Impact of environmental indicators on the COVID-19 pandemic in Delhi, India

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Research Article

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Abstract

Currently there is a huge debate on whether meteorological and air quality parameters are playing a crucial role in the transmission of COVID-19 across the globe. On this background, this study aims to evaluate the impact of air pollutants ($PM_{2.5}$, PM_{10}, CO, NOx, SO_2, AQI), and meteorological parameters (temperature, humidity, wind speed, and rainfall) on the spread, recoveries and mortality due to COVID-19 outbreak in Delhi. Spearman's correlation method is employed on a secondary data collected from the Ministry of Environment, India and the COVID-19 data collected using daily government health bulletins for Delhi. Our result shows that the COVID-19 incidences are significantly positively correlated with temperature ($r_{infections}= 0.90$, $r_{recoveries}= 0.84$, $r_{deaths}= 0.83$, $p<0.05$) and negatively correlated with humidity ($r_{infections} = -0.63$, $r_{recoveries} = -0.58$, $r_{deaths} = -0.56$, $p<0.05$). This finding indicates that temperature and humidity play a significant role on the infections, recoveries and deaths due to the COVID-19. The study results may be useful for policymakers in managing the outbreak of COVID-19 in Delhi, India.

Introduction

The outbreak of the novel coronavirus (COVID-19), which is associated with the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), began in December 2019 in Wuhan, China. The disease has been affirmed to have human-to-human transmissibility (Wang et al., 2020) that elevated huge attention not only in China but over the world. Due to its devastating effects around the world, COVID-19 was declared as a global pandemic by the World Health Organisation (WHO, 2020). In India, the first case of COVID-19 was reported on 30 January 2020 in the state of Kerala. The cases in India started increasing with a higher pace more in exponential manner with each passing day. By July 22, 2020, there were more than 1.19 million confirmed cases of COVID-19 and around 28,000 deaths in India as reported by the WHO official portal for COVID-19 (https://covid19.who.int/region/searo/country/in). New Delhi, being the national capital and the largest commercial city of North India, is one of the worst affected cities due to COVID-19 in India with over 80,000 cumulative infected cases and more than 2,600 causalities by June 30, 2020. Essentially, COVID-19 is directly transmitted by close contact through respiratory droplets that are emitted from an infected person (WHO 2020). Recently, a number of studies from various parts of the world reported that meteorological/weather conditions have a crucial role in the spread of COVID-19 (Wang, et al. 2020; Zhu et al. 2020 and Ma. et al. 2020; Auler et al., 2020). Tosepu et al. (2020) reported that the average temperature is positively correlated with COVID-19 pandemic in Jakarta, Indonesia. Similarly, a study from Singapore revealed that temperature and dew point have a positive impact on the number of daily as well as the cumulative COVID-19 cases (Pani et al., 2020). In another study, Şahin (2020) analysed the impact of weather parameter on COVID-19 in Turkey. Association between COVID-19 and climate indicators was also demonstrated by Muhammad et. al., (2020) in New York, USA. Moreover, in this regard, still insufficiency of data is available in several COVID-19 hotspots in Delhi. In a contagious disease epidemiology, hotspot is defined as an area that is surrounded by other high incidence areas, i.e.

incidence is persistent and higher than the expected number given a random distribution of cases (Lessler et al. 2017; Phanitchat et al. 2019). More vigorous studies are required to better understand these factors to improve forecasting models that can be effective for public health measures.

Thus the study was conducted in the national capital of India, i.e., Delhi with the main aim of analysing the impact of air pollutants (PM2.5, PM10, CO, NOx, SO2, AQI), and meteorological parameters (temperature, humidity, wind speed, and rainfall) on the new cases, recoveries, and mortality due to COVID-19 outbreak. Since the research related to impact of environmental indicators on COVID-19 is limited or in a preliminary stage, this study will provide a rigorous insight to understand this relationship effectively, which may be useful in prevention of COVID- 19 pandemic in Delhi, India and elsewhere.

