IJSRM
INTERNATIONAL JOURNAL OF SCIENCE AND RESEARCH METHODOLOGY
An Official Publication of Human Journals

Human Journals
Research Article
March 2020 Vol.:15, Issue:1

Establishing Relationship between Meteorological Parameters and Criteria Air Pollutants Concentration in Delhi

IJSRM
INTERNATIONAL JOURNAL OF SCIENCE AND RESEARCH METHODOLOGY
An Official Publication of Human Journals

Theogene Ingabire[1*], Abubakar STORAI[2], Jean Paul Nkundabose[3]

[1] University of Delhi, Department of Environmental Studies, University Road, Faculty of Science, University Enclave, Delhi, 110007, India.

2 University of Delhi, Department of Environmental Studies, University Road, Faculty of Science, University Enclave, Delhi, 110007, India.

[3] MSc. Student at Suzhou University of Science and Technology, School of Environmental Science and Engineering, No.1 Kerui Road, Suzhou, China 215009.

Submission: 20 February 2020
Accepted: 27 February 2020
Published: 30 March 2020

Keywords: Particulate matter, meteorological parameters, Delhi, SAFAR, pollutants

ABSTRACT

Meteorological parameters (temperature, humidity, wind speed and wind direction) can be linked to air pollutants concentration levels in any area. The present study purposed to establish the relationship between meteorological parameters and selected criteria air pollutants concentration levels in Delhi. To infer spatial and temporal pattern of air pollutants and relationship with meteorological parameters, the secondary data for criteria pollutants as well as meteorological data (temperature, humidity, wind speed and wind direction) of selected sites were procured from a governmental agency "System of Air quality and weather Forecasting And Research (SAFAR)" for the period of four years (2013 to 2016). Microsoft excel was used for graphical representation purpose. Pearson correlation to establish pollutants relation with meteorological parameters was done by using SPSS. The study found that 2013 was the most polluted year and 2016 was the least in Delhi. It also showed that site 1 which is located in south Delhi is most polluted with regards of gaseous pollutants however; site 6 which is located in north Delhi is the most polluted site in terms of particulate matter. Some meteorological parameters have great influence on the spatial and temporal pattern of criteria pollutants in the selected sites. PM has negative correlation with temperature and humidity while in most sites NO_X (NO & NO_2) have positive relation with temperature. O_3 also have positive relation with temperature because temperature accelerates formation of ozone. However, O_3 has negative relationship with relative humidity because precipitation washes out the pollutant concentration. Generally, wind speed has no effect on concentration of air pollutants.

INTRODUCTION

Historically, air pollution is an old problem. Air pollution can be defined broadly the presence of any toxic material including chemicals, particulate matter, or biological materials in a quantity which alter physical and chemical properties of the air and pose harm or discomfort to humans or other living organisms or cause damage to the natural environment or built environment(Hutton, 2014). Air pollution is a global challenge nowadays which affects our daily lives. Worldwide, India has one of the highest exposure levels to air pollution(Cohen *et al.*, 2017). The major components of air pollution are ambient particulate matter pollution, household air pollution, and to a smaller extent ozone in the troposphere, the lowest layer of atmosphere. The annual population-weighted mean exposure to ambient particulate matter PM2·5 in India was 89·9 μg/m³ (95% uncertainty interval [UI] 67·0–112·0) in 2017 (Balakrishnan *et al.*, 2019a). Most states, and 76·8% of the population of India, were exposed to annual population-weighted mean PM2·5 greater than 40 μg/m³, which is the limit recommended by the National Ambient Air Quality Standards in India(Balakrishnan *et al.*, 2019b). Many cities in India are considered to be among the polluted megacities of the world (Maji *et al.*, 2015). Delhi is considered among the most polluted megacities of the world (Gurjar *et al.*, 2010) and offers a first-hand choice to study air pollution problems. The air quality report published by the Central Pollution Control Board (CPCB), Government of India (GoI) reported that Delhi has exceeded the annual average respirable particulate matter (RSPM) concentration limit by more than four times the national annual standards (CPCB, 2012). In 2010, more than 16000 premature deaths due fine particulate matter were reported in Delhi (Guttikunda and Goel, 2013 ; Ingabire and Nkundabose, 2020).

The US environmental protection agency (EPA) has defined six common air pollutants as criteria pollutants which include: Carbon monoxide (CO), Sulfur dioxide (SO_2), Nitrogen oxides ($NOx=NO+NO_2$), Total Suspended Particulate Matter (TSP, PM fine) and Ozone (O_3). These criteria pollutants come into atmosphere from both anthropogenic and natural sources. Some human activities which cause air pollution include industries, mining, smelting, transportation, agricultural activities, etc. However, some natural phenomena such as; volcanic eruption, bacteria and viruses in the air, wildfires, earthquakes and landslides can also contribute to the air pollution as well (Hewson,1956).

