SHORT-LIVED CLIMATE POLLUTANTS SPECIAL EDITION RESEARCH DIGEST

Covid-19 and Air Pollution

The SAP and the Secretariat have prepared this special edition of the SLCP research digest for the purpose of informing the Climate and Clean Air Coalition partnership of the latest and on-going research and potential links between covid-19 and air pollution and SLCPs. The SAP has not evaluated the content of the publications.

All SLCP research digests are available on the CCAC website (http://ccacoalition.org/en/research-digest)

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of the

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A COVID-19 recovery for climate

Daniel Rosenbloom, Jochen Markard. A COVID-19 recovery for climate. Science (01 May 2020)

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We're flattening the coronavirus curve. We can flatten the climate curve, too

A. R. Ravishankara and Mary M. Glackin.

https://www.washingtonpost.com/outlook/2020/05/19/coronavirus-action-climate-change/

What can COVID-19 teach us about responding to climate change?

Mario Herrero and Philip Thornton, https://doi.org/10.1016/S2542-5196(20)30085-1

https://www.sciencedirect.com/science/article/pii/S2542519620300851

Compound climate risks in the COVID-19 pandemic

Phillips, C.A., Caldas, A., Cleetus, R. et al. Compound climate risks in the COVID-19 pandemic. Nat. Clim. Chang. (2020). https://doi.org/10.1038/s41558-020-0804-2

https://www.nature.com/articles/s41558-020-0804-2#citeas

CHANGES IN EMISSIONS DUE TO COVID-19 RESPONSE

COVID-19 as a factor influencing air pollution?

Journal pre-proof

At the end of 2019, the first cases of pneumonia associated with coronavirus (COVID-19) were reported in Wuhan, China (Huang et al., 2020). Thereafter, the number of infected people increased rapidly and, a month later, the outbreak turned into a national crisis, with infected individuals diagnosed all over the country (CDC, 2020; Chan et al., 2020; World Health Organization, 2020a; 2020b). Chinese authorities shut down transportation and travel in and out of Wuhan. They also curtailed and reduced local business travel, closed down schools, colleges and universities in order to reduce the spread of the disease and established numerous quarantines (Wilder-Smith and Freedman, 2020). The maps in Fig. 1 show the nitrogen dioxide (NO_2) concentrations, resulting primarily from the burning of fossil fuels (He et al., 2020a,b), prior to and following the quarantine, with a massive reduction observed in concentrations after the corona virus outbreak (NASA, 2020). The data were collected by the Tropospheric Monitoring Instruments (TROPOMI) on-board ESA's Sentinel-5 satellite. A related sensor, the Ozone Monitoring Instrument (OMI) on-board NASA's Aura satellite, recorded similar atmospheric changes. NO_2 is a common tracer of air pollution/industrial activity, associated with morbidity and mortality (He et al., 2020a,b). NASA scientists

have commented that the reduction in NO2 pollution was first apparent near Wuhan, but spread across the rest of the country, and eventually worldwide (NASA, 2020). In Central China, NO2 emissions were reduced by as much as 30% (NASA, 2020). CO2 emissions, another common tracer of air pollution (Hanaoka and Masui, 2019), decreased by 25% in China and by 6% worldwide (CarbonBrief, 2020). Air pollution is responsible for many deaths and increased incidences of respiratory disease (Brauer, 2010). According to the World Health Organization, 4.6 million individuals die annually from diseases and illnesses directly related to poor air quality (Cohen et al., 2017). Poor air quality is responsible for more deaths each year than motor vehicle accidents (European Environment Agency, 2005). The impact of air pollution is a global problem and includes developed countries, such as the European nations where 193,000 people died in 2012 from airborne particulate matter (Ortiz et al., 2017). Air pollution associated deaths include but are not limited to aggravated asthma, bronchitis, emphysema, lung and heart diseases, and respiratory allergies (Brauer, 2010). China, where the COVID-19 epidemic started, is also a country severely affected by air pollution (He et al., 2020a,b).

Air pollution in China was responsible for 4000 preventable deaths each day i.e. 1.6 million fatalities in 2016 (Rohde and Muller, 2015; Wang et al., 2012). Several models predict mortality due to air pollution (Hoek et al., 2013), with an increase of all-cause mortality ranging from 0.13% per 10µg/m3 of NO2 per day (He et al., 2020a,b) to 2% per 10µg/m3 of NO2 on a 5 day period (Chiusolo et al., 2011), or a global hazard ratio of 1.052 (95 confidence intervals 1.045 to 1.059) per increase of 8.1 ppb in NO2 (Crouse et al., 2015). In a hypothetical scenario in which the impact of air pollution on mortality was underestimated using the aforementioned models, and in which we considered a time period of two months with a decrease in NO2 air pollution in China, macabre predictions could postulate a 6% reduction in mortality due to air pollution (i.e. around 100 000 life's saved, just in China). Similar calculations could be applied to other countries. At the time of writing this, there are 3,158 reported deaths from COVID-19 in China and 4,607 worldwide. Considering the huge decrease in air pollution following the quarantine (China's CO2 emissions decreased by a quarter), the COVID-19 pandemic might paradoxically have decreased the total number of deaths during this period, by drastically decreasing the number of fatalities due to air pollution. Moreover, in addition to the reduced number of deaths due to air pollution, the reduction in air pollution itself could also have positive benefits in reducing preventable non communicable diseases (Chen and Bloom, 2019; Neira et al., 2018).