Methods

Study Area:

Delhi, the national capital of India is the ninth-most populated metro city in the world and is one of the most polluted cities in the country with the highest volumes of particulate matter pollution. Located in Northern India, the national capital territory covers an area of 1,484 km^2, therefore making it the largest city in terms of area in the country. Delhi possesses a dry-winter humid subtropical climate bordering a hot semi-arid climate. The average annual rainfall is approximately 886 mm, mostly falling out during the monsoon months of July-August. The maximum and minimum temperature in the city ranges between 2°C and 47°C with the exception of −2.2°C and 48.4 °C, lowest and highest temperatures, respectively.

Data collection:

The analysis was carried out in the national capital of India, i.e., Delhi. A part of the data set was gathered using the official handle of Ministry of Environment, Forest, and Climate Change for Government of India. The data comprises of concentrations of PM2.5 (µg/m^3), PM10(µg/m^3), NO(µg/m^3), NO2 (µg/m^3), CO (mg/m^3), SO2 (µg/m^3), Temperature (°C), Humidity(%), Rainfall (mm) and Wind speed (m/s) from 1st January 2020 to 24th June2020. The data for these parameters was collected for the 7 substations in Delhi reporting Central Pollution Control Board (CPCB) (https://app.cpcbccr.com/ccr/#/caaqm-dashboard-all/caaqm-landing/caaqm-comparison-data), whereas the data for Air Quality Index (AQI) for these substations was collected using the “Sameer” app developed by the Government of India. While analysing these parameters, the average of the 7 substations was considered for effective results. The data for daily reported confirmed infected cases, recoveries and deaths due to COVID-19 in Delhi was collected using http://health.delhigovt.nic.in/wps/wcm/connect/doit_health/Health/Home/ from 4th March 2020 to 24th June 2020.

Spearman's correlation test:

Due to lack of normality in the dataset, we employed the use of Spearman’s rank correlation for studying the relationship between different air pollutants along with the meteorological/climate factors and impact of COVID-19 in Delhi during 1 Jan 2020 and 24 Jun 2020. A correlation matrix was calculated for describing the relationship between all the parameters and other components with each other. A mathematical formula for Spearman’s correlation coefficient is given by

$$r_S = 1 - 6\frac{\sum_{i=1}^{n} d_i}{n(n^2 - 1)},$$

where n is the number of observations and di is the difference of the rank between two variables.

Results And Discussions

The pace of daily infections in Delhi has been increasing with a maximum of 3,947 cases on 23 June 2020 (Fig.1). On the same grounds, maximum daily recoveries (7725) were seen on 20 June 2020 and deaths (437) on 16 June 2020 (Fig.1).

The concentrations of pollutants such as PM2.5, PM10, NO, NO2, CO, SO2 play a significant role in influencing the air quality of a region (Fig. 2). The concentrations of these air pollutants along with AQI and meteorological variables such as temperature, humidity, amount of rainfall and wind speed has been taken from 1st January to 24th June 2020, which is classified into different phases of COVID- 19 such as pre-lockdown, during lockdown phase 1-4 and unlock phase 1. Overall, the results show that most of the air pollutants drastically reduced in all four phases of lockdown as well as the 1st unlock period. The most significant reduction was noticed for PM 2.5, PM10, NO2, NO and CO. Similar observation was also reported from other megacities in India (Sharma et al., 2020; Mahato et al., 2020; Jain and Sharma, 2020) and elsewhere (Xu et al., 2020; Krecl et al., 2020).

