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A Study of Meteorological Data and Impact on Pollutants

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Abstract: ***Air pollution is basically a contamination of the indoor or outdoor environment by any chemical, physical or biological agent that alters the natural characteristics of the atmosphere. Household combustion devices, motor vehicles, industrial facilities, agriculture residue burning and forest fires are common sources of air pollution. Pollutants of major public health concern include particulate matter (PM2.5 & PM10), carbon monoxide, ozone, nitrogen dioxide and sulphur dioxide. Outdoor and indoor air pollution cause respiratory and other diseases and are important sources of morbidity and mortality. WHO data show that almost all of the global population (99%) breathe air that exceeds WHO guideline limits and contains high levels of pollutants, with low - and middle - income countries suffering from the highest exposures. Air quality is closely linked to the earth's climate and ecosystems globally. Many of the drivers of air pollution (i. e. combustion of fossil fuels) are also sources of greenhouse gas emissions. Policies to reduce air pollution, therefore, offer a win - win strategy for both climate and health, lowering the burden of disease attributable to air pollution, as well as contributing to the near - and long - term mitigation of climate change.***

Keywords: Pollutants, Humidity, Wind speed, Wind direction, Temperature, Deterministic Dynamic, Stochastic Static simulation, Linear Regression

1. Introduction

The instant study is limited to NCR region of Delhi to properly understand the air pollution, its short term and long - term effects.

The air quality in Delhi, the capital territory of India, according to a WHO survey of 1, 650 world cities, and a survey of 7, 000 world cities by the US - based Health Effects Institute in August 2022, is the worst of any major city in the world. It also affects the districts around Delhi. Air pollution in India is estimated to kill about 2 million people every year; it is the fifth largest killer in India. India has the world's highest death rate from chronic respiratory diseases and asthma, according to the WHO. In Delhi, poor quality air irreversibly damages the lungs of 2.2 million or 50 percent of all children.

On 25 November 2019, the Supreme Court of India made statements on the pollution in Delhi saying "Delhi has become worse than narak (hell) ". Supreme Court Justice Arun Mishra said that it is better to get explosives and kill everyone.

During the COVID - 19 pandemic lockdown in India, The water quality of the Yamuna and Ganges river basins have improved as industries are closed due to the lockdown. The air quality has also significantly improved during the lockdown.

India's Ministry of Earth Sciences published a research paper in October 2018 attributing almost 41% to vehicular emissions, 21.5% to dust and 18% to industries. The director of Centre for Science and Environment alleged that the Society of Indian Automobile Manufacturers is lobbying "against the report" because it is "inconvenient" to the automobile industry.

Air quality index of Delhi is generally in the Good (0–50), Satisfactory (51–100), and Moderate (101–200) levels between March and September, and then it drastically deteriorates to Poor (201–300), Severe (301–400), or Hazardous (401–500+) levels during October to February due to various factors including burning of effigies during Vijayadashami, bursting of firecrackers during Diwali, stubble burning, road dust, vehicle pollution and cold weather. In November 2016, in an event known as the Great Smog of Delhi, the air pollution spiked far beyond acceptable levels. Levels of PM2.5 and PM 10 particulate matter hit 999 micrograms per cubic meter, while the safe limits for those pollutants are 60 and 100 respectively. According to Bloomberg, 16.7 lakh (1, 670, 000) people died due to polluted air in India in the year 2019. Further, according to data released by environment ministry in 2022, the Air Quality Index of Delhi National Capital Region is over 200 for at least half the year.

Air quality index data of Delhi: Table.1

Month	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Average Air quality index	301–400	201–300	101–200	101–200	101–200	101–200	51 - 100	51–100	51 - 100	201 - 300	401 - 500	401–500
	(Severe)	(Poor)	(Moderate)	(Moderate)	(Moderate)	(Moderate)	(Satisfactory)	(Satisfactory)	(Satisfactory)	(Poor)	(Hazardous)	(Hazardous)

AQI range and consequential impacts on human health: Table.2

AQI class (Range)	Health impact	PM_{10} 24 h (μg/m³)	$PM_{2.5}$ 24 h (μg/m³)	SO_2 24 h (μg/m³)	NO_2 24 h (μg/m³)	O_3 8 h (μg/m³)	CO 8 h (mg/m³)	NH_3 24 h (μg/m³)
		Concentration range						
Good (0–50)	Minimal impact	0–50	0–30	0–40	0–40	0–50	0–1	0–200
Satisfactory (51–100)	Minor breathing discomfort, to sensitive people	51–100	31–60	41–80	41–80	51–100	1.1–2	201–400
Moderately polluted (101–200)	Breathing discomfort to the people, with lung disease	101–250	61–90	81–380	81–180	101–168	2.1–10	401–800
Poor (201–300)	Breathing discomfort to people, on prolonged exposure	251–350	91–120	381–800	181–280	169–208	10–17	801–1200
Very poor (301–400)	Respiratory illness to the people, on prolonged exposure	351–430	121–250	801–1600	281–400	209–748	17–34	1200–1800
Severe (401–500)	Respiratory illness to the people, on prolonged exposure	>430	>250	>1600	>400	>748	>34	>1800

Delhi's pollution problem is also caused by the factor of animal agriculture, as smog and other harmful particles are produced by farmers burning their crops in other states since the 1980s. About 80% of agriculturally used land is used for animal agriculture, so animal agriculture can also be attributed as a factor in Delhi's air pollution problem. Initiatives such as a 1, 600km long and 5km wide The Great Green Wall of Aravalli green ecological corridor along Aravalli Range from Gujarat to Delhi which will also connect to the Sivalik Hills range is being considered with planting of 1.35 billion (135 crores) new native trees over 10 years to combat the pollution. In December 2019, IIT Bombay, in partnership with the McKelvey School of Engineering of Washington University in St. Louis, launched the Aerosol and Air Quality Research Facility to study air pollution in India.

On 15 November 2021, Delhi's air quality saw marginal improvement as it reached the lower end of the "severe" category with AQI at 318, according to the System of Air Quality and Weather Forecasting And Research. Delhi CM, Arvind Kejriwal had announced to shut all the schools along with government offices for a week due to the severe air pollution. The AAP government told the Supreme court that they are confident and prepared for a complete lockdown. The Supreme Court asked the centre and states of the NCR region to consider remote work policies for the employees. When the air quality of Delhi on 18 November 2021 slipped to the "severe" category with the AQI at 362, the Supreme Court of India reprimanded the central and state governments asking them to take strict measures to reduce pollution in Delhi and NCR regions.

Gender and age distribution patients of respiratory diseases, Delhi, 2016–2018: Table.3

Variables	Total (N)	Mean	Standard Deviation	Minimum	Maximum
Patients visited	22253	20.3	23.52	0	176
Gender distribution					
Male	8125	7.41	12.04	0	103
Female	14128	12.89	17.37	0	175
Age distribution (Male)					
≥65	4218	72.15	5.15	65	91
45–64	3000	53.23	6.28	45	64
≤44	907	37.61	6.5	4	44
Age female (Female)					
≥65	8009	73.23	6.12	65	93
45–64	5678	56.12	6.3	45	64
≤44	441	37.33	6.23	7	44

- Air pollution severely affects human health. It is found to cause low birth weight in children, tuberculosis, asthma, ischemic heart disease, nasopharyngeal and laryngeal cancers, cataracts, etc.
- According to some research, air pollution can also impair cognitive development.
- Air pollution is associated with infections & diseases that kill around 600, 000 children under five years of age every year.
- Several studies reveal a higher prevalence of symptoms of chronic bronchitis in areas with higher particulate air pollution.
- Nearly 2.5 million people die worldwide each year from the effects of outdoor or indoor air pollution. (National Geographic)
- Air pollution also affects the environment adversely. Many pollutants are greenhouse gases and this leads to global warming. Burning fossil fuels releases carbon dioxide which has the biggest impact on global warming.

Against the background above, the primary objective of this paper to establish the correlation between AQI and meteorological data, pollutants. Studying the varying impacts of meteorological data conducting simulation in datasets in different months like (Jan. - March, April - June, July - September and October - December), also to develop a model so that at least one day forecast of AQI can be made. Objective of study would also to develop a mathematical model for the purpose of calculating AQI in different quarters of the year. Based on this study, necessary measures can be suggested for different time period, which can certainly strengthen the Govt. existing policies in combating with the peculiar problem of air pollution in NCR region.

Depending upon the complete availability of secondary data as required to conduct the study, the data during January, 2019 to June, 2020 have been used.

Sources of data: 1) Meteorological data from official website of NASA 2) Data of pollutants from official website of Central Pollution Control Board, Delhi

Techniques used: ML in Eviews12.0, Deterministic stochastic simulation and linier regression
Descriptive Statistics: Table 4

	AQI	BENZENE	CO	NH3	NO	NO2	NOX	O3	PM10	PM2_5	QV2M	SO2	T2M_MAX	TOLUENE	WD10M	WS10M_MAX	XYLENE
Mean	215.4717	3.435978	1.267349	35.64702	29.00914	41.25415	48.49430	39.52956	195.7972	99.17225	9.562230	13.99673	32.33879	25.89662	214.0989	4.611664	1.050567
Median	191.0000	2.840000	1.130000	33.81000	19.82000	40.05000	39.67000	37.78000	176.2200	73.84000	8.000000	13.25000	33.06000	23.20000	223.6200	4.210000	0.690000
Maximum	659.0000	12.17000	3.660000	70.65000	158.6300	106.0400	195.8100	76.32000	706.5800	582.2800	21.67000	33.50000	47.94000	92.09000	335.0600	10.61000	11.36000
Minimum	51.00000	0.910000	0.520000	21.54000	4.420000	14.36000	13.15000	16.51000	19.51000	10.24000	2.380000	6.670000	13.96000	6.390000	33.56000	1.570000	0.000000
Std. Dev.	111.8049	1.897290	0.505715	8.858064	24.23424	15.44064	28.86891	11.75573	111.0616	78.06358	5.154322	4.503053	8.124481	12.88141	78.47709	1.692217	1.231003
Skewness	0.918349	1.263149	1.698262	1.165420	1.812034	0.573087	1.499449	0.557875	1.132823	1.942869	0.865143	0.845294	- 0.125727	1.397268	- 0.183449	0.828993	3.012724
Kurtosis	3.401075	4.630313	6.244584	4.222865	6.623000	3.273861	5.577196	2.714673	4.373878	7.700976	2.589962	3.589174	1.943548	5.830400	1.733147	3.363997	16.78220
Jarque - Bera	80.55305	206.0391	502.8684	157.9056	598.5092	31.65112	356.3552	30.22880	160.0132	847.8075	72.06774	73.05221	26.87869	360.5777	39.64681	65.67216	5156.732
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000001	0.000000	0.000000	0.000000	0.000000
Sum	117863.0	1879.480	693.2400	19498.92	15868.00	22566.02	26526.38	21622.67	107101.1	54247.22	5230.540	7656.210	17689.32	14165.45	117112.1	2522.580	574.6600
Sum Sq. Dev.	6825178.	1965.441	139.6383	42842.05	320664.9	130173.8	455043.9	75455.69	6734739.	3327281.	14505.60	11071.51	36039.93	90598.23	3362625.	1563.525	827.3913
Observations	547	547	547	547	547	547	547	547	547	547	547	547	547	547	547	547	547

It would be quite imperative to determine the correlation between AQI and other major pollutants and meteorological parameters before proceeding with further analysis. The details of the correlation coefficients and their significance is tabulated below:

Table 5: (Jan - March, 2019)

Sr. No.	Dependent Variable	Pollutants	Correlation Coefficients	Probability
1	AQI	CO	0.84	0.00
2		NH3	0.92	0.00
3		NO2	0.75	0.00
4		O3	- 0.046	0.00
5		PM10	0.91	0.00
6		PM2.5	0.94	0.00
7		SO2	0.11	0.00
8		Temp.	- 0.36	0.00
9		Humidity	- 0.33	0.00
10		Wind direction	- 0.33	0.00
11		Wind speed	- 0.33	0.00

Linear Regression:

Linear regression is a type of supervised machine learning algorithm that computes the linear relationship between a dependent variable and one or more independent features. When the number of the independent feature, is 1 then it is known as Univariate Linear regression, and in the case of more than one feature, it is known as multivariate linear regression. The goal of the algorithm is to find the best linear equation that can predict the value of the dependent variable based on the independent variables. The equation provides a straight line that represents the relationship between the dependent and independent variables. The slope of the line indicates how much the dependent variable changes for a unit change in the independent variable (s).

One of the most important supervised learning tasks is regression. In regression set of records are present with X and Y values and these values are used to learn a function so if you want to predict Y from an unknown X this learned function can be used. In regression we have to find the value of Y, So, a function is required that predicts continuous Y in the case of regression given X as independent features.

Here Y is called a dependent or target variable and X is called an independent variable also known as the predictor of Y. There are many types of functions or modules that can be used for regression. A linear function is the simplest type of function. Here, X may be a single feature or multiple features representing the problem.

Assumption for Linear Regression Model

Linear regression is a powerful tool for understanding and predicting the behaviour of a variable, however, it needs to meet a few conditions in order to be accurate and dependable solutions.

1) Linearity: The independent and dependent variables have a linear relationship with one another. This implies that changes in the dependent variable follow those in the independent variable (s) in a linear fashion.
2) Independence: The observations in the dataset are independent of each other. This means that the value of the dependent variable for one observation does not depend on the value of the dependent variable for another observation.
3) Homoscedasticity: Across all levels of the independent variable (s), the variance of the errors is constant. This indicates that the amount of the independent variable (s) has no impact on the variance of the errors.
4) Normality: The errors in the model are normally distributed.
5) No multicollinearity: There is no high correlation between the independent variables. This indicates that there is little or no correlation between the independent variables.

Hypothesis function for Linear Regression:

As we have assumed earlier that our independent feature is the experience i. e X and the respective salary Y is the dependent variable. Let's assume there is a linear relationship between X and Y then the salary can be predicted using:

Here,

- yi€Y (i=1, 2, ……n) are labels to data (Supervised learning)
- xi€X (i=1, 2, ……. n) are the input independent training data (univariate – one input variable (parameter))
- y^i€Y^i=1, 2, ……. . n) are the predicted values.

The model gets the best regression fit line by finding the best θ1 and θ2 values.

- **θ1:** intercept
- **θ2:** coefficient of x

2. Results and Discussions

January - March, 2019:

Using Least Square (NLS and ARMA)

R - squared	0.929692	Mean dependent var	274.2778
Adjusted R - squared	0.923690	S. D. dependent var	106.3704
S. E. of regression	29.38406	Akaike info criterion	9.683469
Sum squared resid	70800.66	Schwarz criterion	9.905674
Log likelihood	- 427.7561	Hannan - Quinn criter.	9.773075
F - statistic	154.8990	Durbin - Watson stat	1.859928
Prob (F - statistic)	0.000000	Wald F - statistic	229.3790
Prob (Wald F - statistic)	0.000000		

The equation of ordinary least square regression is as below:

$AQI = - 8.39833266661*CO + 3.98647908115*NH3 - 0.598887029333*NO - 0.584886785148*O3 + 0.504746522223*PM10 + 0.403699458944*PM2\_5 - 1.82225827119*SO2 + 28.6126464784$

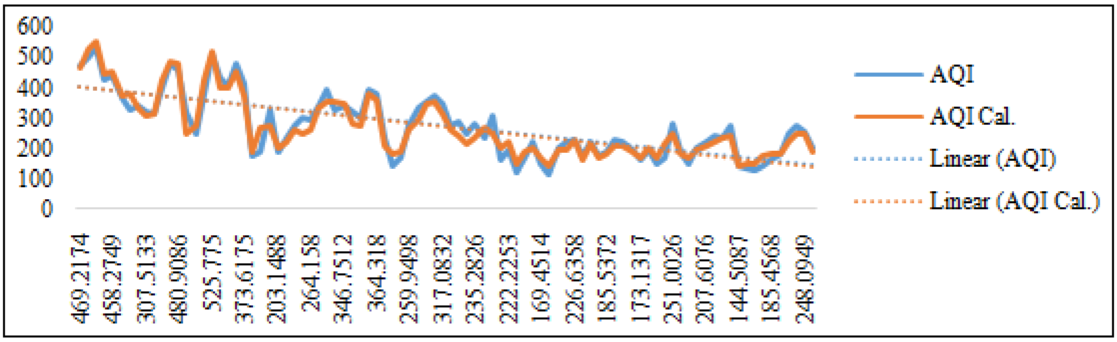

Figure 1: Calculated vs actual AQI during Jan - March, 2019

Using deterministic dynamic simulation in Eviews12.0, annotation in humidity (+20% and - 20%) and its impact on AQI is shown in Fig.2.

