International Journal of Geography, Geology and Environment

P-ISSN: 2706-7483
E-ISSN: 2706-7491
IJGGE 2022; 4(1): 132-140
Received: 26-12-2021
Accepted: 17-02-2022

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COVID-19 restrictions & ease in global air pollution are good in the worst-case scenario

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Abstract
Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), known to cause 2019- coronavirus disease (COVID-19) pandemic is a zoonotic coronavirus and crosses species to infect human populations, where an efficient transmission of virus occurs human-to- human. Nationwide lockdown is being adopted to stop public transport, keep people at their homes and out of their work, and maintain social distancing. In turn, large geographic areas in the world (including China, Italy, Spain, and USA) have been almost halted. This temporary halt is significantly slashing down the air pollution (air pollutants and warming gases) in most cities across the world. This paper: (i) introduces both COVID-19 and air pollution; (ii) overviews the relation of air pollution with respiratory/lung diseases; (iii) compiles and highlights major data appeared in media and journals reporting lowering of air pollution in major cities those have been highly impacted by the COVID-19; and also (iv) lists the way forward in the present context. Because COVID-19 is an ongoing pandemic and currently far from over, strong conclusions could not be drawn with very limited data at present. The temporary slashed down global air pollution as a result of COVID-19 restrictions are expected to stimulate the researchers, policy makers and governments for the judicious use of resources; thereby minimize the global emissions, and maintain their economies once the pandemic eases. On the other, lifting of the nationwide lockdown and eventual normalization of the temporarily halted sectors may also reverse the currently COVID-19 pandemic-led significantly slashed down global air pollution that could make the future respiratory health crisis grimmer.

Keywords: Coronavirus, SARS-CoV-2, COVID-19, respiratory diseases, air pollution

Introduction

The recent global outbreak of an infectious coronavirus disease (COVID-19) has already been considered as a global health emergency by the world health organization (WHO). Previously known by the provisional name 2019-novel coronavirus (2019-nCoV), severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), a strain of coronavirus is known to cause COVID-19 (Chen and Li 2020; El-Feky *et al*. 2020) [9, 13]. SARS-CoV-2 is a zoonotic coronavirus that has crossed species to infect human populations, where an efficient transmission of virus occurs human-to-human. SARS-CoV-2 has already spread over about 200 countries in the world and, as of 4th April, the WHO has reported 1,051, 635 confirmed cases and 56,985 confirmed deaths in total due to COVID-19 (WHO 2020) (Table 1; Fig. 1). Therefore, the world is trying every approach to control the rapid transmission of SAAR-CoV-2 and so the spread of COVID-19 in humans. In an effort to slow the virus' very fast pace spread, a large number of countries is adopting the strategy of practicing social distancing and telling people to stay in their homes through implementing the strict lockdown. Worldwide, the streets of the most cities are deserted; the normally bustling pubs, bars and theatres have been closed; operation of the public transport has been restricted; the most extensive travel restrictions are in place, and people are working remotely from their homes. Since mid-February 2020 and/or beginning of March 2020, about three-week nationwide lockdown has halted increasingly large geographic areas which is impacting economies across the world and also the status of global air pollution.

Table 1: COVID-2019 confirmed cases and deaths as of 4th April 2020 (WHO 2020).

Region	Confirmed cases of COVID-2019	Confirmed death
Global	1051635	56985
European Region	583141	42334
Western Pacific Region	110362	3809
Eastern Mediterranean Region	65903	3592
Region of the Americas	279543	6802
South-East Asia Region	6528	267
African Region	5446	170

