



Effect of COVID-19 outbreak on urban health and environment

Ashish Girdhar¹ · Himani Kapur² · Vijay Kumar³ · Manjit Kaur⁴ · Dilbag Singh⁴ · Robertas Damasevicius^{5,6}

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Abstract

The WHO announced coronavirus disease a Public Health Emergency on 30 January 2020, and it spreads across the whole planet. Aftermath of outbreak of this disease at the global level is more frightening and panicking than anyone's worst nightmare. With more than 23 mln positive coronavirus cases and more than 800,000 casualties all over the world, the potential of this virus cannot be undermined. This pandemic has victimized all human beings residing on 209 countries and territories of the world. It emerged as an unbeatable global challenge that the world has never witnessed before. Consequently, the affected countries have sealed their borders and made populations reside in their homes until the pandemic is over. Thus, the victims of coronavirus are not only the ones who are exposed to it but also the ones who are affected by the lockdown imposed by the governments. The paper aims to evaluate the effect of COVID-19 on air pollution of various countries. Papers indicating the relationship between air pollution levels and lockdown measures are analyzed. The dramatic U-turn from environmental degradation is definitely a silver lining in these black clouds. This paper reviews the repercussions of the pandemic in some nations, while war-like preparations continue to fight it. COVID-19 has dramatically improved the quality of air. Also, it has greatly affected the economy of various countries due to lockdown.

Keywords COVID-19 · Urban health · Air pollution

Introduction

A novel form of coronavirus SARS-CoV-2 was detected in December 2019 that causes severe respiratory illness and death. This disease spreads from infected to healthy individuals through droplets released when the infected person coughs, sneezes, or exhales (Dbouk and Drikakis 2020). Therefore, a distance of at least 3 ft is to be maintained among individuals. This measure leads to closures of public places and avoidance of public meetings. To implement social distancing, lockdown is imposed by different countries. Sealing of international borders is done to prohibit the entry of infected persons. The consequences of

outbreak have affected human race at physical, social, mental, and economical. In such times of stress and trauma, plummeting of environmental degradation certainly cannot be overlooked.

This study is motivated by the need to overview and analyze research studies on the environmental impact of lockdowns introduced due to COVID-19. The main contributions of this paper are:

1. A relationship between COVID-19 and air pollution is discussed.
2. The impact of COVID-19 on economy of different countries is conferred.
3. The impact of lockdown during the COVID-19 pandemic is evaluated on environment.

✉ Dilbag Singh
dilbag@ieee.org

¹ Department of Computer Science and Engineering, Thapar Institute of Engineering and Technology, Patiala, India

² Computer Science, GGSSS, Kaithal, India

³ Computer Science and Engineering Department, National Institute of Technology, Hamirpur, Himachal Pradesh, India

⁴ Computer Science Engineering, School of Engineering and Applied Sciences, Bennett University, Greater Noida 201310, India

⁵ Silesian University of Technology, Gliwice, Poland

⁶ Vytautas Magnus University, Kaunas, Lithuania

Environmental and economic impact of COVID-19

As a preventive measure against SARS-CoV-2 and enforce social distancing, lockdowns were imposed by various countries of the world. Figure 1 shows the duration taken by a country to announce a lockdown after appearance of first coronavirus positive patient on their land.

