International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

A Review on the Investigation of COVID- 19 Lockdown Influence on Air Pollution

Ram Babu Lovewanshi and Kirti Jain

Department of Computer Science & Engineering, SORT
Peoples University Bhopal, Madhya Pradesh, INDIA

A B S T R A C T

COVID-19 has had an effect on millions of people. Because of weather concerns, there is growing fear about the virus spreading in congested areas. This study, based on a review article on the air quality index, aims to investigate future management approaches and preventative sustainable solutions that can help to mitigate the impact of falling air quality and prevent future biological attacks from harming occupant health.

Keywords:COVID-19, Air quality Index

1. Introduction

The rapid spread of the rare worldwide pandemic COVID-19 triggered by SARS-COV-2 had unprecedented global repercussions, with mortality rates rising by 2-3%. (Rodriguez-Morales et al., 2020). Inhaling or coming into touch with infected droplets spreads the extremely contagious disease, which causes mild to severe respiratory illness before progressing to pneumonia, septic shock, acute respiratory distress syndrome, and cytokine release syndrome (Cdc.gov/coronavirus, 2020). A range of factors influence the transmission of this virus and its impact on patients. Recently, scientific attention has been directed to the factors that contribute to the fast spread of viruses and their fatality rate. According to the studies, those who have chronic respiratory illness, diabetes, cardiovascular disease, or even high blood pressure and cancer are more prone to contract coronavirus (Zheng, Ma, Zhang, & Xie, 2020).

The growing number of COVID-19 cases is influenced by socio-demographic factors such as a lack of basic services, congested slum neighbourhoods, and congestion across public transportation, journey time, and infrastructure quality (Das et al., 2021; Li, Peng, He, Wang, & Feng, 2021; Ma, Li, & Zhang, 2020). Furthermore, evidence is increasing that environmental elements such as temperature, humidity, airflow, air quality, solar irradiation, wind speed, and rainfall impact the seasonal distribution of COVID-19 (Tzampoglou & Loukidis, 2020). Poor air quality is a key factor that may increase death rates in the socioeconomic group currently dealing with respiratory disorders, as well as those over the age of 60. Bashir and colleagues (2020).

The combustion of fossil fuels in vehicles and power plants, industrial operations, and animal raising are the principal anthropogenic activities that contribute to the deteriorating of air quality. These activities produce particular pollutants (PM10, NO2, PM2.5, O3, CO, and SO2), which can become harmful if allowed levels are exceeded and may expedite viral propagation. Several studies conducted in pandemic-affected areas have discovered a link between PM2.5 and COVID-19 cases, hospitalizations, and fatalities (Cole, Ozgen, & Strobl, 2020).

A similar positive relationship has been established between increasing COVID-19 level and NO2 concentration (Latif, Dominick, Hawari, Mohtar, & Othman, 2021; Ogen, 2020; Wang & Li, 2021). The data reveal that air pollution has a substantial role in the rise in COVID-19 cases. These emissions must be kept below acceptable levels and monitored on a regular basis in order to take effective measures to combat growing pollution levels. The air quality index (AQI) is one such successful monitoring tool that indicates the status of the air by comparing the concentration of gases in ambient air to regulatory requirements (Beig, Ghude, & Deshpande, 2010).

A typical AQI is an interpretive strategy that simplifies difficult data of observed air pollution concentrations into a single number or collection of numbers. AQI is assessed using diverse language and computed using various methods all across the world. Fuzzy aggregation, connected PCA, and ANN, which combine IoT and cloud computing technologies, are some recent breakthroughs in the field of AQI forecasting (Jo, Jo, Kim, & Choi, 2020).

According to a statistical examination of the impact of AQI and its concentration levels on respiratory illness, genders, and age groups (Ikram & Yan, 2017), the higher the index level, the greater the likelihood of having a respiratory ailment in the elderly.

