Chapter 5
Blessing in Disguise in the Megacities: Environmental Co-benefits in Air Quality Amid Covid-19 Lockdown in Kolkata

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Abstract Kolkata is the third-most populous metropolitan area in India after Delhi and Mumbai, known as eastern India’s cultural, educational, and commercial centre. It is the 2nd furthermost polluted city in India with a yearly average of 59.8 µg/m³ PM2.5 concentrations (IQAir 2019). Kolkata recorded the highest AQI (191) from 12–19 March 2020 & the lowermost (33) on 23–24 March 2020. This is happened due to the government imposed a nationwide lockdown. As a result of the lockdowns, air and noise pollution decreased for a short period, and air and water quality, biodiversity improved due to reduced industrial and human activities. On this backdrop, the present study endeavours to explore the reason and facts of sudden decrement in the concentration of air pollutants during lockdown due to the COVID-19 pandemic. Due to fewer vehicles and the absence of industrial activities and subsequent heavy rainfall made by cyclone Amphan landfall around Kolkata and adjacent areas, it improved air quality by its cleansing effect. It also highlights the interconnections between the air quality and socio-economics fabrics of the city and the collapse of economic activities. The impact of improved air quality on people’s social and health status is positive. The paper also prescribes how these positive impacts can be carried out for the wellbeing of society.

Keywords AQI · Air pollution · Pandemic · Metropolitan · Economic activities

5.1 Introduction

Globally, air pollution is responsible for the death of millions of peoples. According to the report from Global Alliance on Health and Pollution (GAHP Report 2019), air...
pollution is the main reason for the premature deaths, causing 15% of all deaths—some 8.3 million people. India registered around 2.3 million deaths in 2017 because of pollution (India Suffers 2020). Another study on the risk assessment, Global Burden of Disease comparative for 2015, reveals that exposure to air pollution adds around 1.8 million premature deaths and 49 million disability-adjusted life-years (DALYs) lost. Worryingly, India ranked among the top risk factors for India’s health problems (PHFI and CEH 2017). The air quality status has significantly degraded in the last few years, particularly in urban centres, including major metro cities in India, compared to rural set-up. The Air quality is complex as far as its control is concerned, having several linear and non-linear relationships with many parameters including land use, meteorology, sources, location, and many more (Zhang et al. 2014; Wang et al. 2019). Despite several measures taken by agencies including the National Clean Air Programme (NCAP) and Graded Response Action Plan (GRAP), the urban centres maintained their flip side of Air Pollution throughout the year (IQAir 2019; MoEFC 2019). Indian cities have been among the top-most polluted cities globally (Kota et al. 2018).

Different measures have been taken globally to cope with the COVID-19 Pandemic spread: the different lockdown regime is the most common. The government has taken measures to control the spread of this virus. The implementation of complete lockdown had restrained people from moving out of their homes. World Air Quality Index exhibits that countries like the United States, Spain, Italy, China, France, Mexico, and the UK witnessed a fall in the concentration of air pollutants during lockdown due to the restriction of vehicular movement and industries’ closure due to deficient workforce. In India, cities like Delhi, Mumbai, Kolkata, and Hyderabad, which comes under pollution city ranking, have shown improved AQI (IQAir 2019). According to the latest Report on Air Quality of 10 major cities in the world—Delhi, London, Los Angeles, Milan, Mumbai, New York City, Rome, São Paulo, Seoul, and Wuhan have shown a substantial drop in the concentration of fine particulate matter (PM$_{2.5}$). Delhi has witnessed a 60% fall in the concentration of PM$_{2.5}$ as compared to 2019, Seoul by 54%, Wuhan by 44%, and rest other cities by 9–35%. This significant decline in PM 2.5 was observed because there was a decline in the burning of fossil fuels and reduced road dust due to restricted vehicular movements and construction works during lockdown (IQAir 2020).