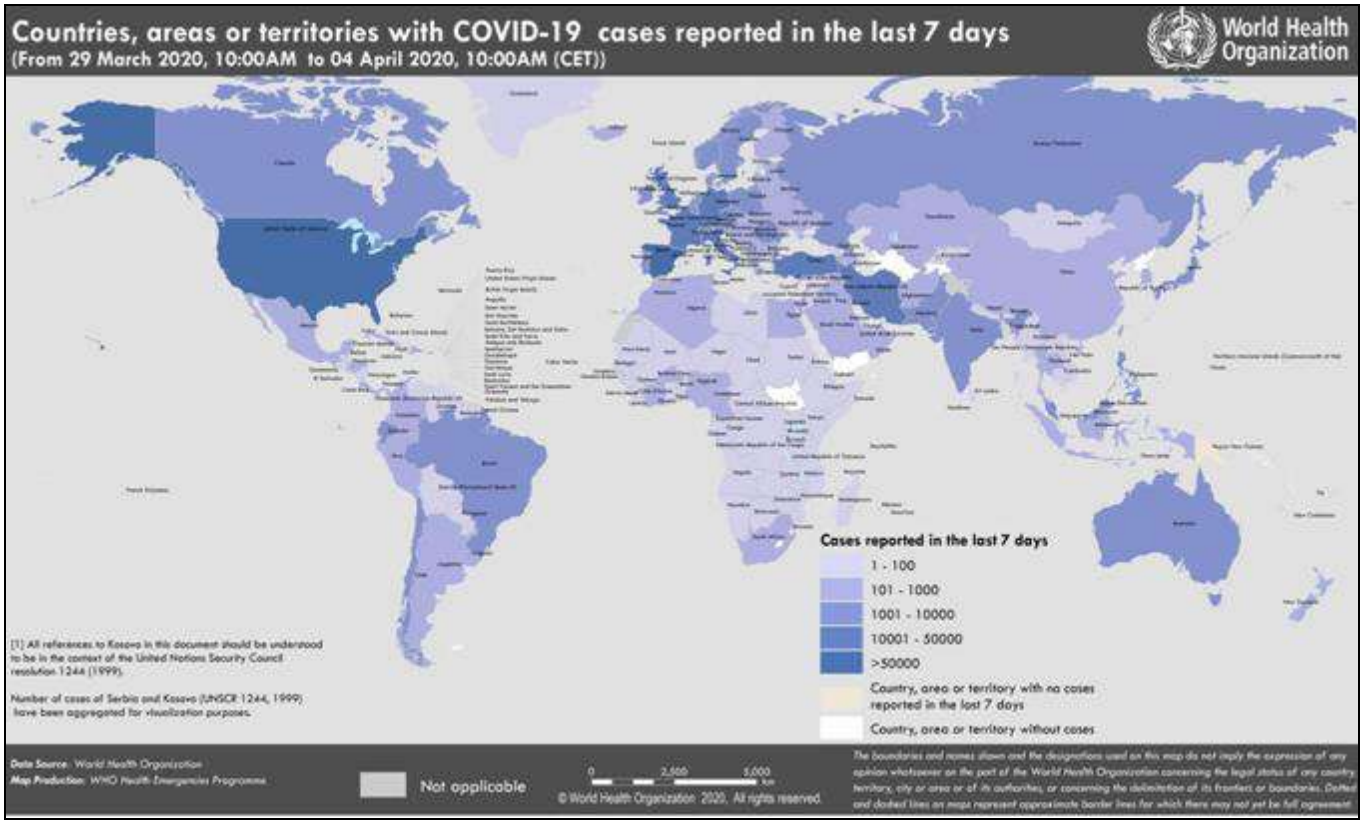

Fig 1: Countries, territories or areas with confirmed reported cases of COVID-19 as of the 30th of March 2020 (WHO 2020).

In the following sections, air pollution is introduced; the relation of air pollution with major respiratory /lung diseases is overviewed; major data appeared in media and journals reporting lowering of air pollution in major cities those have been highly impacted by the COVID-19 are compiled and highlighted; and also the future prospects in the present context are enlightened.

Air pollution

Owing its importance as a major part of several essential cycles on Earth, air is required to survive by most species including human beings. Air provides oxygen (O_2) for respiration to occur, and also carbon dioxide (CO_2) for photosynthesis to happen in plants. However, rapid establishment of industries aimed at making our daily life comfortable, on the other hand, is adding highly toxic substances to air and making it very hard to breath. Air is called polluted when it exhibits harmful concentrations of a mix of particles and gases such as black carbon (soot), smoke, mold, pollen, methane (CH_4), and CO_2. Particulate matter (PM), black carbon, ground-level ozone (O_3), nitrogen dioxide (NO_2), nitrous oxide (N_2O), sulfur dioxide (SO_2) and carbon monoxide (CO) are among the major types of air pollutants.

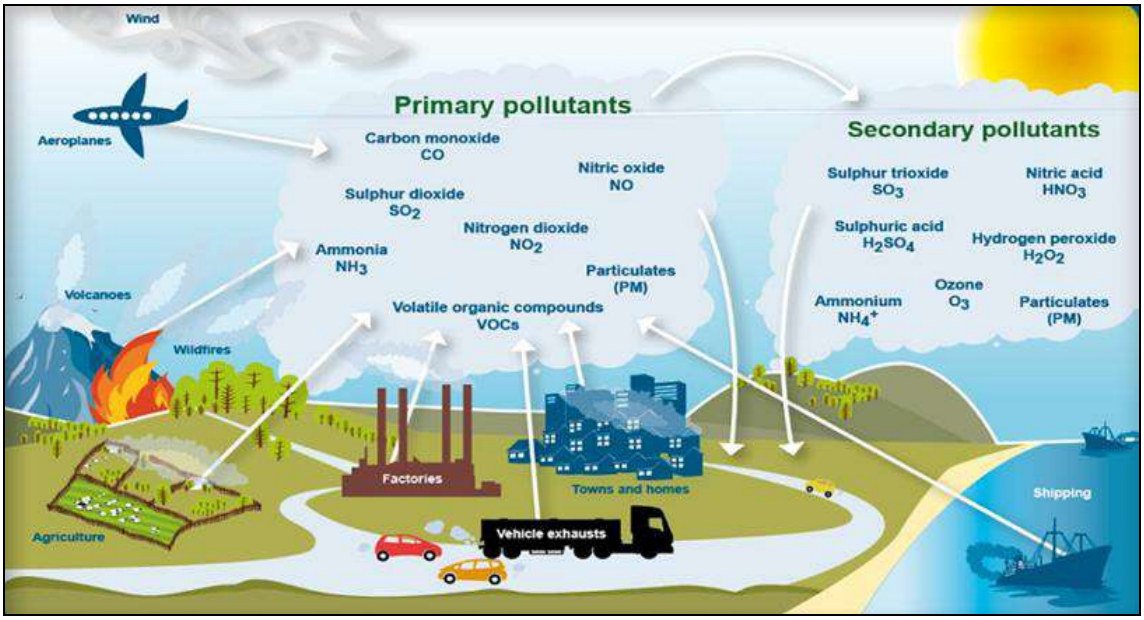

Fig. 2. Types and sources of major air pollutants (Helen 2020) [21].

