaussian approach. In EGU General Assembly Conference Abstracts (Vol. 19, p. 2621).

[23] West, P.W., Gaeke, G.C. Fixation of sulphur dioxide as sulfitomercurate III and subsequent colorimetric determination. Annal. Chem. 1956: 28.

[24] Wang, J. M., Jeong, C. H., Zimmerman, N., Healy, R. M., & Evans, G. J. (2018). Real world vehicle fleet emission factors: Seasonal and diurnal variations in traffic related air pollutants. Atmospheric Environment.