There is a noticeable result in the concentration of Nitrogen Dioxide in China, Italy, and England envisaged by the data from European Space Agency (ESA) comparing 2019 and 2020 (Chen et al. 2020). During the lockdown, NO$_2$ concentration was dropped by 22.8 $\mu$g/m$^3$ and 12.9 $\mu$g/m$^3$ in Wuhan and China, respectively. PM2.5 was dropped by 1.4 $\mu$g/m$^3$ in Wuhan but decreased by 18.9 $\mu$g/m$^3$ across 367 cities (Chen et al. 2020). The concentration of Carbon Dioxide was reduced in New York by 5–10% (Watts et al. 2020) and in China by 25% (Carbon Brief 2020) compared to the 2019 level. This substantial decline was possible because there was a reduction in vehicular and industrial emission during the lockdown.
In India, the nationwide lockdown was imposed starting from 24 March midnight to reduce Corona infections. It caused to suddenly cease down the transport, industries, infrastructure development, which further resulted in emission reduction significantly (Sharma et al. 2020). Significant air quality improvement has been reported across the country, including Kolkata. The Central Pollution Control Board in India informed that out of the 103 cities, air quality for 23 cities was enlisted as ‘acceptable’ air quality, while 65 cities were registered as ‘satisfactory’ air quality during the initial weeks of lockdown (Air Quality 2020).

The decline in air pollution during the complete lockdown, when there was a substantial decline in air pollutant emission from across sources, can give hope to the achievability’s extent to control air pollution targets in city clusters. City wise analysis will further help regulators to come up with better plans to curb air pollution as every city has distinct air pollution characteristics in terms of source, meteorology, location, economic activities the city of Kolkata has.

5.2 On Exploring the Air Quality of the ‘City of Joy’

Kolkata: the city served as the British capital, with the name ‘Calcutt,’ till 1912, before Delhi took the crown. It is also the second-largest city in India by area after the present national capital city of Delhi. Kolkata had significant importance to the British Empire. The city has earned the nickname ‘city of joy’ for its soulful embodiment of culture, enthusiasm, and festivity and the traditions of amazing sweet delicacies. It is a city that upholds a perfect juxtaposition between the old world and the modern one. The Metropolitan Area of Kolkata\(^1\) is located in Hooghly River’s left bank, which provides a very gentle slope towards the east and southeast to the city. The average elevation of Kolkata is 7 feet above sea level. Marshy wetlands characterize the Eastern part of Kolkata with swamps spreading over an area of about 12,500 hectares, creating a unique urban eco-system.

As per the Census of 2011, Kolkata city has a population of around 4.5 million and covers an area of 200.71 square km, divided into 16 Boroughs comprising 144 Wards and governed by the Kolkata Municipal Corporation (KMC). The city is densely populated (24306 persons/km\(^2\)). The Census 2001 enumerated Kolkata’s population as 4,572,876 in 2001 (Census of India 2001, 2011). Among all the West Bengal districts, Kolkata recorded a negative Decadal growth rate (\(-1.7\%\)) between 2001 and 2011 (Fig. 5.1).

The city’s air was degraded due to rapid population growth, increasing vehicles, commercial, industrial activities, which reveal adverse anthropogenic effects on the

\(^1\)Kolkata is the Metropolitan City of West Bengal located between 22°37’ N to 22°30’ N and 88°23’ E to 88°18’ E, and it is bounded by the North 24-Parganas district on the North and East, by South 24-Pargana district on the south, and by river Hooghly on the West (District Census handbook, West Bengal, 2001 and 2011, Series 20, Part XII-A & B, [https://censusindia.gov.in/2011census/ dchb/1916_PART_B_DCHB_KOLKATA.pdf](https://censusindia.gov.in/2011census/dchb/1916_PART_B_DCHB_KOLKATA.pdf)) and, also view: [https://www.censusindia.gov.in/Metadata/Metadata.htm](https://www.censusindia.gov.in/Metadata/Metadata.htm).
city’s environment. Kolkata is the second most polluted city in India, with an annual average of 59.8 $\mu g/m^3$ PM$_{2.5}$ concentration (IQAir 2019). The pollution level of Kolkata city was much higher than the WHO’s guideline for a clean air level, i.e., 10 $\mu g/m^3$ annual mean of PM$_{2.5}$ concentration (WHO Air Quality Guidelines 2005).