(Fig. 2). Increasing levels of small size components or PM (PM10; PM2.5; UFP-ultrafine particles, <0.1 mm in diameter, 20-times smaller than the width of a human hair) have been confirmed in air sampled in the major world cities. PMs are contributed mostly as by-products of combustion from coal-fired power stations, wood and charcoal-burning stoves, vehicle engines and factories. In particular, PM10 (<10 micrometers) and PM2.5 (<2.5 micrometers) can be breathed deeply into the lungs and may cross into the bloodstream; therefore, pose higher health risks (Nunez 2019).

Air pollution and respiratory/lung diseases

Air pollution is known since long back to affect all regions of the world. Notably, in addition to smog, soot, greenhouse gases (CO_2; CH_4), N_2O; O_3), varyingly affect the planet and our health. Both indoor and ambient air pollution exposure have been argued as a major risk to respiratory health worldwide, particularly in low- and middle-income countries (Saleh *et al*. 2020). NO_2 at concentrations above 200 micrograms per cubic meter has been considered as a toxic gas which causes significant inflammation of the airways (WHO 2018a). Major health consequences of air pollutants include respiratory infections, asthma, chronic obstructive pulmonary disease, lung cancer, even in combination with stroke and heart diseases (Kim *et al*. 2018) [26]. Globally, 9% of deaths are contributed by air pollution, and this varies from 2% to 15% by country. During 2017, air pollution contributed to 9% of deaths globally. Give this, air pollution has been considered as one of the world's leading risk factors for death (Ritchie and Roser 2020) (Figs. 3 and 4). Nine out of ten people have to breath in air containing high levels of pollutants. Such data is making the impact of air pollution on human health grimmer (WHO 2018b). Compared to high-income countries, 49% cities and most of the cities (97%) in low- and middle- income countries with >100,000 inhabitants were reported to not meeting the WHO air quality guidelines in the year 2018 (WHO 2018c). Though WHO is continuously working with countries to monitor air pollution and improve air quality, air pollution has been reported to cause 7 million deaths worldwide each year, mostly through no communicable diseases including acute respiratory infections like pneumonia (Healio 2018) [20]. Earlier, notable health risks of air pollution and also the historical highlights of its toxicology has also been very well-discussed in literature (Stanek *et al*. 2011; Kurt *et al*. 2016; Soriano *et al*. 2017; Costa 2018; Glencross *et al*.2020) [12,28, 19].

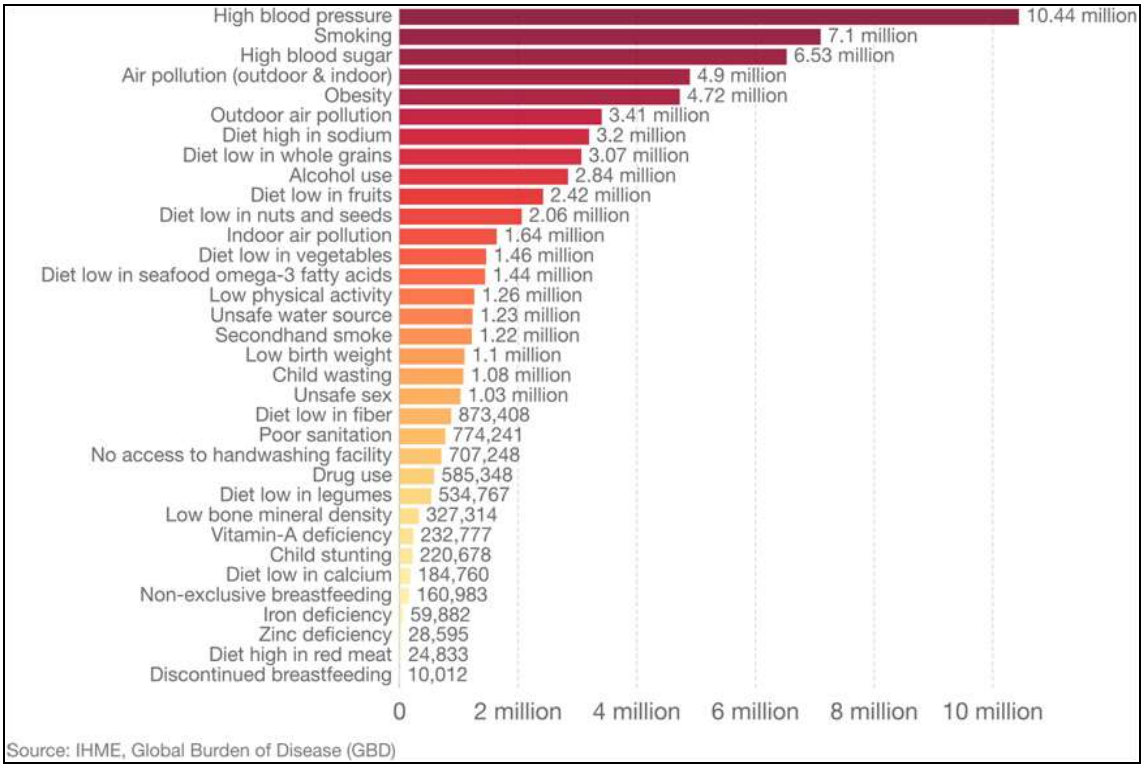

Fig 3. Data exhibiting disease burden by risk factor in the year 2017. (Ritchie and Roser 2020).