The solution is twofold: first, non-pharmaceutical measures such as maintaining social distance in indoor spaces, hand washing, regular surface sanitization, implementing lockdown, and wearing a facemask in a crowded place; second, providing a proper ventilation rate to reduce exposure to aerosols in confined areas via natural, mechanical ventilation or portable, wall-mounted, or in-duct air cleaners (Atkinson et al., 2016).

Scientists, academics, and policy/decision-makers, according to our results, have looked at IAQ parameters and solutions such as non-pharmaceutical measures and engineering controls individually, which can lead to limited solutions. As a result, the focus of this review article is on the factors impacting IAQ and occupant health, as well as a collaborative strategy that can help pave the way for a more sustainable solution.

2. Methodology

The purpose of this research is to assess the factors that lead to poor IAQ, their influence on COVID-19 circumstances, and effective IAQ improvement strategies that can help avoid future bio-attacks. To achieve the goal of the review article, a wide variety of sections related to IAQ and COVID-19 were explored in order to cover all of the relevant features in the current context. We divided the research interests into science regimes such as biology, chemistry, engineering, information, physical, and human resource development to improve comprehension and reach.

As a result, the content is drawn mostly from recent publications such as peer-reviewed research articles, review papers, letters to the editor, dissertations, and books. The search phrases used were Indoor Air Quality, Coronavirus, COVID-19, lockdown, social distance, air purifiers, Air Quality Index, AQI predictions, Indoor air quality improvement, impact or efficacy, ventilation, and face masks. To improve search results, many keyword variants and combinations were used.

3. Effect of Air Quality on Covid-19

Clean air is beneficial to human health since it impacts our bodies' normal metabolism. Continuous exposure to aerosols, particulates, and nitrogen compounds increases the risk of death from any cause, lung cancer, and other respiratory disorders (Heal, Kumar, & Harrison, 2012). Environmental diseases account for 20% of all-cause mortality in Europe, according to WHO data (Beelen et al., 2014). Air quality has deteriorated as a result of excessive emissions, which has directly led to the spread of COVID-19.

According to an Italian epidemiological investigation, PM2.5 increases SARs-COV-2 infectivity (Borro et al., 2020). According to the study, an increase in PM2.5 concentration of 10 25 g/m3 triples the infection incidence and doubles the death rate. Similarly, an epidemiological evaluation was undertaken in 355 towns in the Netherlands to determine the link between air quality and COVID-19 fatalities using a negative binomial regression model with chemical transport modelling, as shown in Eq. (1). (Cole et al., 2020).

$$C_i = \emptyset Pollution + \beta_1 D'_i + \beta_2 P'_i + \beta_3 E'_i + \beta_3 S'_i + \beta_4 L'_i + \gamma_r + \epsilon_i \qquad (1)$$

Where, C is COVID-19 infected cases or personals hospitalized due to COVID-19, or the number of mortals from COVID-19 in municipality i. Pollution specifies annual concentrations of PM2.5, NO2, and SO2 averaged for the period 2015–2019. Vector D', P',E, S' and L'includes control variables capturing demography, social, and physical proximity, employment/education, spatial and health variables, respectively, for the year 2019 and β is the associated parameter. The term γrdenotes province-level fixed effects for each province r. The modeling resulted that all three pollutants were in a positive association with the COVID- 19 cases and concluded that a particular increase in 1 unit (μg/m3) of PM2.5 increases 9.4–15.1 COVID-19 cases, 2.9–4.4 hospital admissions, and 2.2–3.6 mortality cases. A similar study examining deaths due to COVID-19 in the US (Wu et al., 2020), reported that a 1μg/m3 increase in PM2.5 is associated with an 8% hike in the COVID-19 mortality rate.Accordingly, a study conducted using negative binomial regression and spatial interpolation (kriging) data (Coker et al., 2020) in northern Italy accounted that 1 unit μg/m3 increase in PM2.5 relates to a 9% increase in COVID-19 mortality.