The present study analyzes Kolkata’s city’s air pollution status during different stages of lockdown (from mid-March to the end of June 2020) based on air pollutants data collected across the city from a network of automated monitoring stations of CPCB during the study period. Analysis and understanding of data supported with few space-based observations help to pinpoint the impact of stopping major potential sources of air pollutants during the lockdown. This study also gives a glimpse of Kolkata’s socio-economic landscape to understand its linkages of air pollution scenarios. Several mass-media information (Newspaper reports) are also considered for the present investigation.

To study on the Air pollution/Air Quality across the city of Kolkata during the lockdown, eight major air pollutants, namely Particulate Matter (PM$_{10}$, PM$_{2.5}$), NO$_2$, NO$_x$, NH$_3$, Ozone, CO, and SO$_2$, are collected from the CPCB network of air pollution monitoring stations. Data gathered from seven monitoring stations, namely Jadavpur, Rabindra Bharati University, Rabindra Sarobar, Victoria, Ballygunge, Bidhannagar, and Fort William spread across the city. Their respective air pollution data give the representative status of the city as a whole. Concentrations of above mentioned eight pollutants for the time period mid-March to June end, 2020 is analyzed.

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2See for details: https://app.cpcbcr.com/ccr/#/caaqm-dashboard-all/caaqm-landing/caaqm-data-availability.
The daily average concentration of all eight pollutants has been computed station-wise to understand the overall decline in Kolkata’s air quality status. Station wise average gives an average concentration of pollutants as well as the Air Quality Index (AQI) on a daily basis. With the help of computed representative daily concentration of all selected pollutants, several comprehensive graphs have been prepared, which reflect the gradual decline of air pollution in Kolkata during the lockdown. The pollution data-based finding is further supplemented with space-based observations of NASA and some socio-economic findings of few general studies.

### 5.3 Impact on City’s Air Quality

During the COVID19 lockdown environment, Kolkata’s air became healthier, which was reflected through a clear blue sky, clean air, and noise pollution-free environment. PM$_{2.5}$, which had been 60.5 $\mu$g/m$^3$ in pre lockdown period, decreased to 34.3 $\mu$g/m$^3$, 17.2 $\mu$g/m$^3$, and 18.6 $\mu$g/m$^3$ during the 1st, 2nd, and 3rd Phases of lockdown accordingly (Fig. 5.2). It may be linked to the closing of industrial areas of Kolkata like Khidirpur and Garden Reach areas, as unlike other metro cities, Kolkata and Chennai air pollution loads are mainly contributed by industrial sectors (Multi-pollutant 2020). Similarly, PM$_{10}$ also follows a similar trend like PM$_{2.5}$ from March to June end, which indicates less production of transport, domestic and industrial dust particles to a larger extent.

The highest NO$_2$ levels are in eastern India and are primarily associated with fossil fuel and coal-based electricity generation (Aura 2020). NO$_2$ emission is mainly

![Figure 5.2](image.png)

Fig. 5.2 Monthly average concentration of PM$_{2.5}$ and PM$_{10}$ ($\mu$g/m$^3$) in Kolkata (Source Compiled by author Data: CPCB)
associated with coal-powered thermal plants situated near Kolkata, such as Bandel Thermal Power Station, Hugli, New Cossipore Generating Station, Kolkata, and CESC South, Kolkata. Some other plants are situated near the metropolitan area includes Budge Budge, Kolaghat, and Durgapur. The NO₂ level in Kolkata declined gradually from more than 30 $\mu$g/m³ to its one-third value by June (Fig. 5.4). The significant decline of NO₂ levels initially can be further substantiated by finding
NASA’s space-based comparative assessment image of NO₂ levels of pre-lockdown to April end (Fig. 5.3, source: AURA 2020).