Not only emission sources but local meteorological factors like temperature, Relative humidity (RH) and wind speed (WS) also play an important role in deciding fate of pollutants

in any area (Zhang *et al.*, 2015). The source of emission and meteorology together make up the pollution concentrations and air quality scenario of any region, which can pose some severe effects on human health, climate change, agricultural crops, ecosystems and forest species. The health effects are depending on the type of pollutants and time of exposure. The effects are varying from simple symptoms like coughing, irritation to severe symptoms such as; cardiovascular problems (Ghorani-Azam *et al*., 2016). Meterological conditions affect directly or indirectly the emission, formation, transportation and deposition of pollutants (Zhang *et al*., 2015).

Study of atmospheric stability is very important due to its great infuence on the concentration of air pollution. In unstable atmospheric conditions, air pollutants will be dispersed however, in stable atmospheric conditions pollution concentration will pile up near the surface and thus it will be staying for a long time. As typical example of meteorological parameter, temperature affects air pollution in several ways, with increase in temperature, rate of chemical reactions increases. At higher temperature, air holds more water which causes to dissolve more pollutants. Temperature also affects condensation of water vapor. Recent studies (Maji *et al*., 2015) in Dehli reported on air pollution and health risks but there is still a knowledge gap on how meteorological conditions affect the air pollutants concentration. In this perspective, the present study comes therefore to establish a relationship between meteorological parameters (temperature, humidity, wind speed and wind direction) and criteria air pollutants concentration levels in Delhi, one of the most polluted megacities on the globe (Maji *et al*., 2015). The proper understanding of mechanisms that produce air pollution, enhances the forecast accuracy of air pollution along with adequate mitigation system.

MATERIALS AND METHODS

1. Site description

In this study, six institutional sites (Table No.1 and Figure No. 1), were selected to analyse the pollution scenario in Delhi.

Table No.1: Different selected sites of Delhi

Site No	Site name	Location
Site 1	Central Road Research Institute (CRRI)	South Delhi
Site 2	Indian Institute of Trophical Meteorology (IITM)	West Delhi
Site 3	Indian Meteorological Department (IMD), Ayanagar	South Delhi
Site 4	Palam Airport	Southwest Delhi
Site 5	National Center for Medium Range Weather Forecasting (NCMRWF)	East Delhi
Site 6	CV Raman Institute	North Delhi

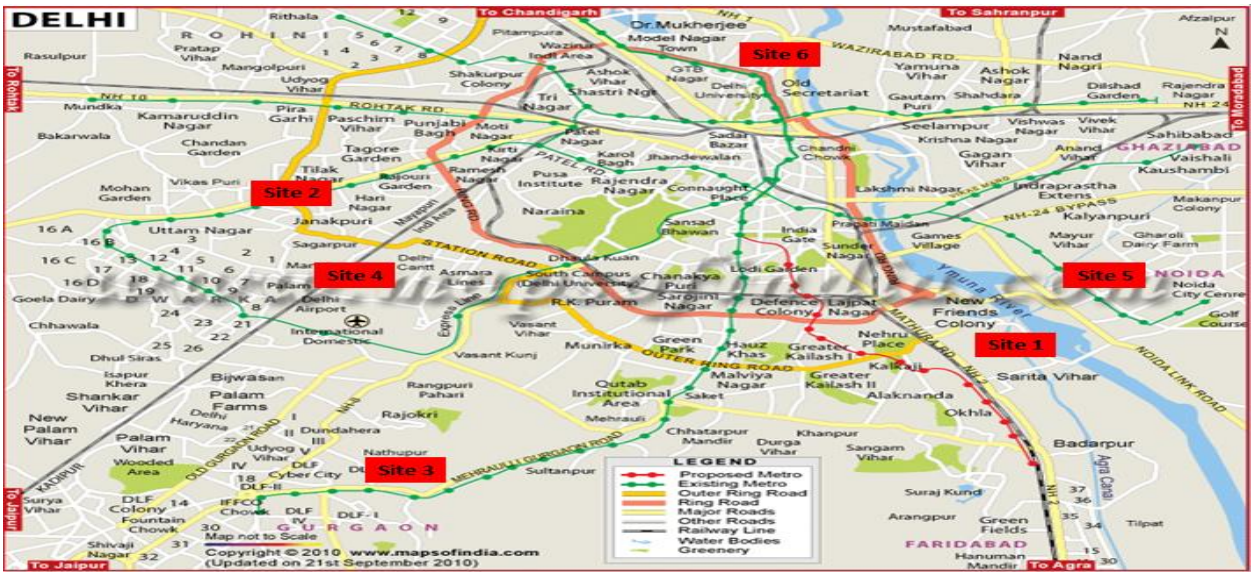

Figure No. 1: Delhi map with all the selected sites.