Scenario 1 is with +20% humidity

Scenario 6 is with - 20% humidity

NOTE: - Below depicted all scenarios have been created with +20% and - 20% annotation

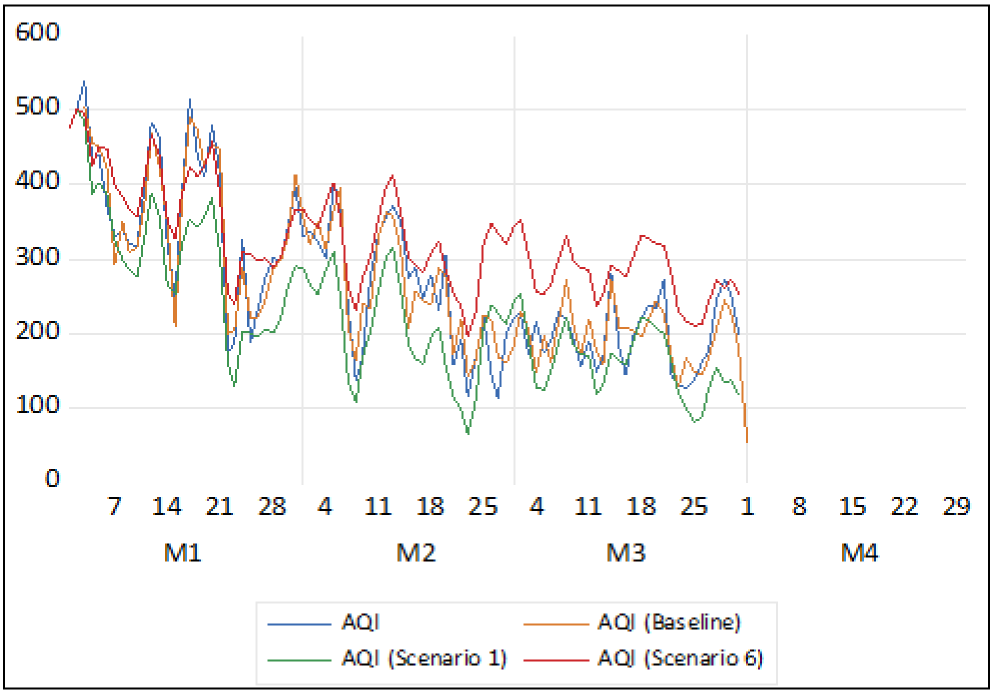

Figure 2: (Effect of humidity on AQI)

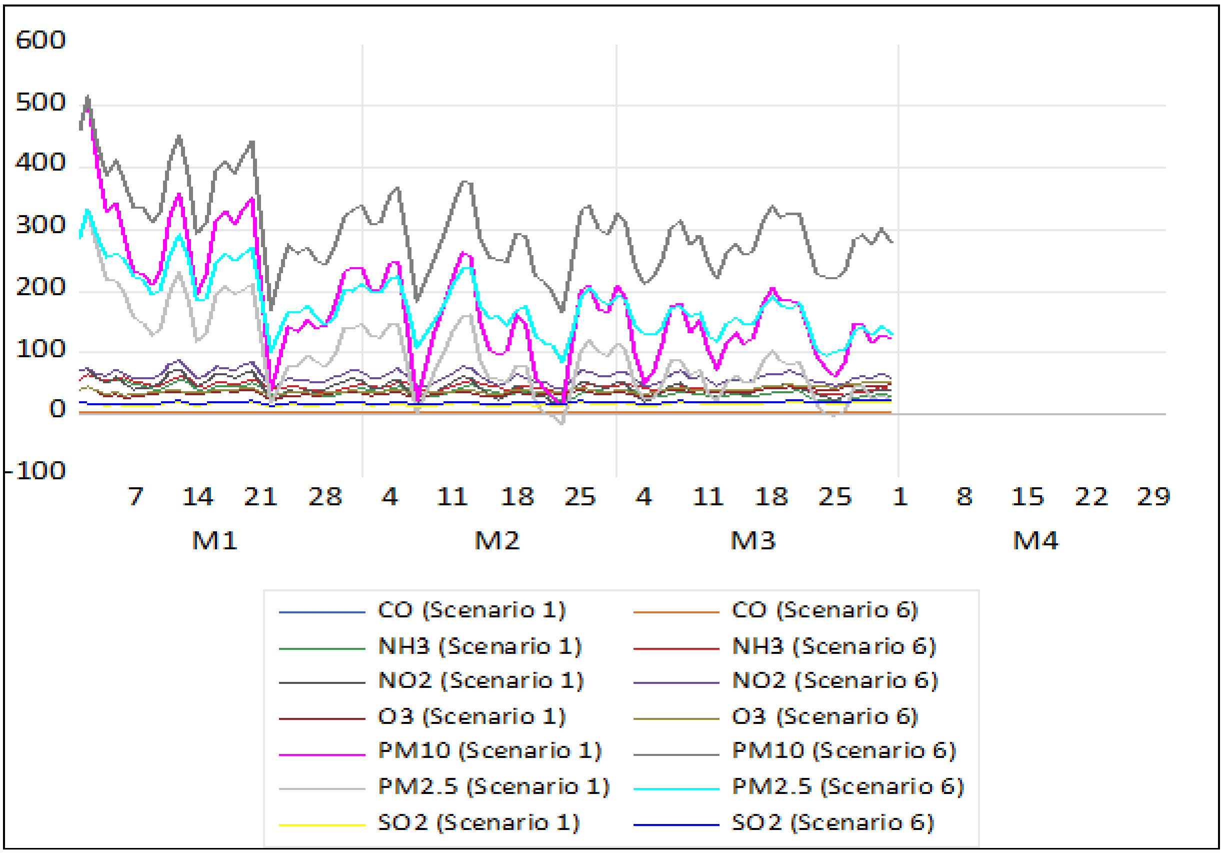

Figure 2: (Effect of humidity on pollutants)

It is observed from the above pattern that except CO, the concentrations of above pollutants increases with increase in humidity and vice - versa.

No. of studies have been conducted in this area to observe the effect of climatic conditions on human health, especially post covid period. Mostly, studies have found strong correlation between meteriological data and pollutants concentration levels and its impact on human body.

In this study, an interesting fact divulged that with increase of only humidity and other atmospheric conditions remain the same, the concentration levels of almost all above pollutants increase, despite the fact above model calculates improved AQI level. Which is in contradiction in respect of other similar studies. The integrity of the model is beyond any doubt depending upon the statistical significance shown above as well as calculated values of AQI quite matching with reported AQI values, which indicates the stability and robustness of model.

The facts behind the above findings are that the humidity can affect pollution dispersion. If humidity is high, pollutants can stick to water droplets and other particles in the air, causing them to be removed from the atmosphere. In turn, this reduces pollutant concentrations and improves air quality. But it can also cause pollution to accumulate on surfaces, which can harm the environment.

Reactions Between Chemicals

Humidity can speed up the chemical reactions that produce air pollutants, like ozone and particulate matter. Basically, water molecules can react with pollutants and other chemicals in the air to create new compounds. In the presence of sunlight, nitrogen oxides and volatile organic compounds may react to form ground - level ozone, which is harmful to the environment. Here too, temperature (factor) plays a part in the chemical process.

Pollutants Movement

Humidity can affect the flow of air pollutants over long distances. Since water molecules attach to air particles and make them heavier, they're more likely to settle down. In different regions, this can have both positive and negative consequences for air quality. Here another discussed factor i. e., wind speed and direction play a major role in the transport of the pollutant.

Affecting Visibility

When humidity levels are high, fog and haze can form and contribute to air pollution. Urban areas that have high levels of particulate matter can be especially vulnerable to this problem. Also, the pollutant type and properties play a role here.

Precipitation: Acid Rain

Humidity also plays a role in precipitation formation, which affects air pollution. High humidity levels can help clouds to form and precipitation to fall, which removes pollutants from the air. But when the precipitation is acidic, it can cause other problems, like acid rain. Temperature and wind in general also affect precipitation.

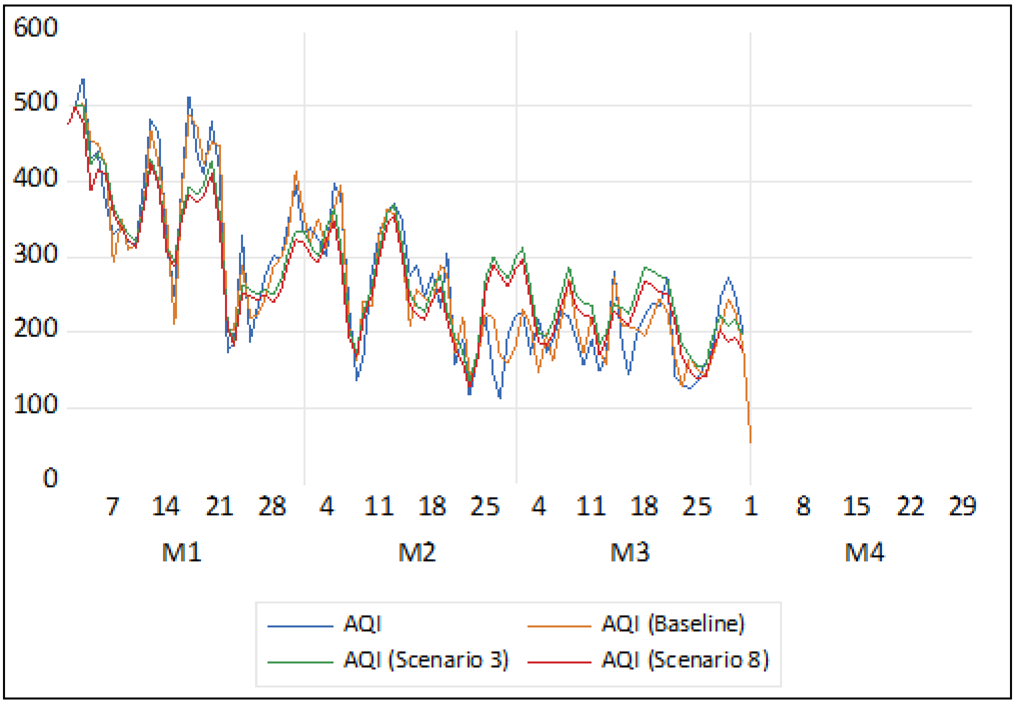

Figure 3: (Effect of temp. on AQI)

Observed that rise in temperature alone with rest of the atmospheric conditions same deteriorates AQI level slightly.

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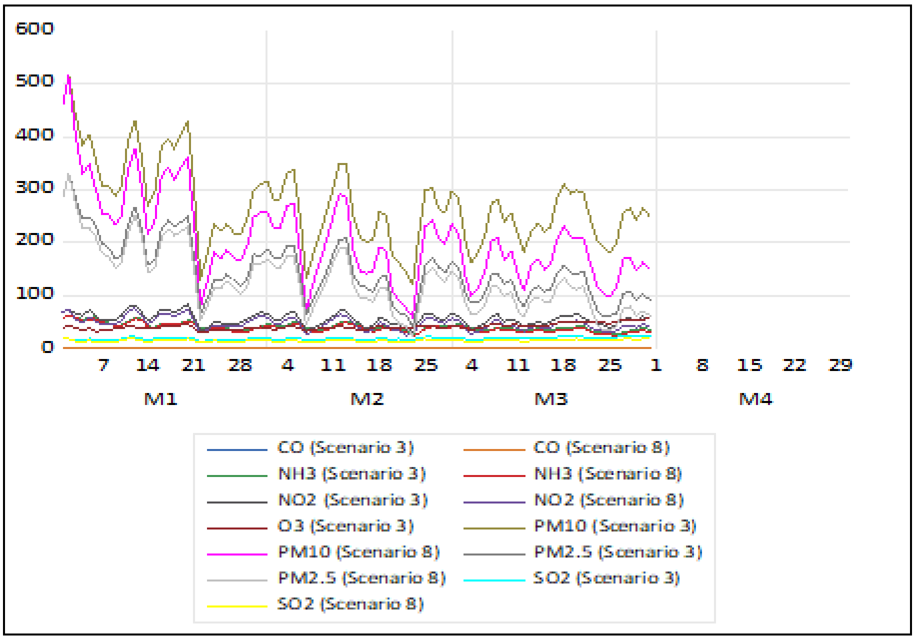

Figure 4: (Effect of temp. on pollutants)

The concentration of all above pollutants increases with rise in temp, except concentration CO. High temperature worsen the air quality problems. During an increased temp. air is often stagnant, so polluted air is not dispersed. Sunlight and high temps also encourage chemical reactions in pollutants and increase smog.

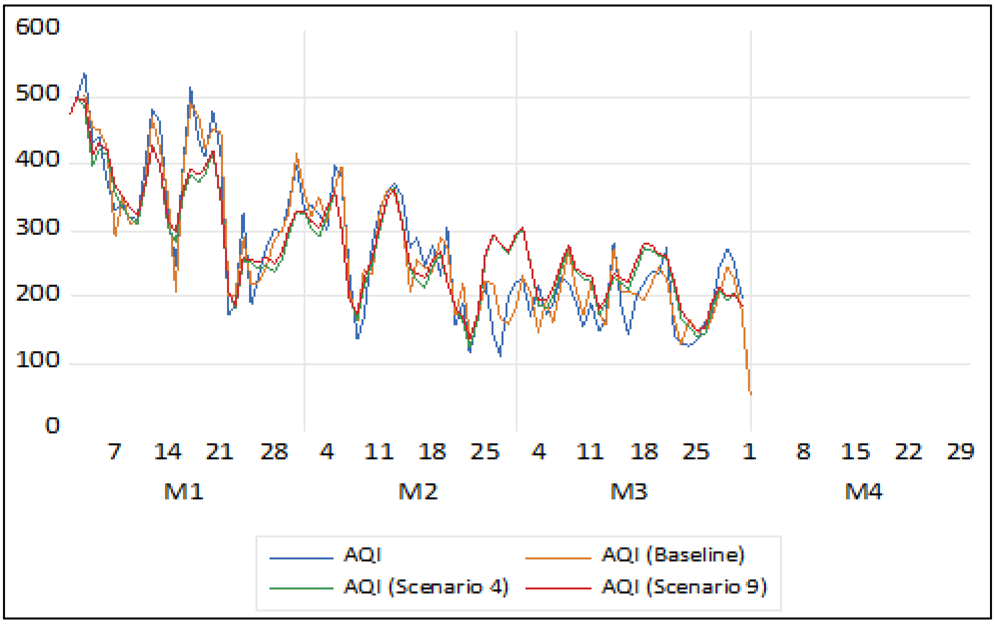

Figure 5: (Effect of Wind direction change on AQI)

Change in direction of wind improves the level of AQI.