Figure 5.3 represents the month-wise variation of NO₂ in Kolkata from March to 5 June, which shows a sudden decrease in NO₂ concentration during the 1st to 4th Phase of lockdown with a slight variation at the beginning of June. This is due to the reduction of power generation in thermal power plants located in and around Kolkata.

The emission of SO₂ is a significant contributor to urban air pollution, an indication of biomass burning. The most considerable amount of pollutants (SO₂) comes from fossil fuel burning in power plants, industries, and most significantly from urban transport. ESA’s finding on comparative SO₂ distribution during lockdown and 2019 also indicates a substantial decrease in spread and concentration (Fig. 5.5). This comparative image of the average concentration of SO₂ emission over India during the Pre-lockdown period (2019) and lockdown in April 2020 is based on measurements gathered by the Copernicus Sentinel-5P satellite (ESA, July 2020).

The finding of the present study on average SO₂ concentration shows a declining trend by the 4th Phase of lockdown with explained reasons for the decline in transport and industry-related emission in line of other pollutants like particulate matter, NOₓ, and others (Fig. 5.6). During June, increasing SO₂ concentration is associ-
ated with the resumption of transport and other activities gradually. The percentage of 24 hours average of SO$_2$ is under the acceptable limit of 20 µg/m$^3$ (WHO Air Quality Guidelines 2005) in Kolkata. However, as a reactive pollutant, it converts easily into sulfates and generates PM$_{2.5}$ as a secondary pollutant.

Like other urban cities reported to have significant improvements in their Air Quality across the country during the lockdown, Kolkata observed cleaning of their air space. Air quality analysis of Kolkata is based on data collected from eight automated stations of the CPCB network during several phases of lockdown, which shows spatial variation over the urban fabric. Among all stations, only two (Victoria, Bullygung WBPCB Stations) have shown moderate (AQI value 101–200) air quality, whereas the rest of four stations indicated satisfying (51–100) air quality. The city areas with a substantial green cover, comprising housing complexes (i.e., Jadavpur, Golf Green), showed the lowest AQI as the Jadavpur station’s average concentration. In contrast, areas with mixed land use like that of Rabindra Bharati University and Victoria stations indicated a slight increase in pollution lead from both residential and commercial areas with restricted activities.$^3$

Data based analysis of pollutants shows average decline throughout the lockdown period having synchronized minimum concentration (for all studies pollutants) during Phase second onward (3rd week of April onward). This may be associated with pollutants’ residence time in the air and meteorological events in the city (good rainfall) during the 3rd Phase of lockdown. The ferocious wind and rains of cyclone Amphan further flushed the air pollutants from the city sky, which is reflected in low pollution concentration across the average daily concentrations across the city (BBC 2020).

$^3$For details, view: https://app.cpcbccr.com/AQI_India/.
5.4 Impact on Socio-Economic Environment

5.4.1 Economic Sector

Kolkata is the 3rd productive metropolitan of India, which depends on medium-sized industries, heavy industries, and services, and these medium-sized and heavy industries are the major source of pollutants in Kolkata (Fig. 5.7). GDP of Kolkata is US$170 billion during 2018–2019, with a growth rate of 14.6%, which indicates a steady economic growth of Kolkata City.\(^4\) During COVID-19 pandemic, travel restriction affected Kolkata’s tourism industry, which had a direct impact on the GDP of Kolkata. Labour statistics released by CMIE indicate loss of jobs of some portion of salaried employees and labourers during the 1st Phase of lockdown, which negatively impacted the economy of the state (Economic Outlook 2020). The jobless migrated labourers, who returned back to West Bengal, made the situation much more complicated. According to news sources, about 75% of workers returned to UP, Bihar, Orissa, Jharkhand at the beginning of the lockdown in March that created a labour shortage in industries, wholesale trade, manufacturing, construction, and informal sectors (Javed 2020). However, as soon as they returned to Kolkata’s commercial hub, economic activities geared up from the 1st week of June (The Times of India, 13 July 2020).

