A Correlation based study using air quality and meteorological parameters for the outbreak of COVID-19 on major affected districts in India

Amitesh Gupta (✉ amitesh13gupta14@gmail.com)

RBased Services Pvt. Ltd. <https://orcid.org/0000-0002-6664-2351>

Research Article

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Abstract

Air quality is an important factor for human health conditions. Simultaneously, suitable meteorology poses the circumstances for virus transmission. Hence, we investigated both these two important aspects for the COVID-19 pandemic. We correlated the remote sensing based observations of meteorological parameters and air quality parameters with COVID-19 cases from 657 districts all over the country and found that air quality parameters are playing very crucial role along with a few meteorological parameters for this outbreak. We observed that air temperature, and wind speed were significantly and positively correlated with COVID-19 cases but precipitation and humidity were negatively correlated with confirmed cases. Cloudiness had no significant relation in this aspect. Among the air pollutants, O_3 was better correlating with COVID-19 cases. AOD representing the particulate matter concentration also significantly correlated with such cases majorly over Indo-Gangetic plain region. The carbon-pollutants CO was also very high over the same region. Though NO_2 and SO_2 were reduced during lockdown, due to the power generation and mining activities both these gases were quite highly correlated over eastern India region. We noted the eastern and western coastal districts of India and districts from the low-lying plain areas had more cases during this pandemic. Our study suggests that improving air quality with proper strict regulations and complete lockdown during the peak of pandemic could reduce the misfortune in all over India. Hence, the summer season could be susceptible and might pose a gesture of seasonality for this disease.

Introduction

In the 21st century, the world has been battle-scarred by the pernicious ordeal of coronavirus disease (COVID-19) since early 2020. By the end of May, 2021, a total of 171230341 confirmed cases with a death toll of 3692084 have been registered all over the world. This pneumonia infection caused by SARS-CoV-2 had initially broken out in Wuhan, Hubei province, China during late 2019 (Liu et al., 2020a; Zhu et al., 2020a; Zu et al., 2020) and gradually spread all over the world (Bertuzzo et al., 2020; Gorbalenya et al., 2020). Contemplating the hasty unfurl of this virus and its human-to-human transmissibility from contagion (Wang et al., 2020a; Wang et al., 2020b; Wang et al., 2020c), the World Health Organization (WHO) declared this disease to be a global pandemic on March 11, 2020. India, had noted its very first COVID-19 confirmed case on January 27, 2020, and afterwards a total of 27493812 cases have been confirmed by the end of May, 2021 with a death count of 338561 (<https://www.covid19india.org/>).

Worldwide sundry clinical inspections of COVID-19 have diagnosed respiratory droplets and fomites from contaminated persons as the spawn agent of this lethal disease (Alag, 2020; Ge et al., 2013; Huang et al., 2020a; Jana et al., 2020; Jung et al., 2021; Kunz et al., 2020; Sathian et al., 2020; Tuttle, 2020). Umpteen researchers also reported about analogous symptoms of this disease to MERS and SARS (Holshue et al., 2020; Perlman, 2020; Tan et al., 2005; Wang et al., 2020c). Since the SARS-CoV-2 virus initially causes respiratory damage (Harapan et al., 2020; Khorramdelazad et al., 2021; Larsen et al., 2020; Li et al., 2021), a few researchers have already exhorted about significant association of environmental parameters to

Loading [MathJax]/jax/output/CommonHTML/fonts/TeX/fontdata.js al., 2020; Eslami and Jalili, 2020; Gupta and