Frédéric Dutheil, Julien S.Baker, Valentin Navel. "COVID-19 as a factor influencing air pollution?" Environmental Pollution 263(Part A) (August 2020). https://www.sciencedirect.com/science/article/pii/S0269749120316468?via%3Dihub

COVID-19, City Lockdown, and Air Pollution Evidence from China

The rapid spread of COVID-19 is a global public health challenge. To prevent the escalation of its transmission, China locked down one-third of its cities and strictly restricted human mobility and economic activities. Using timely and comprehensive air quality data in China, we show that these counter-COVID-19 measures led to remarkable improvement in air quality. Within weeks, the Air Quality Index and PM2.5 concentrations were brought down by 25%. The effects are larger in colder, richer, and more industrialized cities. We estimate that such improvement would avert 24,000 to 36,000 premature deaths from air pollution on a monthly basis.

He, Guojun, Yuhang Pan, and Takanao Tanaka. "COVID-19, City Lockdown, and Air Pollution: Evidence from China." medRxiv (2020).

Good in The Worst: Covid-19 Restrictions and Ease in Global Air Pollution

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) has 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 minimise the global emissions, and maintain their economies once the pandemic eases. On the other, lifting of the nationwide lockdown and eventual normalisation 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.

Anjum, N.A. Good in The Worst: COVID-19 Restrictions and Ease in Global Air Pollution. Preprints 2020, 2020040069 (doi: 10.20944/preprints202004.0069.v1). https://www.preprints.org/manuscript/202004.0069/v1

Severe air pollution events not avoided by reduced anthropogenic activities during Covid-19 outbreak

Due to the pandemic of coronavirus disease 2019 in China, almost all avoidable activities in China are prohibited since Wuhan announced lockdown on January 23, 2020. With reduced activities, severe air pollution events still occurred in the North China Plain, causing discussions regarding why severe air pollution was not avoided. The Community Multi-scale Air Quality model was applied during January 01 to February 12, 2020 to study PM2.5 changes under emission reduction scenarios. The estimated emission reduction case (Case 3) better reproduced PM2.5. Compared with the case without emission change (Case 1), Case 3 predicted that PM2.5 concentrations decreased by up to 20% with absolute decreases of 5.35, 6.37, 9.23, 10.25, 10.30, 12.14, 12.75, 14.41, 18.00 and 30.79 μg/m3 in Guangzhou, Shanghai, Beijing, Shijiazhuang, Tianjin, Jinan, Taiyuan, Xi'an, Zhengzhou, Wuhan, respectively. In high-pollution days with PM2.5 greater than 75 μg/m3, the reductions of PM2.5 in Case 3 were 7.78, 9.51, 11.38, 13.42, 13.64, 14.15, 14.42, 16.95 and 22.08 μg/m3 in Shanghai, Jinan, Shijiazhuang, Beijing, Taiyuan, Xi'an, Tianjin, Zhengzhou and Wuhan, respectively. The reductions in emissions of PM2.5 precursors were ~2 times of that in concentrations, indicating that meteorology was unfavorable during simulation episode. A further analysis shows that benefits of emission reductions were overwhelmed by adverse meteorology and severe air pollution events were not avoided. This study highlights that large emissions reduction in transportation and slight reduction in industrial would not help avoid severe air pollution in China, especially when meteorology is unfavorable. More efforts should be made to completely avoid severe air pollution.

Wang, Pengfei, et al. "Severe air pollution events not avoided by reduced anthropogenic activities during COVID-19 outbreak." Resources, Conservation and Recycling 158 (2020): 104814.

The Effects of Outdoor Air Pollution Concentrations and Lockdowns on Covid-19 Infections in Wuhan and Other Provincial Capitals in China

Background: Covid-19 was first reported in Wuhan, China in Dec 2019. Since then, it has been transmitted rapidly in China and the rest of the world. While Covid-19 transmission rate has been declining in China, it is increasing exponentially in Europe and America. Although there are numerous studies examining Covid-19 infection, including an archived paper looking into the meteorological effect, the role of outdoor air pollution has yet to be explored rigorously. It has been shown that air pollution will weaken the immune system, and increase the rate of respiratory virus infection. We postulate that outdoor air pollution concentrations will have a negative effect on Covid-19 infections in China, whilst lockdowns, characterized by strong social distancing and home isolation measures, will help to moderate such negative effect.

Methods: We will collect the number of daily confirmed Covid-19 cases in 31 provincial capital cities in China during the period of 1 Dec 2019 to 20 Mar 2020 (from a popular Chinese online platform which aggregates all cases reported by the Chinese national/provincial health authorities). We will also collect daily air pollution and meteorology data at the city-level (from the Chinese National Environmental Monitoring Center and the US National Climatic Data Center), daily inter-city migration flows and intra-city movements (from Baidu). City-level demographics including age distribution and gender, education, and median household income can be obtained from the statistical yearbooks. City-level co-morbidity indicators including rates of chronic disease and co-infection can be obtained from related research articles. A regression model is developed to model the relationship between the infection rate of Covid-19 (number of confirmed cases/population at the city level) and outdoor air pollution at the city level, after taking into account confounding factors such as meteorology, inter- and intra-city movements, demographics, and co-morbidity and co-infection rates. In particular, we shall study how air pollution affects infection rates across different cities, including Wuhan. Our model will also study air pollution would affect infection rates in Wuhan before and after the lockdown. Expected findings: We expect there be a correlation between Covid-19 infection rate and outdoor air pollution. We also expect that reduced intra-city movement after the lockdowns in Wuhan and the rest of China will play an important role in reducing the infection rate. Interpretation: Infection rate is growing exponentially in major cities worldwide. We expect Covid-19 infection rate is related to the air pollution concentration, and is strongly dependent on inter- and intra-city movements. To reduce the infection rate, the international community may deploy effective air pollution reduction plans and social distancing policies.