4. Air Quality Assessment

Because pollutants and air travel in a variety of ways and directions as a result of natural causes and atmospheric events, it is challenging to simulate pollutant concentrations in a specific place (Kurt & Oktay, 2010). AQI was established to reflect the level of deteriorating air quality and is frequently referred to by a variety of names, with significant parametric changes such as the inclusion of PM2.5 after 2009 and other toxic elements for valid AQI measurement, as indicated in Table 1. The air quality index (AQI) is a measure that helps the public recognise the degree of air quality in their surroundings on a daily basis. The PSI was designed by the EPA to determine air quality using five major pollutants (PM10, NO_2, O_3, CO, and SO_2). The PSI value was determined by dividing a scale of 0-500 into 5 equal parts and taking the largest value of one of the five pollutants' concentrations.

- **Table1: Air quality indices**

References	Year	Name of Index	Parameters included
Ott& Hunt,1976	1976	Pollution Standard Index	PM_{10}, NO_2, O_3, CO, and SO_2
USEPA, 2004	1999	Air Quality Index	PM_{10}, NO_2, $PM_{2.5}$, O_3, CO, and SO_2
Bishoi et al., 2009	2009	New AQI	PM_{10}, NO_2, $PM_{2.5}$, O_3, CO, and SO_2
Sicard et al., 2011	2011	Aggregate Risk Index	PM_{10}, NO_2, $PM_{2.5}$, O_3, and SO_2
CPCB, 2014	2014	National AQI	PM_{10}, NO_2, $PM_{2.5}$, O_3, CO, and SO_2
Nawras Shatnawi and HaniAbu-Qdais, 2021	2021	Pollutant concentration	PM_{10}, NO_2, and SO_2

However, many other pollutants were neglected, such as PM2.5, whose exposure had a detrimental influence on human health. The USEPA renamed PSI as AQI after including new sub-indices for 24-hour PM2.5 concentrations, an 8-hour average O_3 concentration sub-index, and O_3 breakpoints. The AQI was calculated using Eq (2).

$$I_P = \frac{I_{Hi} - I_{Lo}}{BP_{Hi} - BP_{Lo}} (C_P - BP_{Lo}) + I_{Lo} \quad (2)$$

Where IP is the pollutant index value, P; CP is the truncated pollutant concentration, P; BPHi is the breakpoint Cp; BPLo is the breakpoint Cp; IHi is the AQI value that corresponds to BPHi, ILo is the AQI value that corresponds to BPLo. Using the aforementioned equation, the indices of each pollutant were determined, and the highest index value was reported as AQI, which may be expressed mathematically as in Eq (3).

$$AQI = Max\ (I_P) \quad (3)$$

According to the values, the AQI is classified into six health concern levels. The air quality index (AQI) ranges from 0 to 50, 51–100, 101–150, 151–200, 201–300, 301–500, and reflects excellent, moderate, unhealthy for sensitive groups, unhealthy, extremely unhealthy, and hazardous air quality, respectively.

A comparative study utilising the correlation- regression approach between the revised AQI and PSI revealed that the revised AQI had a higher correlation with PM10 than the PSI, indicating that the revised AQI provided more accurate findings than the PSI. Many research proved alternative methodologies for assessing the AQI for different places that produced more accurate findings than the USEPA AQI. analysed the air quality of Delhi, Calcutta, Mumbai, Nagpur, and Chennai by changing the ORAQI based on Indian environmental parameters. The ORAQI was developed for five contaminants and is shown in Eq (4).

$$ORAQI = 5.7 \times \left(\sum_{i=1}^{S} I_i\right)^{1.37} \quad (4)$$

Where Ii is the ratio of pollutant concentration to standard level of pollution. As standards for specific pollutants, SO2, NO2, and SPM, were established in India, the modified equation for distinct sectors, such as residential, commercial, and industrial, and the standard levels were received from the CPCB, as shown in Eqs. (5) and (6). (7).The AQI on the 24 -hly basis for the residential area can be calculated by:

$$AQI_{(RSPM, SO_2, NO_2)} = 55.16 \times \left(\frac{RSPM}{STD} + \frac{SO_2}{STD} + \frac{NO_2}{STD}\right)^{0.901} \quad (5)$$

The 24- hourly AQI for commercial and industrial sectors can be calculated by:

$$AQI_{(RSPM, SO_2, NO_2)} = 24.48 \times \left(\frac{RSPM}{STD} + \frac{SO_2}{STD} + \frac{NO_2}{STD}\right)^{1.07} \quad (6)$$

Furthermore, AQI levels were classified as excellent if they were less than 30, moderate if they were between 30–49, poor if they were between 50–79, awful if they were between 80–99, and hazardous if they were greater than or equal to 100.