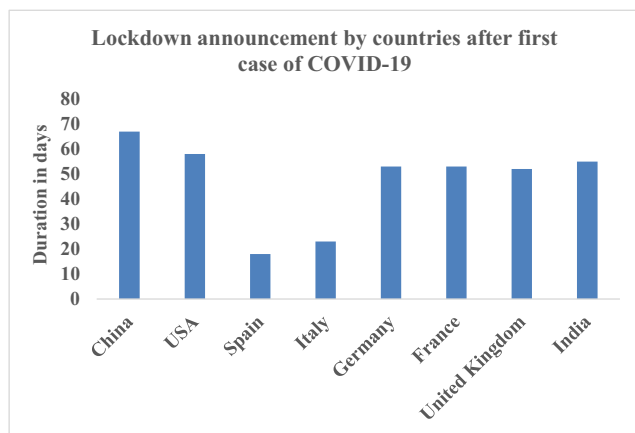


Fig. 1 Lockdown announcement after first case of COVID-19 by some countries

China

The pandemic first broke out in Wuhan, China. Afterwards, number of positive cases in China had been on an increase since mid of February 2020. China announced lockdown on 23 January 2020, 67 days after first case was reported. While online gaming and education sector saw an upsurge for obvious reasons, sales of other consumer goods lowered down. China eventually started to improve its manufacturing sector after slowing down of new cases in March 2020. China has been in and out of stage 3 of coronavirus, i.e., community transmission (WHO 2019). Thus, China is able to retract its economy in its place globally and motivate other countries. Environment has however achieved a lot from this lockdown. In 44 cities across Northern China, levels of NO₂, PM₁₀, SO₂, PM_{2.5}, and CO decreased by 24.67%, 13.66%, 6.76%, 5.93%, and 4.58%, respectively (Bao and Zhang 2020). In central China, average levels of atmospheric NO₂, PM₁₀, SO₂, PM_{2.5}, and CO in three cities in Hubei Province in February 2020 decreased by 61.4%, 40.5%, 33.4%, 30.1%, and 27.9%, respectively, when compared with levels in 2017–2019 (Xu et al. 2020). Lockdown measures accounted for up to 70% reduction of NO₂ in areas with very intensive anthropogenic activities (Fan et al. 2020). The transportation sector

contributed most to reduction of NO₂, indicating effect of movement limitations, but levels of SO₂ have not been affected so much as people who stayed at home still used heating facilities (mostly powered by coal) during colder season. However, ozone levels have increased significantly by a factor 1.5 to 2 during lockdown (Shi and Brasseur 2020).

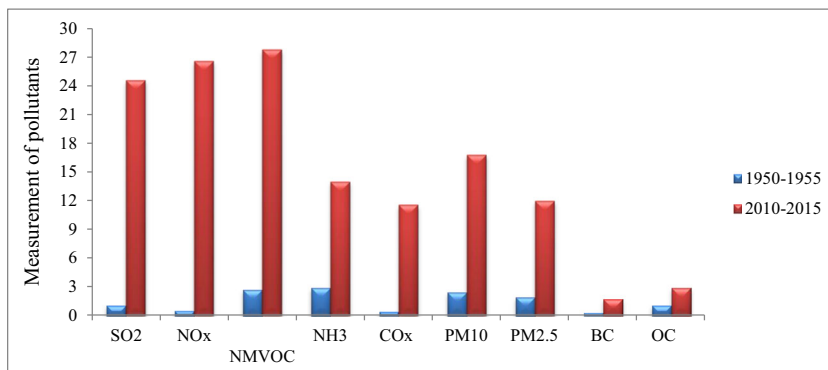
In Fig. 2, growth rate of pollutants over a period of 60 years from 1950–1955 to 2010–2015 can be observed. The measure of CO_x (CO and CO₂) is in terms of Pg, while other pollutants are measured in Tg. Carbon emissions fell by 25% (Le Quere et al. 2020). Improved air quality in China is expected to save 4000 children under 5 years of age (Burke, 2020). Significant drop in air pollution by lockdown regulations has led to positive impact on human health by reducing mortality rate attributed to air pollution from 7.6 to 3.4% attributed to COVID-19 (Isaifan 2020).

Decrease in NO₂ levels can also be observed from this before and after pair of photographs taken around China as shown in Fig. 3. These remote sensing pictures depicting NO₂ pollutants in Hubei air are released by NASA (NASA 2020a). The “after” photograph has been clicked after a gap 20 days only, and almost negligible concentrations of NO₂ pollutant in “after” photograph has made Chinese environment more breathable.

USA

The first case of coronavirus positive patient came into light on 21 January 2020. But the USA resisted from announcing a lockdown on economy for about 58 days. Only after cases arose to 20,000 in mid-March, lockdown was announced on some parts of the USA. People stayed away from public gatherings/meetings on their own. No official announcement was made prior to it. This resulted in several coronavirus positive roaming on streets and exposure to many other human beings. Impact of coronavirus has been largely felt in the USA with 16.8 million Americans losing their jobs in just 3 weeks. The USA emitted 9667.77 thousand tons of nitrogen oxides in 2017 (OECD 2020). But after announcement of lockdown, a 30% descent was recorded in NO₂ pollution over New York

Fig. 2 Growth rate of pollutants in China (Burke 2020)