Pradhan, 2020a; Kifer et al., 2021; Rume and Islam, 2020; Saadat et al., 2020; Shakil et al., 2020). Mention Worthy, earlier shedload of studies have conjectured about conspicuous impact of weather conditions on dissemination of respiratory viruses and its seasonality (D'Amato et al., 2018; Pica and Bouvier, 2012; Price et al., 2019). There are also a few global as well as regional studies that had been carried out in the context of China, USA, England, Germany, Spain, Italy, Indonesia, Iran, Pakistan, Bangladesh, India, and found significant correlation between weather parameters and the COVID-19 cases (Ahmadi et al., 2020; Chen et al., 2021; Fadli et al., 2020; Ficetola and Rubolini, 2021; Gupta et al., 2020a; Gupta and Pradhan, 2020b; Islam et al., 2020; Liu et al., 2020b; Ma et al., 2020; Mehmood et al., 2021; Nottmeyer and Sera, 2021; Oliveiros et al., 2020; Qi et al., 2020; Tosepu et al., 2020). On a contrary, a few studies have also reported that meteorological observations are not significantly associated with the outbreak pattern (Iqbal et al., 2020; Jahangiri et al., 2020; Jamil et al., 2020; Mollalo et al., 2020; Shi et al., 2020; Xie and Zhu, 2020). Studies carried out by Bochenek et al., 2021; Borah et al., 2020; Briz-Redón and Serrano-Aroca, 2020; Emediegwu, 2021; Guo et al., 2021; Gupta et al., 2020b; Mecenas et al., 2020; Runkle et al., 2020; Şahin, 2020; Sil and Kumar, 2020 suggested that warm and humid condition seem to foreshorten the proliferation of COVID-19. On the other hand, (Al-Rousan and Al-Najjar, 2020; Awasthi et al., 2020; Bashir et al., 2020a; Fawad et al., 2021; Gupta and Pradhan, 2020a; Kumar and Kumar, 2020; Pani et al., 2020; Sangkham et al., 2021; Selcuk et al., 2021; Sharma et al., 2021) reported that hotter days might be more susceptible for COVID-19 dissemination while the role of humidity was still incongruous (Aidoo et al., 2021; Auler et al., 2020; Gupta et al., 2020c; Kumar, 2020; Yuan et al., 2021). Menebo, 2020 found negative association between precipitation and COVID-19 cases, while Gunthe et al., 2020 found no significance of precipitation and cloudiness for this outbreak.

Studies have enunciated that frequent short-term exposure to air pollutants could aggrandize the likelihood of symptomatic acute respiratory infections among adults (Kim et al., 2018; Kirwa et al., 2021; Xing et al., 2016). Recent studies have stated that both short-term and long-term exposure to different air pollutants could contribute significantly to the higher rates of COVID-19 infections in different parts of the world (Ali and Islam, 2020; Bourdrel et al., 2021; Coker et al., 2020; Gujral and Sinha, 2021; Jain et al., 2021; Li et al., 2020; Lin et al., 2020; Ma et al., 2021; Matthew et al., 2021; Mele et al., 2021; Sharma et al., 2021; Suhaimi et al., 2020; Wu et al., 2020). The carbonaceous pollutants i.e. CO and BC and OC, which also includes the primary and secondary organic carbon, are mainly produced during different anthropogenic activities of biomass burning and fossil fuel combustion, with relatively little contribution from various natural sources (Li et al., 2016; Prabhu et al., 2020; Schmidt, 2011; Wang et al., 2019; Winiger et al., 2016; Zhang and Wang, 2011). AOD, an illustrious indicant of Particulate Matter pollution (Chudnovsky et al., 2014; Engel-Cox et al., 2004; Gupta et al., 2021; Karimian et al., 2016), accounts columnar concentration of gaseous and liquid airborne particles has not been often related to such malady study.

Scanty studies have been carried out on the importance of freshen air for the melioration of human health and to dodge any convalescence (Cragg et al., 2016; Kampa and Castanas, 2008; Manisalidis et al., 2020; White et al., 2019). Since a handful of studies had reckoned that the inferior air quality had

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investigate whether the convivial air quality has been benevolent to convalesce the COVID-19 patients in India. Therefore, the present study has been firm to analyse the association of COVID-19 incidences (i.e. transmission) and recovery cases with weather and air quality parameters across the country, as well as proffered a comparative assessment for estimating confirm and recovery cases availing the non-linear complex relationship.