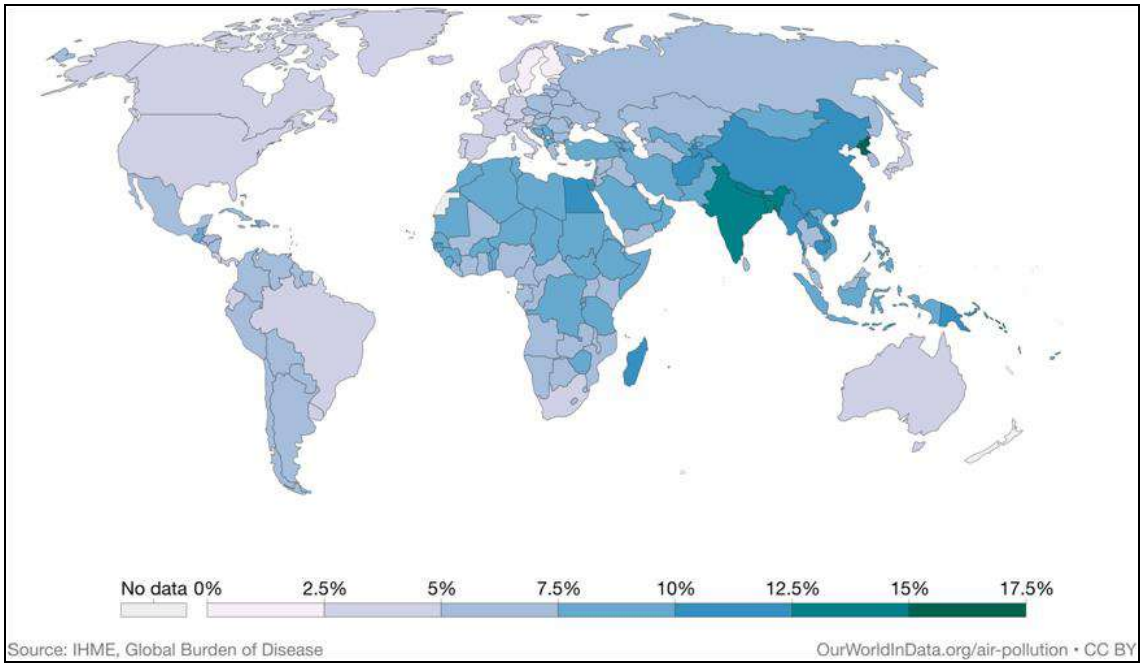

Fig. 4. World map highlighting share of deaths from air pollution in the year 2017 (Ritchie and Roser 2020).

COVID-19 and the status of global air pollution

In the present condition of COVID-19, experts have argued that high air pollution and smoking make people more vulnerable to this disease (Korber 2020; Perappadan 2020; TWC India Edit Team 2020) [27]. Morevoer, air pollution has been expected as a common denominator for countries with major cases of severe COVID-19 infection, China, South Korea, Iran, and northern Italy (BMJ 2020a) [4]. In particular, cities with higher air pollution were arugued as at more risk of COVID-19 (Basu 2020; Barbiroglio 2020; Korber 2020) [3, 27, 2]. Earlier, varying extents of air pollution have been associated with increased occurrence of respiratory tract infections and pulmonary diseases (Schikowski *et al*. 2005; Ciencewicki and Jaspers 2007; Neupane *et al*. 2010; Cohen *et al*. 2017; Horne *et al*. 2018; Liu *et al*. 2019; BMJ 2020b) [10, 11, 5, 29, 23]. Conditions caused by dirty air may be likely to cut survival chances under COVID-19 (European Public Health Alliance 2020) [16].

Despite the most stringent World Health Organization guidelines and EU standards for air pollution, the levels of air pollutants still high in most cities. In particular, PM2.5 alone has been reported to cause about 412,000 premature deaths in 41 European Countries in 2016. About 374,000 of those deaths occurred in the European Union (EU) (European Environment Agency 2019a) [14]. Therefore, air pollution has become one of the biggest environmental

health risks in Europe (European Environment Agency 2019b) [15]. The Northern Italy, center of Europe's COVID-19 pandemic occurred, has the hotspot of the air pollution. In Italy, the highest daily jump was recorded in COVID-19 deaths, whereas of 29th March 2020, more than 10,000 people have died since the start of this pandemic (Spary *et al*. 2020). After Italy, the world's second-highest coronavirus death toll was recorded in Spain, where deadly COVID-19 has so far claimed 5,690 lives (Regencia and Alsaafin 2020). As of 29th March 2020, the US had the most confirmed cases worldwide, surpassed China and Italy. COVID-19 caused death in US soared to 2,100.

