8 A Literature Review of the Impact of COVID-19 Pandemic on Land Surface Temperature and Air Quality of India

Vanlalchhuanga, Brototi Biswas, and Jonmenjoy Barman

Abstract

The unprecedented upsurge of the COVID-19 has disrupted human life in many ways. Although the pandemic has severely crashed the global economy, the envisaged positive results were experienced in many countries, especially in the case of the natural environment. India, the country which experienced one of the worst environmental pollutions, has witnessed the growth of positive impact on land surface temperature and air quality. India's since March 25, 2020, the federal and state governments have imposed a countrywide total and partial lockdown at various times and locations. This paper highlights the various research literatures in land surface temperature (LST) and air quality monitoring during India's pandemic lockdown. According to the study, the primary air pollutants' concentration levels had reduced significantly across the country: PM10 (33%), PM2.5 (34%), CO (21%), NO_2 (47%), and SO_2 (21%). The lockdown time is related with better air quality in most cities, the Central Pollution Control Board NAQI result reveals that the prominent pollutants are found to be particulate matter, during the lockdown, Kolkata (62%) saw the greatest reduction in PM2.5 levels, other major cities also experienced high reduction, New Delhi had witness 26% reduction, likewise, Chennai (34%) and Mumbai (49%). In addition to air quality, the LST also decreased during the lockdown with major cities experiencing decreases of mean surface temperature during the lockdown in India.

Keywords

Air quality · LST · COVID-19 · Lockdown · Pollutants

8.1 Introduction

The novel pandemic SARS-COVID-19 is a transmittable infectious disease associated with severe respiratory illness (Islam et al. 2020). COVID-19 has profound global consequences, resulting in an increase in death and widespread economic losses. (Bukhari and Jameel 2020). India enacted a mandatory community lockdown on March 22, 2020. Following this several parts of the nation were put under lockdown or partial lockdown over a year, with distinct rates of regulations. The high-density areas and megacities were highly affected in terms of social and economic activity. Nonetheless, COVID-19 had

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J. Das and S. K. Bhattacharya (eds.), *Monitoring and Managing Multi-hazards*, GIScience and Geo-environmental Modelling, https://doi.org/10.1007/978-3-031-15377-8_8

a substantial impact on major cities environmental aspects which including air quality and land surface temperature. A study between 1901 and 2001 reveals that the India's overall urban population rose by more than tenfold, from 26 to 285 million (Mohan 1996). Environmental degradation has been intensifying in India as a result of unregulated urbanization, resulting in a slew of issues (Uttara et al. 2012). The impact may be seen in the rise of harmful greenhouse gases and urban heat island, with India having one of the worst pollution issues in the world. This paper does a detailed study of the works of several scholars who studied the impact and implications of corona virus induced confinement on the air quality and urban heat island through LST in India using various techniques. The studies revolve across India's different cities. The findings of the studies appear to suggest that lockdown had enhanced the air quality index and led to a decrease in mean urban heat island (Nanda et al. 2021).

8.2 Land Surface Temperature

Land surface temperature was previously known as conventional surface-air temperature and is recorded by a protected thermometer. However, with the advancement in satellite technology, new forms of LST, termed as skin temperature has become available worldwide (Dickinson 1994). The level of LST is a significant factor in the surface energy budget because it regulates the amount of sensible heat transfer and, as a direct consequence, the air temperature (Frey and Kuenzer 2014). LST can become a useful indicator of monthly average air temperature over a long period of time as well as, relative humidity, and total precipitation (Ozelkan et al. 2014). It depends on LULC types with vegetation playing an important role (Mallick et al. 2008*)*. LST has such a negative relationship with the abundance of green space (Li et al. 2013). Negative relationship between vegetation area and LST is observed with a 1.750 °C lower when compared to the built-up area (John et al. 2020). LST has a negative relationship with vegetation index and built up (positive) (Guha et al. 2018). The highest increase in LST has been about 20 °C over the Delhi metropolitan built-up regions (Chakraborty et al. 2017). NDVI trends can be utilized to establish an urban heat island (Grover and Singh 2015).