Using this technique, Delhi was found to be the most polluted city out of the five studied, with the residential and business sectors classified asharmful. Calcutta and Mumbai came in second and third place,respectively, while Nagpur and Chennai were the least polluted cities.

4. Forecasting of Air Quality

Sowlat, Gharibi, Yunesian, Tayefeh Mahmoudi, and Lotf (2011) developed an AQI using a fuzzy interference system, taking into account toxic pollutants such as toluene, benzene, xylene, ethylbenzene, and 1, 3-butadiene, as well as the criteria pollutants (PM10, NO2, O3, CO, and SO2), and then assigning weighing factors to each pollutant The trapezoidal membership function was used to create fuzzy AQI, which was then compared to the USEPA AQI for study.As a result, all contaminants should be evaluated, and fuzzy logic is an appropriate method for forecasting air quality.
Bishoi et al. (2009) proposed a NAQI based on factor analysis usingthe PCA technique. The PC can be calculated using Eq. (9).

$$P_i = \sum_{j=1}^{n} \frac{a_{ji} X_j}{\lambda_i} \tag{7}$$

where Pi is the ithPC; ajiis the factor loading of the jth variable on the ithPC and λiis the eigenvalue associated with Pi. After obtaining the PCs, the NAQI is computed using the expression given in Eq. (10).

$$NAQI = \frac{\sum_{i=1}^{n}(P_i E_i)}{\sum_{i=1}^{n}(E_i)} \tag{8}$$

Where Eiis the initial eigenvalue (≥1) for the ’percentage of variance’. NAQI took into account the variances of concentrations of different pollutants which were useful for the determination of air quality.
Despite the fact that it did not give any information on the impact of air quality on health, it was regarded better than the EPA AQI. Notably, hybrid statistical models are currently in use due to their great precision in forecasting air quality condition. MLR, ARIMA, SVRs, ANNs, and hybrid models are examples of statistical models. These models alone are insufficient for air quality forecasting, as Kumar and Goyal (2011) demonstrated in their study measuring AQI for Delhi. (Goyal, Chan, &Jaiswal, 2006) suggested three statistical models, namely MLR, ARIMA, and a mixture of both MLR and ARIMA, for determining interrelationships in meteorological factors and pollutants concentrations and their effciency in forecasting AQI in Hong Kong and Delhi. According to the analysis, the combination of both models MLR-ARIMA was better at forecasting AQI than individual models, and humidity, temperature, and wind speed were significant factors in determining the concentration of pollutants in Delhi, whereas humidity and wind speed were significant factors in Hong Kong. Zhu et al. (2017) developed two hybrid models, EMD-SVR-Hybrid and EMD-IMFs-Hybrid, both of which are merged with EMD and S-ARIMA. In the former model, data pre-processing technique EMD shifts the original AQI data driving a collection of smoother IMFs and noise series.
The SVR forecasted the sum of the IMFs, and then, S-ARIMA revised the residual sequence. In the latter model, EMD-IMFs-Hybrid frstly fore-casted the IMFs withstatistical models and then models the residual dataalong with S-ARIMA. Similarly, a novel optimal-hybrid model based on Secondary Decomposition (SD), Sample Entropy (SE), Long Short-Term Memory (LSTM) Neural Network, and Least Squares Support Vector Machine optimized by Bat Algorithm (BA-LSSVM) named SD-SE-LSTM-BA-LSSVM was developed (Wu & Lin, 2019) for impro-vising AQI forecasting bearing the ability to capture the original AQI series characteristics and possess forecasting accuracy of AQI classes. Such hybrid models need to be embraced at the government level as they possess high precision. Moreover, the toxic compounds should be takeninto consideration while calculating AQI as exposure to a small dose of these compounds can be lethal.