Han, Yang, et al. "The Effects of Outdoor Air Pollution Concentrations and Lockdowns on Covid-19 Infections in Wuhan and Other Provincial Capitals in China." (2020).

Changes in air quality during the lockdown in Barcelona (Spain) one month into the SARS-CoV-2 epidemic

Lockdown measures came into force in Spain from March 14th, two weeks after the start of the SARS-CoV-2 epidemic, to reduce the epidemic curve. Our study aims to describe changes in air pollution levels during the lockdown measures in the city of Barcelona (NE Spain), by studying the time evolution of atmospheric pollutants recorded at the urban background and traffic air quality monitoring stations. After two weeks of lockdown, urban air pollution markedly decreased but with substantial differences among pollutants. The most significant reduction was estimated for BC and NO2 (-45 to -51%), pollutants mainly related to traffic emissions. A lower reduction was observed for PM10 (-28 to -31.0%). By contrast, O3 levels increased (+33 to +57% of the 8 h daily maxima), probably due to lower titration of O3 by NO and the decrease of NOx in a VOC-limited environment. Relevant differences in the meteorology of these two periods were also evidenced. The low reduction for PM10 is probably related to a significant regional contribution and the prevailing secondary origin of fine aerosols, but an in-depth evaluation has to be carried out to interpret this lower decrease. There is no defined trend for the low SO2 levels, probably due to the preferential reduction in emissions from the least polluting ships. A reduction of most pollutants to minimal concentrations are expected for the forthcoming weeks because of the more restrictive actions

implemented for a total lockdown, which entered into force on March 30th. There are still open questions on why PM10 levels were much less reduced than BC and NO2 and on what is the proportion of the abatement of pollution directly related to the lockdown, without meteorological interferences.

Tobías, Aurelio, et al. "Changes in air quality during the lockdown in Barcelona (Spain) one month into the SARS-CoV-2 epidemic." Science of The Total Environment (2020): 138540.

Abrupt declines in tropospheric nitrogen dioxide over China after the outbreak of COVID-19

China's policy interventions to reduce the spread of the coronavirus disease 2019 have environmental and economic impacts. Tropospheric nitrogen dioxide indicates economic activities, as nitrogen dioxide is primarily emitted from fossil fuel consumption. Satellite measurements show a 48% drop in tropospheric nitrogen dioxide vertical column densities from the 20 days averaged before the 2020 Lunar New Year to the 20 days averaged after. This is 20% larger than that from recent years. We relate to this reduction to two of the government's actions: the announcement of the first report in each province and the date of a province's lockdown. Both actions are associated with nearly the same magnitude of reductions. Our analysis offers insights into the unintended environmental and economic consequences through reduced economic activities.

Liu, Fei, et al. "Abrupt declines in tropospheric nitrogen dioxide over China after the outbreak." arXiv.2004.06542.

Biomass use and COVID-19: A novel concern

Evidence supports the link between air pollution and COVID-19 and thus it is likely that exposure to biomass smoke is associated with COVID-19. The poor, including refugees and migrant workers staying in fragile conditions, are most vulnerable. An outbreak of COVID-19 in a place where the concept of physical distancing is next to impossible could easily overwhelm the public health system. It is thus essential to understand the consequences of being exposed to smoke in relation to COVID-19 infection.

Thakur, Megha, et al. "Biomass use and COVID-19: A novel concern." Environmental Research (2020): 109586.

A preliminary assessment of the impact of COVID-19 on environment – A case study of China

The coronavirus disease (COVID-19) is seriously threatening world public health security. Currently, >200 countries and regions have been affected by the epidemic, with the number of infections and deaths still increasing. As an extreme event, the outbreak of COVID-19 has greatly damaged the global economic growth and caused a certain impact on the environment. This paper takes China as a case study, comprehensively evaluating the dynamic impact of COVID-19 on the environment. The analysis results indicate that the outbreak of COVID-19 improves China's air quality in the short term and significantly contributes to global carbon emission reduction. However, in the long run, there is no evidence that this improvement will continue. When China completely lifts the lockdown and resumes large-scale industrial production, its energy use and greenhouse gas (GHG) emissions are likely to exceed the level before the event. Moreover, COVID-19 significantly reduces the concentration of nitrogen dioxide (NO2) in the atmosphere. The decline initially occurred near Wuhan and eventually spread to the whole country. The above phenomenon shows that the decreasing economic activities and traffic restrictions directly lead to the changes of China's energy consumption and further prevent the environment from pollution. The results in this study support the fact that strict quarantine measures can not only protect the public from COVID-19, but also exert a positive impact on the environment. These findings can provide a reference for other countries to assess the influence of COVID-19 on the environment.

Wang, Qiang, and Min Su. "A preliminary assessment of the impact of COVID-19 on environment–A case study of China." Science of The Total Environment (2020): 138915.