The heterogeneity of land cover and other atmospheric conditions causes LST to vary spatially (Talukdar 2020). The influence of change in elevation at various sites must also be addressed when analyzing the spatial distribution of LST across a large area (Khandelwal et al. 2017). In high altitude places, the LST-elevation scatterplot reveals an adverse correlation (Mathew et al. 2017). Shaded relief plays a significant role and is positively related to LST. (Peng et al. 2020). Despite the fact that there are still numerous research gaps in atmospheric composition, air quality modeling, and forecasting studies (Baklanov and Zhang 2020), Sen's slope estimator and basic linear regression are the two approaches and models that are dependable for studying. In terms of estimating the long-term variation trend of the mean monthly LST, the results show that there was no significant difference between the two models. (Firoozi et al. 2020).

In order to determine distinct land surface classifications, LST is generated from satellite-thermal IR data using a single-channel (SC) method utilizing atmospheric correction parameters, as well as the land surface emissivity (LSE) derived by a hybrid-ground-based model (Chatterjee et al. 2017). The LST can also be predicted using the multivariate adaptive regression spline (MARS), adaptive-network-based fuzzy inference system (ANFIS), and dynamic evolving neural-fuzzy inference systems (DENFIS) models. (Mustafa et al. 2020). The machine learning linear regression model for prediction of particulate matter shows the model was performed better as compared to the traditional model (Doreswamy et al. 2020). A novel hybrid model for predicting the air quality is also reliable. This combines two recurrent neural network (RNN) models, and the result has shown overall improvement in model performance (Hossain et al. 2020).

8.3 Air Quality

Air is the elixir of life, and hence, the increasing level of air pollution is a cause of great concern. (Reddy et al. 2020). According to the World Health Organization, air pollution is a serious cause of premature death in the general public, culminating in millions of deaths each year. Air pollution is a complex mixture of gases, particles, aerosols, and water vapor caused by human activity as well as other anthropogenic and natural processes (Nigam et al. 2016). The air quality index (AQI) is a statistical index that government agencies use to notify about how polluted the air is or will become. (Tiwari 2015). Many organizations and nations across the world have created and developed AQI standards. In India, the Central Pollution Control Board (CPCB) is in charge of setting the standard for ambient air quality.

8.4 Impact of COVID-19 Lockdown on LST and Air Quality in India

The COVID-19 shutdown has resulted in a massive drop in global economic activity and related air pollution levels, owing mostly to a decrease in inland transport mobility (Venter et al. 2021). The Indian government imposed a countrywide shutdown on March 25, 2020, as a result of COVID-19 fast and devastating spread throughout India. This led to a sharp reduction in the air pollution levels of India, with a countrywide decrease of 33% in average "PM10, PM2.5, carbon monoxide (CO), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2)" of 21% and 21%, of 21%, respectively, (Verma and Kamyotra 2020). Particulate matter and various human-induced greenhouse gases are significant contributors to air pollution in India (Nasir et al. 2016).

Prior to the shutdown, India's air quality showed alarmingly high levels of air pollution in various places throughout the country. In Agra city, foundries using coal as fuel, coupled with vehicular emissions have yielded to the city's high pollution rates. The levels of nitrogen dioxide (NO_2), respirable suspended particulate matter (RSPM), and suspended particulate matter (SPM) levels were discovered to be constantly above average National Ambient Air Quality Standards (NAAQS). Pollution levels were found to be higher in the winter, but lower in the summer and monsoon seasons. (Nasir et al. 2016). If the concentration of pollutants of eight sample cities is compared with data from the prior year during the lockdown period, as well as the NAAQS, lockdown time is linked to better air quality (Dasgupta and Srikanth 2020) PM2.5 and PM10 levels were reduced by 52% and 53.5%, respectively, during the initial lockdown in the foremost cities of Punjab and Chandigarh paralleled to pre-lockdown levels. With relaxation on lockdown measures, a slow rise in the pollutant levels was noted again (Sahoo et al. 2021). During the lockdown, Kolkata experienced the greatest reduction in PM2.5 (62%), followed by Mumbai (49%), Chennai (34%), and New Delhi (26%). The level of PM2.5 in Hyderabad, in comparison, fell slightest by 10%. (Ravindra et al. 2021). This is true for the majority of pollutants and cities in the study, with pollution levels being significantly lower than in 2019. CO, NO_2, and SO_2 levels have all dropped drastically in Kolkata, during the lockdown in 2020. Meanwhile, due to the complete halt of vehicular movement, biomass burning, and dust particles from construction projects, during lockdown, the percentage decrease in PM10 and PM2.5 was around 17.5% as compared to previous year (Bera et al. 2020). Automobile, power stations and home emissions are the major sources of emission in Kolkata, suggesting that local emissions are dominated by the concentration of SO_2, NO_2, NH_3, and PM10 (Gupta et al. 2008). In Kolkata, the mean LST was 28.76 °C before lockdown (March 13, 2020); however, after lockdown (30 April 2020) it fell to 26.56 °C (Sahani et al. 2020). Substantial improvement in the nature of air pollution and AQI was the consequence of the shutdown, according to research. The AQI has decreased during the first and second phase of lockdown and rose during the third phase of lockdown owing to government relaxations dur-