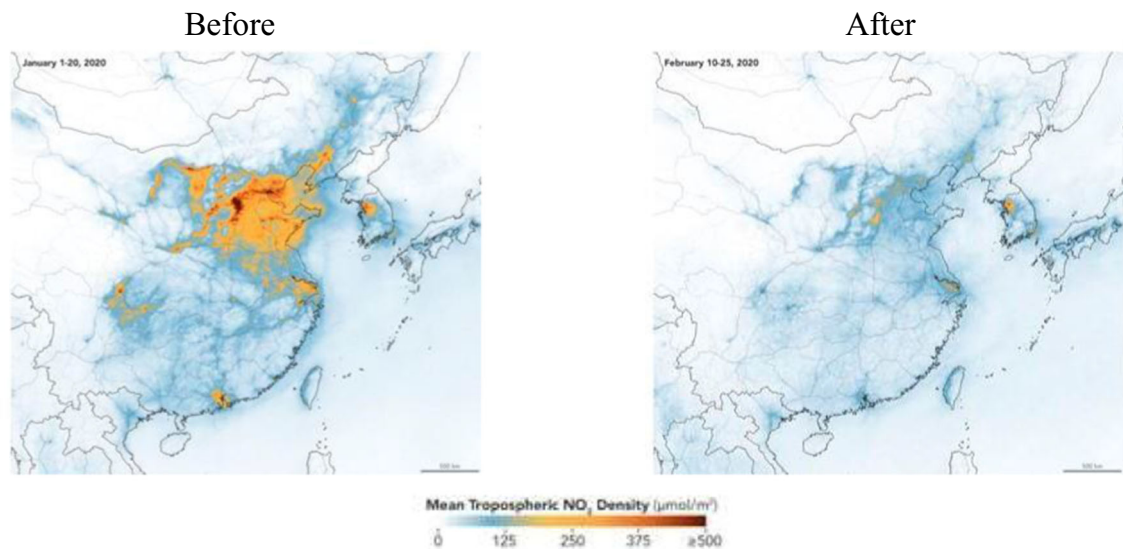


Fig. 3 NO₂ concentrations over China after a gap of 20 days only (NASA 2020a)

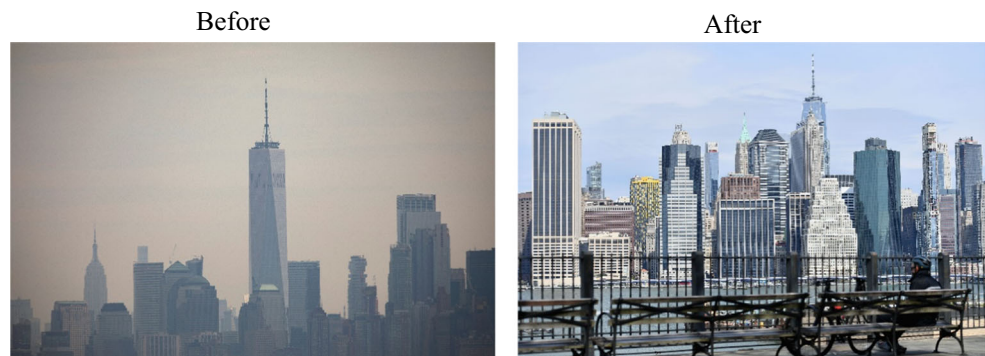
(Blumberg 2020) as observed in Fig. 4. Image displayed in before column of figure has been taken on 17 May 2019, while one shown in after has been clicked on 21 April 2020.

Carbon emissions also went down by 7.5%, because of 71% fewer planes in sky after outbreak (Faramarzi 2020). In Fig. 5, the level of pollutants before and after lockdown was imposed has been shown.

France

The first coronavirus positive case appeared on 24 January 2020, and lockdown was announced on 17 March 2020, 53 days later than date of first coronavirus positive case. By this time, number of active coronavirus patients had rose to 6400 patients. As reported by the Bank of France, French economy has recorded its worst ever since 1945. For every 2 weeks under lockdown, economic impact causes economy to go down by 1.5%. Nevertheless, a decline of about 62% was observed in levels of NO₂ due to strict implementation of lockdown (World, 2020). Figure 6 shows impact of lockdown on level of air pollutants.