Does lockdown reduce air pollution? Evidence from 44 cities in northern China

Responding to the ongoing novel coronavirus (agent of COVID-19) outbreak, China implemented "the largest quarantine in human history" in an attempt to prevent the spread of the virus on 23 January 2020. Human mobility and relevant production and consumption activities have since decreased significantly. As a likely side effect of this decrease, many regions have recorded significant reductions in air pollution. We employed daily air pollution data and Intracity Migration Index (IMI) data form Baidu between 1 January and 21 March 2020 for 44 cities in northern China to examine whether, how, and to what extent travel restrictions affected air quality. On the basis of this quantitative analysis, we reached the following conclusions: (1) The reduction of air pollution was strongly associated with travel restrictions during this pandemic—on average, the air quality index (AQI) decreased by 7.80%, and five air pollutants (i.e., SO2, PM2.5, PM10, NO2, and CO) decreased by 6.76%, 5.93%, 13.66%, 24.67%, and 4.58%, respectively. (2) Mechanism analysis illustrated that the lockdowns of 44 cities reduced human movements by 69.85%, and a reduction in the AQI, PM2.5, and CO was partially mediated by human mobility, and SO2, PM10, and NO2 were completely mediated. (3) Our findings highlight the importance of understanding the role of green production and consumption.

Rui, Bao and Achen Zhang. "Does lockdown reduce air pollution? Evidence from 44 cities in northern China." Science of The Total Environment (2020): 139052

Exploring Dependence of COVID-19 on Environmental Factors and Spread Prediction in India

The pandemic of "Corona Virus Disease 2019" or COVID-19 has taken the world by storm. Majority of nations of the world have been challenged by the novel coronavirus, which is supposedly of zoonotic origin and is known as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The present work attempts to evaluate the spread of COVID-19 in India. The methodology of assessment uses SEIR (Susceptible-Exposed-Infectious-Removed) model to establish the impact of socio-behavioural aspect, especially social distancing, affecting the numbers of COVID-19 cases per day. The lockdown initiated by Government of India (GoI) scenario is weighed against a scenario with a possible initiation of community spread due to crowded gatherings in India. The resultant changes, as against the lockdown scenario, has been reported in terms of the increase in the number of cases and stretch of the timeline to mitigate the COVID-19 spread. Impact of environmental factors like temperature and relative humidity have also been analyzed using statistical methods, including Response Surface Methodology (RSM) and Correlation. It has been found that the spread of cases is dependent on environmental conditions, i.e. temperature and relative humidity. This study is expected to help the policymakers and stakeholders to device an improved action plan to alleviate the COVID-19 spread, especially in India.

Bherwani, H., et al. "Exploring Dependence of COVID-19 on Environmental Factors and Spread Prediction in India." (2020).

Assessing air quality changes in large cities during COVID-19 lockdowns: The impacts of traffic-free urban conditions in Almaty, Kazakhstan

Number of cities worlwide experienced air quality improvements during COVID-19 lockdowns; however, such changes may have been different in places with major contributions from nontraffic related sources. In Almaty, a city-scale quarantine came into force on March 19, 2020, which was a week after the first COVID-19 case was registered in Kazakhstan. This study aims to analyze the effect of the lockdown from March 19 to April 14, 2020 (27 days), on the concentrations of air pollutants in Almaty. Daily concentrations of PM2.5, NO2, SO2, CO, O3, and BTEX were compared between the periods before and during the lockdown. During the lockdown, the PM2.5 concentration was reduced by 21% with spatial variations of 6–34% compared to the average on the same days in 2018 – 2019, and still, it exceeded WHO daily limit values for 18 days. There were also substantial reductions in CO and NO2 concentrations by 49%

and 35%, respectively, but an increase in O3 levels by 15% compared to the prior 17 days before the lockdown. The concentrations of benzene and toluene were 2–3 times higher than those during in the same seasons of 2015–2019. The temporal reductions may not be directly attributed to the lockdown due to favorable meteorological variations during the period, but the spatial effects of the quarantine on the pollution levels are evidenced. The results demonstrate the impact of traffic on the complex nature of air pollution in Almaty, which is substantially contributed by various nontraffic related sources, mainly coal-fired combined heat and power plants and household heating systems, as well as possible small irregular sources such as garbage burning and bathhouses.

Kerimray, Aiymgul, et al. "Assessing air quality changes in large cities during COVID-19 lockdowns: The impacts of traffic-free urban conditions in Almaty, Kazakhstan." Science of The Total Environment (2020): 139179.

Effect of lockdown amid COVID-19 pandemic on air quality of the megacity Delhi, India

Amid the COVID-19 pandemic, a nationwide lockdown is imposed in India initially for three weeks from 24th March to 14th April 2020 and extended up to 3rd May 2020. Due to the forced restrictions, pollution level in cities across the country drastically slowed down just within few days which magnetize discussions regarding lockdown to be the effectual alternative measures to be implemented for controlling air pollution. The present article eventually worked on this direction to look upon the air quality scenario amidst the lockdown period scientifically with special reference to the megacity Delhi. With the aid of air quality data of seven pollutant parameters (PM10, PM2.5, SO2, NO2, CO, O3 and NH3) for 34 monitoring stations spread over the megacity we have employed National Air Quality Index (NAQI) to show the spatial pattern of air quality in pre and during-lockdown phases. The results demonstrated that during lockdown air quality is significantly improved. Among the selected pollutants, concentrations of PM10 and PM2.5 have witnessed maximum reduction (>50%) in compare to the pre-lockdown phase. In compare to the last year (i.e. 2019) during the said time period the reduction of PM10 and PM2.5 is as high as about 60% and 39% respectively. Among other pollutants, NO2 (- 52.68%) and CO (-30.3%) level have also reduced during-lockdown phase. About 40% to 50% improvement in air quality is identified just after four days of commencing lockdown. About 54%, 49%, 43%, 37% and 31% reduction in NAQI have been observed in Central, Eastern, Southern, Western and Northern parts of the megacity. Overall, the study is thought to be a useful supplement to the regulatory bodies since it showed the pollution source control can attenuate the air quality. Temporary such source control in a suitable time interval may heal the environment.