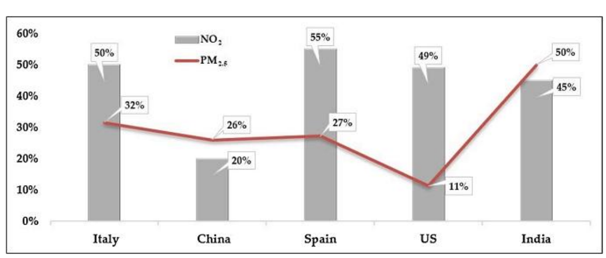

Fig. 1. Reduction in (a) NO2 and (b) PM2.5 concentration amid lockdown due to COVID-19[4].

5. Discussion

The COVID-19 epidemic has had extraordinary consequences not just for health but also for lifestyle, business, and the environment. This pandemic raised several problems, including its genesis, impacting characteristics, and medicines to heal the condition, as well as future preventative measures, as it is neither the first nor the last of its sort. The whole scientific community is working to find answers to these questions. Air quality, like temperature and humidity, is a measure that corresponds with both COVID-19 and occupant health in the interior environment. As COVID-19 is deemed airborne by numerous research and trials, PM2.5 and NOX were observed to enhance infection exposure in ambient air (Ferguson et al., 2020; Wang & Li, 2021). These criteria not only aggravate the issue in the outer environment, but they also exacerbate the problem indoors.

6. Conclusion

The astounding rate of spread of the unusual worldwide pandemic COVID-19 compelled scientists to deconstruct the variables assisting the pandemic's intensification and assess all potential preventative methods to resist the sickness. The relative air quality and COVID-19 and IAQ improvement approaches were examined in this review study. The following are the important conclusions from the evaluated papers and recommendations for the development of a sustainable society and environment:

The AQI has been extremely beneficial to the people since it alerts them to the degree of pollution in their area and allows them to take appropriate action. AQI is now anticipated using fiveparameters: PM10, NO2, O3, CO, andSO2;nevertheless, the tiny number of harmful substances in the air can potentially cause severe concerns. As a result, it is preferable to include harmful substances when projecting AQI.

The positive relationship between air pollutants (PM2.5 and NO2) and COVID-19 transmission calls for an increase in the air quality index. Using preventative actions to reduce air pollution can kill two birds with one stone, lowering exposure rates because COVID-19 is airborne and fighting climate change. As a result, two of the sustainable development goals have been met.

•The health of people in confined places should be prioritised. The evaluated publications concluded that IAQ can be improved using non-pharmaceutical approaches and engineering controls, although both have advantages and disadvantages. The ideal approach is to find a happy medium for all of the strategies that can help lower infection risk.

The review concludes that facemasks are beneficial in open areas or busy situations. However, prolonged use inside might induce hypercapnia and hypoxia, particularly in vulnerable individuals.

Face shields are one of the options that may be focused on since they allow for greater airflow and are reusable, reducing medical waste. Lockdown was widely used across the world to reduce the peak of growing instances. It also benefited the environment in its early stages, but it cannot be regarded a long-term solution owing to its negative economic impact.

• Social distance is an effective non-pharmaceutical approach in indoor environments that can significantly minimise infection risk. Although maintaining social distance was difficult due to low-income households, socio-cultural emotions, and mental health, the government, IoT, learning-based models, and numerous social media platforms aided in making this feasible. By giving incentives and monitoring public spaces, social separation might be fostered. Furthermore, medical robots and unmanned aerial vehicles can be used to decrease human involvement in critical jobs. Ventilation can assist dilute impurities and minimise infection risk from the standpoint of engineering controls. As previously said, air should not be recirculated, and using 100% fresh air may waste more energy. It is now time to transition to smart city design concepts in which hygienic ventilation may be accomplished utilising 100 percent fresh air while consuming little energy for long-term sustainability.