\(^4\)For details, view: https://www.india-briefing.com/regional-intelligence/kolkata.html.
5.4.2 Industrial and Energy Sectors

Global emission of CO\textsubscript{2} has increased substantially during the last few decades. Surprisingly lockdown brings down the pace of daily emission of CO\textsubscript{2} and other GHGs. The Daily global fossil CO\textsubscript{2} emission is decreased 17\% during early April 2020 compared to the mean daily estimates in 2019 level (United in Science 2020; Le Quere et al. 2020). According to the analysis made by the Centre for Research on Energy and Clean Air, CO\textsubscript{2} emission of India fell by 15\% during March and 10\% in April during nationwide lockdown (Carbon Brief 2020). A similar decreasing trend has been observed in Coal powered thermal power electricity generation for India by 10 and 25\% in March and April 2020, respectively.

Drastic fall in pollution levels is observed during lockdown due to the absence of emissions from vehicular sources, industries, constructions, and brick kilns. PM\textsubscript{2.5}, and Nitrogen dioxide level decreased in Kolkata may be linked to suspension of work in factories, thermal power plants, and suspension of public, private transports. At the end of April, IT Sectors and Jute industries provided selective relaxation to reopen with 25 and 15\% workforce, respectively. The Government of West Bengal permitted to deploy a cent per cent workforce in Jute industries from 1st June to overcome the problem of job loss and prevent the migration of labourers (The New Indian Express 2020). Pollution level increased slightly at the late stage of the 4th and 5th Phase of lockdown when industrial activities started partially. The sudden suspension of industrial activities had a negative impact on the finance and investment sectors also.

5.4.3 Transport, Construction, and Household Sectors

Congested and polluted roads of Kolkata have changed entirely due to the absence of petrol-fueled cars, buses, and other public and private vehicles on the roads. As a result, a sudden drop in pollutants like NO\textsubscript{x}, SO\textsubscript{x}, and fine particulate matter changed air quality. During the 1st Phase of lockdown not only the roadway, but each and every mode of transport such as railways, waterways, and airways also stopped functioning, which reduces the emission of CO, CO\textsubscript{2}, and ultimately enhances the quality of air of Kolkata. Public transport was restarted from 18th of May 2020 (Times of India 23 March; 18 May, 2020). The emission of dust particles was also reduced due to the temporary halting of construction work during the lockdown. The emission of pollutants from household activities increased (Fig. 5.7).
5.4.4 Impact on Health

Ambient air pollution is a significant cause of death and disease globally. Global data shows that respiratory diseases cause 26%, chronic pulmonary diseases cause 25%, and ischaemic heart diseases cause 17% death globally (GHO, WHO 2016). Pollutants can make COVID-19 Pandemic more potent because air pollution aggravates diseases like Diabetes, Hypertension, Cardiovascular diseases, which makes people vulnerable to COVID-19 fatalities (Bandyopadhyay K 2020). On the other hand, pollution-free clean air enables one to fight with diseases, especially lung diseases, which will help to flatten the curve of COVID-19.

The patient-statistics of three major hospitals in Kolkata, namely, Seth Sukhlal Karnani Memorial Hospital (SSKM), R.G. Kar Medical College & Hospital, and Calcutta Medical College (CMC), are taken into consideration to analyze the impact of air pollution on disease patterns during several phases of major lockdown. During the 1st Phase of lockdown, patients admitted in those hospitals in Kolkata with respiratory diseases (13%), Acute Myocardial (10%), Invasive diseases (20%), and Non-Invasive (14%) diseases, and other types of diseases, including COVID-19 (40%) (Fig. 5.8). It reveals that diseases caused due to air pollution shared fewer patients (CCMIS, Health and Family Welfare Department, Govt. of W. B. 2020).

Figures 5.9 and 5.10 represent the trend of patients admitted to public hospitals in Kolkata, which reveals a sudden decreasing trend in respiratory and invasive diseases from April to July (i.e., from the 1st Phase to 5th Phase of Lockdown). On the other hand, it was high in the Pre Lockdown stage (i.e., from January to March) (Health and Family Welfare Department, Govt. of W.B. 2020). The sudden decrease in air pollutants’ emission helped reduce invasive diseases like Pneumonia, Epiglottitis, infectious Arthritis, and specifically the respiratory diseases in Kolkata.