Air Quality Index has a high positive correlation with the concentrations of PM2.5 (r=0.914), PM10(r=0.847) and NO2(r =0.814) and a negative correlation with the temperature (r = -0.502) and the COVID-19 infected cases (r = -0.532) (Fig.3). The factors such as wind speed and amount of rainfall does not seem to have a good quality of correlation with COVID-19 in this study as of now. Although the air pollutants have shown a strong negative correlation with COVID-19 incidences, this may not be true on the ground, as during the lockdown all the pollutants were drastically reduced (Sharma et al., 2020). On the other hand, temperature is found to have a strong positive correlation with the daily increase in number of infected cases (r infections =0.906). Daily recoveries and deaths are also positively correlated with temperature having coefficient values r recoveries=0.840 and r deaths= 0.831, respectively. While, humidity is negatively associated with COVID-19 incidence, such as daily infections, recoveries and deaths (Fig 3 and Fig 4). These findings are corroborated with previous studies (Ma et al., 2020; pani et al., 20200. Ma et al. (2020) reported a significant positive relation between daily temperature and deaths cases due to COVID-19, and a negative correlation for relative humidity. In low humidity the moisture in the exhaled bioaerosols evaporates rapidly and form droplet nuclei that may remain in the air for longer period, which facilitates the increase pathogen transmission (Lowen et al., 2007). Moreover, low humidity can lead to reduce the airway cilia cells' ability to remove virus particles, thereby expose the host to the virus (Sun et al., 2020). Thus, this study indicates that the human body is at a higher risk of infection by SARS-CoV-2 in high temperature and low humidity environments.

Conclusions

The present study investigated the role of environmental indicators in the fight against COVID-19 in Delhi, India. Our research finds that increasing temperature and decreasing humidity may have association with increasing daily new cases, recoveries and deaths due to COVID-19 pandemic, while other meteorological and air pollutants exhibit no significant relation with COVID-19 pandemic. Thus, these factors may be taken into consideration in policy development for the control and prevention of COVID-19 pandemic.

Declarations

Competing interests:

The authors declare no competing interests.

Authors' contributions:

All authors contributed equally.