2. Data collection and analysis

The secondary data for criteria air pollutants as well as meteorological data (temperature, humidity, wind speed and wind direction) was procured from a governmental agency "System of Air quality and weather Forecasting and Research (SAFAR)" for the period of four years (2013 to 2016). The data was retrieved for six sites which are mentioned in Table No.1.The given data was organized in ten days average by using MS Excel. For every year, 36 averages were obtained. Bar graphs were used to represent spatial and temporal variation of pollutants at the selected sites. These meteorological parameters and pollution data of the

sites were then statistically analysed using SPSS (23.0) pearson correlation to establish pollutants relationship with meteorological parameters.

RESULTS AND DISCUSSION

Spatial and temporal pattern of criteria pollutants at the selected sites in Delhi.

A) Particulate pollutants:

It was found that both PM_{10} and $PM_{2.5}$ have the highest concentration in site 6 (north Delhi) in all the years. Major sources of PM_{10} and $PM_{2.5}$ in Delhi include vehicular emissions, biomass burning, soil and road dust, construction activities, secondary particles and incineration of waste (CPCB, 2016). Industrial pollution contributes less than 1% to the concentration of PM_{10} while it contributes less than 1-2% of $PM_{2.5}$ concentration in Delhi (CPCB, 2016). The major constituent of $PM_{2.5}$ is black carbon (90%) which is released due to the incomplete combustion of fossil fuels and burning of biofuels (Tiwari *et al.*, 2013). The high concentration of PM_{10} and $PM_{2.5}$ at site 6 (North Delhi) may be due to the high population density and hence higher vehicular number compared to other parts of Delhi, also dust from construction activities add to the higher concentration of Particulate matter in north Delhi. There temporal variation is maximum in 2013 (Figure No.2 and 3). The reason could be less precipitation in 2013 because precipitation washout particulate matter from the ambient air.