Fig. 4 Clearer skies of New York City after coronavirus lockdown (Lewis, 2020)

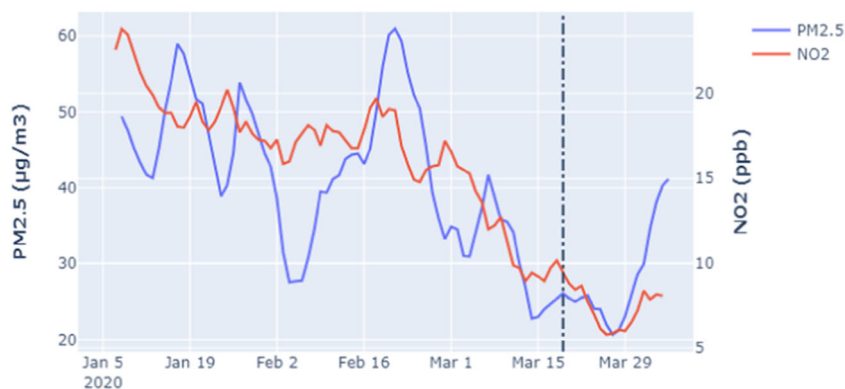


Italy

In Italy, the first coronavirus positive case was detected on 30 January 2020 in a Chinese couple from Wuhan, China. After duration of about 23 days, Italy announced a lockdown on some provinces on 22 February 2020. By 9 March 2020, the entire country went into national lockdown. Italy GDP may shrink slightly more than 8% in 2020, says economy minister. Industries, which account for 24% of GDP of Italy, were closed, accounting for about 45% reduction in level of nitrogen dioxide emissions (Worldbank 2020). Air pollutants have perturbed northern Italy more because smoke particles from closely located factories eventually get trapped at the end of Po valley and make northern Italy one of the pollution hotspots. Due to lockdown, levels of particulate matter in air have reduced drastically (Zoran et al. 2020). Figure 7 shows impact of keeping people at home on level of air pollutants.

An image of clearer skies over Milan, Italy, has surfaced as shown in Fig. 8. “Before” photograph shown in figure has been taken on 28 December 2015, while “after” picture was

Fig. 5 PM_{2.5} and NO₂ pollutants prior to and after lockdown in Los Angeles (Bhattacharyya 2020). Dashed line shows lockdown date



clicked on 9 April 2020. The difference in two images promises a clearer and better environment to future generations.

India

The first case of coronavirus positive patient arrived in India on 30 January 2020, and active cases remained to some two-digit numbers till mid-March when on 15 February 2020 number of active cases were mere 99. Government proactively issued advisories related to keeping physical distance, personal hygiene, etc. However, conditions worsen with people participating in large numbers of religious gatherings at Sikh festival of Hola Mohalla and Muslim gathering of Tablighi Jamaat. In order to contain spread of virus, a Janta Curfew on 22 March followed by national lockdown of 21 days starting from 25 March was announced by government. This national lockdown is largest ever lockdown in history with 1.38 billion keeping to their homes and stepping out of homes only for emergency. Economy of a developing nation like India suffered a lot due to outbreak of this pandemic. Panic buying was reported between 20 March and 21 March as Janta Curfew was announced for 22 March by Indian Prime Minister. Long processions of migrant workers left without work hogged television screens for a couple of days as a complete lockdown was announced. They were afterwards taken to safe houses/homes as gathering of such large number of people would only add risk. Due to active development of industrial sectors

and introduction of fossil fuel-based power plants in India in recent decades, 21 Indian cities have entered into list of worlds' 30 most polluted cities. As can be observed from Fig. 9, growth rate of pollutants has reached an alarming situation. In this graph, CO₂ is measured in terms of Pg, while other pollutants are measured in Tg (1Tg = 0.001 Pg).

After lockdown, the level of NO₂ dropped to a whopping 70% in Delhi (Mahato et al. 2020), while CO dropped by almost 82% (Srivastava et al. 2020). By end of first week of lockdown, announced level of PM 2.5 went down by 71% (Anjum 2020). The air quality index (AQI) decreased by 44, 33, 32%, 29, and 15 in north, south, western, east, and central India, respectively (Sharma et al. 2020). This was confirmed by study of PM_{2.5} and AQI in major metropolitan cities (Chennai, Delhi, Hyderabad, Kolkata, and Mumbai) (Singh and Chauhan 2020). Changes in AOD (aerosol optical depth) over Northern India can be observed in Fig. 10. While average AOD values hang around 0.4–0.6, actual observed values have declined to 0.1.