Mahato, Susanta, Swades Pal, and Krishna Gopal Ghosh. "Effect of lockdown amid COVID-19 pandemic on air quality of the megacity Delhi, India." Science of the Total Environment (2020): 139086.

Air quality changes during the COVID-19 lockdown over the Yangtze River Delta Region: An insight into the impact of human activity pattern changes on air pollution variation

The outbreak of COVID-19 has spreaded rapidly across the world. To control the rapid dispersion of the virus, China has imposed national lockdown policies to practise social distancing. This has led to reduced human activities and hence primary air pollutant emissions, which caused improvement of air quality as a side-product. To investigate the air quality changes during the COVID-19 lockdown over the YRD Region, we apply the WRF-CAMx modelling system together with monitoring data to investigate the impact of human activity pattern changes on air quality. Results show that human activities were lowered significantly during the period: industrial operations, VKT, constructions in operation, etc. were significantly reduced, leading to lowered SO2, NO*x*, PM2.5 and VOCs emissions by approximately 16–26%, 29–47%, 27–46% and 37–57% during the Level I and Level II response periods respectively. These emission reduction has played a significant role in the improvement of air quality. Concentrations of PM2.5, NO2 and SO2 decreased by 31.8%, 45.1% and 20.4% during the Level I period; and 33.2%, 27.2% and 7.6% during the

Level II period compared with 2019. However, ozone did not show any reduction and increased greatly. Our results also show that even during the lockdown, with primary emissions reduction of 15%–61%, the daily average PM2.5 concentrations range between 15 and 79 μg m -3, which shows that background and residual pollutions are still high. Source apportionment results indicate that the residual pollution of PM2.5 comes from industry (32.2–61.1%), mobile (3.9–8.1%), dust (2.6–7.7%), residential sources (2.1–28.5%) in YRD and 14.0–28.6% contribution from long-range transport coming from northern China. This indicates that in spite of the extreme reductions in primary emissions, it cannot fully tackle the current air pollution. Re-organisation of the energy and industrial strategy together with trans-regional joint-control for a full long-term air pollution plan need to be further taken into account.

Li, Li, et al. "Air quality changes during the COVID-19 lockdown over the Yangtze River Delta Region: An insight into the impact of human activity pattern changes on air pollution variation." Science of The Total Environment (2020): 139282.

Air quality status during 2020 Malaysia Movement Control Order (MCO) due to 2019 novel coronavirus (2019-nCoV) pandemic

An outbreak of respiratory illness which is proven to be infected by a 2019 novel coronavirus (2019-nCoV) officially named as Coronavirus Disease 2019 (COVID-19) was first detected in Wuhan, China and has spread rapidly in other parts of China as well as other countries around the world, including Malaysia. The first case in Malaysia was identified on 25 January 2020 and the number of cases continue to rise since March 2020. Therefore, 2020 Malaysia Movement Control Order (MCO) was implemented with the aim to isolate the source of the COVID-19 outbreak. As a result, there were fewer number of motor vehicles on the road and the operation of industries was suspended, ergo reducing emissions of hazardous air pollutants in the atmosphere. We had acquired the Air Pollutant Index (API) data from the Department of Environment Malaysia on hourly basis before and during the MCO with the aim to track the changes of fine particulate matter (PM2.5) at 68 air quality monitoring stations. It was found that the PM2.5 concentrations showed a high reduction of up to 58.4% during the MCO. Several red zone areas (>41 confirmed COVID-19 cases) had also reduced of up to 28.3% in the PM2.5 concentrations variation. The reduction did not solely depend on MCO, thus the researchers suggest a further study considering the influencing factors that need to be adhered to in the future.

Abdullah, Samsuri, et al. "Air quality status during 2020 Malaysia Movement Control Order (MCO) due to 2019 novel coronavirus (2019-nCoV) pandemic." Science of The Total Environment 729 (2020): 139022.

Air pollution reduction and mortality benefit during the COVID-19 outbreak in China

To control the coronavirus disease 2019 (COVID-19) outbreak, China adopted stringent traffic restrictions and self-quarantine measures, first in Wuhan and neighboring cities beginning Jan 23, 2020, and then 2 days later in all provinces in China (figure). The countrywide ban on traffic mobility greatly reduced transportation emissions, whereas emissions from residential heating and industry remained steady or slightly declined.1 In this Comment, we examine the change in air pollution and the potentially avoided cause-specific mortality during this large-scale quarantine.

Chen, Kai, et al. "Air Pollution Reduction and Mortality Benefit during the COVID-19 Outbreak in China." medRxiv (2020).