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Figures

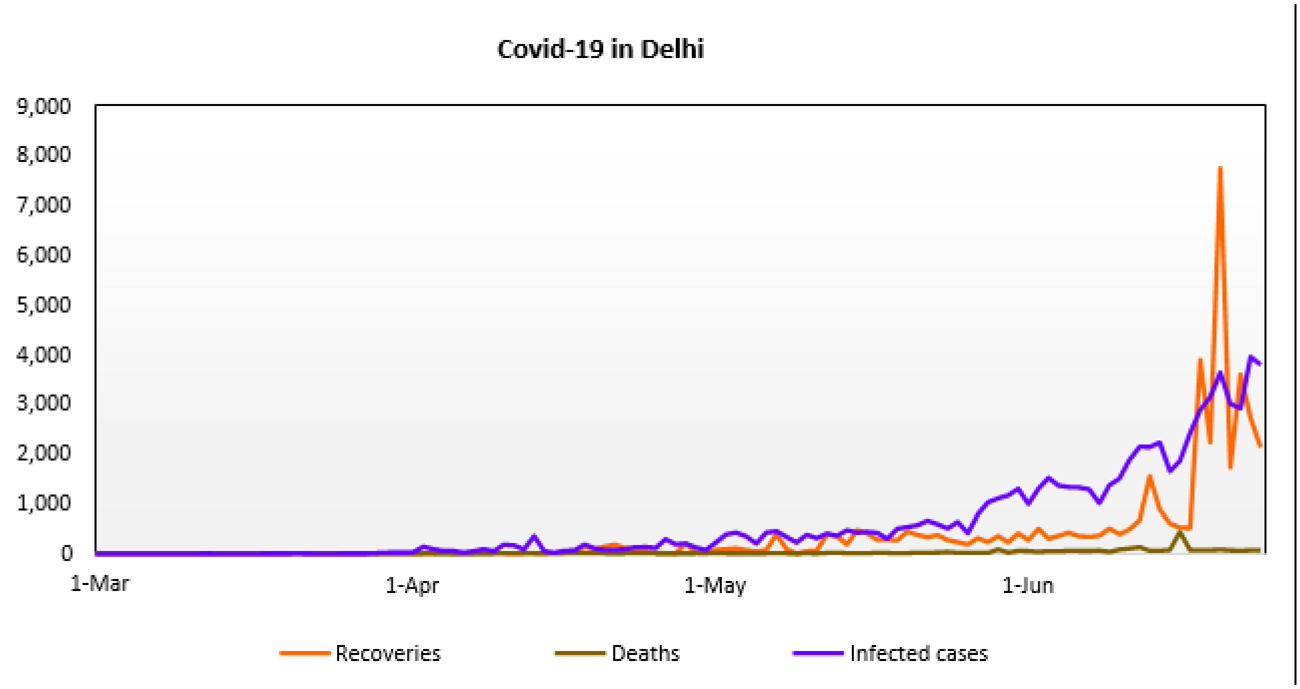
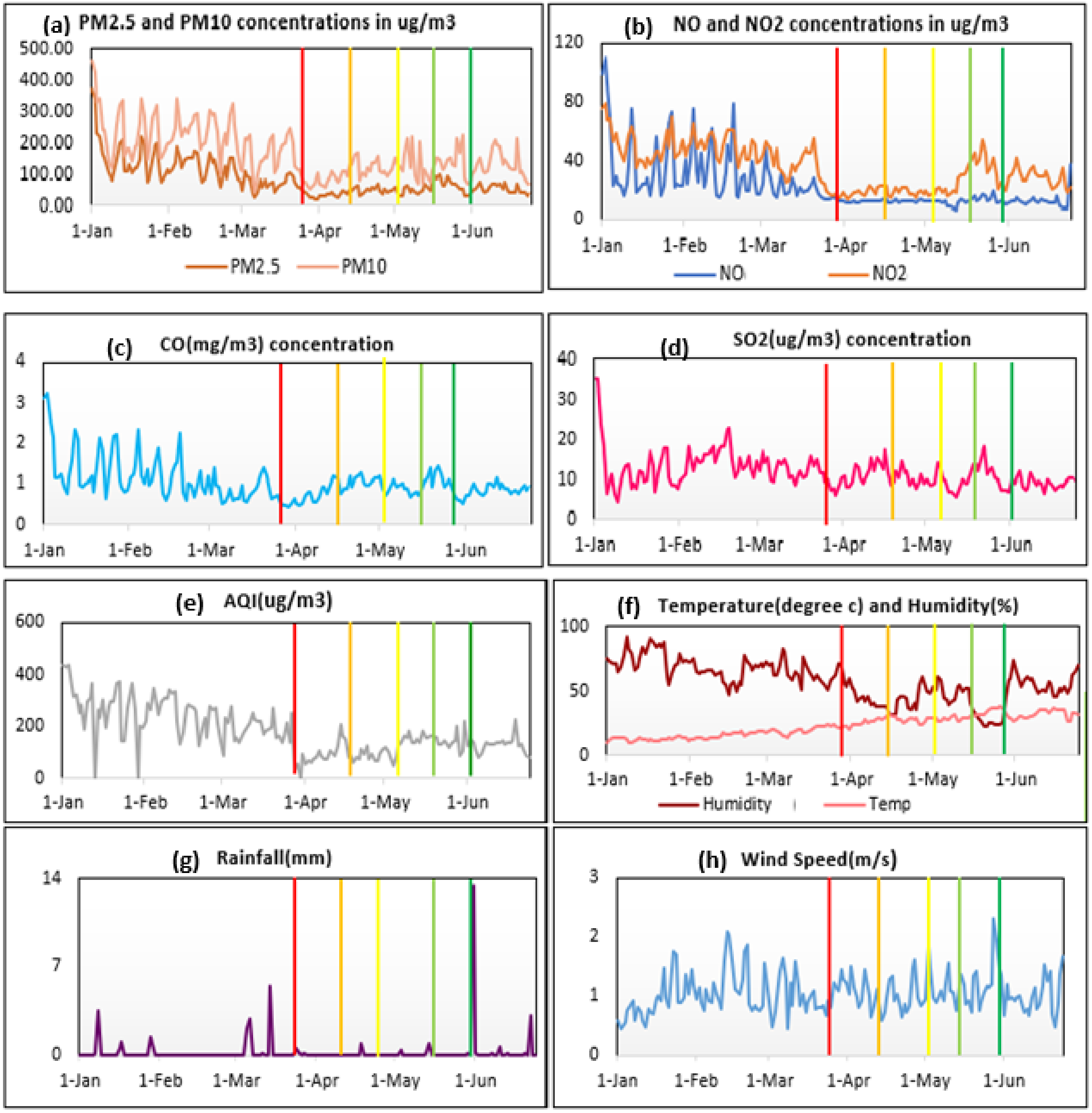