![Fig. 5.8](source.png)

Fig. 5.8 Types of indoor patients during 1st Phase of lockdown in Kolkata (as on 30th April) (Source Compiled by author Data: Health and Family Welfare Department, West Bengal)
Fig. 5.9  Disease wise monthly variation of indoor patients in Kolkata (Source Compiled by author Data: Health and Family Welfare Department, West Bengal)

Fig. 5.10  Trend of indoor patients in Kolkata during pre lockdown and lockdown Phase 1 to 5 (Source Compiled by author Data: Health and Family Welfare Department, WB)

5.5 Conclusion

Change in air quality and its consequences is eye-opening to all. Nature is changing unexpectedly and reclaiming itself. But it is a short-term improvement of the air quality due to the reduction of emission of pollutants. So, the main concern is how to maintain long-lasting positive environmental change after the lockdown.

- It is possible to reduce air pollutant particles’ emission from industries by introducing improved technology such as Spark Ignition engine equipment to maintain
Bharat stage emission standards or BS-VI norm.\(^5\) Along with these old pollutants, vehicles should be phased out.

- To improve the city air quality Calcutta State Transport Corporation will deploy 5000 electric buses and fully electric ferries on the Ganges river by 2030. As of 2019, 80 electric buses have been introduced to the city, with another 100 planned for 2020. These 180 electric buses will lead to an annual reduction of 14086 tonnes of CO\(_2\) emission (Calcutta State Transport Corporation, WBTC 2019).
- Some species of plants are good absorbers of suspended particulate matters. The city environment can be changed by plantation of pollution resistant species with the additional benefit of maintaining city ecology and aesthetic values. The plantation can be done in Bidhannagar, Salt Lake area, Maidan, and densely populated residential areas and in and around the industrial belt along river Hooghly.
- Green infrastructure will be initiated massively mostly in highly congested residential areas where the new plantation is not possible. The green roof, green wall, the green building should be initiated on a priority basis.
- Urban waste management should be run properly.
- The country should move towards non-conventional energy instead of using coal or non-renewable energy. In recent years, India has made progress in renewable electricity deployment and successfully coped up increasing electricity demand and clean cooking. Investing more in renewable energy under the National Clean Air Programme (2019) will help in achieving clean air.
- Emergency Relief Fund should be developed to provide liquid funds to small scale entrepreneurs to manage financial uncertainties.
- Mass awareness through social media can be a key element of environmental movements across India’s megacities.
- A sustainable environmental management plan is required to improve the environment of Kolkata city.

Indian megacities experienced the blissful blue sky and cleaner air during the nationwide lockdown. It gave opportunities to rethink and properly implement eco-friendly technologies in India’s energy and industrial, commercial, and transport sectors. A large portion of pollution is locally generated and associated with emissions from the power plants, industries, vehicles, road dust, burning of waste materials, cooking fuel, etc. It needs area-specific effective planning and mass awareness on a priority basis. Due to restricted activities during confinement, the present environmental co-benefits scenario strengthened the positive relationship between man and its natural environment and raised hope for a pollution-free city.

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\(^5\)The Bharat Stage (BS) are emission standards instituted by the Government of India to regulate the output of air pollutants from motor vehicles. The central government has mandated that vehicle makers must manufacture, sell, and register only BS-VI (BS6) vehicles from April 1, 2020.
References

Air quality improving in India as 130 bn people stay home amid lockdown (2020) Business Standard, 22 April. Accessed from https://www.business-standard.com/article/current-affairs/air-quality-improves-significantly-across-india-amid-lockdown-cpcb-120040200831_1.html

AURA (2020) Reductions in sulfur dioxide & nitrogen dioxide air pollution over South Asia associated with efforts to control the spread of COVID-19. Accessed from https://aura.gsfc.nasa.gov/science/feature-20200501.html