Interestingly, halting of large geographic areas due to lockdown has also led to some unexpected consequences in terms of moderate to significant lowering of air pollution in most parts of the world including China, Italy, and California (Calma 2020a,b) [6]. In addition to pollution, greenhouse gas emissions have also fallen across continents (Henriques 2020) [22]. In context with the greenhouse gas emissions, 72% and 11% of the transport sector's greenhouse gas emissions are contributed by the driving and aviation respectively (IPCC 2018) [24].

In China, the measures to minimize the spread of SARS-CoV-2 have resulted in reductions of 15% to 40% in output across key industrial sectors and also has temporarily reduced China's CO_2 emissions by a quarter (Table 2).

With electricity demand and industrial output commencing 3 February 2020

Table 2: Status of decreases in energy demand and emissions in major sectors related

Sector	Status of decreases (%)
Coal consumption at power plants	35
Operating rates for main steel products	15
Coal throughput at the largest coal port	29
Coking plant utilization	23
Satellite-based NO_2 levels	37
Utilization of oil refining capacity	34

In particular with CO_2, around 800m tonnes of CO_2 ($MtCO_2$) were released in China over the same period in 2019. On the other, NO_2, an air pollutant closely associated with fossil-fuel burning exhibited 36% lower over China (in the week after the 2020 Chinese new year holiday) than in the same period in 2019 (Myllyvirta 2020; NASA 2020) [31] (Fig. 5).

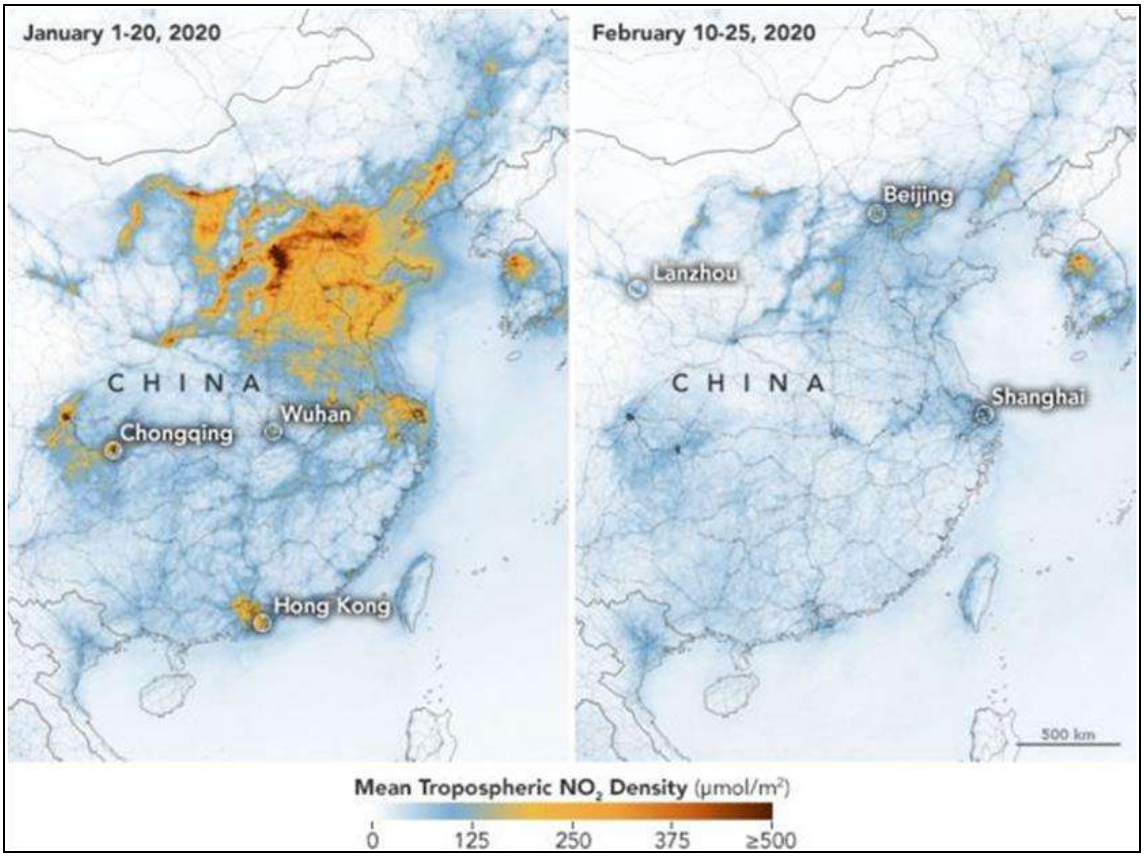

Fig 5: Images showing the status of NO_2 in major cities of China during January 1-20, 2020 and February 10-25, 2020 amid COVID-19 restrictions (image credit: McGrath 2020) [30].