A before and after photograph of capital city of India shown in Fig. 11 has come online, and one can easily make out which of two was clicked after lockdown imposition (Lewis 2020). Image showing polluted air was clicked on 30 October 2018, while cleaner air around monument was captured on 30 March 2020, merely a week after lockdown was announced in country. Moreover, Himalayas have become visible at a distance even up to 200 km (Picheta 2020).

Fig. 6 PM_{2.5} and NO₂ pollutants prior to and after lockdown in France (Bhattacharyya 2020). Dashed line shows lockdown date

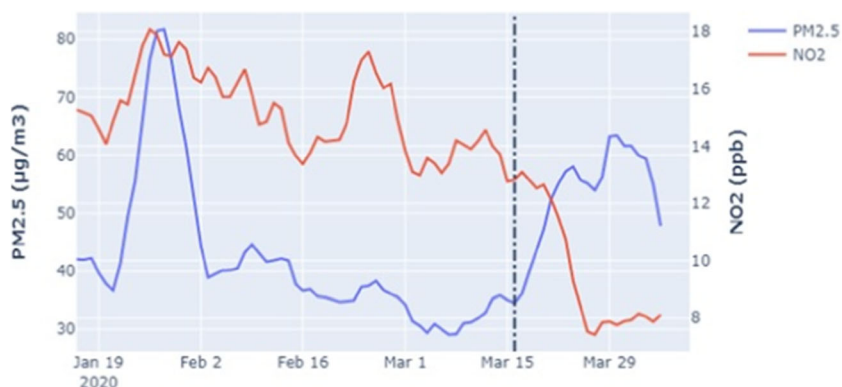
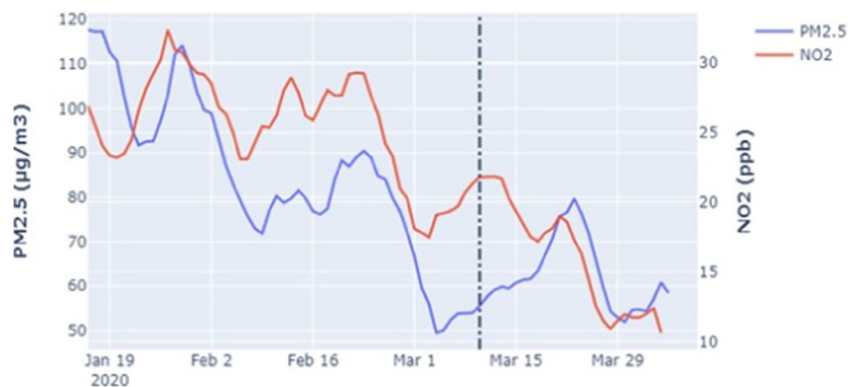


Fig. 7 PM_{2.5} and NO₂ pollutants prior to and after lockdown in Italy (Bhattacharyya 2020). Dashed line shows lockdown date



UK

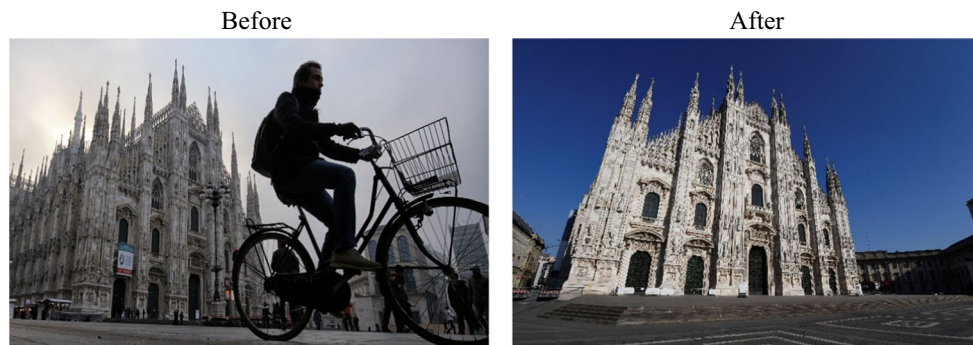
A strategy of combating disease in some nations was herd immunity. Herd immunity is a concept of attaining immunity in some people who cannot be vaccinated such as children. The UK was keen on implementing this strategy and avoided lockdown even after number of active cases in the UK reached 5000. It was then national lockdown was announced on 23 March, about 52 days later first coronavirus positive case in country.