Bandyopadhyay K (2020) Kolkata: Transport system gears up for Monday test as offices reopen. The Times of India, May 18. Retrieved from https://timesofindia.indiatimes.com/city/kolkata/transport-system-gears-up-for-monday-test-as-offices-reopen/articleshow/75795456.cms

Bandyopadhyay K, TNN (2020) Lockdown, rain make Kolkata’s air cleanest in recorded history. The Times of India, 29 April. Retrieved from https://timesofindia.indiatimes.com/city/kolkata/lockdown-rain-make-kolkatas-air-cleanest-in-recorded-history/articleshow/75436576.cms

BBC (2020) Amphan: Kolkata devastated as cyclone kills scores in India and Bangladesh. BBC News. Retrieved from https://www.bbc.com/news/world-asia-india-52749935#:~:text=Amphan%3A%20Kolkata%20devastated%20as%20cyclone%20kills%20scores%20in%20India%20and%20Bangladesh,-21%20May&text=The%20eastern%20Indian%20city%20of,Kolkata%20with%20fierce%20wind%20and%20rain

Carbon Brief (2020) EMISSIONS, analysis: coronavirus temporarily reduced China’s CO2 emissions by a quarter, 19 February. Available at https://www.carbonbrief.org/

Census of India (2001, 2011) West Bengal, District Census Handbook Kolkata, Village and Town wise Primary Census Abstract (PCA). Series 20 (Pt XII-A & B)

Chen K et al (2020) Air pollution reduction and mortality benefit during the COVID-19 outbreak in China. medRxiv preprint. https://doi.org/10.1101/2020.03.23.20039842

Delhi, Mumbai, Bengaluru and Kolkata attain 95% of clean air targets during lockdown (2020) Climate Trends, 3 July. News Desk. https://citizenmatters.in/lockdown-reduces-air-pollution-in-indian-megacities-delhi-mumbai-kolkata-bengaluru-19370

Economic Outlook (2020) Accessed from http://economicoutlook.cmie.com/

Economy of Kolkata. Wikipedia. https://en.wikipedia.org/wiki/Economy_of_Kolkata

ESA (2020) Sulphur dioxide concentrations drop over India during CovID-19, July. https://www.esa.int/ESA_Multimedia/Images/2020/06/Sulphur_dioxide_concentrations_over_India

Global CO2 emissions to decline 8 per cent in 2020, surpassing any previous declines: IEA

Global Alliance on Health and Pollution (GAHP) Report (2019) Pollution and health metrics: global, regional and country analysis

Global Energy Review (2020) The Economic Times, 24 May. Accessed from https://energy.economictimes.indiatimes.com/

Health and Family Welfare Department, Government of West Bengal (2020) Data accessed from http://ccu.wbhealth.gov.in:8001/

India suffers most pollution linked deaths in world, study finds (2020) WION News, 19 December. Accessed from https://www.wionews.com/india-news/india-leads-world-in-pollution-linked-deaths-study-269127

IQAir (2019) ‘World Air Quality Report’, 2019 World Air Quality Report, pp 1–22. Available at https://www.iqair.com/world-most-polluted-cities/world-air-quality-report-2019-en.pdf

IQAir (2020) COVID-19Air Quality Report, pp 1–13. Available at https://www.iqair.com/us/blog/air-quality/report-impact-of-covid-19-on-global-air-quality-earth-day

Javed Z (2020). Kolkata hint of eco turnaround in reverse migration trend. The Times of India. Published and accessed on 13 June. http://timesofindia.indiatimes.com/articleshow/76350299.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst

Kolkata Municipal Corporation (CMC) Kolkata city map. Accessed from https://www.kmcgov.in/KMCPortal.jsp/UAABoroughWiseMap.jsp
Kota SH, Guo H, Myllyvirta L, Hu J, Sahu SK, Garaga R et al (2018) Year-long simulation of gaseous and particulate air pollutants in India. Atmos Environ 180:244–255. https://doi.org/10.1016/j.atmosenv.2018.03.003

Le Quere C et al (2020) Temporary reduction in daily global CO₂ emissions during the COVID-19 forced confinement. Nat Climate Change 10:647–653. https://www.nature.com/articles/s41558-020-0797-x#citeas