Changes in air quality related to the control of coronavirus in China: Implications for traffic and industrial emissions

Measures taken to control the disease (Covid-19) caused by the novel coronavirus dramatically reduced the number of vehicles on the road and diminished factory production. For this study, changes in the air quality index (AQI) and the concentrations of six air pollutants (PM2.5, PM10, CO, SO2, NO2, and O3) were evaluated during the Covid-19 control period in northern China. Overall, the air quality improved, most likely due to reduced emissions from the transportation and secondary industrial sectors. Specifically, the transportation sector was linked to the NO2 emission reductions, while lower emissions from secondary industries were the major cause for the reductions of PM2.5 and CO. The reduction in SO2 concentrations was only linked to the industrial sector. However, the reductions in emissions did not fully eliminate air pollution, and O3 actually increased, possibly because lower fine particle loadings led to less scavenging of HO2 and as a result greater O3 production. These results also highlight need to control emissions from the residential sector.

Wang, Yichen, et al. "Changes in air quality related to the control of coronavirus in China: Implications for traffic and industrial emissions." Science of The Total Environment (2020): 139133.

Effect of restricted emissions during COVID-19 on air quality in India

The effectiveness and cost are always top factors for policy-makers to decide control measures and most measures had no pre-test before implementation. Due to the COVID-19 pandemic, human activities are largely restricted in many regions in India since mid-March of 2020, and it is a progressing experiment to testify effectiveness of restricted emissions. In this study, concentrations of six criteria pollutants, PM10, PM2.5, CO, NO2, ozone and SO2 during March 16th to April 14th from 2017 to 2020 in 22 cities covering different regions of India were analysed. Overall, around 43, 31, 10, and 18% decreases in PM2.5, PM10, CO, and NO2 in India were observed during lockdown period compared to previous years. While, there were 17% increase in O3 and negligible changes in SO2. The air quality index (AQI) reduced by 44, 33, 29, 15 and 32% in north, south, east, central and western India, respectively. Correlation between cities especially in northern and eastern regions improved in 2020 compared to previous years, indicating more significant regional transport than previous years. The mean excessive risks of PM reduced by ~52% nationwide due to restricted activities in lockdown period. To eliminate the effects of possible favourable meteorology, the WRF-AERMOD model system was also applied in Delhi-NCR with actual meteorology during the lockdown period and an un-favourable event in early November of 2019 and results show that predicted PM2.5 could increase by only 33% in unfavourable meteorology. This study gives confidence to the regulatory bodies that even during unfavourable meteorology, a significant improvement in air quality could be expected if strict execution of air quality control plans is implemented.

Sharma, Shubham, et al. "Effect of restricted emissions during COVID-19 on air quality in India." Science of The Total Environment 728 (2020): 138878.

Possible environmental effects on the spread of COVID-19 in China

At the end of 2019, a novel coronavirus, designated as SARS-CoV-2, emerged in Wuhan, China and was identified as the causal pathogen of COVID-19. The epidemic scale of COVID-19 has increased dramatically, with confirmed cases increasing across China and globally. Understanding the potential affecting factors involved in COVID-19 transmission will be of great significance in containing the spread of the epidemic. Environmental and meteorological factors might impact the occurrence of COVID-19, as these have been linked to various diseases, including severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS), whose causative pathogens belong to the same virus family as SARS-CoV-2. We collected daily data of COVID-19 confirmed cases, air quality and meteorological variables of 33 locations in China for the outbreak period of 29 January 2020 to 15 February 2020. The association between air quality index (AQI) and confirmed cases was estimated through a Poisson regression model, and the effects of temperature and humidity on the AQI-confirmed cases association were analyzed. The results show that

the effect of AQI on confirmed cases associated with an increase in each unit of AQI was statistically significant in several cities. The lag effect of AQI on the confirmed cases was statistically significant on lag day 1 (relative risk (RR) = 1.0009, 95% confidence interval (CI): 1.0004, 1.0013), day 2 (RR = 1.0007, 95% CI: 1.0003, 1.0012) and day 3 (RR = 1.0008, 95% CI: 1.0003, 1.0012). The AQI effect on the confirmed cases might be stronger in the temperature range of 10 °C ≤ T < 20 °C than in other temperature ranges, while the RR of COVID-19 transmission associated with AQI was higher in the relative humidity (RH) range of 10% ≤ RH < 20%. Results may suggest an enhanced impact of AQI on the COVID-19 spread under low RH.

Xu, Hao, et al. "Possible environmental effects on the spread of COVID-19 in China." Science of The Total Environment (2020): 139211.

COVID-19's impact on the atmospheric environment in the Southeast Asia region

Since its first appearance in Wuhan, China at the end of 2019, the new coronavirus (COVID-19) has evolved a global pandemic within three months, with more than 4.3 million confirmed cases worldwide until mid-May 2020. As many countries around the world, Malaysia and other southeast Asian (SEA) countries have also enforced lockdown at different degrees to contain the spread of the disease, which has brought some positive effects on natural environment. Therefore, evaluating the reduction in anthropogenic emissions due to COVID-19 and the related governmental measures to restrict its expansion is crucial to assess its impacts on air pollution and economic growth. In this study, we used aerosol optical depth (AOD) observations from Himawari-8 satellite, along with tropospheric NO2 column density from Aura-OMI over SEA, and ground-based pollution measurements at several stations across Malaysia, in order to quantify the changes in aerosol and air pollutants associated with the general shutdown of anthropogenic and industrial activities due to COVID-19. The lockdown has led to a notable decrease in AOD over SEA and in the pollution outflow over the oceanic regions, while a significant decrease (27% - 30%) in tropospheric NO2 was observed over areas not affected by seasonal biomass burning. Especially in Malaysia, PM10, PM2.5, NO2, SO2, and CO concentrations have been decreased by 26–31%, 23–32%, 63–64%, 9–20%, and 25–31%, respectively, in the urban areas during the lockdown phase, compared to the same periods in 2018 and 2019. Notable reductions are also seen at industrial, suburban and rural sites across the country. Quantifying the reductions in major and health harmful air pollutants is crucial for health-related research and for air-quality and climate-change studies.