Figure 1

Impact of COVID-19 in the national capital Delhi, India from 4 Mar 2020 to 24 Jun 2020



Pre-Lockdown - Lockdown Phase 1	Lockdown Phase 1 - Phase 2	Lockdown Phase 2 - Phase 3	Lockdown Phase 3 - Phase 4	Lockdown Phase 4-Unlock phase 1

Figure 2

(a) PM2.5 and PM10 concentration(μg/m3), (b)NO and NO2 concentration(μg/m3), (c) CO concentration (mg/m3), (d) SO2 concentration (μg/m3), (e) Air Quality Index values, (f) Temperature (ºC) and Humidity (%), (g)Amount of Rainfall (mm), (h) Windspeed(m/s) from 1 Jan 20 to 24 Jun 20

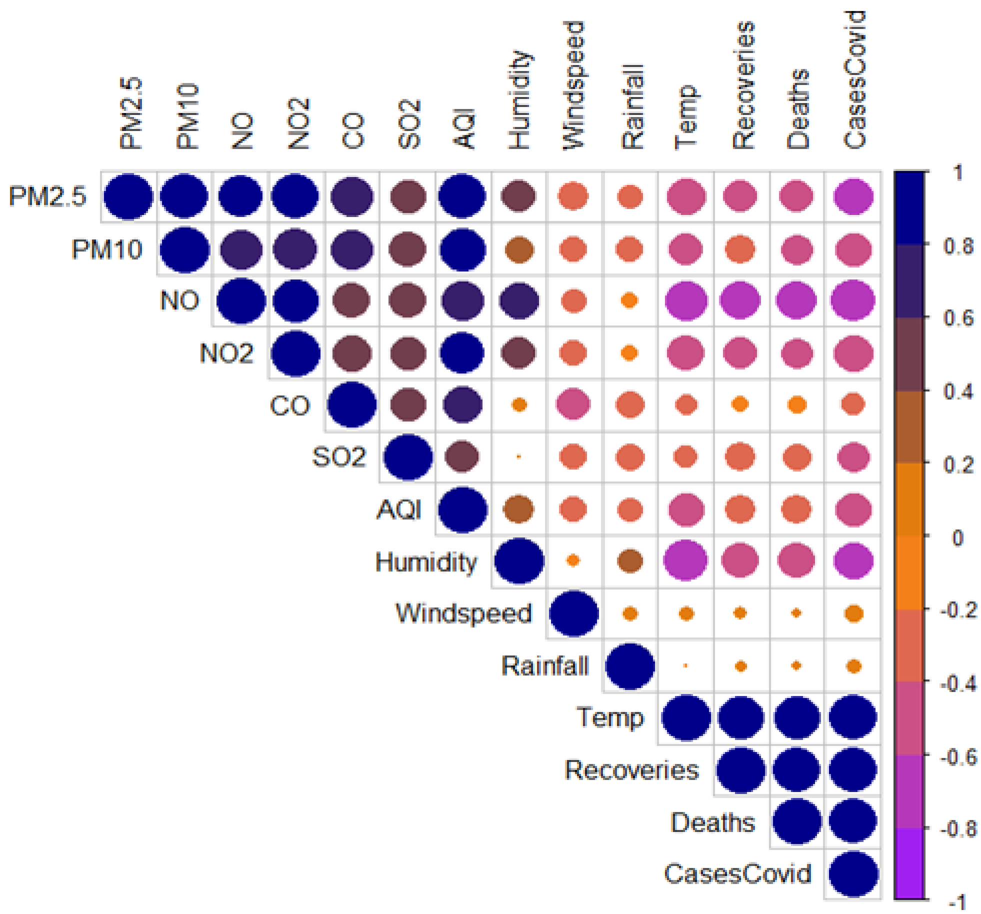
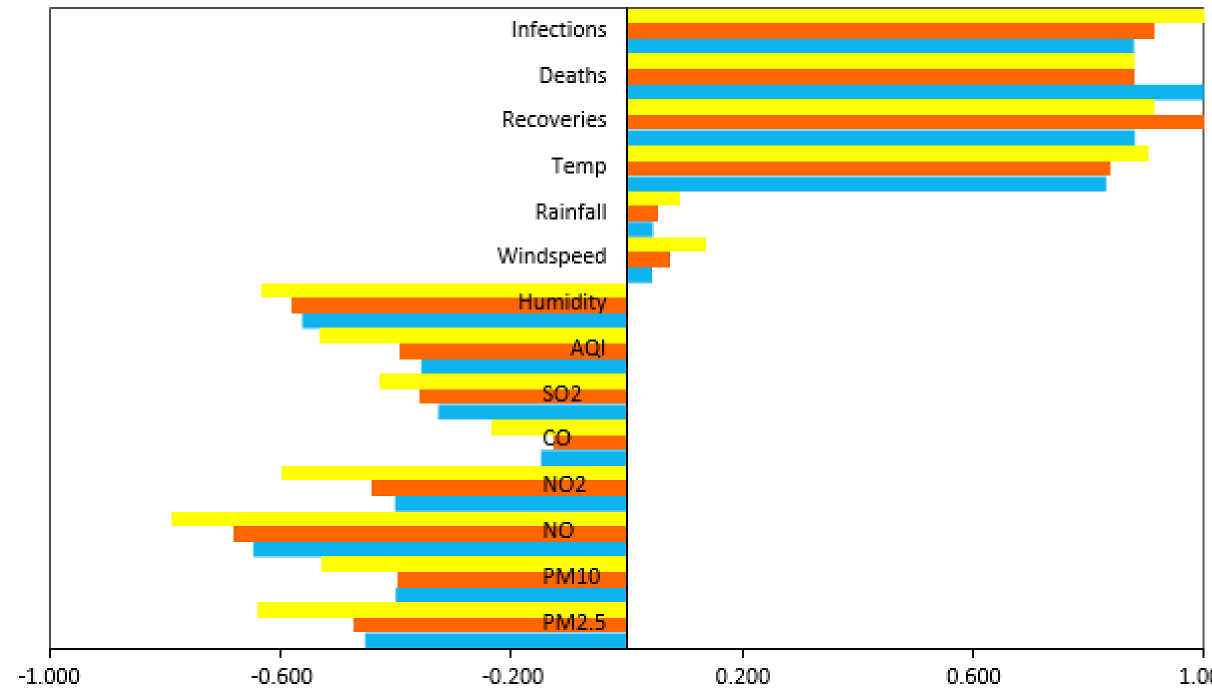