Environmental reciprocation of lockdown in the UK has been on similar lines as that of other nations described above as shown in Fig. 13. While some cities have reported a fall by 60% (Khoo 2020) in NO₂, a descent of around 24% on average was recorded for PM_{2.5} (Carrington 2020). Impact on levels of other pollutants is yet to be determined. Difference in skies of London, England, has been shown in Fig. 12, where air and water finally show up in same shade of blue in right image after a gap of 5 years.

Spain

The first case of coronavirus positive patient was detected on 26 February 2020. Spanish Government was unsure of outbreak of pandemic in community owing to its 7th best medical care services in the world. However, officials underestimated potent of coronavirus and number of active coronavirus positive patients crossed 5000 when Spain issued a national

Fig. 8 Clearer skies of Milan City, Italy, after coronavirus lockdown (Lewis 2020)



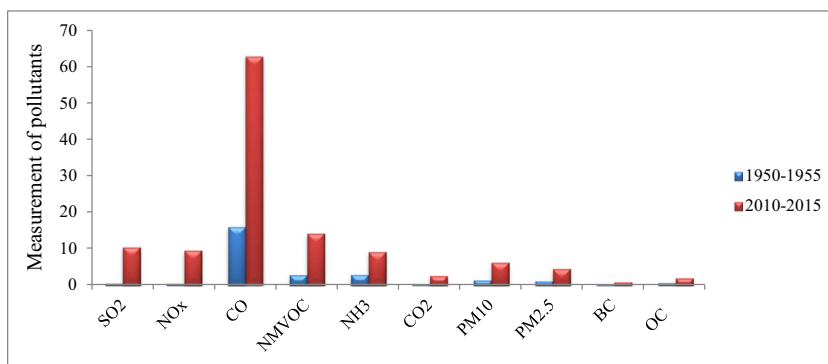
lockdown on 15 March. Public transport users plunged by 93%, NO₂ emissions lowered by up to 60%, and traffic accidents diminished by 67% (Aloi et al. 2020). As far as environmental bounce back is concerned, NO₂ levels have fallen down to drastic 60% by first week of April (Worldbank 2020). Vehicles on roads have reduced to 90%. A website has been created to check consequences of lockdowns on European economies on European air and environment (Copernicus 2020). In Barcelona, NO₂ decreased from 45 to 51%, while PM₁₀ decreased from -28 to -31.0% (Tobias et al. 2020). Figure 14 shows curves of NO₂ and PM_{2.5} air pollutants before and after lockdown.

A pair of before and after images of Barcelona city of Spain has surfaced online, as shown in Fig. 15, in which cleaner sky is unmissable. Image on left was clicked on 23 December 2015 and one on right was captured on 10 April 2020.

Other countries

The similar trends of reducing air pollution and increasing air quality due to introduction of lockdowns were observed in several other countries as well. In urban areas of Malaysia, SO₂, CO, NO₂, PM₁₀, and PM_{2.5} concentrations decreased during lockdown by 9–20%, 25–31%, 63–64%, 26–31%, and 23–32%, when compared with same time of year in 2018 and 2019 (Kanniah et al. 2020). However, there was a noticeable increase of ozone pollution by 36% in Wuhan (China), 27% in Turin (Italy), 24% in Nice (France), 14% in Rome (Italy), and

Fig. 9 Growth rate of pollutants in India from 1950–1955 to 2010–2015 (Burke 2020)