Data and Methodology

Counts of Confirmed and Recovered cases for all the available districts in India have been acquired from <https://www.covid19india.org/> for the period of April, 2020 to May, 2021. Spatial data for different meteorological parameters - Air Temperature, Bias-corrected Total Precipitation, Humidity, Cloud Cover, Incoming Short-wave Radiation, Wind Speed, and different air quality parameters - Aerosol Optical Depth, Nitrogen di-Oxide, Ozone, Carbon Monoxide, Sulphur di-Oxide, Organic Carbon and Black Carbon have been incorporated in the present study. Remote Sensing based datasets are highly useful for various environmental studies (Bhatt et al., 2021; Das et al., 2017; Das and Gupta, 2021; Gupta et al., 2020b; Gupta et al., 2019; Nanda et al., 2018; Roustia et al., 2020). Monthly mean of these variables were further processed in ArcGIS software, adjoined and related with the monthly cumulative counts of confirmed and recovery cases for each months for each of those selected districts.

Infections and recoveries during 1st COVID-19 waves in India

The district wise spatial distribution of COVID-19 confirmed cases and recoveries during the 1st COVID-19 wave (up to March, 2021) are shown in Fig. 1. It shows that 34.8% districts had noted cases within the range of 10,000 to 1,00,000; while only 3% districts in India registered more than 1 lakh cases during this study period. Noteworthy, most of the districts have registered counts of infective cases within the range of 2500–5000 following the range of 10000–25000. The spatial distribution of cases also depict that the coastal districts were more anguished by misfortune than the districts located in the interior part of the country whereas the districts from the Himalayan Mountains and its foothills had lesser strife during this pandemic. The peak of pandemic was during the early September, 2020 when the daily death counts and confirmed cases were highest, however daily test positivity was highest during July. These trends were at their trough during the winter followed by the post-monsoon seasons but again started to incline since March, 2021.

Pearson's correlation test

Pearson's correlation technique was applied to explore the degree of association of environmental parameters with infected and recovered cases. A correlogram is also being prepared to better represent the interrelation of the variables.

$$r = \frac{\sum_{i=1}^n \left(En_i - \bar{En} \right) \left(C_i - \bar{C} \right)}{\sqrt{\sum_{i=1}^n \left(En_i - \bar{En} \right)^2 \sum_{i=1}^n \left(C_i - \bar{C} \right)^2}}$$

Results And Discussion

Pearson's correlation test (Fig. 3) found that confirmed cases have significantly ($p < 0.05$) positive correlation with the AT (0.483), ISWR (0.268) and WS (0.391), negative association with Hm (-0.304) and PRC (-0.288); however positive but non-significant ($p > 0.05$) relation with CLD (0.109). It depicts that areas with areas with comparatively higher AT with greater ISWR and drier atmospheric conditions (lower humidity and lesser precipitation) seem to register more infected cases in India. Dowell, 2001; Lowen et al., 2007 had shown that the transmission of respiratory virus via aerosol could be suppressed by higher humid conditions, but enhanced under dry conditions. Thus, the summer conditions become more susceptible for this viral transmission in India. A few studies such as Coccia, 2021; Rendana, 2020; Rosario et al., 2020 have opined that higher wind could lower the emanation of the virus, however we found persuasive correlation between wind and COVID-19 cases in India, thus agreeing to Babu et al., 2020; Gautam et al., 2021. Another crucial reason behind this might be that the districts located near and along the western coast in Kerala, Maharashtra as well as the districts of Tamilnadu, Andhra Pradesh and Odisha located in the eastern coast of India catalogued maximum cases during May to July, 2020 which is the onset duration of monsoon over Indian subcontinent, thus experience higher wind from the sea-side towards the land.

In agreement of numerous scientific research conducted in the last two decades, the link between environmental pollution and chronic illnesses mainly the cardiovascular and respiratory diseases are quite comprehensible (Andersson et al., 2020; Mehta et al., 2013; Orru et al., 2017; Zhang et al., 2019b). In the current study we found all the seven air quality parameters to be significantly and positively correlated with confirmed cases. Figure 2 depicts that monthly confirmed cases was better correlated with monthly average concentration of O_3 (0.588) followed by AOD (0.562), CO (0.491), NO_2 (0.396), BC (0.378) and SO_2 (0.302). It confers that concentration of oxidant pollutants had a significant impact on COVID-19 transmission in Indian scenario. There were several hotspots observed in the northern IGP and eastern India contributing detestable amounts of CO and NO_2 that could be held accountable for the appalling air quality in those regions as it might have significantly swayed the exposed individuals to get intensely infected by the coronavirus. Therefore, higher concentration of O_3 along with its precursors (CO and NO_2) could be held noxious for such awful viral emanation especially over northern and eastern part of India. Thus we agreed with Bashir et al., 2020; Li et al., 2020; Pansini and Fornacca, 2020; Zhu et al., 2020b; Zoran et al., 2020 about the significance of O_3 , with CO and NO_2 pollution regarding the COVID-19