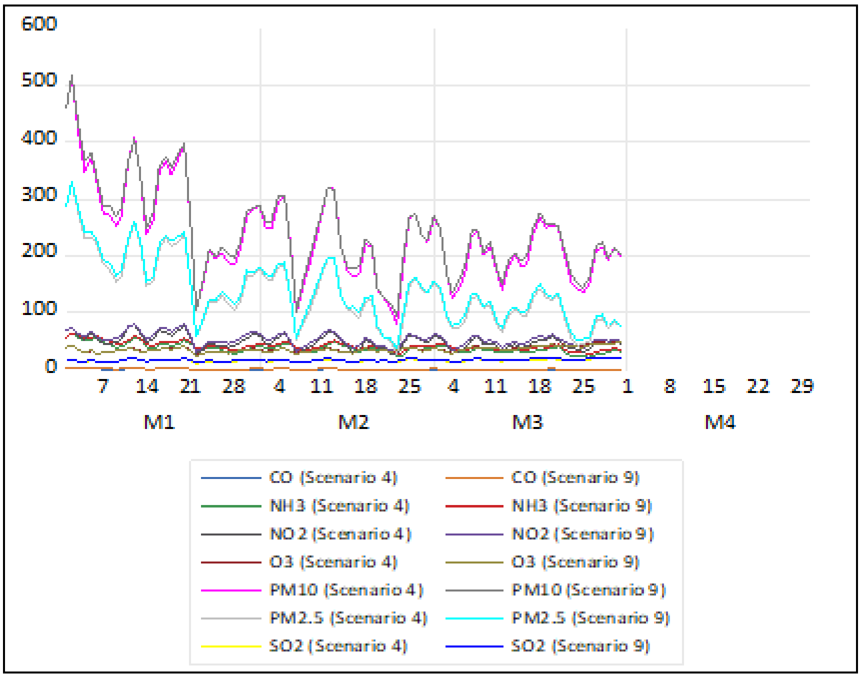

Figure 6: (Effect of Wind Direction on Pollutants)

The concentration of pollutants slightly decreases with change of wind direction. wind speed and direction are an integral part of understanding the complete picture of air pollution. Wind can move air pollution away from its original source, both locally and on global scales, and accounts for historical patterns of air pollution disparities according to prevailing wind patterns. Understanding wind speed and direction can help pinpoint air pollution sources, allowing for more informed decisions to better protect human and environmental health.

While wind is not an air pollutant, wind speed and direction data are essential measurements to collect when looking to understand air quality dynamics in a given region. Wind plays an important role in the movement and dispersion of air pollution — we can think of wind speed and direction data as a map of the air quality “landscape”, providing information on where air pollution originates and where it is prone to travel.

Wind itself is simply the movement of air, arising as a result of climatic and weather patterns that cause differences in air pressure. Pockets of warmer and colder air form as sunlight hits the earth, unevenly warming the air due to various geographical features on Earth’s surface and the varying angles at which the sunlight strikes.

Temperature changes in the air cause pressure differences, as warm air rises and leaves an area of low pressure behind it. In lower pressure areas, gases in the air are less dense. Due to the principle of diffusion, gases move from areas of high pressure to low pressure. The greater the difference in the pressure between two areas, the faster the gases will move, creating wind.

On a larger scale, different wind patterns occur in different environments and geographical regions. Sea breezes commonly occur because inland areas heat up on sunny days, warming the air above the land. The cooler air above the sea then moves inland through diffusion, creating a breeze.

Wind disperses the air pollution formed from both natural and anthropogenic activities. Air pollutants that travel higher up into the air can also react to form other types of pollutants. For example, sulfur dioxide and nitrous oxides emitted from upwind sources can undergo chemical reactions in the atmosphere to form particulate matter, and nitrous oxides may also react to form ground - level ozone, or smog. Even though wind may move air pollutants to another geographic location, these pollutants still threaten human and environmental health wherever they settle.

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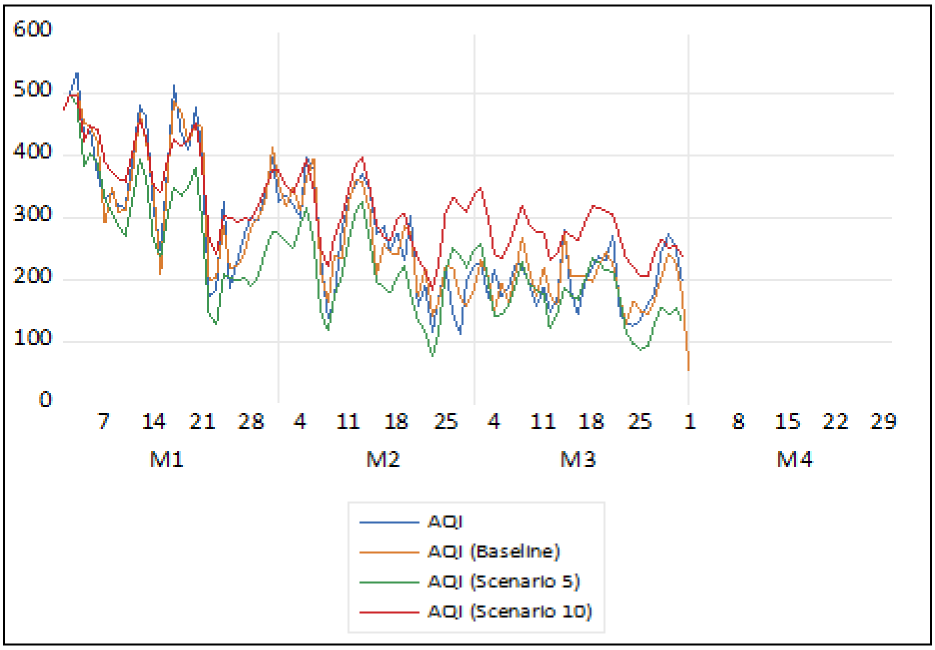

Figure 7: (Effect of Wind Speed on AQI)

Increase in wind speed improves the level of AQI.

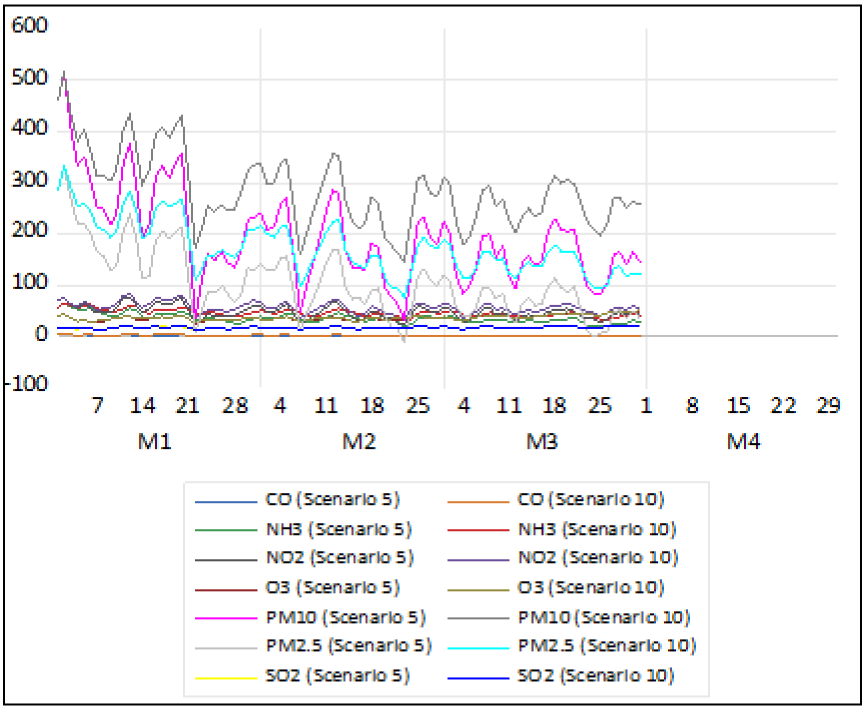

Figure 8: (Effect of Wind Speed on Pollutants)

Increase in wind speed improves the level of almost all pollutants.

April - June, 2019:

R - squared	0.863912	Mean dependent var	217.8681
Adjusted R - squared	0.852435	S. D. dependent var	61.18319
S. E. of regression	23.50306	Akaike info criterion	9.235944
Sum squared resid	45848.70	Schwarz criterion	9.456679
Log likelihood	- 412.2354	Hannan - Quinn criter.	9.324997
F - statistic	75.27126	Durbin - Watson stat	1.952954
Prob (F - statistic)	0.000000		

AQI = 19.8187403865*CO + 0.558790787976*NH3 - 0.686429417559*NO2 + 0.70947884476*O3 + 0.511745587022*PM10 + 0.486892935293*PM2_5 + 12.417887782

Table 6

Sr. No.	Dependent Varaiable	Pollutants	Correlation Coefficients	Probability
1	AQI	CO	0.52	0.00
2		NH3	0.29	0.00
3		NO2	0.41	0.00
4		O3	0.21	0.00
5		PM10	0.90	0.00
6		PM2.5	0.84	0.00
7		SO2	0.52	0.00
8		Temp.	0.37	0.00
9		Humidity	- 0.48	0.00
10		Wind direction	0.05	0.00
11		Wind speed	0.01	0.00

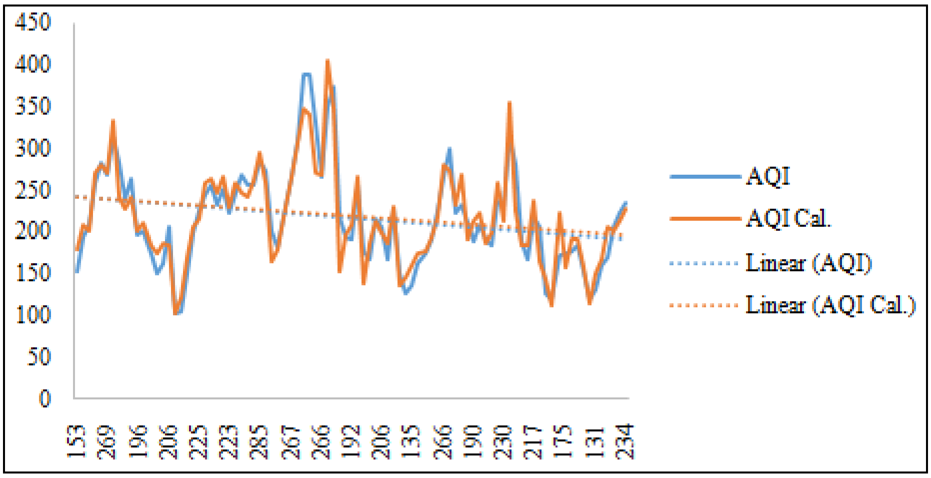

Figure 9: (Calculated vs actual AQI during Apr - June, 2019)

Using deterministic dynamic simulation in Eviews12.0, annotation in humidity (+20% and - 20%) and its impact on AQI is shown in Fig.2.
Scenario 1 is with +20% humidity
Scenario 6 is with - 20% humidity
NOTE: - Below depicted all scenarios have been created with +20% and - 20% annotation

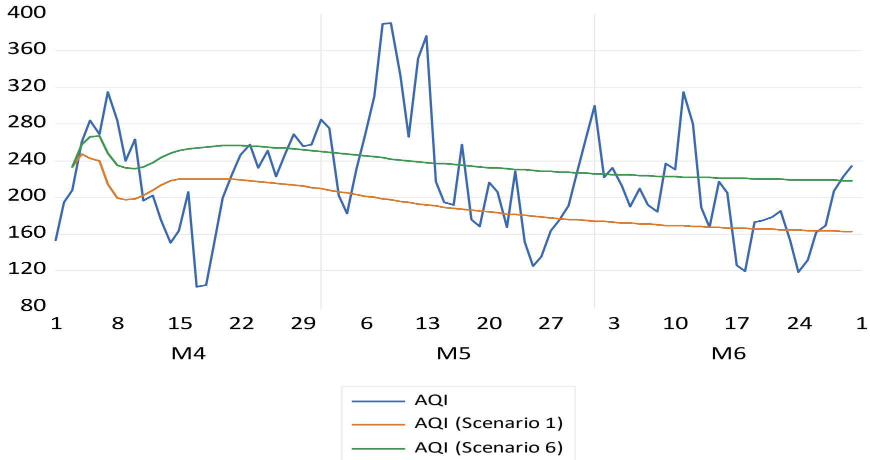

Figure 10: (Effect of Humidity on AQI during Apr - June, 2019)

Increase in humidity significantly improves the AQI level

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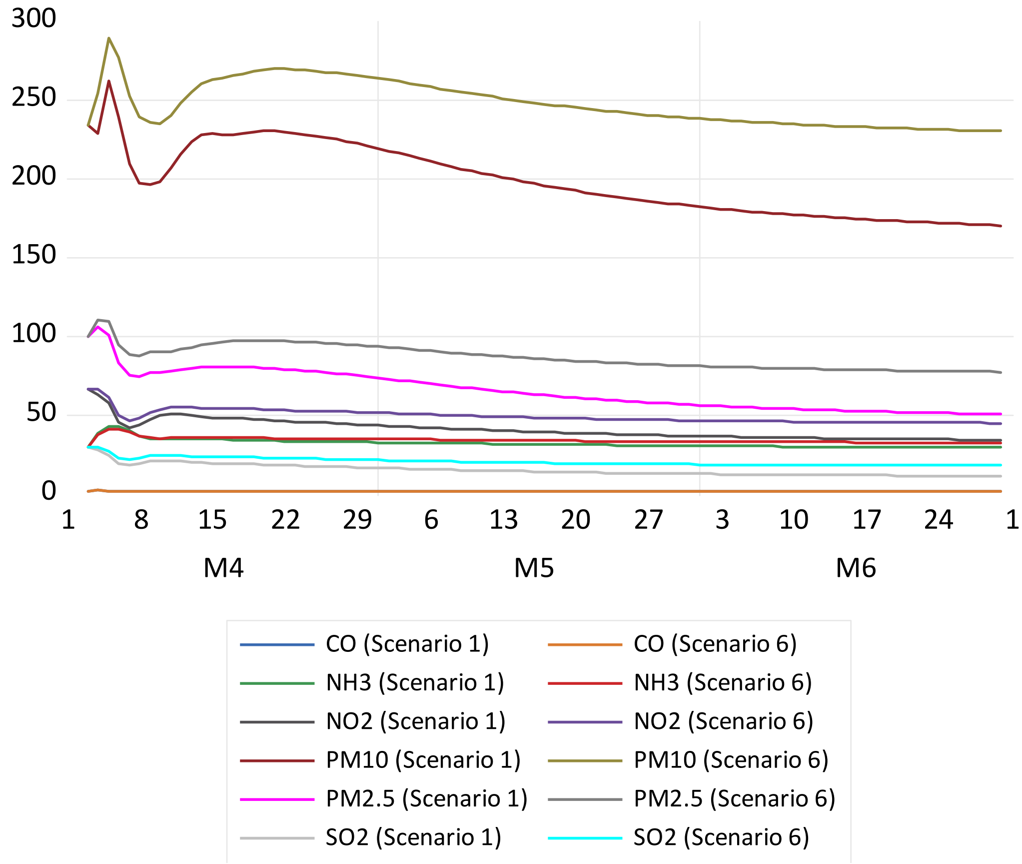


Figure 10: (Effect of Humidity on Pollutants during Apr - June, 2019)

Concentration of all the pollutants improve with increased humidity.

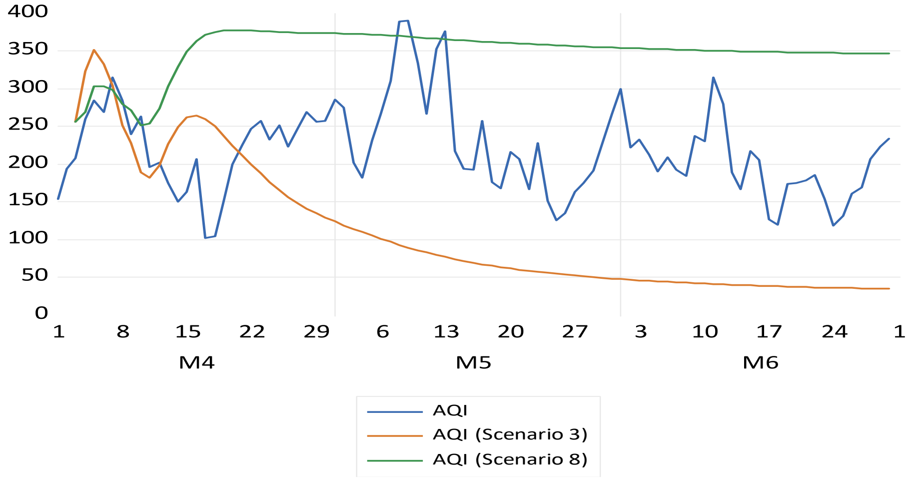


Figure 11: (Effect of Temp. on AQI during Apr - June, 2019)

Increase in temp. significantly improves the AQI level.