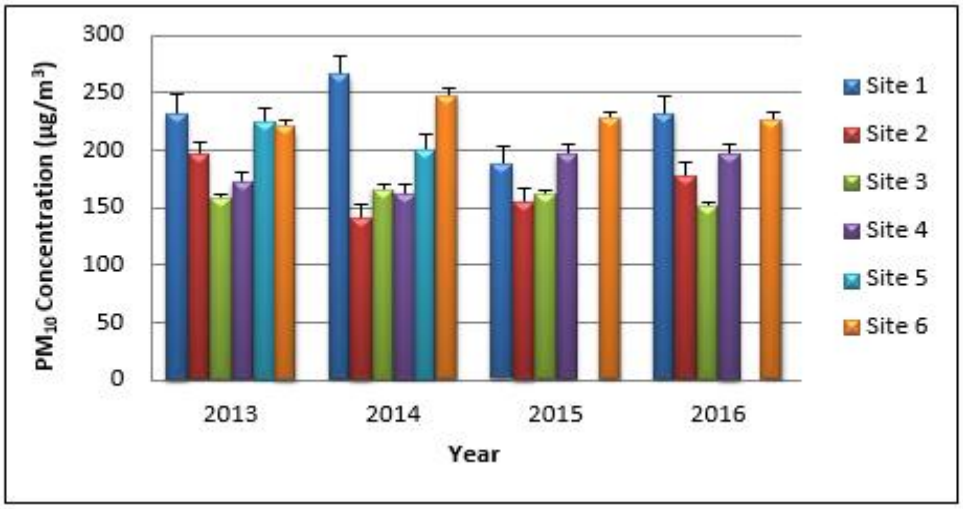

Figure No. 2: Variation of PM_{10} concentration

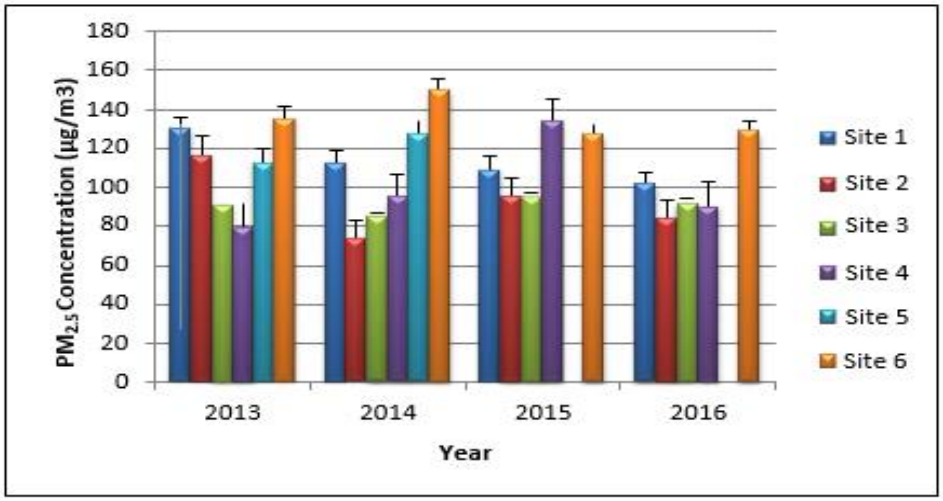

Figure No. 3: variation of $PM_{2.5}$ concentration

B) Nitrogen Oxides (NO and NO_2)

Concentration of NO and NO_2 are plotted in figure No.4 and 5 respectively. The study found that NO and NO_2 have similar trends in all four years. Maximum pollutant concentration occurs at Site 1 (South Delhi) (29.99 ppb and 22.86 ppb respectively). It is well known that mobile emission sources predominantly characterized by CO and NO_x while Point source emissions are characterized by high SO_2 and NO_x. Mobile sources are the major contributor to NO_x concentration in Delhi (Aneja *et al.*,2001). Hence, Site 1 (south Delhi) is just beside a major connecting road between Delhi and Uttar Pradesh and Delhi and Faridabad (Mathura road). So, this high concentration might be due to the high traffic density of the road. Weng and Yang, 2006 reported similar findings in their study (Weng and Yang, 2006).

The temporal variation showed that 2013 was the most polluted year with regards to NO and NO_2 having 32.42 ppb and 28.94 ppb concentration respectively.

