Managing Pollution – Emergent need in Urban Cities (with special reference to NCR region)

Dr. Deepti Rani

Associate Professor
Department of Physics
MMH College, CCS University, Ghaziabad

Dr. Yogender Singh

Assistant Professor
Department of Mathematics
Aryabhatta College, Delhi University

Abstract

One of the major challenge before the people living in Urban areas is consistent increase in air pollution. It has risen to such a level that the issue has drawn attention of not only Government but also policy makers, researchers and other responsible section of the society. There is immense need for people to understand and educate others as well, the causes and effects of Air pollution. This paper has been written with the objective of examining the impact of relative humidity and temperature on various pollutants of Air pollution. Among the various components of Air pollution, pollutants such as PM 2.5 and PM 10 are contributed mainly through dust from construction activities, combustion of vehicle fuels, factory waste, burning of waste products, etc. As the level of these activities considerably various from area to other therefore the extent of these pollutants also varies quite significantly in different areas. This study has been conducted using data released by Central Pollution Control Board in respect pollution level at different parts of Delhi and NCR region for the month of November, 2017. Various statistical tools such as coefficient of correlation, ANOVA and Multiple regression analysis have been employed to draw meaningful interpretation from the available data for pollution level in NOIDA. The region has been chosen as the level of construction activities, traffic congestion and emission of various pollutants through combustion of solid and liquid fuels, etc. are quite significant in this area. The conclusion of the study based on statistical evidences is likely to serve as important input for controlling pollution and improving quality of air for the entire society**.**

Keywords : Air pollutants, Relative Humidity , Temperature, PM 2.5, PM 10, SO_2 , NO_2 , CO, Meteorological Variables, Correlation, ANOVA , Multiple Regression Analysis

Introduction

Air pollution has always been a major concern for human life since the industrialization process began and expanded. Gradual increase in number of vehicles, manufacturing units, factories, etc. have increased the Air Quality Index to the alarming level in most of the Urban cities. There is urgent need to take adequate steps for understanding the causes and effects of such high level of Air Quality Index . Infact, one should not only focus on the level of pollution matters rather the constituents of air pollution as some of the constituents such as PM 2.5, PM 10 ,etc. are very hazardous for the human health . It can lead to various kind of respiratory and cardiovascular diseases, In the recent past , developed economies like USA had taken several steps to clean their environment whereas the situation has worsened in our country. According to the World Health Organization (WHO) , India has 14 out of the 15 most populated cities in the world in terms of PM 2.5 concentration , the worst being Kanpur with PM 2.5 concentration of 173 microgram per cubic meter, followed by Faridabad, Varanasi and Gaya. India is among the bottom five on the Environmental Performance Index 2018. Though , reasonable steps have been taken by various State Government to reduce the level of Air Pollution but their impact is yet to be observed. The constituents in the polluted air such as PM 2.5, PM 10, CO, SO_2 etc are very harmful for human life and have been the major cause of health problems. There is immense need for the society to understand relationship with various meteorological factors. With this objective at the background , this paper aims to examine the impact of Relative humidity and Temperature on various Air pollutants. Data for the month of Nov, 2017 at NOIDA has been used for the study. Multiple regression model for the all the pollutants under study , namely, PM 2.5, PM 10, SO_2 , NO_2 and CO has been developed with Relative humidity and Temperature as independent variables and accordingly meaningful inferences have been drawn.

Review of Existing literature

Various scientist and researchers in India and abroad have studied relationship between different meteorological parameters and air pollutants and based on their observations , diverse interpretations were drawn. According to Hernandez , Terri-Ann Berry , Shannon L Wallis & David Poyner (2017), temperature was observed to have a negative correlation with PM10 over a diurnal timescale. RH generally showed a positive correlation with PM10 up to a threshold value of 75% RH, beyond which the correlation ceased. According to Jianhua Wang and Susumu Ogawa