Figure 3

Correlation Matrix Plot between all the climate parameters and COVID-19 data.



	PM2.5	PM10	NO	NO2	CO	SO2	AQI	Humidity	Windspeed	Rainfall	Temp	Recoveries	Deaths	Infections
Infections	-0.640	-0.528	-0.788	-0.599	-0.234	-0.427	-0.532	-0.632	0.139	0.092	*0.906	0.916	0.878	1.000
Recoveries	-0.475	-0.396	-0.682	-0.443	-0.125	-0.361	-0.393	-0.581	0.074	0.056	^0.840	1.000	0.880	0.916
Deaths	-0.454	-0.400	-0.647	-0.402	-0.148	-0.326	-0.356	-0.562	0.044	0.045	#0.831	0.880	1.000	0.878

Figure 4

Spearman Rank correlation coefficient and corresponding p-values of daily infected cases, daily recovered cases and daily deaths with PM2.5, PM10, NO, NO2, CO, SO2, AQI, Humidity, Windspeed, Rainfall and Temperature from 1 Jan 2020 to 24 June 2020. Spearman Correlation is significant at the 0.05 level (2-tailed), p-value=9.17E-67, ^ Spearman Correlation is significant at the 0.05 level (2-tailed), p-value= 5.34E-48, # Spearman Correlation is significant at the 0.05 level (2- tailed), p-value= 3.86E-46