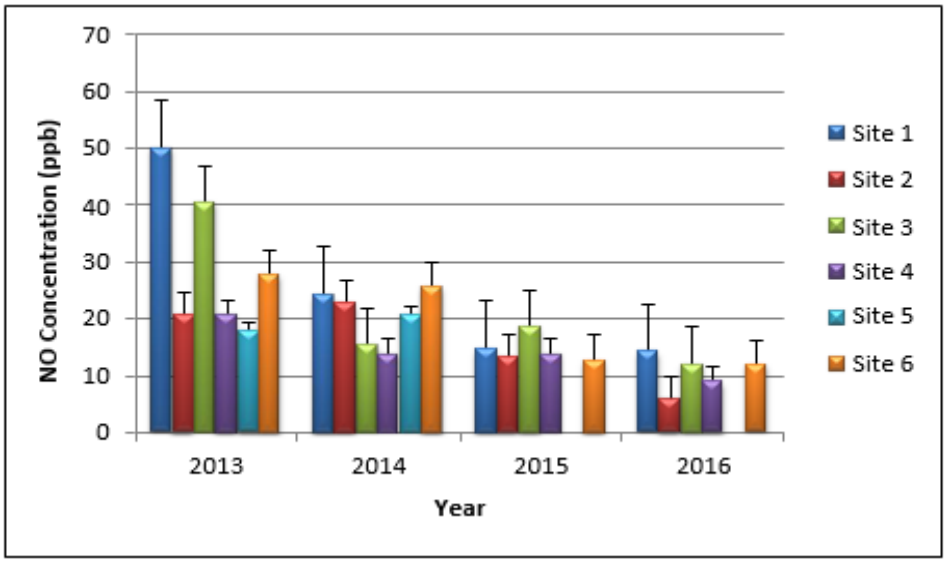

Figure No. 4: Variation of NO concentration

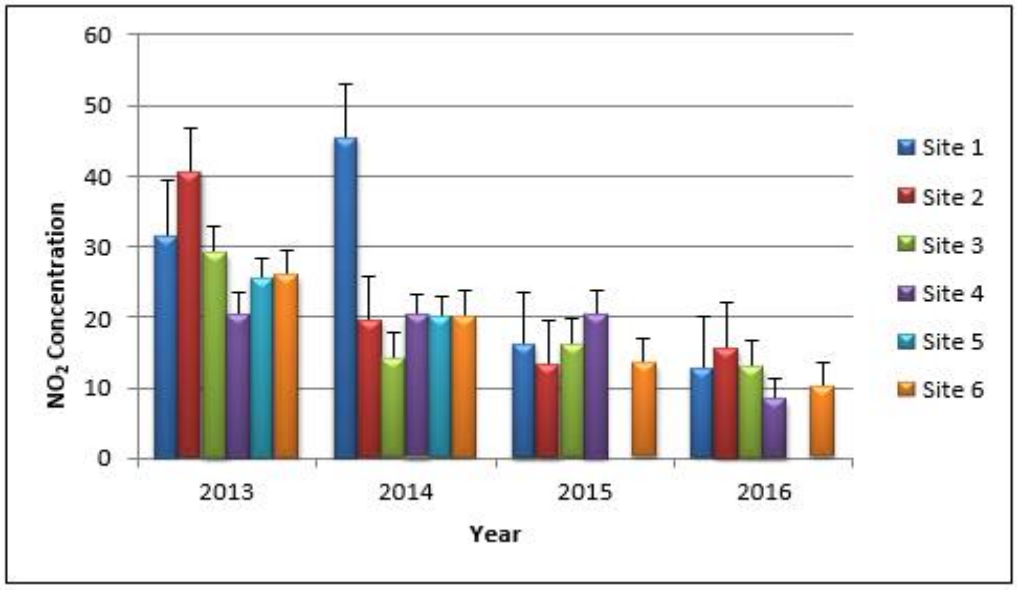

Figure No. 5: Variation of NO_2 concentration

C) Ozone (O_3)

As per the temporal analysis, 2015 showed the highest concentration (44.84ppb) of ozone (Figure No.6). Spatial Variation showed that overall Site 4 (South West Delhi) had the highest concentration of ozone (38.87 ppb). However, site 2 (West Delhi) showed excessively high concentration in year 2015. Site 4 is a domestic airport and high emission rate of Ozone precursors like NOx and VOCS from aircraft emission which can result in formation of high level of ozone in this area. Pison and Menut (2004) quantified the impact

of aircraft emissions on ozone concentrations over Paris area. They found that during daytime, ozone levels increase as much as 10 ppb in NOX-limited areas due to aircraft emissions(Pison and Menut, 2004).

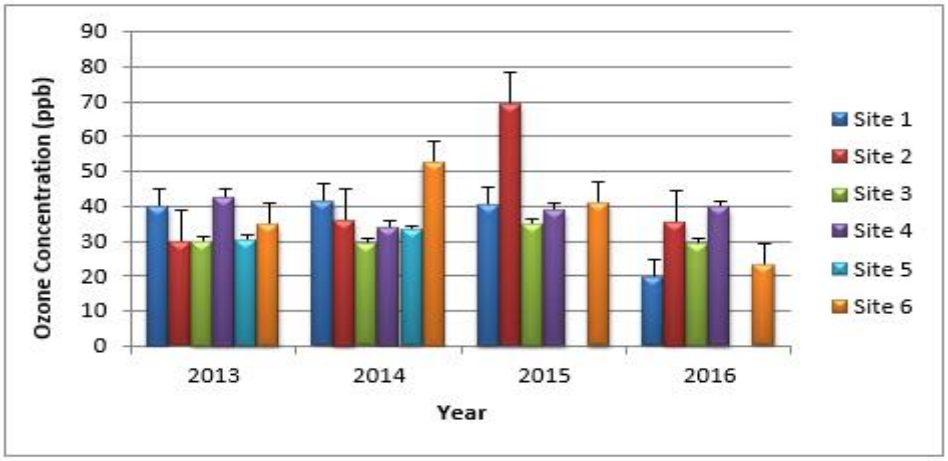

Figure No. 6: Variation of ozone concentration

As per the spatiotemporal analyses, site 6 (North Delhi) was highly contaminated with particulate matter whereas site 1 (South Delhi) showed high gaseous concentration. The temporal study showed that 2013 was highly polluted year for all pollutants except ozone which was highest in 2015.

Relationships between meteorological parameters and pollutant dispersion.

A) Correlation of Temperature and Pollutants

The study majorly depicted negative correlation of pollutants with temperature specifically for PM_{10} and $PM_{2.5}$ at all the selected sites except of site 4 (South West) in year 2016 (Table No. 2-11). The negative relation with temperature could be because of temperature inversion phenomenon. During winter months temperature drops and atmosphere is stagnant & stable and results in more pollution concentration during this time (Jayamurugan *et al*.,2013). Interestingly at site 6 (North Delhi) NO_2 showed positive correlation ($P<0.01$) with temperature and O_3 at site 1 (South Delhi) in year 2016 depicted positive relationship with temperature. In post-monsoon relatively lower temperature reduces mixing height which is responsible for pollution dispersion thus resulting in moderate positive correlation of temperature wih NO_x. Similar findings were reported by Jayamurugan *et al*.,2013. Increasing solar radiation increases the photolyses of NO_x and hence increases in O_3 formation. Similar

findings were obtained in twin cities of Pakistan by Ahmad and other collegues in 2013 (Ahmad *et al*., 2013).