Kanniah, Kasturi Devi, et al. "COVID-19's impact on the atmospheric environment in the Southeast Asia region." Science of The Total Environment (2020): 139658.

Emergence of Blue Sky Over Delhi Due to Coronavirus Disease (COVID-19) Lockdown Implications

Due to coronavirus pandemic (COVID-19) prevailing in more than 210 countries, out of them only few have promulgated lockdown and on March 24, 2020 India also implemented lockdown for 21 days to prevent the community spread of virus among people. Since then, lockdown heavily restricts travel movements of fights, rail, intercity bus services besides industrial activity halt throughout the country. The significant improvement in the air quality of Delhi region was observed due to strict implementation of lockdown. During the lockdown period, improvement in ambient air quality helped us in circumventing the coronavirus community spread. The preliminary results showing the decrease in horizontal advection of pollutants has given an opportunity to understand the background concentrations of air pollutants over Delhi. To analyse this peculiar situation, we have assessed the pollutants datasets collected by twelve different online ambient air quality monitoring stations (AQMS) of Central Pollution Control Board (CPCB), New Delhi, India and observed a colossal improvement in the ambient air quality. The analysis of data confirms the sharp decline in concentrations (nearly 200%) of PM2.5 and PM10. The concentration of nitrous oxides (NOx), recorded its maximum (342 ppb) on 12 January 2020 in CRRI–Mathura Road, Delhi with the lowest value as 24 ppb on 30 March 2020 (reduced to nearly 14 times of the peak value). In the

triad of this infectious disease, the role of environment is not linked better however, the ground reality cannot be ignored due to environment around us receives, maintains, protects and transports the alethiological agents to host prevailing in polluted environment which makes our lungs more susceptible to viral attacks. Therefore, a cleaner environment would prove to be an effective measure to halt and reduce the transmission of viral infections.

Kotnala, Garima, et al. "Emergence of Blue Sky Over Delhi Due to Coronavirus Disease (COVID-19) Lockdown Implications." Aerosol Science and Engineering: 1.

COVID-19: air pollution remains low as people stay at home

Coronavirus diseases 2019 (COVID-19) is transmitted worldwide in over a very short time, as it was originated in late 2019 from Wuhan city, China. To reduce the possible effects due to COVID-19, some sort of lockdown activities have been applied in many countries. In this regard, the outcomes reported bonus benefits to the natural environment showing a significant decrease in air pollution worldwide due to COVID-19. The National Aeronautics and Space Administration (NASA) and European Space Agency (ESA) released air pollution data for Asian and European countries to assess the significant changes in air quality. The main objective of the study is to compare the air quality data released by international agencies before and after the novel coronavirus pandemic.

Gautam, Sneha. "COVID-19: air pollution remains low as people stay at home." Air Quality, Atmosphere, & Health (2020): 1.

Amplified ozone pollution in cities during the COVID-19 lockdown

The effect of lockdown due to coronavirus disease (COVID-19) pandemic on air pollution in four Southern European cities (Nice, Rome, Valencia and Turin) and Wuhan (China) was quantified, with a focus on ozone (O3). Compared to the same period in 2017–2019, the daily O3 mean concentrations increased at urban stations by 24% in Nice, 14% in Rome, 27% in Turin, 2.4% in Valencia and 36% in Wuhan during the lockdown in 2020. This increase in O3 concentrations is mainly explained by an unprecedented reduction in NOx emissions leading to a lower O3 titration by NO. Strong reductions in NO2 mean concentrations were observed in all European cities, ~53% at urban stations, comparable to Wuhan (57%), and ~65% at traffic stations. NO declined even further, ~63% at urban stations and ~78% at traffic stations in Europe. Reductions in PM2.5 and PM10 at urban stations were overall much smaller both in magnitude and relative change in Europe (~8%) than in Wuhan (~42%). The PM reductions due to limiting transportation and fuel combustion in institutional and commercial buildings were partly offset by increases of PM emissions from the activities at home in some of the cities. The NOx concentrations during the lockdown were on average 49% lower than those at weekends of the previous years in all cities. The lockdown effect on O3 production was ~10% higher than the weekend effect in Southern Europe and 38% higher in Wuhan, while for PM the lockdown had the same effect as weekends in Southern Europe (~6% of difference). This study highlights the challenge of reducing the formation of secondary pollutants such as O3 even with strict measures to control primary pollutant emissions. These results are relevant for designing abatement policies of urban pollution.

Sicard, Pierre, et al. "Amplified ozone pollution in cities during the COVID-19 lockdown." Science of The Total Environment (2020): 139542.

COVID-19 pandemic and environmental pollution: A blessing in disguise?

In late 2019, a novel infectious disease with human to human transmission (COVID-19) was identified in Wuhan China, which now has turned into a global pandemic. Countries all over the world have

implemented some sort of lockdown to slow down its infection and mitigate it. Lockdown due to COVID-19 has drastic effects on social and economic fronts. However, this lockdown also has some positive effect on natural environment. Recent data released by NASA (National Aeronautics and Space Administration) and ESA (European Space Agency) indicates that pollution in some of the epicenters of COVID-19 such as Wuhan, Italy, Spain and USA etc. has reduced up to 30%. This study compiled the environmental data released by NASA and ESA before and after the coronavirus pandemic and discusses its impact on environmental quality.