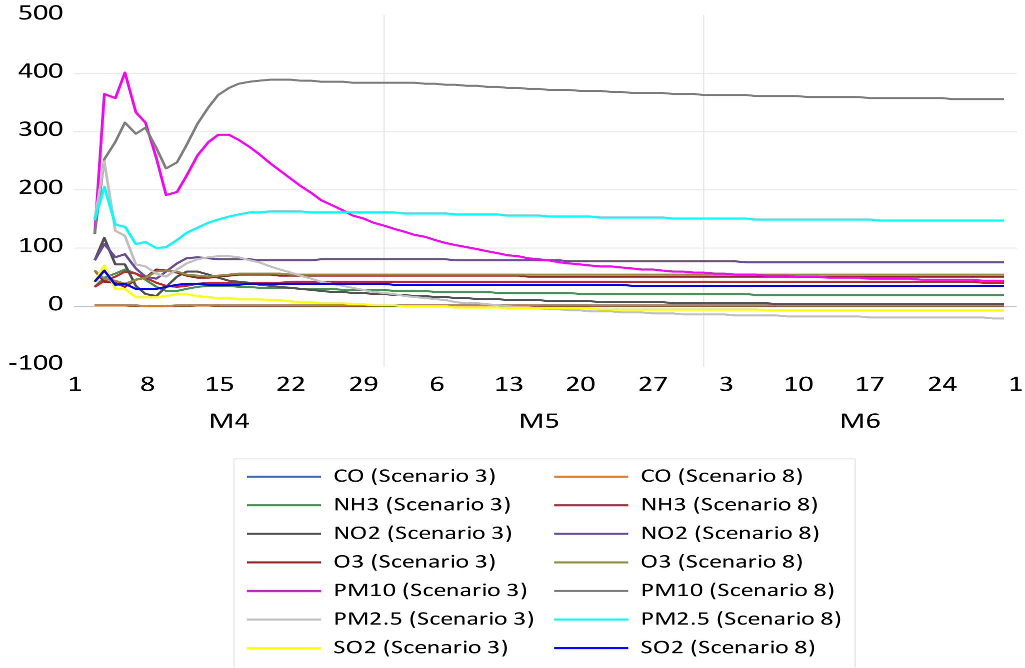


Figure 12: (Effect of Temp. on Pollutants during Apr - June, 2019)

Increase in temp. significantly improves the concentration level of pollutants

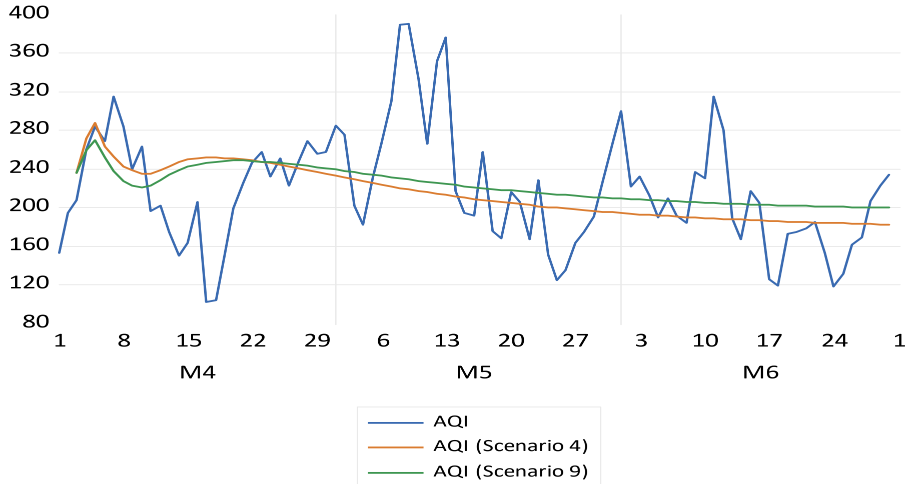


Figure 13: (Effect of Wind direction on AQI during Apr - June, 2019)

Change in wind direction also improves the AQI level.

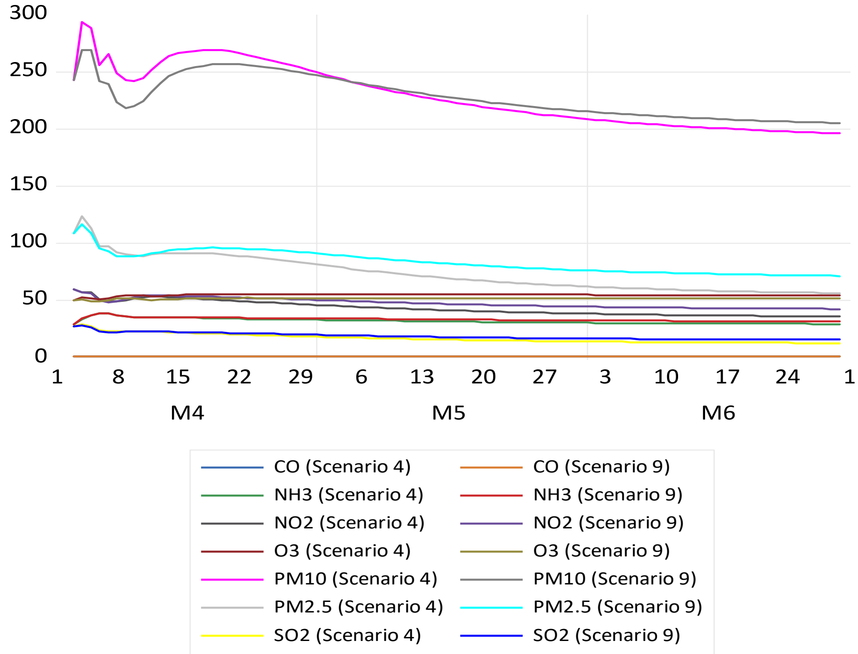


Figure 13: (Effect of Wind direction on Pollutants during Apr - June, 2019)

Change in wind direction also improves the concentration level of pollutants

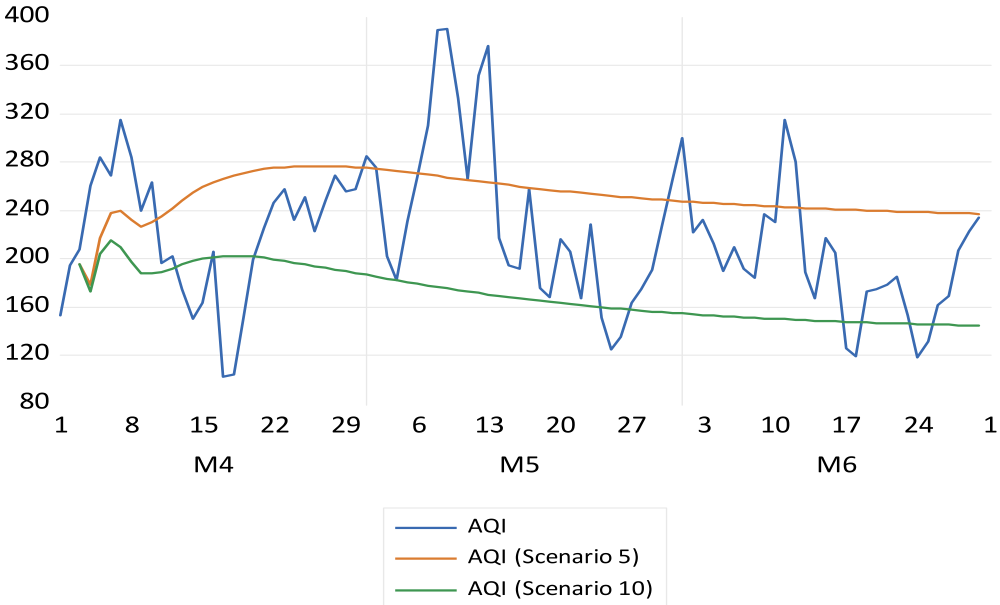


Figure 14: (Effect of Wind speed on AQI during Apr - June, 2019)

Adverse effect has been observed, as wind speed increases AQI level also increases and vice - versa during April - June, 2019

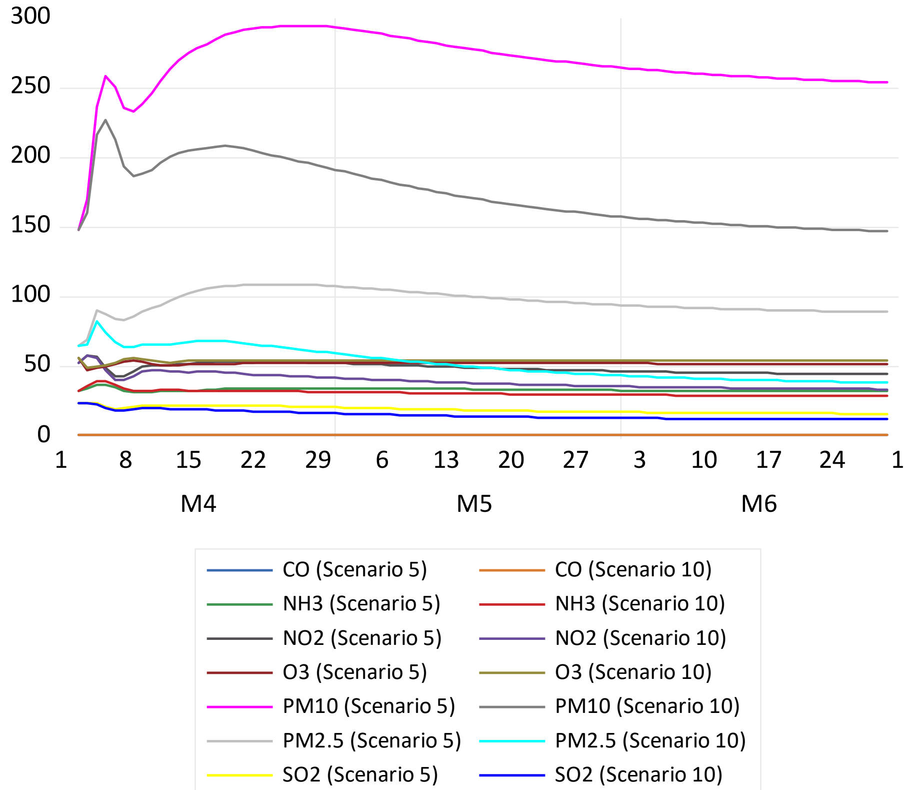


Figure 15: (Effect of Wind speed on pollutants during Apr - June, 2019)

Adverse effect has also been observed, as wind speed increases concentration level of pollutants also increases and vice - versa during April_June

July - September, 2019:

R - squared	0.883954	Mean dependent var	117.0870
Adjusted R - squared	0.874284	S. D. dependent var	46.40212
S. E. of regression	16.45255	Akaike info criterion	8.521779
Sum squared resid	22737.65	Schwarz criterion	8.741065
Log likelihood	- 384.0018	Hannan - Quinn criter.	8.610285
F - statistic	91.40768	Durbin - Watson stat	1.869289
Prob (F - statistic)	0.000000	Wald F - statistic	83.48631
Prob (Wald F - statistic)	0.000000		

AQI = 14.2880516858*CO + 0.588447973256*NH3 - 0.936895148957*NO2 + 0.524179303388*O3 + 0.734334300401*PM10 - 0.272536747307*PM2_5 - 1.69872135893*SO2 + 44.7420994934

Table 7

Sr. No.	Dependent Varaiable	Pollutants	Correlation Coefficients	Probability
	AQI	CO	0.23	0.00
		NH3	0.21	0.00
		NO2	0.20	0.00
		O3	0.42	0.00
		PM10	0.93	0.00
		PM2.5	0.76	0.00
		SO2	0.27	0.00
		Temp.	0.69	0.00
		Humidity	- 0.52	0.00
		Wind direction	0.42	0.00
		Wind speed	0.29	0.00

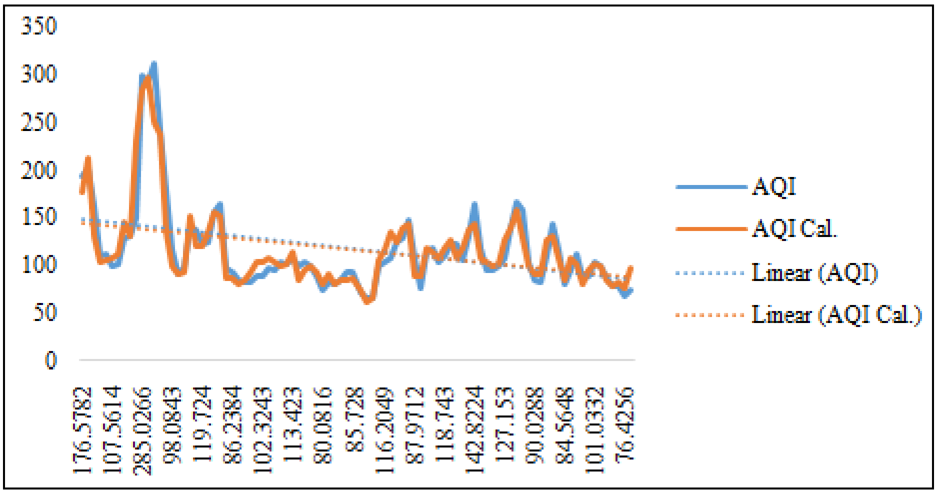


Figure 16: (Calculated vs actual AQI during Apr - June, 2019)

Using deterministic dynamic simulation in Eviews12.0, annotation in humidity (+20% and - 20%) and its impact on AQI is shown in Fig.17.