• Self-disinfecting air purifying filters have been shown to be beneficial in reducing the transmission of possible airborne or aerosolized COVID-19. UV germicidal filters, ionization filters, PCO, or newer developing SOP may all aid with viral inactivation in residential and public buildings. However, they are unable to protect humans from both direct and indirect exposure. To protect people from future bio-attacks like the one we are facing, it is critical to adapt the HVAC system utilised in interior spaces by merging mechanical ventilation with air purifying techniques like UVGI.

Overall, it is clear that all of the remedies are condition-specific, and adding merely one or two of these procedures may not be sufficient to reduce COVID-19 situations. However, combining or integrating these strategies canaccount for a practical solution that may assist reduce the current issue and prevent a similar situation in the future. As the globe attempts to return to normalcy, it is advised that occupancy density be reduced and smart building designs be used for a more sustainable future.

References

Ahlawat, A., Wiedensohler, A., & Mishra, S. K. An overview on the role of relative humidity in airborne transmission of sars-cov-2 in indoor environments. Aerosol and Air Quality Research, 2020. https://doi.org/10.4209/aaqr.2020.06.0302

Barcelo, D. An environmental and health perspective for COVID-19 outbreak: Meteorology and air quality influence, sewage epidemiology indicator, hospitals disinfection, drug therapies and recommendations. Journal of Environmental Chemical Engineering, 2020. https://doi.org/10.1016/j.jece.2020.104006

Berman, J. D., & Ebisu, K. Changes in U.S. air pollution during the COVID-19 pandemic. Science of the Total Environment, 2020, 739, Article 139864. https://doi.org/ 10.1016/j.scitotenv.2020.139864

Nehul Agarwal, ChandanSwaroopMeena, Binju P Raj, Lohit Saini, Ashok Kumar, N. Gopalakrishnan, Anuj Kumar, NageshBabuBalam, TabishAlam, Nishant Raj Kapoor and Vivek Aggarwal, "Indoor air quality improvement in COVID-19 pandemic: Review," Elsevier, Sustainable Cities and Society, 2021, 70, 102942, pp.1-15.

Feng Liu, Meichang Wang and Meina Zheng, "Effects of COVID-19 lockdown on global air quality and health," Elsevier, Science of the Total Environment, 2021, 755,142533, pp. 1-13.

Zheng, Y. Y., Ma, Y. T., Zhang, J. Y., &Xie, X. COVID-19 and the cardiovascular system. Nature Reviews Cardiology, 2020, 17, 259-260. https://doi.org/10.1038/s41569- 020-0360-5

Das, A., Ghosh, S., Das, K., Basu, T., Dutta, I., & Das, M. Living environment matters: Unravelling the spatial clustering of COVID-19 hotspots in Kolkata megacity, India. Sustainable Cities and Society, 2021, 65, Article 102577. https://doi.org/ 10.1016/j.scs.2020.102577

Tzampoglou, P., &Loukidis, D. Investigation of the importance of climatic factors in COVID-19 worldwide intensity. International Journal of Environmental Research and Public Health, 2020, 17, 1–25. https://doi.org/10.3390/ijerph17217730

Bashir, M. F., Ma, B., Bilal, Komal, B., Bashir, M. A., Tan, D., et al. Correlation between climate indicators and COVID-19 pandemic in New York, USA. The Science of the Total Environment, 2020, 728, Article 138835. https://doi.org/10.1016/j. scitotenv.2020.138835

Cole, M. A., Ozgen, C., &Strobl, E. Air pollution exposure and COVID-19, 2020, Discussion paper series. IZA DP No. 13367 (p. 31).

Latif, M. T., Dominick, D., Hawari, N. S. S. L., Mohtar, A. A. A., & Othman, M. The concentration of major air pollutants during the movement control order due to the COVID-19 pandemic in the Klang Valley, Malaysia. Sustainable Cities and Society, 2021, 66, Article 102660. https://doi.org/10.1016/j.scs.2020.102660