(2015), the correlation analysis results between PM2.5concentration and meteorological data showed that temperature had a negative, and precipitation had a positive, correlation with PM2.5. There was a threshold in the correlations between humidity and wind speed and PM2.5. The correlation was positive or negative depending on the meteorological variable values, if these were lower or higher than the threshold. J. Jovi Wilfet , R. Sathyanathan, A. Aarthy and K. C. Vinuprakash (2017) in their study observed that PM2.5 is positively correlated with temperature in South-West Monsoon season, and it had a negative correlation during North-East and winter seasons, because of the impact of decreasing temperature in the atmosphere on the concentration of PM2.5. Jamal A Radaideh (2017) in his study , Effect of Meteorological Variables on Air Pollutants Variation in Arid Climates, concluded that most of observed key air pollutants increase with increase in relative humidity, except NO2, which experiences a decrease in concentrations simultaneous with increasing relative humidity. The observations made by different researchers are slightly different as the experiments were conducted at different parts of the world with varying climatic conditions.

Objective of the study

The study has been conducted to examine the impact of Relative Humidity and Temperature on different air pollutants as the outcome of the study would help in taking necessary steps for reducing pollution under different levels of relative humidity and temperature. The level of relative humidity and temperature varies significantly across different cities in our country therefore the policy makers need to initiate plans for reducing pollution accordingly. Further, the society should also be aware of impact of change in temperature and relative humidity on different air pollutants.

Research Methodology

In order to study the impact of Relative Humidity and Temperature on various air pollutants, data for the month of November, 2017 published by Central Pollution Control Board in respect of Noida has been taken. The value for the air pollutants – PM 10 (in μg/m3), PM 2.5(in μg/m3) SO2 (in μg/m3), NO2(in μg/m3) and CO(in mg/m3) have been taken as dependent variables and relative humidity alongwith temperature as independent variables for each pollutant. Multiple linear regression using SPSS has been employed for each pollutant as dependent variable whereas relative humidity and temperature as independent variables. The output obtained from the calculations have been analyzed and inferences were drawn

Analysis of Result

The secondary sources of information have already revealed that the level of different air pollutants are dependent on different meteorological factors. The multiple regression output with PM 10 (Dependent variable) and relative humidity alongwith temperature (Independent variable) is shown below in table 1.1, 1.2 and 1.3.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.472[a]	.222	.155	180.21799

a. Predictors: (Constant), Temp, RH

Table 1.1 : Coefficient of Correlation and Determination between PM 10 and independent variables.

The value of R square is 0.222 which implies that independent variables under study ie. RH and temperature explains only 22.2 percent of variation in PM 10 (dependent variable). The value of PM 10 depends on other factors as well which are not being reflected in this case.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	213550.454	2	106775.227	3.288	.055[b]
1	Residual	747006.046	23	32478.524		
	Total	960556.500	25			

a. Dependent Variable: PM10

b. Predictors: (Constant), Temp, RH

Table 1.2 : ANOVA output among variables – PM 10, Temperature and RH

The significance value is 0.055 which is slightly greater than 0.05 which implies that RH and Temp are not making significant impact on the values of PM 10. However, the noteworthy point in this case is that the significance value is quite close to 0.05 therefore the above conclusion ,though acceptable at 5% level of significance but may not hold true if level of significance is increased. The model is reasonably good for predicting movement in PM 10 due to changes in RH and temperature.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
	(Constant)	-421.586	450.092		-.937	.359
1	RH	6.033	5.924	.307	1.018	.319
	Temp	19.285	30.546	.190	.631	.534

a. Dependent Variable: PM10

Table 1.3 : Regression output among variables – PM 10, Temperature and RH

The above output can be represented as

PM 10 = - 421.586 + 6.033 (RH) + 19.285 (Temp)

According to the above equation, increase in RH and Temp have positive impact on the pollutant PM 10. As the beta value of RH is 0.307 higher than beta value of Temp which is 0.190 , this implies change in Relative humidity has higher impact on PM 10 as compared to same amount of change in Temperature.

The multiple regression output with PM 2.5 (Dependent variable) and relative humidity alongwith temperature (Independent variable) is shown below in table 2.1, 2.2 and 2.3.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.354[a]	.125	.049	126.81799

a. Predictors: (Constant), Temp, RH

Table 2.1 : Coefficient of Correlation and Determination between PM 2.5 and independent variables.