Table No.2: Correlation of pollutants and meteorological parameters at Site 1 (South Delhi) in2013

	Temp	RH	WS (m/s)
PM_{10}	-.444*		NS
$PM_{2.5}$	-.408*	NS	.416*
NO	NS	NS	NS
NO_2	NS	NS	NS
NO_X	NS	-.367*	NS
CO	-.389*	NS	NS
CO_2	NS	NS	NS
O_3	NS	NS	NS

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Temp. Temperature NS. Not Significant

B) Pollutants relation with relative humidity (RH)

Some of the pollutants did not show any significant effect of RH on their concentration. However, pollutants like PM_{10}, $PM_{2.5}$, CO and O_3 did show negative relation with RH at site 2 (West Delhi),4 (Southwest Delhi) and 6 (North Delhi) (Table No.2-11). The negative correlation with RH could be because of the washing effect in monsoon where precipitation washes off the pollutants from atmosphere and decreases their concentration in air (Jayamurugan *et al*.,2013). High relative humidity causes reduction of the incoming solar radiation due to the formation of inversion layer thus reduction in dispersal of the pollutants (Jayamurugan *et al*., 2013).

C) Pollutants relation with wind speed (WS)

Wind speed showed both positive and negative relation with some pollutants but no significant pattern was observed at all selected sites (Table No.2-11). Wind speed plays an important role in decreasing or increasing the level of pollution in a particular area.

By wind movement, pollutants can come from nearby areas and can disperse to another area. Higher the wind speed lower the concentration of particulate matter will be as it is dispersed by wind(Li *et al.*, 2015).

Table No.3: Correlation of pollutants and meteorological parameters Site 1 (South Delhi) in 2016

	Temp	RH	WS (m/s)
PM_{10}	NS	NS	NS
$PM_{2.5}$	NS	NS	NS
NO	NS	NS	NS
NO_2	NS	NS	NS
NO_X	NS	NS	NS
CO	NS	NS	NS
CO_2	NS	NS	NS
O_3	.964*	NS	NS

Table No.4: Correlation of pollutants and meteorological parameters Site 2 (west Delhi) in 2013

	Temp	RH	WS (m/s)
PM_{10}	-.433**	NS	NS
$PM_{2.5}$	-.341*	NS	NS
NO	NS	NS	-.519**
NO_2	.407*	.531**	-.386*
NO_X	.424*	.505**	-.466**
CO	NS	-.406*	NS
CO_2	NS	NS	NS
O_3	NS	-.866**	.426**

Table No.5: Correlation of pollutants and meteorological parameters Site 2 (west Delhi), 2016

	Temp	RH	WS (m/s)
PM_{10}	NS	NS	NS
$PM_{2.5}$	NS	-.992**	NS
NO	-.934*	NS	NS
NO_2	NS	NS	NS
NO_X	NS	NS	NS
CO	NS	NS	NS
CO_2	NS	NS	NS
O_3	NS	NS	NS

Table No.6: Correlation of pollutants and meteorological parameters Site 3 (South Delhi) in 2013.

	Temp	RH	WS (m/s)
PM_{10}	-.522**	-.567**	
$PM_{2.5}$	-.468*	-.545**	.383*
NO	.495**	NS	NS
NO_2	.782**	-.494**	-.443*
NO_X	.649**		-.403*
CO	-.567**	-.439*	
CO_2	NS	NS	-.608**
O_3	NS	NS	NS

Table No.7: Correlation of pollutants and meteorological parameters Site 4 (South West Delhi) in 2013

	Temp	RH	WS (m/s)
PM_{10}	-.451*	-.455*	NS
$PM_{2.5}$	NS	-.419*	NS
NO	.604**	NS	NS
NO_2	.590**	NS	NS
NO_X	.573**	NS	NS
CO	NS	NS	NS
CO_2	NS	-.396*	NS
O_3	NS	NS	NS

Table No.8: Correlation of pollutants and meteorological parameters at site 4 (South West Delhi) in 2016.

	Temp	RH	WS(m/s)
PM10	.607*	NS	NS
PM2.5	.632*	NS	.814*
NO	.637*	NS	NS
NO2	NS	NS	NS
NOX	NS	NS	NS
CO	NS	.667*	NS
CO2	NS	.666*	NS
O3	-653*	NS	NS

Table No.9: Correlation of pollutants and meteorological parameters at Site 5 (East Delhi) in 2013.