emanation. In the present study we have found a high correlation between pollutants emitted due to fossil

fuel combustion and COVID-19 outbreak patterns. Till date, a minimal study has obtained SO_2 and BC to investigate the surging of COVID-19. It was quite distinctive that higher SO_2 and coronavirus outbreak were experienced over IGP, Odisha, coastal areas of Gujarat and Maharashtra. Therefore, it can be quite distinctive that the ensued elevated pollution due to outrageous fossil fuel consumption could cause the neighbourhood to be less immune and predisposed to severe respiratory infection like COVID-19 (Kyung and Jeong, 2020; Suhaimi and Jalaludin, 2015; Thurston et al., 2017), hence prominently associated with pulmonary diseases (Anenberg Susan C. et al., 2010; Peters et al., 2001; Rosenthal et al., 2013). Since PM concentration can't be directly assessed through Satellite based observations (Gupta et al., 2021, 2006; Gupta and Christopher, 2009), we correlated satellite AOD with infective cases and found that the IGP was limned with exorbitant AOD where the coronavirus outbreak was also quite austere. Recently, Comunian et al., 2020; Tang et al., 2020 also discussed the evidence of SARS-CoV-2 virus transmission via dust particles. Therefore, considering the elevated AOD over semi-arid north-west India along with scorching summer conditions, and the infective cases from Rajasthan, Punjab, Haryana and Uttar Pradesh during April-June. Interaction between the meteorological parameters and air pollutants' concentrations are quite complex and varying seasonally, and often influenced by the local physiography including the topographic variations such as location of mountains, valleys, or the presence of substantial water bodies such as large rivers, and lakes (Eum et al., 2015; Prabhu et al., 2020). While comparing with the long term average conditions, many studies had acknowledged the imposition of four tier countrywide lockdown for relatively cleaner air in India during April to mid of June, 2020 (Gupta et al., 2020d; Naqvi et al., 2021; Singh and Chauhan, 2020). Even though we found that the IGP followed by the coastal districts of West Bengal, Odisha, Andhra Pradesh, Maharashtra, Kerala, Tamilnadu had inhaled quite bad air where each states had registered more than 30,000 cases during that period. Therefore, it suggests that the shoddy air quality could not be discretely blameworthy for coronavirus dissemination in India, rather bad air with successively increasing AT in summer environment could be held responsible.

Conclusion

Our conscientious study suggests that the summer tropical environment in India may spare a more affirmative condition for SARS-CoV-2 transmission. Instead of squashing the COVID-19 curve, higher air temperature may significantly assist an augment in pandemic predicament in India. Comparatively higher wind in drier areas could indulge the virus to unfurl more. Besides, the negative correlation between precipitation and infections. The positive correlation between coal blazed pollution and COVID-19 outbreak, as well as the negative association between the recovery count from this disease and prevailing regional pollution levels stoutly suggest that the exorbitant air pollution due to bounteous non-renewable energy generation and its perpetual consumption might perturb the inbred immunity of residents in circumjacent area, and hinder them also in agile recovery from this disease. The concurrent health tribulation and the interconnection of diseases affecting multiple organs are also decisively discerned during COVID-19 infections. During or in a later stage of treatment, several patients are also condemned to various post-syndrome infections mostly related to cardiovascular and respiratory disorders which

that the environment needs to be ameliorated immensely by its standards to alleviate such deadly pandemic. The pre-eminence of weather parameters on air quality is indubitable and evinced globally and its significant association with COVID-19 dissemination during a year-long period over India has been certainly revealed through the present study.

Declarations

Competing interests: The author declares no competing interests.

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Figures

Figure 1

Correlogram for the present analysis