Aerosol Optical Depth (550 nm) over Northern India

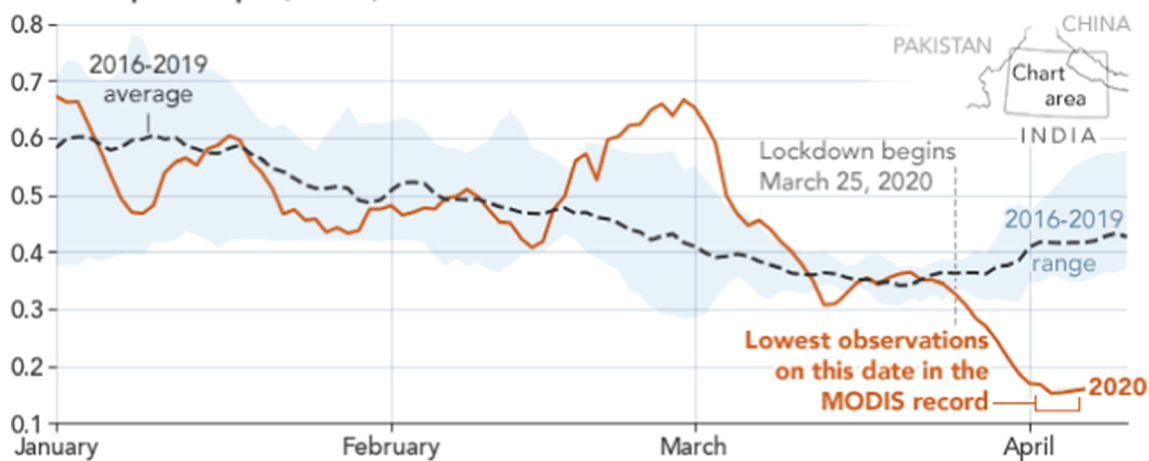


Fig. 10 Impact of lockdown on AOD (NASA 2020b)

Fig. 11 Clearer skies of New Delhi, India, after coronavirus lockdown (Lewis 2020)



Fig. 13 Clearer skies of London, England, after coronavirus lockdown (Lewis 2020)



Fig. 12 Average daily levels of NO_2 (Khoo 2020)

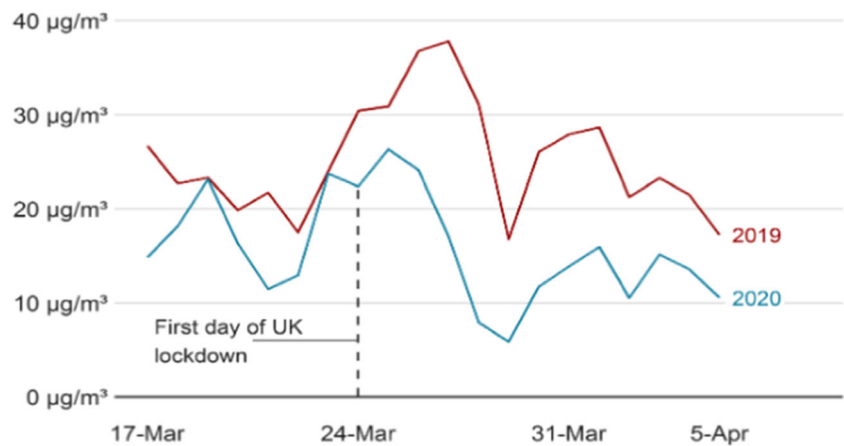
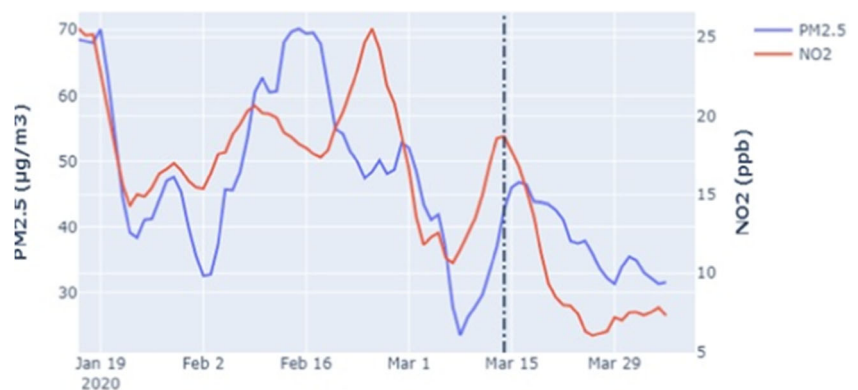


Fig. 14 $\text{PM}_{2.5}$ and NO_2 pollutants prior to and after lockdown in Spain (Bhattacharyya 2020). Dashed line shows lockdown date



2.4% in Valencia (Spain) during lockdown (Sicard et al. 2020). In Ecuador, concentrations of NO_2 and $\text{PM}_{2.5}$ reduced significantly since introduction of lockdown, but O_3 concentrations have grown (Zambrano-Monserrate and Ruano 2020). A study (Bilal et al. 2020) found that $\text{PM}_{2.5}$, O_3 , and NO_2 have a significant relationship with cases of COVID-19 in Germany.