The value of R square is 0.125 which implies that independent variables under study ie. RH and temperature explains only 12.5 percent of variation in PM 2.5 (dependent variable). The value of PM 2.5 depends on other factors as well which are not being reflected in this case.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	52858.136	2	26429.068	1.643	.215[b]
	Residual	369904.480	23	16082.803		
	Total	422762.615	25			

a. Dependent Variable: PM2.5

b. Predictors: (Constant), Temp, RH

Table 2.2 : ANOVA output among variables – PM 2.5, Temperature and RH

The significance value is 0.215 which is slightly greater than 0.05 which implies that RH and Temp are not making significant impact on the values of PM 2.5. The model does not provide proper basis for predicting movement in PM 2.5 due to changes in RH and temperature. The preciseness of the model can be increased by adding more variables which are found to have high degree of correlation with PM 2.5.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-11.110	316.727		-.035	.972
	RH	5.080	4.169	.389	1.219	.235
	Temp	-3.110	21.495	-.046	-.145	.886

a. Dependent Variable: PM2.5

Table 2.3 : Regression output among variables – PM 2.5, Temperature and RH

The above output can be represented as

PM 10 = - 11.11 + 5.080 (RH) – 3.110 (Temp)

According to the above equation, increase in RH have positive impact on the pollutant PM 2.5 but increase in temperature has negative impact on PM 2.5. The beta value of RH is 0.389 whereas beta value of Temp which is -0.046 , this implies change in Relative humidity has higher impact on PM 2.5 as compared to same amount of change in Temperature. Further, direction of change is positive between RH and PM 2.5 whereas it is negative in case of Temperature and PM 2.5.

The multiple regression output with NO_2 (Dependent variable) and relative humidity alongwith temperature (Independent variable) is shown below in table 3.1, 3.2 and 3.3.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.556[a]	.310	.250	.98999

a. Predictors: (Constant), Temp, RH

Table 3.1 : Coefficient of Correlation and Determination between NO_2 and independent variables.

The value of R square is 0.310 which implies that independent variables under study ie. RH and temperature explains only 31 percent of variation in NO_2 (dependent variable). The value of NO_2 depends on other factors as well which are not being reflected in this case.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10.112	2	5.056	5.159	.014[b]
	Residual	22.542	23	.980		
	Total	32.654	25			

a. Dependent Variable: NO_2

b. Predictors: (Constant), Temp, RH

Table 3.2 : ANOVA output among variables – NO_2, Temperature and RH

The significance value is 0.014 which is less than 0.05 which implies that RH and Temperature determine the emission of NO_2 to a large extent and the model formed under the study proves effective in predicting movement of NO_2 due to changes in RH and temperature.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	16.158	2.472		6.535	.000
	RH	-.021	.033	-.182	-.643	.526
	Temp	-.237	.168	-.401	-1.413	.171

a. Dependent Variable: NO_2

Table 3.3 : Regression output among variables – NO_2, Temperature and RH

The above output can be represented as

NO_2 = 16.158 -0.021 (RH) – 0.237 (Temp)

According to the above equation, both the independent variables namely RH and Temp have inverse relationship with NO_2. Any increase in their value would result in decreasing NO_2. However, the impact of proportionate decrease would be higher due to change in Temperature than Relative Humidity as the magnitude of the beta value corresponding to temperature is -0.40 compared to -0.182 for RH.

The multiple regression output with CO (Dependent variable) and relative humidity alongwith temperature (Independent variable) is shown below in table 4.1, 4.2 and 4.3.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.209[a]	.044	-.040	.20254

a. Predictors: (Constant), Temp, RH

Table 4.1 : Coefficient of Correlation and Determination between CO and independent variables.