Notably, in Italy, a remarkable drop has been revealed in NO_2 pollution that comes mainly from traffic, especially diesel vehicles, which are also a major source of PM (European Public Health Alliance 2020) [16] (Fig. 6A). PM10 levels in Lombardy have fallen dramatically after 10 days of COVID-19 social distancing measures (Fig. 6B). France also showed the measured drop in NOx as economic activity and transportation therein are at a bare minimum due to COVID-19 (Balken Green Energy News 2020) (Fig. 7).

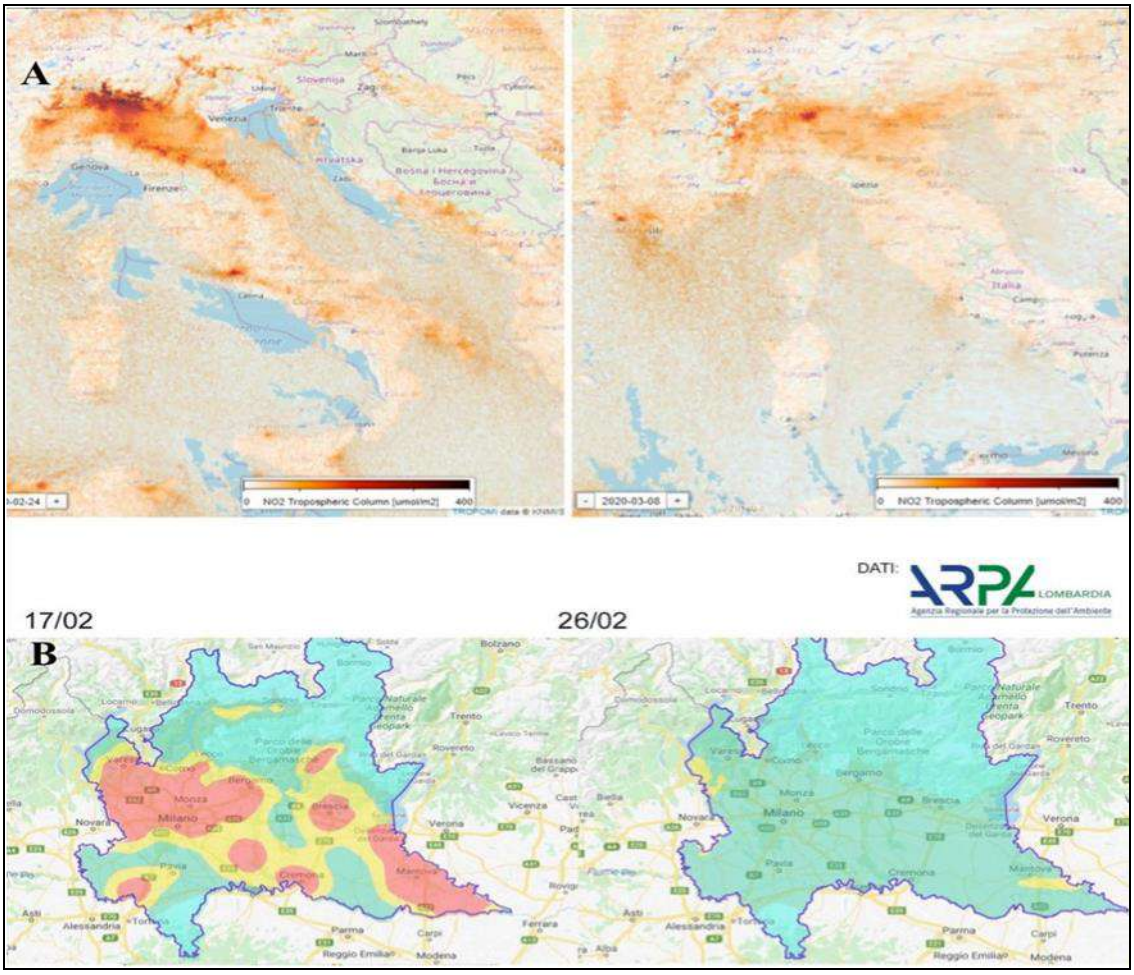

Fig 6: Images showing the reduction in the levels of particulate matter of size 10 micrometer (PM10) in Lombardy (A) and NO_2 in major cities of Italy after 10 days of COVID-19 social distancing measures (image credit: European Public Health Alliance 2020) [16].