ing this phase; however, the AQI declined again during the fourth phase of lockdown in 2020 (Tripathi 2020). During Delhi's post-lockdown period, the percentages of "PM10, PM2:5, NO_2, and SO_2" dropped by 55%, 49%, 60%, and 19%, respectively, whereas in Mumbai, they decreased by 44%, 37%, 78%, and 39%, respectively, (Kumari and Toshiwal 2020).

In 2020, the air quality in 39 Indian cities improved (including ten cities in India that are among the global highest 20 worst polluted). During the lockdown period in 2020, only 15% of cities had an AQI in the "unhealthy" category (151–200), whereas 56% of cities had an AQI in the "unhealthy" category in 2019 (Kumari et al. 2020). The pollution levels in the northern part of India were poor during shutdown (including Delhi which is one of the most polluted) improved up to 30–46.67% (Gautam et al. 2020). The "Central Pollution Control Board" data about PM 2.5 emissions in the Delhi area show a significant decrease during the shutdown period (Fig. 8.1), in Delhi, PM10 and PM2.5 dwindled by 50% during the lockdown period from the pre-lockdown period along with NO_2 (52.68%) and CO (30.35%). National Air Quality Index (NAQI) reported a reduction in the Central, Eastern, South, Western, and Northern portions of Delhi by 54%, 49%, 43%, and 37%, respectively, (Mohato et al. 2020). Pan India an improvement in air quality of 40–50% has been observed by 40–50% just four days into lockdown.

The "European Space Agency Sentinel" 5p mission image shows the lockdown impact has clearly visible as the western and northern portion of the sub-continent has witness a swept clean the emission concentration spot which shows tremendous decreases in nitrogen dioxide emission (Fig. 8.2). The mean tropospheric NO_2 concentration in India, according to the data, was 214.4×1013 cm^2 from March 1 to March 21, 2020, and then decreased by 12.1% over the next four weeks. As a result, the decline in tropospheric NO_2 levels is attributable to less anthropogenic activities. In 2019, tropospheric NO_2 concentration had increased by 0.8%. Several research works done during the lockdown were studied, and biomass emissions were discovered to be a significant source of tropospheric NO_2. (Biswal et al. 2020). Significant shift of 7% to 67% in AQI has been recorded in Chandigarh and Ballygunge (Kolkata). There has been a huge change from 25.76% to 68.55% in AQI of Ahmedabad, Worli, Talkatora, and Lalbagh (Alok et al. 2020).