Location of Kolkata Metropolitan City (2020) Created through Google Earth. http://google.com/earth

Lockdown: Jute industry in Bengal allowed to deploy 100 percent workforce (2020) The New Indian Express, 29 May. Accessed from https://www.newindianexpress.com/nation/2020/may/29/lockdown-jute-industry-in-bengal-allowed-to-deploy-100-per-cent-workforce-2149724.html

MoEFC. Ministry of Environment, Forest and Climate Change (2019) In: SNk, Sundaray, DSR, Bharadwaj (eds) National Clean Air Programme, New Delhi

Multi-pollutant emission inventory (2020) Accessed from https://urbanemissions.info/india-apna/kolkata-india/

NAQI (National Air Quality Index) (2020) Central Pollution Control Board (CPCB). https://app.cpcbccr.com/AQI_India/

National Atlas and Thematic Mapping Organization (NATMO) West Bengal, India Base Map. Accessed from http://www.natmo.gov.in/

PHFI and CEH (2017) Air pollution and health in India: a review of the current evidence and opportunities for the future. Public Health Foundation of India and Center for Environmental Health, p 64

Sharma S, Zhang M, Gao AJ, Zhang H, Kota H (2020) Effect of restricted emissions during COVID-19 on air quality in India. Sci Total Environ 728:138878. https://doi.org/10.1016/j.scitotenv.2020.138878

United in Science Report (2020) Accessed from https://trello-attachments.s3.amazonaws.com/5f560af19197118ed74cf93/5f5f9f8b11a9063544de4bf39/cdb10977949b38128408f5322f9f676d/United_In_Science_2020_8_Sep_FINAL_LowResBetterQuality.pdf

Urbanemission.info retrieved from various associated pages of URL www.urbanemission.info

Wang P, Guo H, Hu J, Kota H, Qi Ying, Zhang H (2019) Responses of PM₂.₅ and O₃ concentrations to changes of meteorology and emissions in China. Sci Total Environ 662:297–306. https://doi.org/10.1016/j.scitotenv.2019.01.227

West Bengal Transport Corporation (WBTC)

WHO (2005) WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide: global update 2005; summary of risk assessment. https://apps.who.int/iris/bitstream/handle/10665/69477/WHO_SDE_PHE_OEH_06.02_eng.pdf?sequence=1

WHO (2016) Mortality and burden of disease from ambient air pollution: situation and trends. GHO. Accessed from https://www.who.int/gho/phe/outdoor_air_pollution/burden_text/en/

WHO (2020) How does COVID-19 spread? Accessed 20 July 2020. https://www.who.int/news-room/q-a-detail

World’s Biggest Lockdown May Have Cost Rs 7–8 Lakh Crore to Indian Economy. The Economic Times (2020) Retrieved from www.economictimes.indiatimes.com/news/economy/finance/worlds-biggest-lockdown-may-have-cost-rs-7-8-lakh-crore-to-indiandeconomy/articlenews/75123004.cms?from=mdr

World Health Organization (2020) WHO Director general’s opening remarks at the media briefing on covid-19. Accessed from https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19—27-july-2020

Xing J, Pleim J, Mathur R, Poulion G, Hogrefe C, Gan CM, Wei C (2013) Historical gaseous and primary aerosol emissions in the United States from 1990 to 2010. Atmos Chem Phys 13(15):7531–7549. https://acp.copernicus.org/articles/13/7531/2013/acp-13-7531-2013.html
Zhang H, Hu J, Kleeman M, Ying Q (2014) Source apportionment of sulfate and nitrate particulate matter in the eastern United States and effectiveness of emission control programs. Sci Total Environ 490:171–181. https://doi.org/10.1016/j.scitotenv.2014.04.064

Zhipeng P, Han G, Ma X, Su H, Gon W (2020) Response of major air pollutants to COVID-19 lockdowns in China. Sci Total Environ 743:140879. https://doi.org/10.1016/j.scitotenv.2020.140879

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