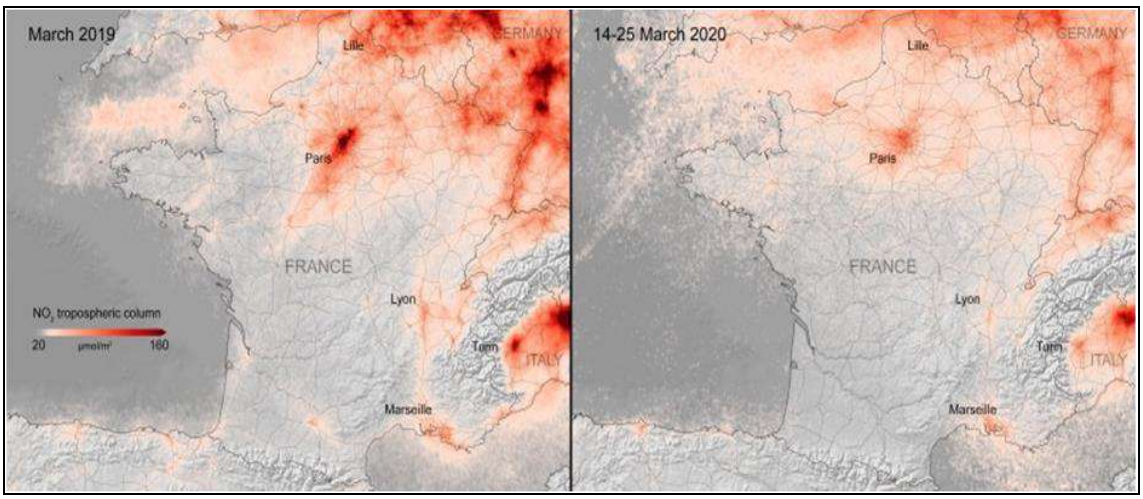

Fig 7: Images showing the reduction in the level of NO_2 in major cities of France on COVID-19 lockdowns (image credit: Balkan Green Energy News 2020) [1].

In the United States, the Centers for Disease Control and Prevention (CDC) had issued travel advisory for 3 states including New York, New Jersey and Connecticut to avoid non-essential travel for two weeks in an attempt to tamp down spread of coronavirus in the region. New York remains the epicenter of the COVID-19 outbreak in the US (CBS News 2020) [8]. Earlier, New York air monitoring work had revealed exceptionally high CO numbers in New York for the last year and a half (Pascus 2020). However, during the spread of COVID-19 pandemic in New York, traffic levels were estimated to be down 35% compared with a year ago. Significant decreases in the emission of CO and that of the planet-heating gas CO_2 have also fallen sharply. New York had also exhibited 5-10% drop in CO_2 and a solid drop in methane as well (McGrath 2020) [30]. Additionally, COVID- 19 pandemic led less commercial activity and traffic dropped NO_2 levels in certain areas across the United States (Fox2Detroit 2020) [18] (Fig. 8).