	Temp	RH	WS (m/s)
PM_{10}		-.435*	NS
$PM_{2.5}$	-.599**	NS	NS
NO	NS	NS	NS
NO_2	.422*	-.474**	-.481**
NO_X	NS	NS	-.401*
CO	NS	NS	NS
CO_2	NS	NS	NS
O_3	NS	-.413*	-.362*

Table No. 10: Correlation of pollutants and meteorological parameters at Site 6 (North Delhi) in 2013.

	Temp	RH	WS (m/s)
PM_{10}	-.468**	-.635**	NS
$PM_{2.5}$	-.656**	-.436*	NS
NO	.532**	NS	NS
NO_2	.458**	NS	NS
NO_X	616**	NS	NS
CO	NS	NS	NS
CO_2	NS	NS	NS
O_3	458**	-.513**	NS

Table No. 11: Correlation of pollutants and meteorological parameters Site 6 (North Delhi), 2016

	Temp	RH	WS (m/s)
PM_{10}	NS	NS	NS
$PM_{2.5}$	-.813**	NS	-.559*
NO	-.850**	NS	-.516*
NO_2	.838**	NS	.535*
NO_X	-.840**	NS	-.476*
CO	.684**	NS	NS
CO_2	.684**	NS	NS
O_3	NS	NS	NS

CONCLUSION

The study was designed to evaluate spatio-temporal variation of criteria air pollutants and the relation of meteorological parameters with concentration of air pollutants, in six institutional locations of Delhi. The study found that 2013 was the most polluted year and 2016 was the least in Delhi. It also showed that site 1 which is located in south Delhi is most polluted in regard of gaseous pollutants however; site 6 which is located in north Delhi is the most polluted site in term of particulate matter. This could be because of different land use and population density of these areas. South Delhi is mostly residential area and densely vegetated compared to north Delhi, the high concentration of particulate matter might be due to the construction activities vehicular emissions in North Delhi. PM concentration in Delhi is also increased due to the long-range movement of air masses from western southern parts of India coming to Delhi. In local scale pollutants are mostly dispersed by wind to southeast, southwest and southern directions in Delhi.

Some meteorological parameters have great influence on the spatial and temporal pattern of criteria pollutants in the selected sites. PM has negative correlation with temperature and humidity while in most sites NO and NO has positive relation with temperature. O_3 also have positive relation with temperature because temperature accelerates formation of ozone. But it has negative relationship with relative humidity because precipitation washout the pollutant concentration. In general wind speed has no effect on concentration of air pollutants.

ACKNOWLEDGEMENTS

The authors are grateful to the University of Delhi for its support and we cannot fail to commend and appreciate the work of various authors used for the review. We are very thankful to **SAFAR** Program for providing secondary Data.

REFERENCES

1. Ahmad, S. S., & Aziz, N. (2013). Spatial and temporal analysis of ground level ozone and nitrogen dioxide concentration across the twin cities of Pakistan. Environmental Monitoring and Assessment, 185(4), 3133–3147. https://doi.org/10.1007/s10661-012-2778-7.
2. Aneja, V. P., Agarwal, A., Roelle, P. A., Phillips, S. B., Tong, Q., Watkins, N., & Yablonsky, R. (2001). Measurements and analysis of criteria pollutants in New Delhi, India. Environment International, 27(1), 35–42.
3. Balakrishnan, K., Dey, S., Gupta, T., Dhaliwal, R. S., Brauer, M., Cohen, A. J., Stanaway, J. D., Beig, G., Joshi, T. K., Aggarwal, A. N., Sabde, Y., Sadhu, H., Frostad, J., Causey, K., Godwin, W., Shukla, D. K., Kumar, G. A., Varghese, C. M., Muraleedharan, P., … Dandona, L. (2019a). The impact of air pollution on deaths, disease burden, and life expectancy across the states of India: the Global Burden of Disease Study 2017. The Lancet Planetary Health, 3(1), e26–e39. https://doi.org/10.1016/S2542-5196(18)30261-4