Scenario 1 is with +20% humidity

Scenario 6 is with - 20% humidity

NOTE: - Below depicted all scenarios have been created with +20% and - 20% annotation

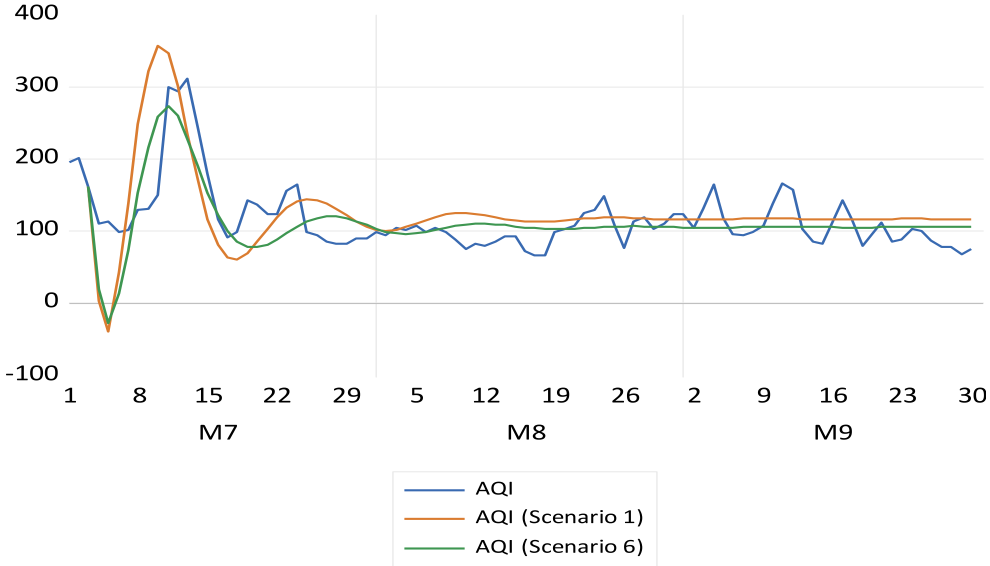


Figure 17: (Effect of Humidity on AQI during July - September, 2019)

Increase in humidity slightly increases level of AQI and vice - versa during July - September, 2019

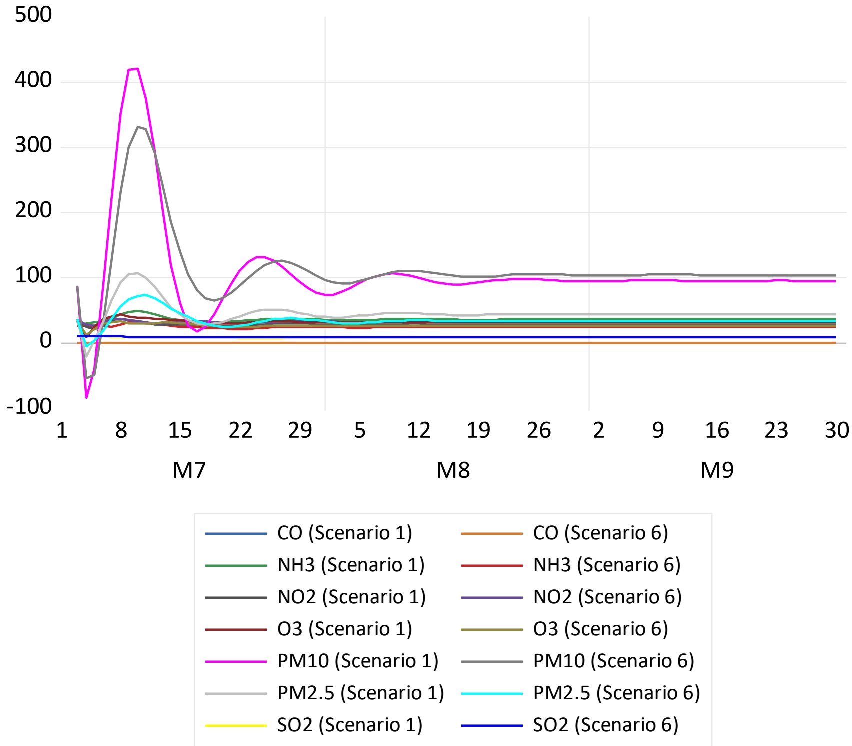


Figure 17: (Effect of Humidity on pollutants during July - September, 2019)

With increase in humidity, concentration of PM10, PM2.5 decreases in month of July, however afterward concentration of PM2.5, PM10 increases, rest of the pollutants do not get effected much.

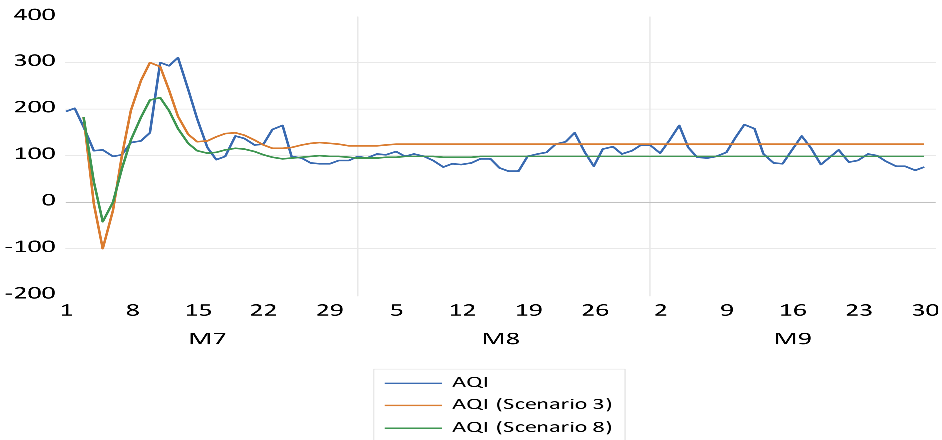


Figure 18: (Effect of Temp. on AQI during July - September, 2019)

Increase in temp. also increases the level of AQI during July - September, 2019

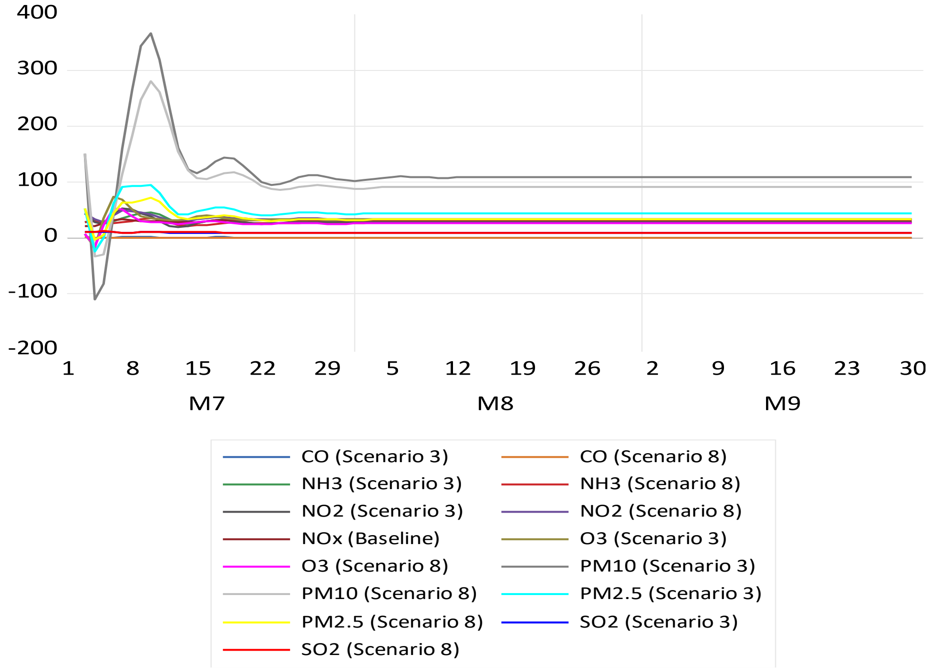


Figure 19: (Effect of Temp. on pollutants during July - September, 2019)

Increase in temp. also increases the concentration level of pollutants during July - September, 2019

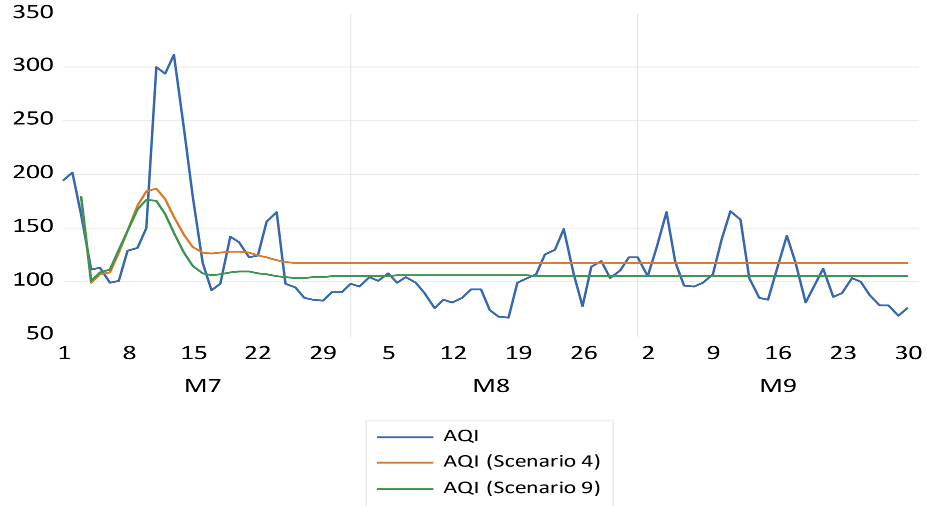


Figure 20: (Effect of Wind direction on AQI during July - September, 2019)

Change in wind direction improves the AQI level.

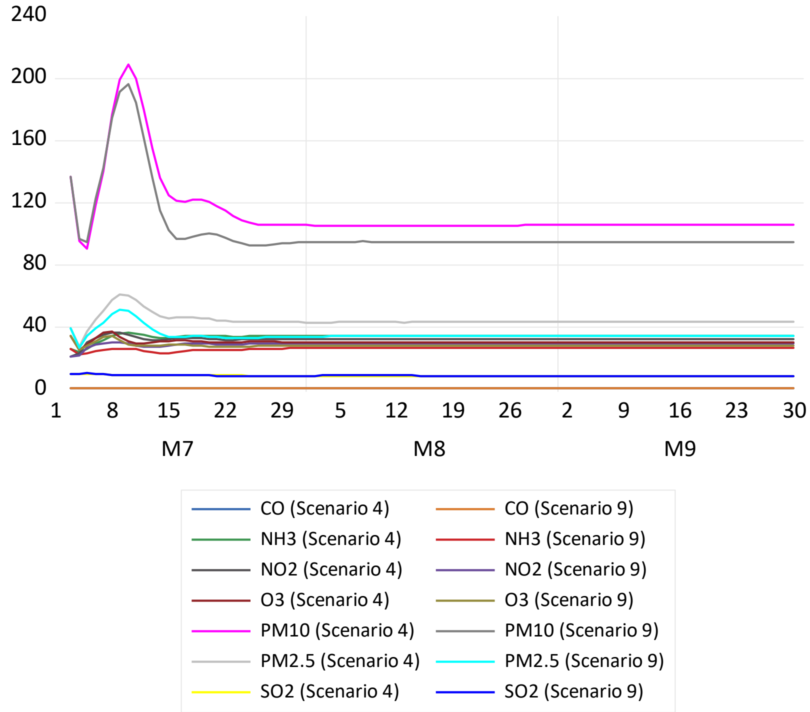


Figure 21: (Effect of Wind direction on pollutants during July - September, 2019)

Change in wind direction improves the concentration level of pollutants.

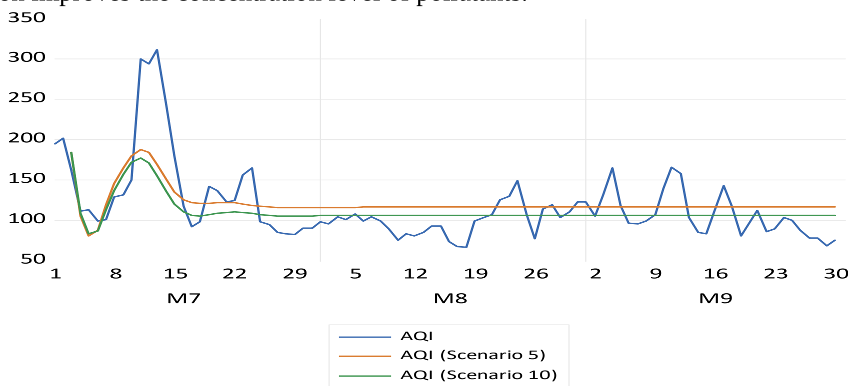


Figure 22: (Effect of Wind speed on AQI during July - September, 2019)

Change in wind speed increases the level of AQI.

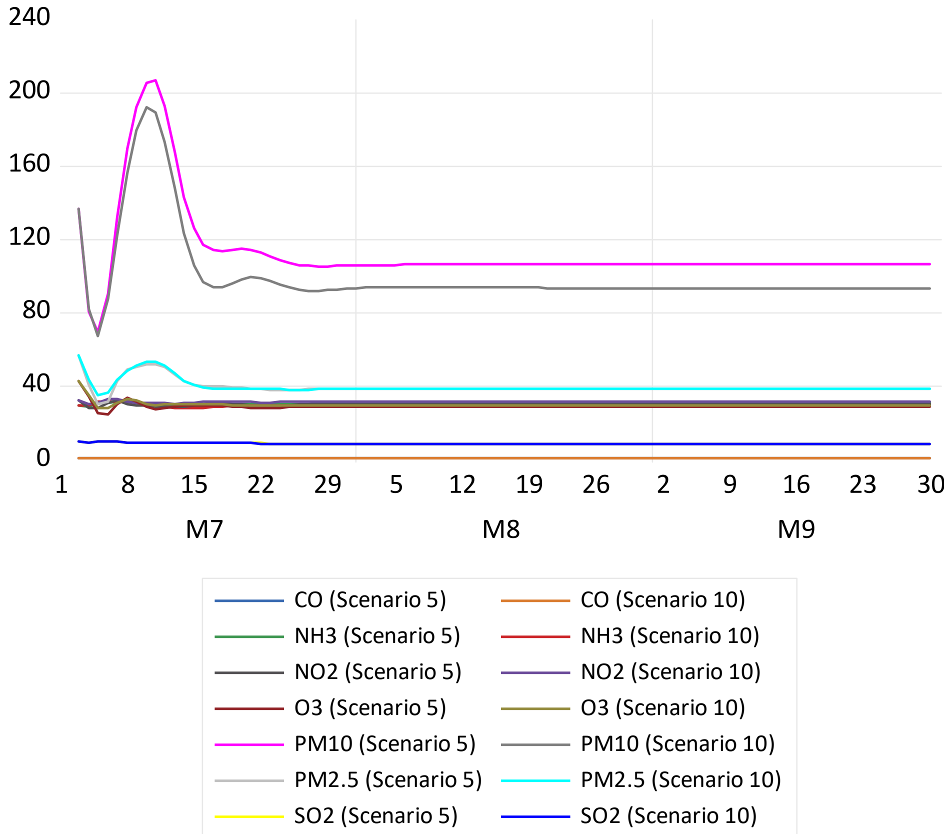


Figure 23: (Effect of Wind speed on Pollutants during July - September, 2019)

Change in wind speed increases the concentration level of Pollutants.

October - December, 2019:

R - squared	0.916746	Mean dependent var	319.9457
Adjusted R - squared	0.909808	S. D. dependent var	123.5255
S. E. of regression	37.09723	Akaike info criterion	10.14790
Sum squared resid	115601.2	Schwarz criterion	10.36719
Log likelihood	- 458.8035	Hannan - Quinn criter.	10.23641
F - statistic	132.1364	Durbin - Watson stat	1.446010
Prob (F - statistic)	0.000000		

AQI = - 49.7912783544*CO + 3.03173772943*NH3 - 0.799240489602*NO2 - 1.13200383341*O3 + 0.692312906671*PM10 + 0.184836569167*PM2_5 + 10.890639826*SO2 - 0.409422968578

Table 8

Sr. No.	Dependent Variable	Pollutants	Correlation Coefficients	Probability
1	AQI	CO	0.73	0.00
2		NH3	0.73	0.00
3		NO2	0.60	0.00
4		O3	0.06	0.00
5		PM10	0.93	0.00
6		PM2.5	0.93	0.00
7		SO2	0.42	0.00
8		Temp.	- 0.18	0.00
9		Humidity	- 0.48	0.00
10		Wind direction	- 0.06	0.00
11		Wind speed	0.02	0.00

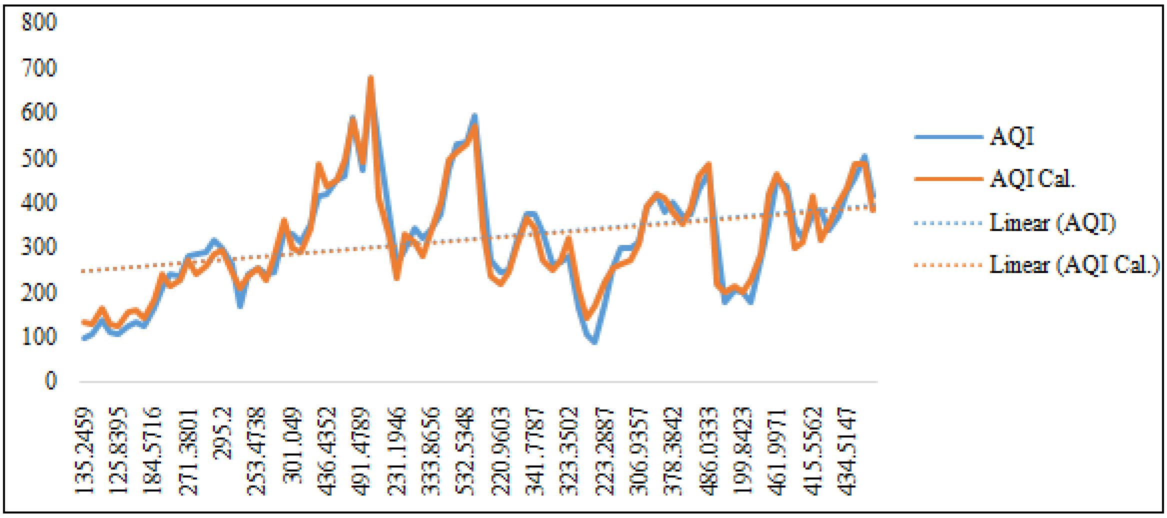


Figure 24: (Calculated vs actual AQI during Oct - Dec, 2019)