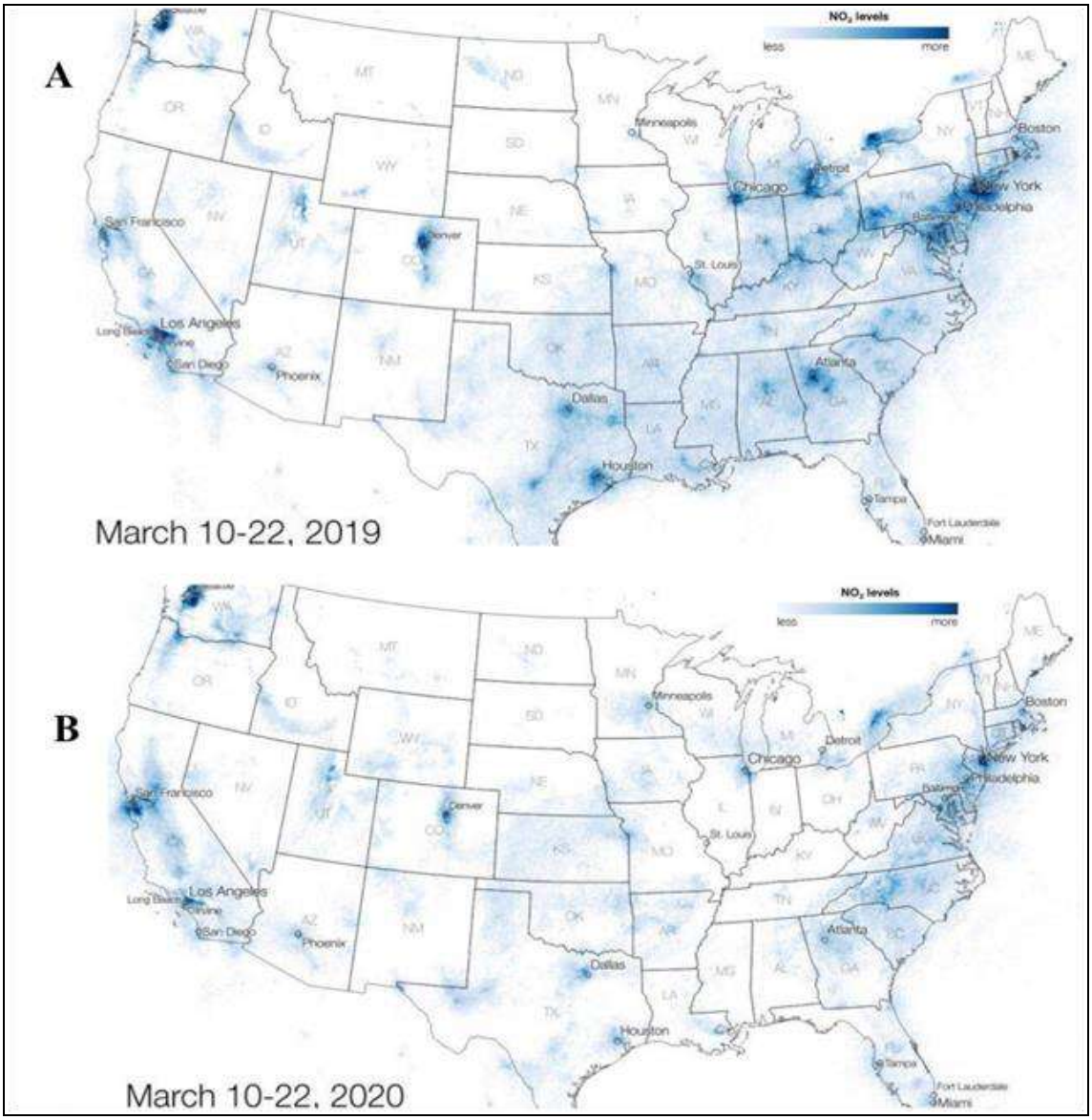

Fig 8: Images showing the status of NO_2 in major cities of United States during March 1- 22, 2019 and March 10-22, 2020 amid COVID-19 restrictions (image credit: Fox 2 Detroit 2020) [18].

In context with India, air pollution has been reported to plummet in the end of second week of COVID-19 lockdown. In terms of air quality index (AQI; range: 0 to 500; good: 0-50; satisfactory: 51-100; poor: 201-300), a total of 91 cities were under 'Good' & 'Satisfactory' category, with 31 cities with 'Good' AQI values; and no city was under 'Poor' AQI category, as on March 29, 2020 (SAFAR-India 2020; Vishnoi 2020) (Fig. 9). Additionally, the measures against COVID-19 have led to a drop in PM2.5 30% in Delhi and by 15% in Ahmedabad and Pune, respectively (The Hindu 2020). In New Delhi, the diversion and/or cessation of flights witnessed dropping down of the air pollution levels by 71% in just one week, where the level of PM2.5 dropped from 91 micrograms per cubic meter (on 20 March 2020) to 26 micrograms per cubic meter in just a couple days of the lockdown (Davidson 2020). Earlier, the 'Janata Curfew', observed on March 22 (from 7 am-9 pm) led to a significant reduction in particulate matter (PM10) and nitrogen oxide (NOx), where a 44 percent reduction in PM10 levels particularly in Delhi between 22 and 23 March 2020 (FP 2020).

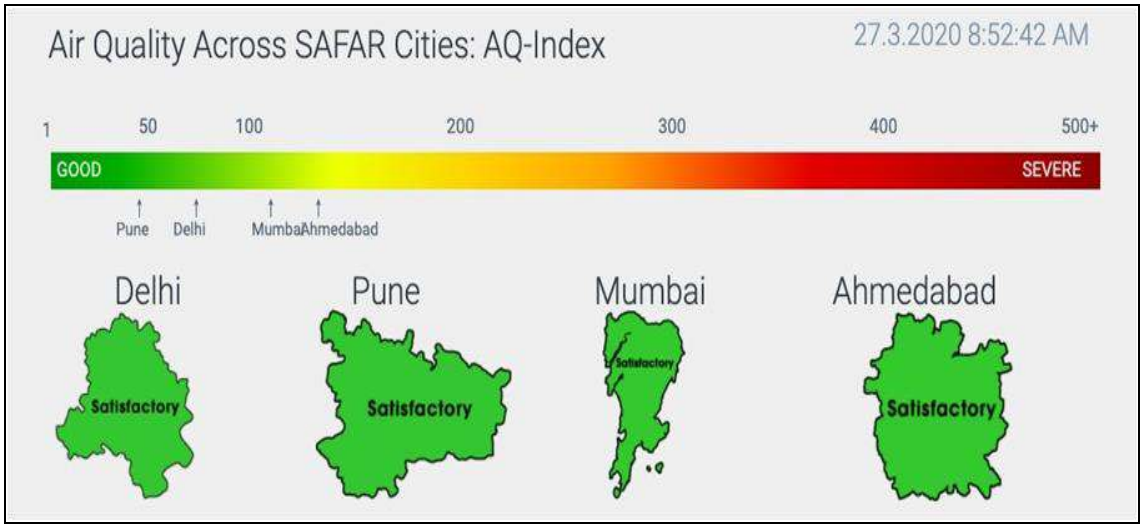

Fig 9: Image showing air quality across major cities in India as on 27th March 2020 (SAFAR-India 2020).

Conclusions & Prospects

Because COVID-19 is an ongoing pandemic and currently far from over, strong conclusions could not be drawn with very limited data at present. No doubt air pollution is increasing worldwide and has been widely reported to be closely related with the severe lung/respiratory diseases in human. The nationwide halting of public transports and closure of major industrial units has resulted in obvious significant reductions in emissions of a variety of gases related to energy and transport. Indeed, industrial developments and production are necessary for supporting the world population. However, lifting of the nationwide lockdown and eventual normalization of the temporarily halted sectors may also reverse the currently COVID-19 pandemic-led slashed down global air pollution and can make the future respiratory health crisis grimmer. Hence, the indication of slowing down of public and personal transport, and travel in slashing down the air pollution is expected to stimulate the researchers, policy makers and governments to judicious use of resources and thereby minimize the global emissions and maintain their economies once the pandemic eases.

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