4. Balakrishnan, K., Dey, S., Gupta, T., Dhaliwal, R. S., Brauer, M., Cohen, A. J., Stanaway, J. D., Beig, G., Joshi, T. K., Aggarwal, A. N., Sabde, Y., Sadhu, H., Frostad, J., Causey, K., Godwin, W., Shukla, D. K., Kumar, G. A., Varghese, C. M., Muraleedharan, P., … Dandona, L. (2019b). The impact of air pollution on deaths, disease burden, and life expectancy across the states of India: the Global Burden of Disease Study 2017. The Lancet Planetary Health. https://doi.org/10.1016/S2542-5196(18)30261-4
5. Cohen, A. J., Brauer, M., Burnett, R., Anderson, H. R., Frostad, J., Estep, K., Balakrishnan, K., Brunekreef, B., Dandona, L., Dandona, R., Feigin, V., Freedman, G., Hubbell, B., Jobling, A., Kan, H., Knibbs, L., Liu, Y., Martin, R., Morawska, L., … Forouzanfar, M. H. (2017). Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: an analysis of data from the Global Burden of Diseases Study 2015. The Lancet. https://doi.org/10.1016/S0140-6736(17)30505-6
6. CPCB. (2012). Epidemiological study on effect of air pollution on human health (adults) in Delhi, Central Pollution Control Board, New Delhi, 2012; https://www.cpcb.nic.in
7. Ghorani-Azam, A., Riahi-Zanjani, B., & Balali-Mood, M. (2016). Effects of air pollution on human health and practical measures for prevention in Iran. Journal of Research in Medical Sciences, 21(5). https://doi.org/10.4103/1735-1995.189646
8. Gurjar, B. R., Jain, A., Sharma, A., Agarwal, A., Gupta, P., Nagpure, A. S. and Lelieveld, J. (2010). Human health risks in megacities due to air pollution. Atmos. Environ., 44(36), 4606–4613.
9. Guttikunda S. K. & Goel R. (2013). Health impacts of particulate pollution in a megacity-Delhi, India. Environmental Development, 6(1), 8–20. https://doi.org/10.1016/j.envdev.2012.12.002
10. Hewson, E. W. (1956). Meteorological factors affecting causes and controls of air pollution. Journal of the Air Pollution Control Association, 5(4), 235–241. https://doi.org/10.1080/00966665.1956.10467718.
11. Hutton, G. (2014). Air Pollution: Global Damage Costs from 1900 to 2050. How Much Have Global Problems Cost the World?, 70–98. https://doi.org/10.1017/cbo9781139225793.003
12. Ingabire, T., & Nkundabose, J. P. (2020). Assessment of Air Quality and Respiratory Health Status within an Institutional Area. International Journal of Science and Research Methodology, 14(3), 23–33. www.ijsrm.humanjournals.com
13. Jayamurugan, R., Kumaravel, B., Palanivelraja, S., & Chockalingam, M. P. (2013). Influence of Temperature, Relative Humidity and Seasonal Variability on Ambient Air Quality in a Coastal Urban Area. International Journal of Atmospheric Sciences, 2013, 1–7. https://doi.org/10.1155/2013/264046.
14. Li, H., Guo, B., Han, M., Tian, M., & Zhang, J. (2015). Particulate Matters Pollution Characteristic and the Correlation between PM (PM_{2.5}, PM₁₀) and Meteorological Factors during the Summer in Shijiazhuang. Journal of Environmental Protection. https://doi.org/10.4236/jep.2015.65044
15. Maji, S., Ahmed, S., & Siddiqui, W. A. (2015). Air quality assessment and its relation to potential health impacts in Delhi, India. Current Science, 109(5), 902–909. https://doi.org/10.18520/v109/i5/902-909
16. Pison, I., & Menut, L. (2004). Quantification of the impact of aircraft traffic emissions on tropospheric ozone over Paris area. Atmospheric Environment. https://doi.org/10.1016/j.atmosenv.2003.10.056
17. Tiwari, S., Srivastava, A. K., Bisht, D. S., Parmita, P., Srivastava, M. K., & Attri, S. D. (2013). Diurnal and seasonal variations of black carbon and PM 2 . 5 over New Delhi, India: Influence of meteorology. Atmospheric Research, 125–126, 50–62. https://doi.org/10.1016/j.atmosres.2013.01.011.
18. Weng, Q., & Yang, S. (2006). Urban air pollution patterns, land use, and thermal landscape: An examination of the linkage using GIS. Environmental Monitoring and Assessment. https://doi.org/10.1007/s10661-006-0888-9
19. Zhang, H., Wang, Y., Hu, J., Ying, Q., & Hu, X. M. (2015). Relationships between meteorological parameters and criteria air pollutants in three megacities in China. Environmental Research. https://doi.org/10.1016/j.envres.2015.04.004

	***Theogene Ingabire – Corresponding Author*** *University of Delhi, Department of Environmental Studies, University Road, Faculty of Science, University Enclave, Delhi, 110007, India*
	***Abubakar STORAI*** *University of Delhi, Department of Environmental Studies,University Road, Faculty of Science, University Enclave, Delhi, 110007, India*
	***Jean Paul Nkundabose (MSc Student)*** *Suzhou University of Science and Technology, School of Environmental Science and Engineering, No.1 Kerui Road, Suzhou, China 215009*