Using deterministic dynamic simulation in Eviews12.0, annotation in humidity (+20% and - 20%) and its impact on AQI is shown in Fig.25.
Scenario 1 is with +20% humidity
Scenario 6 is with - 20% humidity
NOTE: - Below depicted all scenarios have been created with +20% and - 20% annotation

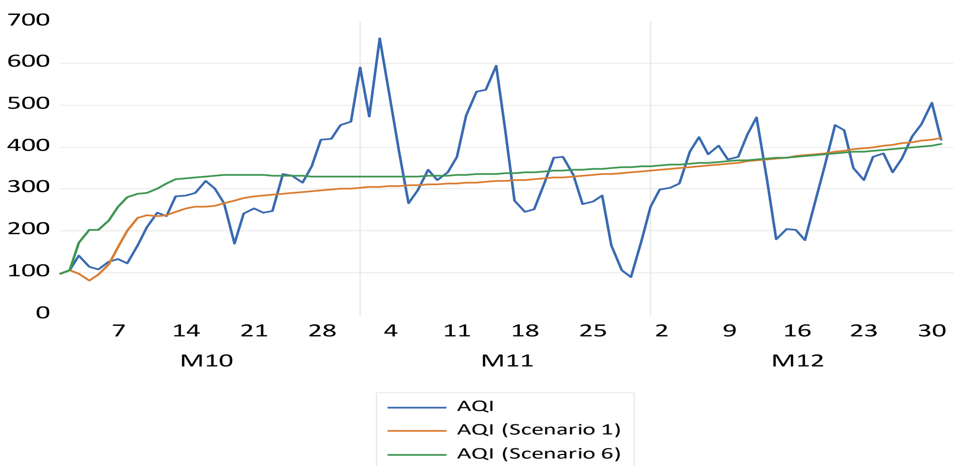


Figure 25: (Effect of Humidity on AQI during Oct - Dec, 2019)

With increase in humidity, initially till mid Dec. AQI level improves thereafter AQI level shows increasing trend

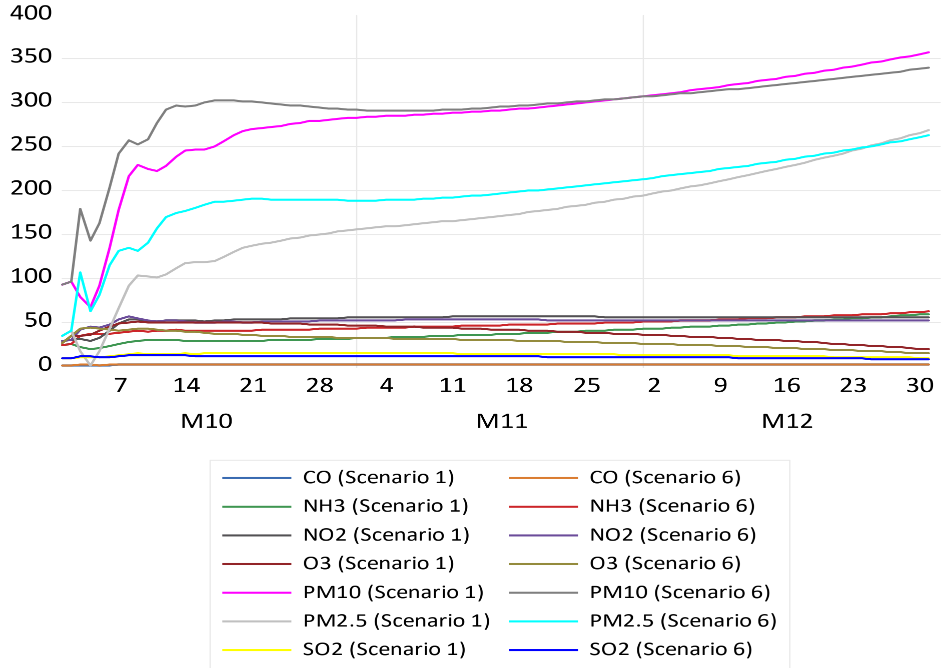


Figure 26: (Effect of Humidity on Pollutants during Oct - Dec, 2019)

With increase in humidity, PM10 initially decreases but shows increasing trend from start of Dec., similarly PM2.5 initially decreases but shows increasing trend from Dec. last. Concentration level of O3 remains on higher side but starts decreasing from Dec. last. Level of NH3 remains on lower side, however starts increasing from Dec. start. Rest of the pollutants do not exhibit significant change in behaviour.

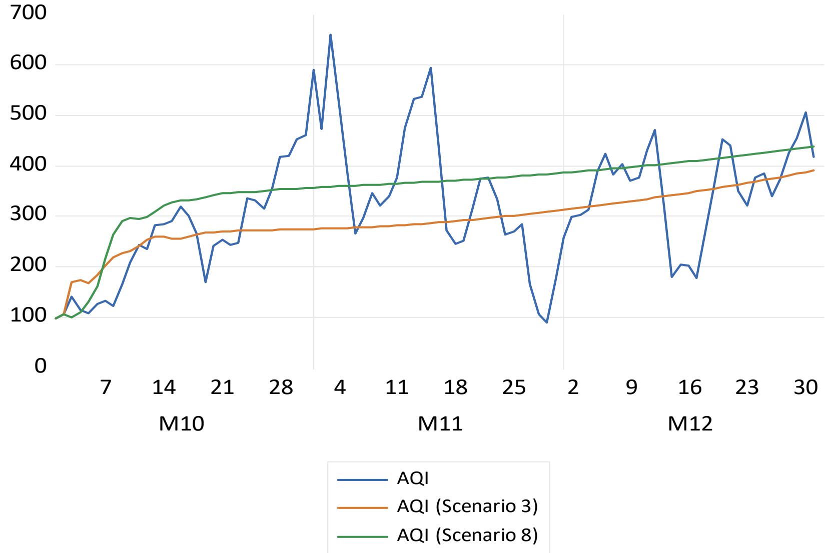


Figure 25: (Effect of Temp. on AQI during Oct - Dec, 2019)

Increased temp. exhibits improved AQI level.

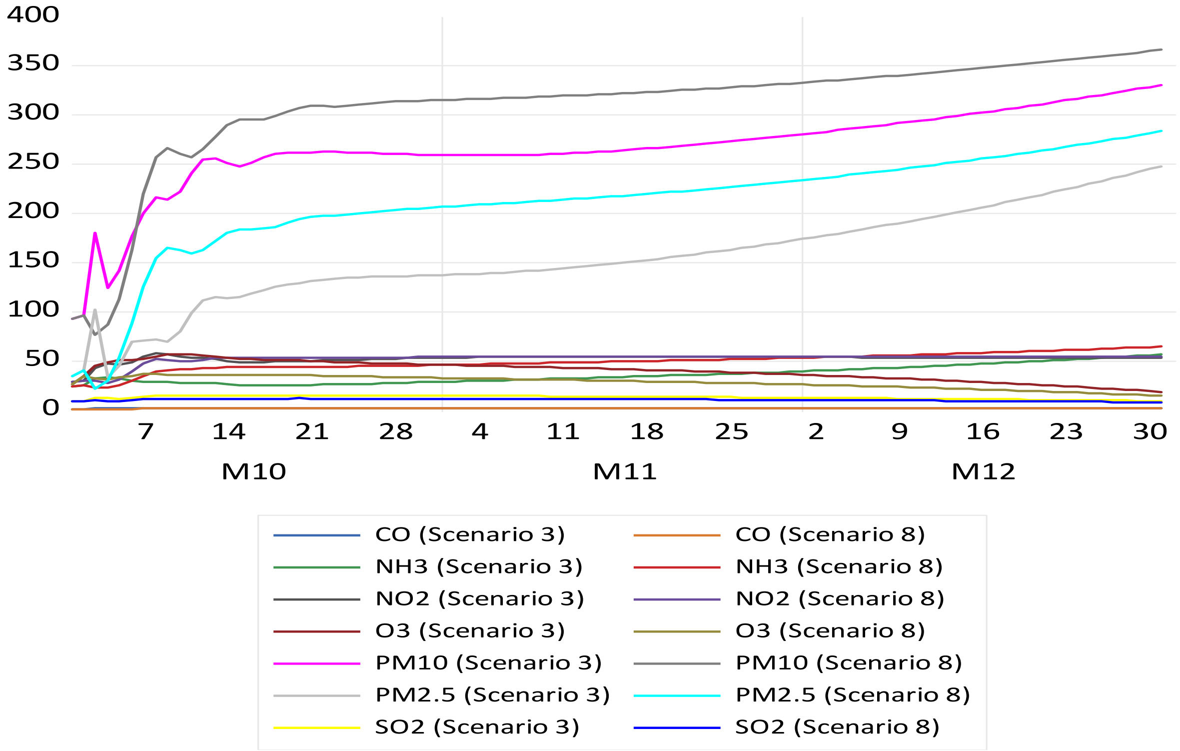


Figure 26: (Effect of Temp. on Pollutants during Oct - Dec, 2019)

With increased temp. concentration level of PM2.5, PM10 improves. Level of O3 remains high, which starts decreasing from start of Dec. NH3 shows increasing trend but under the effect of increased temp. level remains in lower side.

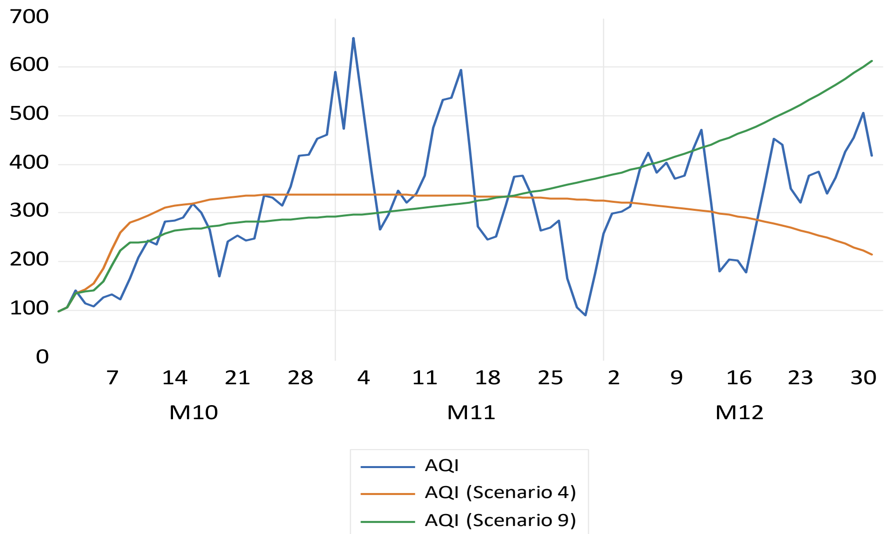


Figure 27: (Effect of wind direction on AQI during Oct - Dec, 2019)

With change in wind direction, AQI level remains on higher side till mid Nov., afterward decreases exponentially.

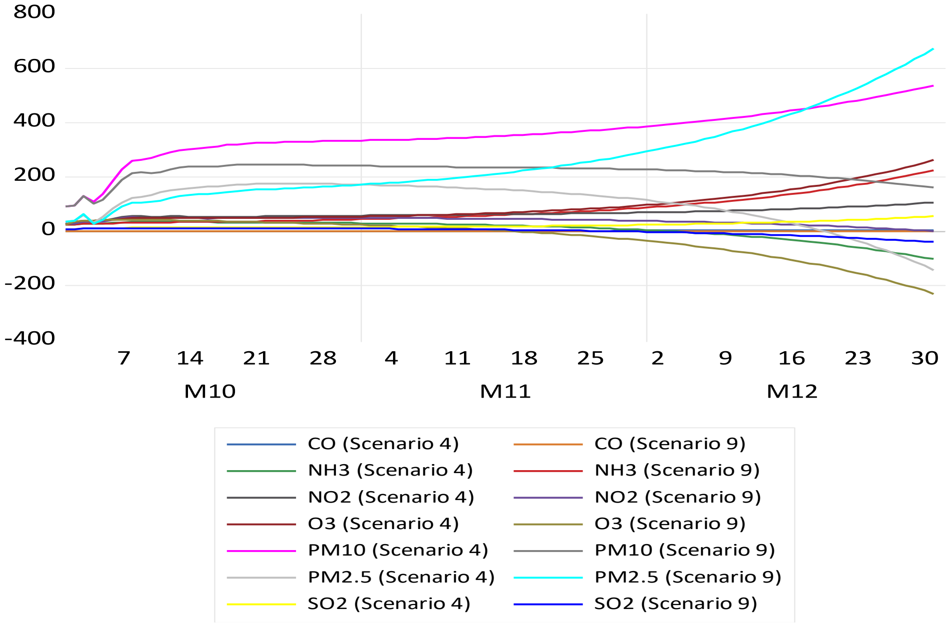


Figure 28: (Effect of wind direction on Pollutants during Oct - Dec, 2019)

With changed wind direction, PM10 remains on lower side, however PM2.5 initially remains upward and from Oct. Last starts decreasing. O3 shows upward trend and NH3 shows downward trend.

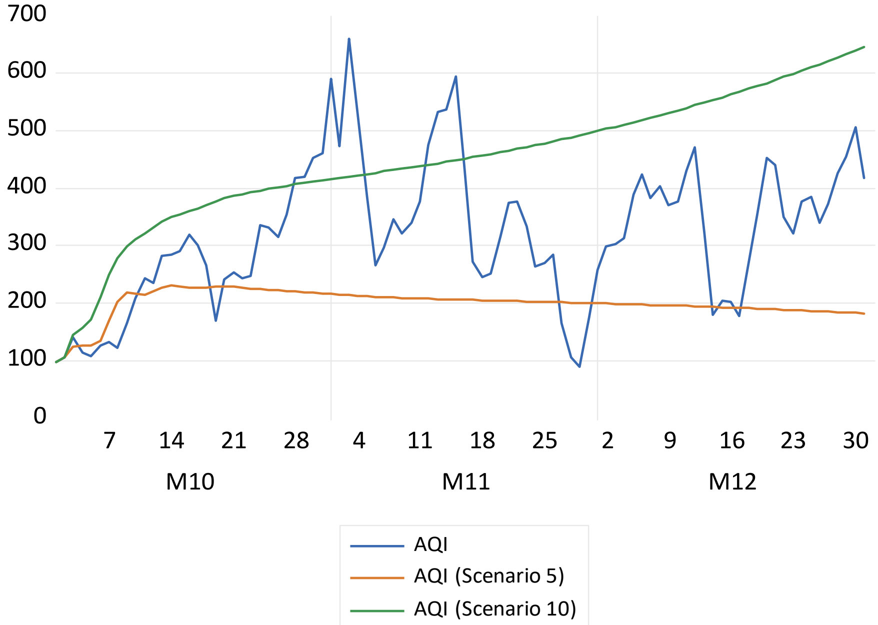


Figure 29: (Effect of wind speed on AQI during Oct - Dec, 2019)

Increased wind speed considerably improves AQI level.