8.5 Conclusions

The COVID-19 pandemic-induced shutdown has already had a favorable influence on environmental concerns. The present work is a review of articles published during lockdown of 2020 revolving around various environmental issues in the backdrop of diminished anthropogenic

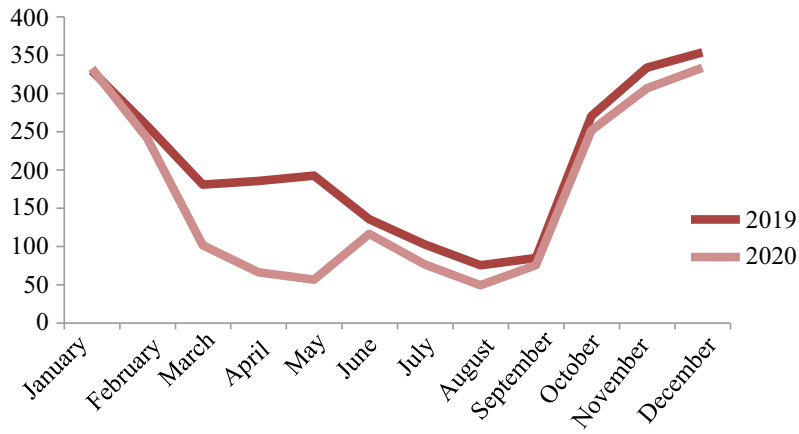

Fig. 8.1 Delhi PM 2.5 emission. *Source* Central Pollution Control Board

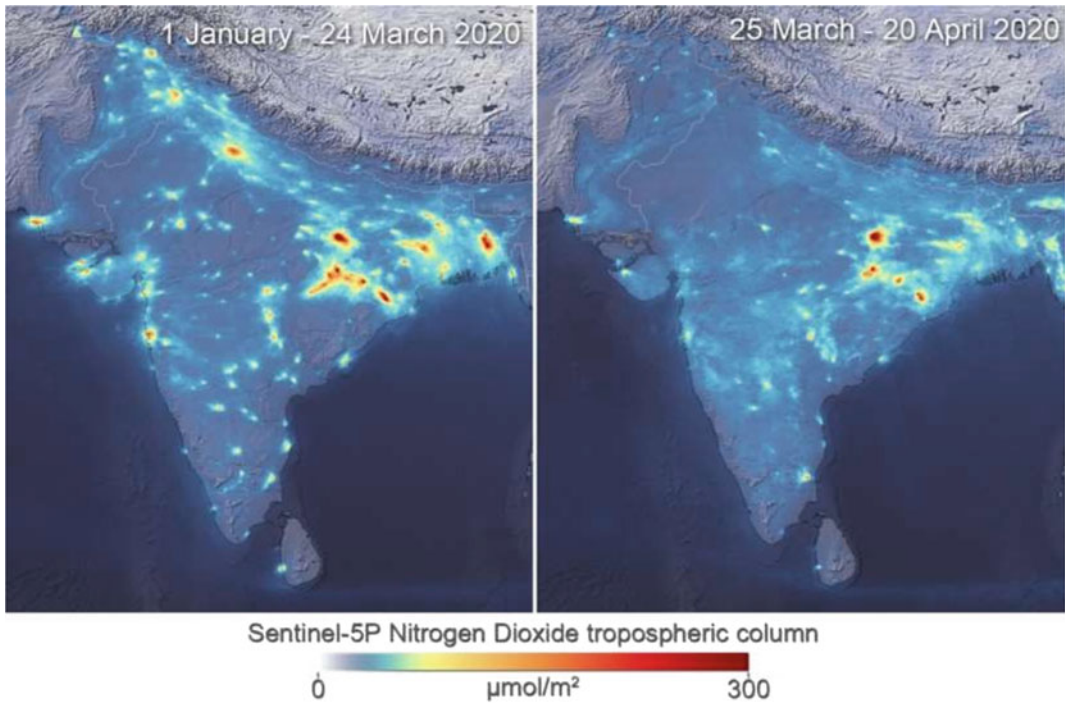

Fig. 8.2 Nitrogen dioxide drops due to lockdown in India. *Source* European Space Agency (2020)

activities owing to COVID-19 induced lockdown. During the COVID-19 lockdown, many socio-economic activities came to a complete halt, resulting to have positive results in the air quality and also decrease in land surface temperature pan India. This gives us hope for environmental sustainability, not only for India, but for the world's megacities that are notoriously polluted. All the polluted Indian cities, within just four days into implementing lockdown, saw air quality has improved by 40–50%. There has been a reduction by 60–39% in the PM10 and PM2.5 level, respectively. The lockdown phase significantly lowered NO_2 (52.68%) and CO (30.35%) among other pollutants.

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