Discussion

Reduction in economic activities has resulted in improved air quality across the world (Saadat et al. 2020). Figure 16 depicts

world's most polluted country ranking in 2019 and 2020 (IQAir 2020). It can be observed from Fig. 16 that improvement in ranks of developed nations like European nations and the USA was drastic (Berman and Ebisu 2020). Some models can be used to predict future trend of reducing air pollutants in environment (Bai et al. 2018).

A relationship has been established between COVID-19 and air pollution. Data released by ESA and NASA shows that on average air pollution has reduced up to 30% in hotspots of COVID-19 such as Wuhan, Spain, Italy, and the USA (Muhammad et al. 2020). Reduction in NO_2 is observed during lockdown process. PM_{10} , NO_2 and SO_2

Fig. 15 Clearer skies of Barcelona, Spain, after coronavirus lockdown (Lewis 2020)

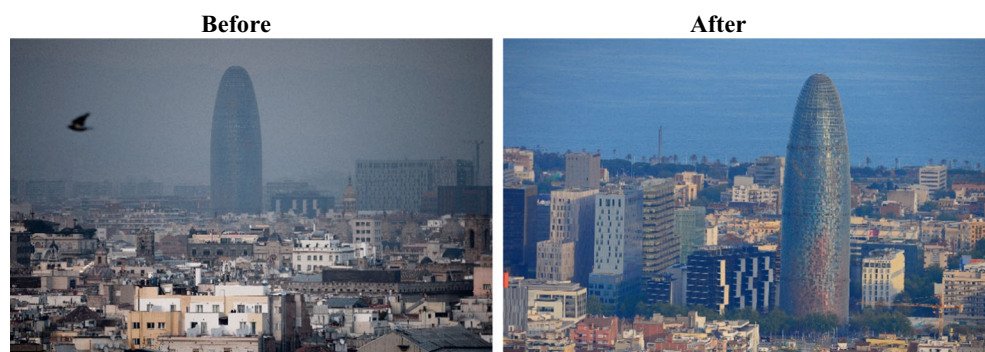
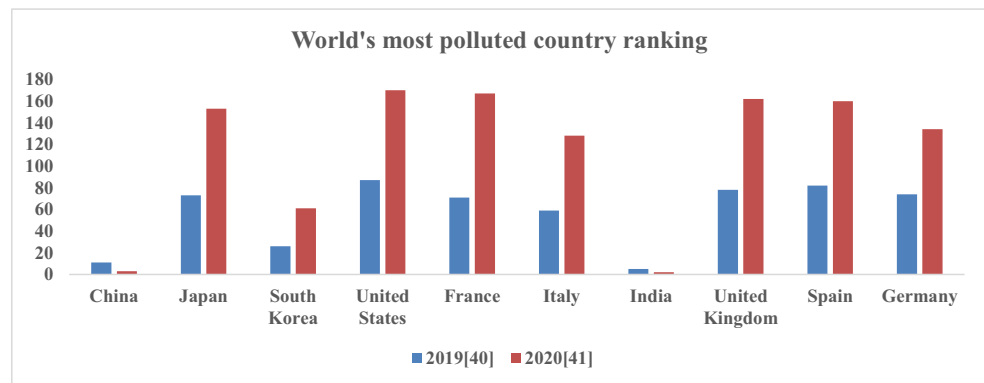


Fig. 16 Ranking in world's most polluted country in 2019 and 2020



concentrations were reduced by more than half during the covid-19 lockdown period. However, achieved reductions are not likely to be sustainable (Zambrano-Monserrate et al. 2020).

Conclusion

The outbreak of SARS-CoV-2 in various nations of the world has led to various preventive measures taken to inhibit the transmission of this disease. In the majority of countries, the non-essential business were shutdown, and the restrictions on surface and air travel were introduced. Some countries have introduced limited lockdowns such as South Korea and Japan trying to combat this disease without a lockdown for a single day. Other countries such as Sweden did not introduce any lockdown. The lockdowns have led to the dramatic improvement in air quality and the reduction of pollution (as measured in the levels of NO₂, PM₁₀, SO₂, PM_{2.5}, and CO) on average up to 30% in the hotspots of COVID-19. However, the decrease in car and industry emissions did not fully eliminate air pollution, while ozone levels actually increased up to 36%. As lockdown measures are eased, the levels of air pollution are returning to the pre-COVID-19 numbers.

Data availability Not applicable

Compliance with ethical standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical approval This research work does not involve chemicals, procedures, or equipment that have any unusual hazards inherent in their use.

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