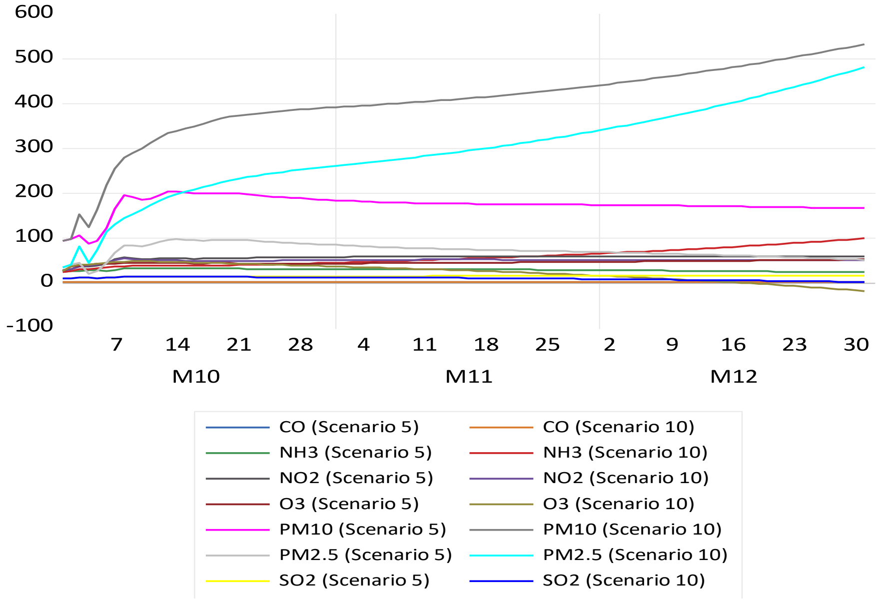
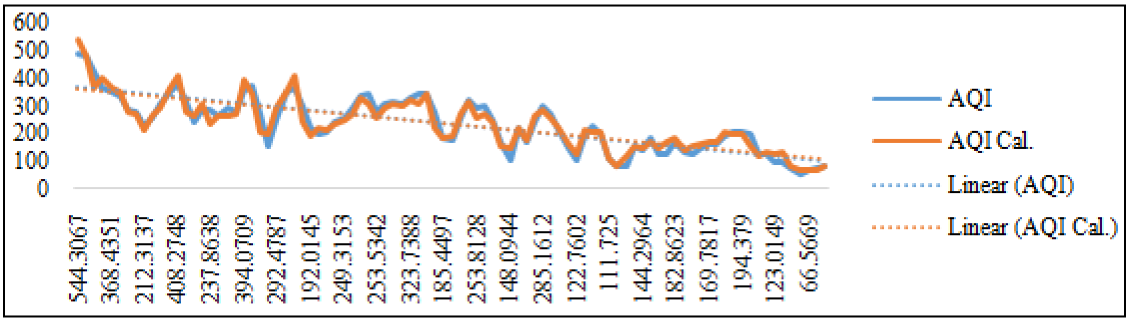


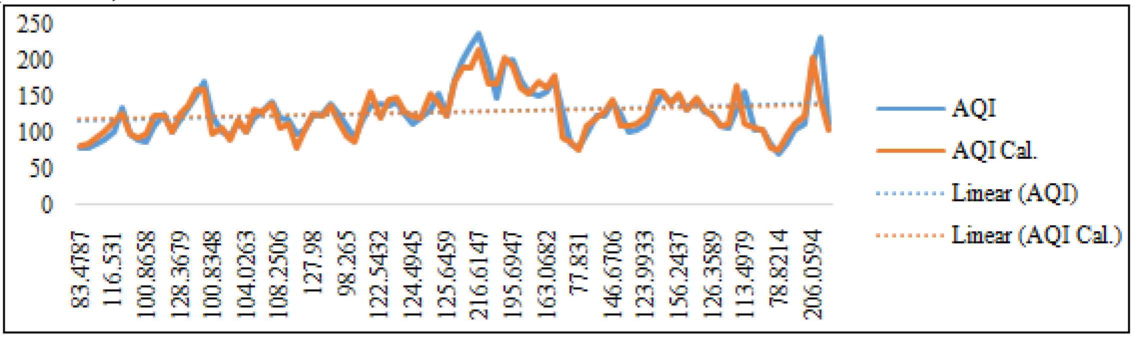
Figure 30: (Effect of wind speed on Pollutants during Oct - Dec, 2019)

Increased wind speed considerably reduces concentration level of PM2.5 and PM10. O3 exhibits upward trend and NH3 downward trend.

Period Jan - March, 2020



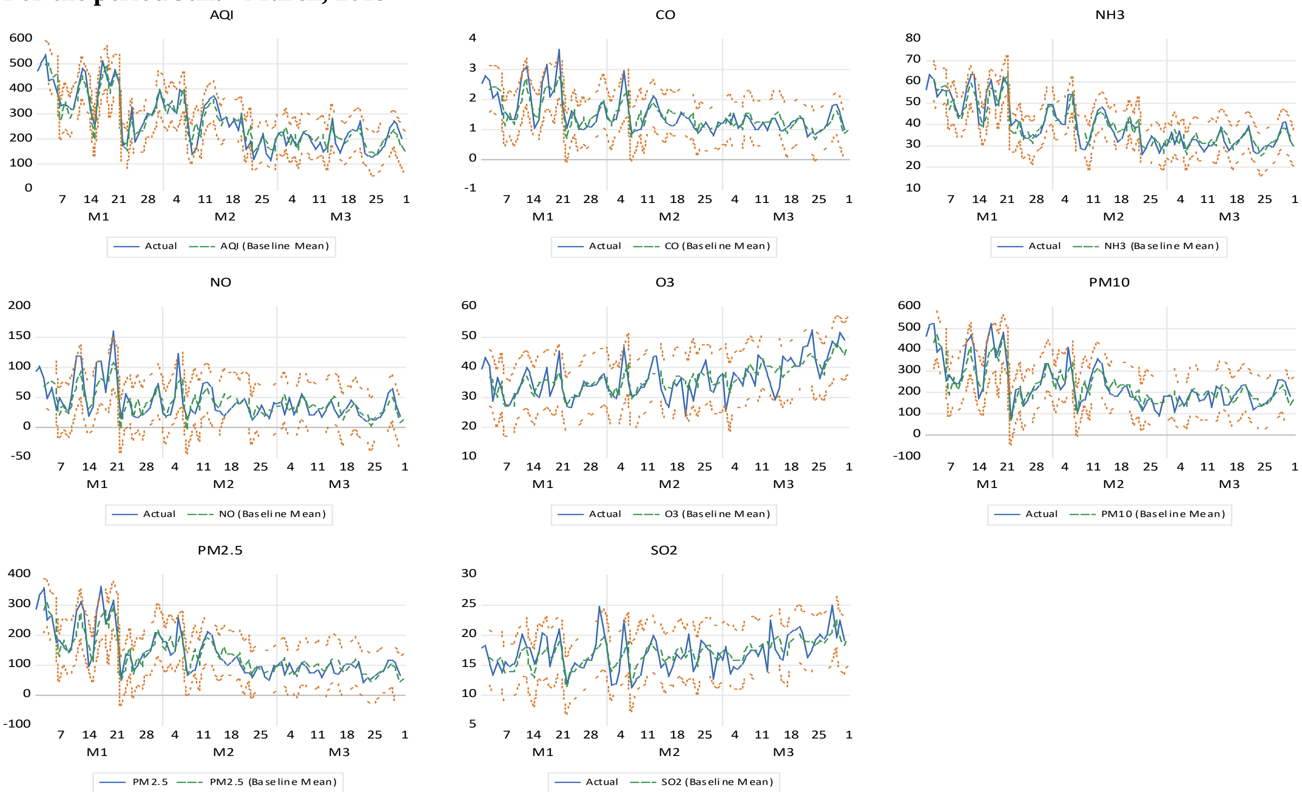
Period April - June, 2020



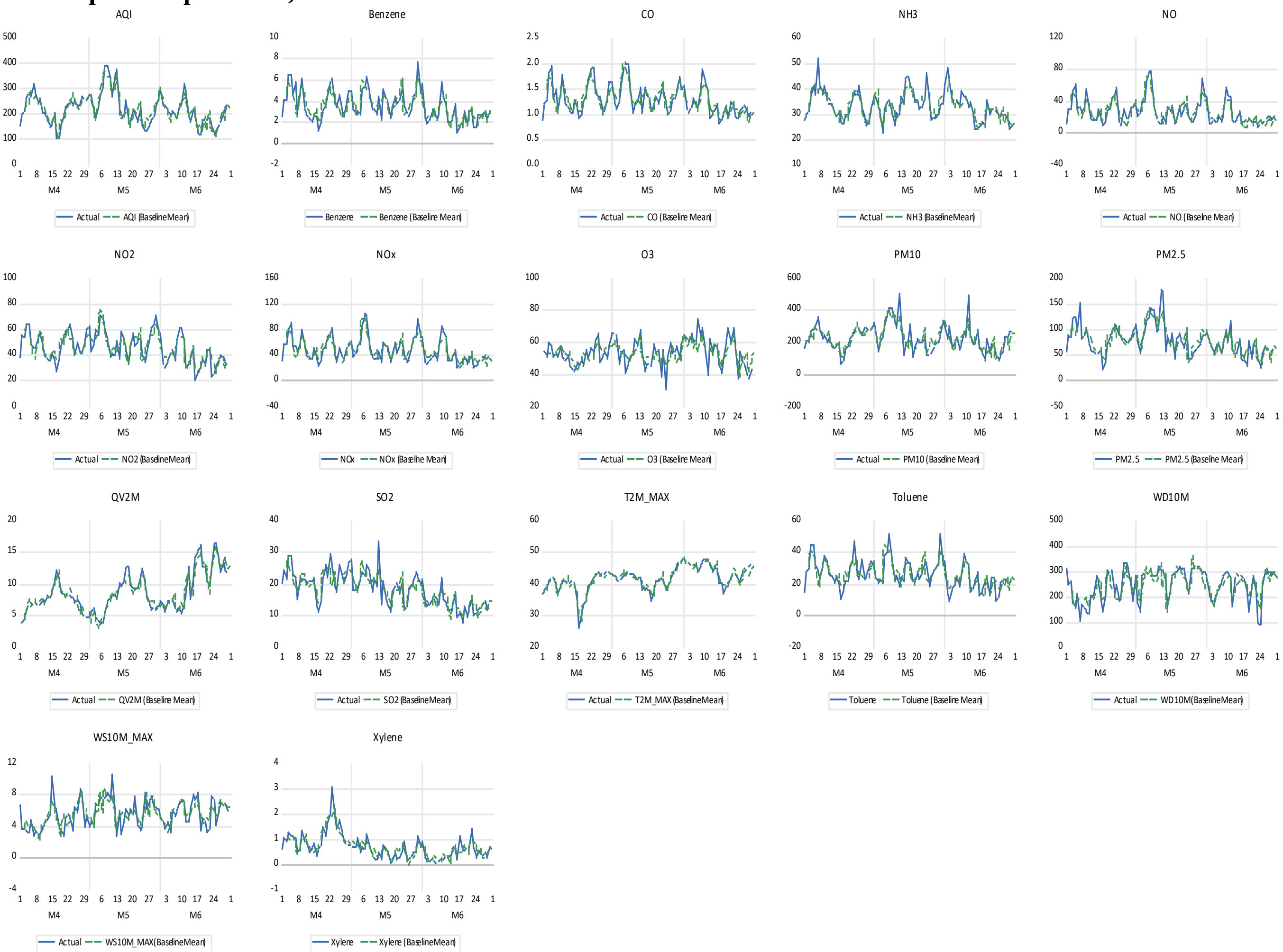
Here we can see that AQI trend for the period Jan - Mar, 2019 matches with Jan - Mar, 2020 and trend of Apr - June, 2019 differs with Apr - june, 2020 due to I lock down of COVD - 19.

Further, Stochastic static simulation model has also been solved for one day forecasting of AQI and various pollutants. The detailed trends are given here as under:

For the period Jan. - March, 2019

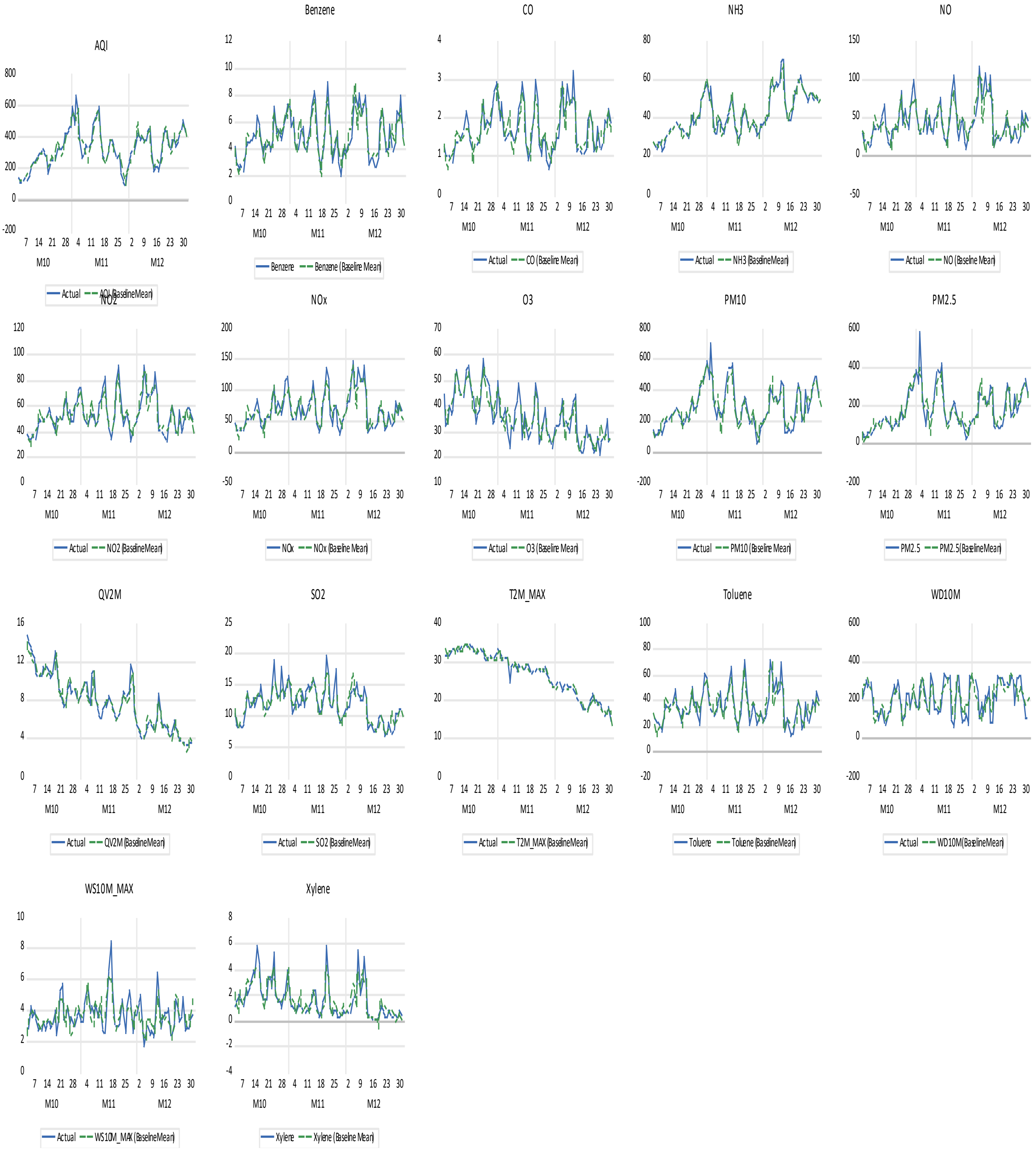


For the period Apr. - June, 2019



For the period July. - Sep., 2019

For the period Oct. - Dec., 2019



Forecasted AQI:

Date	AQI	AQIF	Date	AQI	AQIF	Date	AQI	AQIF	Date	AQI	AQIF
01 - 01 - 2019	475		04- 01- 2020	80	80	07- 01- 2019	195		10- 01- 2019	98	98
01 - 02 - 2019	501		04- 02- 2020	78	78	07- 02- 2019	202		10- 02- 2019	105	105
01 - 03 - 2019	537	503.3821	04- 03- 2020	84	94.82343	07- 03- 2019	162	183.8348	10- 03- 2019	140	143.948
01 - 04 - 2019	432	459.1204	04- 04- 2020	90	103.5532	07- 04- 2019	111	108.6423	10- 04- 2019	113	156.9204
01 - 05 - 2019	440	432.812	04- 05- 2020	103	116.3715	07- 05- 2019	113	83.20392	10- 05- 2019	108	170.7042
01 - 06 - 2019	371	435.3818	04- 06- 2020	134	118.3523	07- 06- 2019	99	86.11062	10- 06- 2019	127	210.3507
01 - 07 - 2019	331	281.5376	04- 07- 2020	100	121.0072	07- 07- 2019	101	112.6763	10- 07- 2019	133	249.0983
01 - 08 - 2019	340	383.3525	04- 08- 2020	91	117.6011	07- 08- 2019	129	136.9237	10- 08- 2019	123	278.9734
01 - 09 - 2019	321	283.5034	04- 09- 2020	89	116.185	07- 09- 2019	131	157.2203	10- 09- 2019	165	299.6277
01 - 10 - 2019	317	337.3198	04- 10- 2020	111	116.8855	07- 10- 2019	150	172.2447	10- 10- 2019	208	310.5697
01 - 11 - 2019	401	358.9303	04- 11- 2020	126	116.1366	07- 11- 2019	300	177.4187	10- 11- 2019	243	321.0607
01 - 12 - 2019	482	482.1327	04- 12- 2020	102	115.6874	07- 12- 2019	294	170.8718	10- 12- 2019	235	331.566

1/13/2019	464	405.8658	4/13/2020	119	113.4817	7/13/2019	312	154.8811	10/13/2019	282	341.5111
1/14/2019	320	358.6139	4/14/2020	134	110.8186	7/14/2019	243	136.0619	10/14/2019	285	348.9805
1/15/2019	248	179.5092	4/15/2020	152	108.1737	7/15/2019	180	120.2538	10/15/2019	291	354.414
1/16/2019	383	403.9985	4/16/2020	172	105.9349	7/16/2019	117	110.4349	10/16/2019	320	359.2941
1/17/2019	515	458.5932	4/17/2020	123	104.6807	7/17/2019	92	106.0712	10/17/2019	300	364.7897
1/18/2019	437	488.1415	4/18/2020	102	104.0402	7/18/2019	98	105.4148	10/18/2019	265	370.7793
1/19/2019	411	393.0271	4/19/2020	95	104.0696	7/19/2019	142	106.6753	10/19/2019	170	376.6693
1/20/2019	480	477.2484	4/20/2020	115	104.4338	7/20/2019	137	108.4742	10/20/2019	242	381.84
1/21/2019	413	440.1391	4/21/2020	102	104.9742	7/21/2019	123	109.7826	10/21/2019	254	386.0935
1/22/2019	174	195.2077	4/22/2020	122	105.7515	7/22/2019	124	110.1031	10/22/2019	243	389.573
1/23/2019	186	211.811	4/23/2020	129	106.7712	7/23/2019	156	109.4348	10/23/2019	248	392.613
1/24/2019	328	294.6474	4/24/2020	143	108.0895	7/24/2019	165	108.1469	10/24/2019	335	395.5116
1/25/2019	188	234.8415	4/25/2020	121	109.6349	7/25/2019	98	106.7266	10/25/2019	331	398.4143
1/26/2019	231	202.1658	4/26/2020	119	111.3273	7/26/2019	94	105.5771	10/26/2019	315	401.2917
1/27/2019	275	267.3407	4/27/2020	98	113.0695	7/27/2019	85	104.8922	10/27/2019	354	404.0478
1/28/2019	301	275.5713	4/28/2020	105	114.7606	7/28/2019	83	104.6683	10/28/2019	417	406.6284
1/29/2019	297	299.4447	4/29/2020	123	116.3495	7/29/2019	82	104.7806	10/29/2019	419	409.059
1/30/2019	342	316.3591	4/30/2020	128	117.8047	7/30/2019	90	105.0718	10/30/2019	452	411.4008
1/31/2019	397	418.0589	05- 01 - 2020	140	119.117	7/31/2019	90	105.4076	10/31/2019	460	413.6953
02 - 01 - 2019	329	342.0265	05- 02- 2020	127	120.2757	08- 01- 2019	98	105.7019	11- 01- 2019	591	415.9488
02 - 02 - 2019	338	327.3445	05- 03- 2020	110	121.2628	08- 02- 2019	95	105.916	11- 02- 2019	473	418.1568
02 - 03 - 2019	323	357.0573	05- 04- 2020	92	122.0619	08- 03- 2019	104	106.0464	11- 03- 2019	659	420.3282
02 - 04 - 2019	301	304.1717	05- 05- 2020	117	122.6625	08- 04- 2019	101	106.1092	11- 04- 2019	532	422.4874
02 - 05 - 2019	398	378.5354	05- 06- 2020	139	123.0693	08- 05- 2019	108	106.1283	11- 05- 2019	385	424.6605
02 - 06 - 2019	380	400.3107	05- 07- 2020	140	123.2999	08- 06- 2019	99	106.1254	11- 06- 2019	265	426.864
02 - 07 - 2019	233	198.6471	05- 08- 2020	138	123.3796	08- 07- 2019	104	106.1162	11- 07- 2019	296	429.103
02 - 08 - 2019	136	176.8648	05- 09- 2020	142	123.336	08- 08- 2019	99	106.1096	11- 08- 2019	346	431.3775
02 - 09 - 2019	169	220.6664	05- 10- 2020	127	123.1946	08- 09- 2019	89	106.1098	11- 09- 2019	321	433.6879
02 - 10 - 2019	277	243.7056	05- 11- 2020	113	122.9786	08- 10- 2019	75	106.118	11- 10- 2019	339	436.0375
02 - 11 - 2019	332	355.8278	05- 12- 2020	122	122.7099	08- 11- 2019	83	106.1334	11- 11- 2019	376	438.432
02 - 12 - 2019	357	345.7698	5/13/2020	132	122.4103	08- 12- 2019	80	106.1535	11- 12- 2019	475	440.8778
2/13/2019	372	369.6896	5/14/2020	154	122.1017	8/13/2019	85	106.1748	11/13/2019	532	443.3799
2/14/2019	350	309.3716	5/15/2020	125	121.8048	8/14/2019	93	106.1929	11/14/2019	537	445.9413
2/15/2019	275	212.3524	5/16/2020	175	121.5374	8/15/2019	93	106.2044	11/15/2019	595	448.5631
2/16/2019	288	248.1888	5/17/2020	202	121.3132	8/16/2019	73	106.2075	11/16/2019	438	451.246
2/17/2019	247	223.4979	5/18/2020	222	121.1415	8/17/2019	67	106.2025	11/17/2019	273	453.9906
2/18/2019	278	225.6936	5/19/2020	238	121.0273	8/18/2019	66	106.1914	11/18/2019	245	456.7983
2/19/2019	232	285.1561	5/20/2020	196	120.9721	8/19/2019	99	106.1773	11/19/2019	251	459.67
2/20/2019	305	247.8322	5/21/2020	149	120.9751	8/20/2019	103	106.1633	11/20/2019	315	462.6062
2/21/2019	158	202.1666	5/22/2020	199	121.0331	8/21/2019	107	106.1519	11/21/2019	375	465.6069
2/22/2019	191	190.8335	5/23/2020	202	121.141	8/22/2019	125	106.1443	11/22/2019	377	468.6723
2/23/2019	116	161.0971	5/24/2020	174	121.2922	8/23/2019	130	106.1403	11/23/2019	334	471.8028
2/24/2019	169	158.9478	5/25/2020	157	121.4784	8/24/2019	149	106.139	11/24/2019	264	474.9987
2/25/2019	221	244.8469	5/26/2020	153	121.6906	8/25/2019	107	106.1389	11/25/2019	269	478.2606
2/26/2019	144	211.0036	5/27/2020	156	121.9195	8/26/2019	77	106.1388	11/26/2019	284	481.5886
2/27/2019	112	170.5956	5/28/2020	174	122.156	8/27/2019	114	106.1379	11/27/2019	166	484.9832
2/28/2019	198	180.0605	5/29/2020	129	122.3916	8/28/2019	119	106.1359	11/28/2019	106	488.4445
03 - 01 - 2019	222	209.8758	5/30/2020	84	122.6191	8/29/2019	103	106.1332	11/29/2019	89	491.9729
03 - 02 - 2019	227	225.1377	5/31/2020	80	122.8324	8/30/2019	110	106.1303	11/30/2019	175	495.5688
03 - 03 - 2019	172	202.0599	06- 01- 2020	100	123.0265	8/31/2019	123	106.1278	12- 01- 2019	257	499.2329
03 - 04 - 2019	217	143.5313	06- 02- 2020	123	123.1979	09- 01- 2019	123	106.1259	12- 02- 2019	299	502.9658
03 - 05 - 2019	173	218.7554	06- 03- 2020	123	123.3444	09- 02- 2019	105	106.1249	12- 03- 2019	302	506.7681
03 - 06 - 2019	189	125.5108	06- 04- 2020	144	123.4652	09- 03- 2019	131	106.1247	12- 04- 2019	313	510.6405
03 - 07 - 2019	228	242.6813	06- 05- 2020	126	123.5605	09- 04- 2019	165	106.1249	12- 05- 2019	389	514.5839
03 - 08 - 2019	220	241.8963	06- 06- 2020	102	123.6321	09- 05- 2019	118	106.1254	12- 06- 2019	423	518.5992
03 - 09 - 2019	194	217.9524	06- 07- 2020	104	123.6822	09- 06- 2019	96	106.1259	12- 07- 2019	382	522.6872
03 - 10 - 2019	157	178.846	06- 08- 2020	112	123.7141	09- 07- 2019	95	106.1262	12- 08- 2019	404	526.849
03 - 11 - 2019	190	227.6029	06- 09- 2020	138	123.7313	09- 08- 2019	99	106.1263	12- 09- 2019	371	531.0855
03 - 12 - 2019	149	180.1142	06- 10- 2020	154	123.7377	09- 09- 2019	107	106.1263	12- 10- 2019	377	535.398
3/13/2019	168	170.6456	06- 11- 2020	142	123.7372	09- 10- 2019	139	106.1263	12- 11- 2019	430	539.7875
3/14/2019	281	286.1995	06- 12- 2020	152	123.7336	09- 11- 2019	166	106.1263	12- 12- 2019	471	544.2553
3/15/2019	183	207.1863	6/13/2020	132	123.7303	09- 12- 2019	158	106.1263	12/13/2019	322	548.8026
3/16/2019	143	206.2321	6/14/2020	147	123.7303	9/13/2019	103	106.1265	12/14/2019	179	553.4307
3/17/2019	198	206.3212	6/15/2020	130	123.7361	9/14/2019	85	106.1267	12/15/2019	205	558.141
3/18/2019	221	221.1187	6/16/2020	126	123.7496	9/15/2019	83	106.1269	12/16/2019	202	562.9348
3/19/2019	239	224.5747	6/17/2020	110	123.772	9/16/2019	111	106.1271	12/17/2019	178	567.8136
3/20/2019	234	246.6667	6/18/2020	107	123.8039	9/17/2019	143	106.1273	12/18/2019	273	572.7788

3/21/2019	272	218.7974	6/19/2020	132	123.8452	9/18/2019	117	106.1275	12/19/2019	354	577.832
3/22/2019	141	179.035	6/20/2020	158	123.8954	9/19/2019	80	106.1276	12/20/2019	452	582.9746
3/23/2019	131	101.5074	6/21/2020	105	123.9534	9/20/2019	96	106.1276	12/21/2019	441	588.2083
3/24/2019	126	186.5031	6/22/2020	104	124.0177	9/21/2019	112	106.1277	12/22/2019	351	593.5346
3/25/2019	136	128.7284	6/23/2020	85	124.0864	9/22/2019	86	106.1277	12/23/2019	321	598.9551
3/26/2019	162	170.8411	6/24/2020	71	124.1578	9/23/2019	89	106.1278	12/24/2019	376	604.4716
3/27/2019	177	162.0406	6/25/2020	86	124.2297	9/24/2019	103	106.1278	12/25/2019	384	610.0857
3/28/2019	245	210.4684	6/26/2020	104	124.3003	9/25/2019	100	106.1279	12/26/2019	340	615.7992
3/29/2019	273	241.7103	6/27/2020	112	124.3675	9/26/2019	87	106.1279	12/27/2019	372	621.6139
3/30/2019	252	217.7144	6/28/2020	196	124.4298	9/27/2019	78	106.1279	12/28/2019	425	627.5314
3/31/2019	198	170.4175	6/29/2020	233	124.4858	9/28/2019	78	106.128	12/29/2019	455	633.5538
04 - 01 - 2019		42.05431	6/30/2020		124.5343	9/29/2019		106.128	12/30/2019		639.6827

On the basis of this model, further forecasting may be done on daily basis.

3. Conclusion

The correlation coefficients calculated in different time period are validated giving shocks individually on Humidity, Temperature, Wind Direction and Wind speed through Deterministic Dynamic simulation and satisfactory results are obtained. In the study, when forecasting of one day period conducted through Scholastic Static simulation, all the results are obtained under 95% of confidence band, supporting the solved models perfectly.

Although, Delhi Government has implemented various measures time to time to fight with air pollution in NCR region, however awareness program at micro level would help undertand the Sevier impacts of air pollution on human health.

The link between health and environment is complex. The impact of air pollution on human health has been analysed by correlating air pollution levels and number of deaths caused by it. Results reveal that asthma, bronchitis and pneumonia are responsible for most deaths due to air pollution in Delhi.

Here are the steps taken by the authorities to solve the situation:

- The first and foremost step is to plant more trees. The fresh can help in reduce the pollution and emit healthy gasses.
- Pollution check of all the vehicles by transport department, and encouraging fuel efficient cars.
- Encourage car pool or public transport to help reduce flow of more vehicles on roads. Citizens should take initiative for car polling with their friends and family. This will also help in traffic control. To discourage public from using their own vehicles authorities have decided to raise the parking fees.
- Burning of any garbage or leaves or wood is being prohibited. Ban on Fire crackers is being implemented on the day of Diwali.
- Halt on all the construction activities. This will also mean ban on all stone crushers, diesel generator sets, to prevent the dust coming from the activities.
- Mechanical sweepers and water sprinklers have been introduced, to clean the roads.
- Air purifiers in offices are being installed even home owners are encouraged to install purifiers in their homes to cope up with the bad air.
- Long term measures such as ban on burning and sale of firecrackers completely. The Badrapur thermal Power plant to be shut down as soon as possible, which causes lot of pollution by emitting hazardous gasses.

Government should also take measures to control number of industries around the city limits and also strict laws should be made to control pollution.

The pollution or smog levels must be understood and solved for coming years, so that this situation does not repeat again and again. Educating public about pollution and steps to tackle would help in reducing the pollution to a great extent.

References

[1] MS Haque, RB Singh - Climate, 2017 - mdpi. com
[2] R Kaur, P Pandey - Frontiers in Sustainable Cities, 2021 - frontiersin. org
[3] L Conibear, EW Butt, C Knote, SR Arnold… - …, 2018 - Wiley Online Library
[4] R Rajak, A Chattopadhyay - International journal of environmental …, 2020 - Taylor & Francis
[5] K Mukhopadhyay, O Forssell - Ecological Economics, 2005 – Elsevier
[6] KT Bency, J Jansy, B Thakappan, B Kumar… - Proceedings of the Third …, 2003 - yorku. ca
[7] KJ Maji, AK Dikshit, A Deshpande - Cogent Environmental Science, 2016 - Taylor & Francis
[8] S Kesarwani, A James - Journal of Pharmacognosy and …, 2017 - phytojournal. com
[9] DA Nagdeve - Southeast Asia's Population in a Changing Asian …, 2002 - academia. edu
[10] A Kumar, RK Mishra - Journal of Transport & Health, 2018 - Elsevier