The value of R square is 0.044 which implies that independent variables under study ie. RH and temperature explains only 4.4 percent of variation in CO (dependent variable). The value of CO depends on other factors as well which are not being reflected in this case.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.043	2	.022	.525	.599[b]
	Residual	.943	23	.041		
	Total	.987	25			

a. Dependent Variable: CO

b. Predictors: (Constant), Temp, RH

Table 4.2 : ANOVA output among variables – PM 2.5, Temperature and RH

The significance value is 0.599 which is significantly greater than 0.05 which implies that RH and Temp are not making significant impact on the values of CO. The model does not provide proper basis for predicting movement in CO due to changes in RH and temperature. The preciseness of the model can be increased by exploring variables which have high degree of correlation with CO and subsequently using them as independent variable.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.223	.506		2.418	.024
	RH	.006	.007	.305	.915	.370
	Temp	-.035	.034	-.336	-1.006	.325

a. Dependent Variable: CO

Table 4.3 : Regression output among variables – CO, Temperature and RH

The above output can be represented as

CO = 1.223 + 0.006 (RH) – 0.035 (Temp)

According to the above equation, impact of CO is directly proportional to change in RH whereas it inversely proportional to change in temperature. Any increase in RH value will result in increasing CO whereas increase in temperature would reduce the presence of CO in air pollution. The magnitude of impact due to change in variables on CO are almost same though in opposite direction as beta value of RH is 0.305 and for Temp , it is -0.336.

The multiple regression output with SO_2 (Dependent variable) and relative humidity alongwith temperature (Independent variable) is shown below in table 5.1, 5.2 and 5.3.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.347[a]	.121	.044	7.36881

a. Predictors: (Constant), Temp, RH

Table 5.1 : Coefficient of Correlation and Determination between SO_2 and independent variables.

The value of R square is 0.121 which implies that independent variables under study ie. RH and temperature explains only 12.1 percent of variation in SO_2 (dependent variable). The value of SO_2 depends on other factors as well which are not being reflected in this case

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
	Regression	171.154	2	85.577	1.576	.228[b]
1	Residual	1248.884	23	54.299		
	Total	1420.038	25			

a. Dependent Variable: SO_2

b. Predictors: (Constant), Temp, RH

Table 2.2 : ANOVA output among variables – SO_2, Temperature and RH

The significance value is 0.228 which is greater than 0.05 which implies that RH and Temp are not making significant impact on the values of SO_2. The model does not provide proper basis for predicting movement in SO_2 due to changes in RH and temperature. The preciseness of the model can be increased by adding more variables which are found to have high degree of correlation with SO_2.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	64.793	18.404		3.521	.002
	RH	-.069	.242	-.091	-.284	.779
	Temp	-1.056	1.249	-.271	-.846	.406

a. Dependent Variable: SO_2

The above output can be represented as

$$SO_2 = 64.793 - 0.069 (RH) - 1.056 (Temp)$$

According to the above equation, both the independent variables namely RH and Temp have inverse relationship with SO_2. Any increase in their value would result in decreasing SO_2. However, the impact of proportionate decrease would be higher due to change in Temperature than Relative Humidity as the magnitude of the beta value corresponding to temperature is -0.271 compared to -0.091 for RH.

Conclusion

The study clearly reflects that the extent of various constituents in polluted air exhibit different relationship with varying level of relative humidity and temperature. Certain pollutants such as NO_2 are largely determined by level of Relative Humidity and temperature in comparison to other pollutants under study. Both the pollutants, SO_2 and NO_2, exhibited negative relationship with Relative Humidity and temperature whereas CO and PM 2.5 exhibited positive relationship with RH and negative relationship with temperature. In contrast to these pollutant such as PM 10 exhibited positive relationship with both RH and temperature. The extent to which these pollutants are affected at varying level of RH and Temperature also differ significantly. Thus, the level of

PM 2.5 and PM 10 is dependent more on other factors such as dust from construction activities, emission due to combustion of fuels through vehicles, factories, households, etc. The problem arising from combustion of fuels through vehicles is more prominent in urban cities and therefore to control this problem, various preventive steps such as reducing use of fuel, proper maintenance of vehicles, covering areas under construction activities through dust proof tents, minimizing the burning of garbage and other waste, etc. A small initiative in these directions can be of great help to the entire community and our future generations.

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