Muhammad, Sulaman, Xingle Long, and Muhammad Salman. "COVID-19 pandemic and environmental pollution: A blessing in disguise?." Science of The Total Environment (2020): 138820.

Impact of Covid-19 lockdown on PM10, SO2 and NO2 concentrations in Salé City (Morocco)

Covid-19 was first reported in Morocco on March 2, 2020. Since then, to prevent its propagation, the Moroccan government declared a state of health emergency. A set of rapid and strict countermeasures have taken, including locking down cities, limiting population's mobility and prohibiting almost all avoidable activities. In the present study, we attempted to evaluate the changes in levels of some air pollutants (mainly PM10, NO2 and SO2) in Salé city (North-Western Morocco) during the lockdown measures. In this context, a continuous measurement of PM10, SO2 and NO2 was carried before and during the Covid-19 lockdown period. As a consequence of the security measures and control actions undertaken, the emissions from vehicle exhaust and industrial production were significantly reduced, which contribute to the decrease in the concentrations of the studied pollutants. The obtained results showed that the difference between the concentrations recorded before and during the lockdown period were respectively 75%, 49% and 96% for PM10, SO2 and NO2. PM10 levels were much less reduced than NO2. The three-dimensional air mass backward trajectories, using the HYSPLIT model, demonstrated the benefits of PM10 local emission reductions related to the lockdown were overwhelmed by the contribution of long-range transported aerosols outside areas. In addition, noteworthy differences in the air mass back trajectories and the meteorology between these two periods were evidenced.

Otmani, Anas, et al. "Impact of Covid-19 lockdown on PM10, SO2 and NO2 concentrations in Salé City (Morocco)." Science of The Total Environment (2020): 139541.

The Response in Air Quality to the Reduction of Chinese Economic Activities during the COVID-19 Outbreak

During the COVID-19 outbreak that took place in early 2020, the economic activities in China were drastically reduced and accompanied by a strong reduction in the emission of primary air pollutants. On the basis of measurements made at the monitoring stations operated by the China National Environmental Monitoring Center, we quantify the reduction in surface PM2.5, NO2, CO and SO2 concentrations in northern China during the lockdown, which started on 23 January 2020. We find that, on the average, the levels of surface PM2.5 and NO2 have decreased by approximately 35 and 60 percent, respectively, between the period 1-22 January 2020 and the period 23 January-29 February 2020. At the same time, the mean ozone concentration has increased by a factor 1.5–2. In urban area of Wuhan, where drastic measures were adopted to limit the spread of the coronavirus, similar changes in the concentrations of PM2.5, NO2 and ozone are found.

Shi, Xiaoqin, and Guy P. Brasseur. "The Response in Air Quality to the Reduction of Chinese Economic Activities during the COVID‐19 Outbreak." Geophysical Research Letters (2020): e2020GL088070.

Temporary reduction in daily global CO2 emissions during the COVID-19 forced confinement

Government policies during the COVID-19 pandemic have drastically altered patterns of energy demand around the world. Many international borders were closed and populations were confined to their homes, which reduced transport and changed consumption patterns. Here we compile government policies and activity data to estimate the decrease in CO2 emissions during forced confinements. Daily global CO2 emissions decreased by –17% (–11 to –25% for ±1σ) by early April 2020 compared with the mean 2019 levels, just under half from changes in surface transport. At their peak, emissions in individual countries decreased by –26% on average. The impact on 2020 annual emissions depends on the duration of the confinement, with a low estimate of –4% (–2 to –7%) if prepandemic conditions return by mid-June, and a high estimate of –7% (–3 to –13%) if some restrictions remain worldwide until the end of 2020. Government actions and economic incentives postcrisis will likely influence the global CO2 emissions path for decades.

Le Quéré, Corinne, et al. "Temporary reduction in daily global CO 2 emissions during the COVID-19 forced confinement." Nature Climate Change (2020): 1-7.

Air Quality Variation in Wuhan, Daegu, and Tokyo during the Explosive Outbreak of COVID-19 and Its Health Effects

This study was designed to assess the variation of the air quality actually measured from the air pollution monitoring stations (AQMS) in three cities (Wuhan, Daegu, and Tokyo), in Asian countries experiencing the explosive outbreak of COVID-19, in a short period of time. In addition, we made a new attempt to calculate the reduced DosePM2.5 (μg) at the bronchiolar (Br.) and alveolar-interstitial (AI) regions of the 10-year-old children after the city lockdown/self-reflection of each city. A comparison of the average PM2.5 of a month before and after the lockdown (Wuhan) and self-reflection (Daegu and Tokyo) clearly shows that the PM2.5 concentration was decreased by 29.9, 20.9, and 3.6% in Wuhan, Daegu and Tokyo, respectively. Wuhan, Daegu and Tokyo also recorded 53.2, 19.0, and 10.4% falls of NO2 concentration, respectively. Wuhan, which had the largest decrease of PM2.5 concentration due to COVID-19, also marked the largest reduced DosePM2.5 10-year-old children (μg) (3660 μg at Br. and 6222 μg at AI), followed by Daegu (445 μg at Br. and 1287 μg at AI), and Tokyo (18 μg at Br. and 52 μg at AI), over two months after the city lockdown/self-reflection. Our results suggest that the city lockdown/self-reflection had the effect of lowering the concentration of PM2.5, resulting in an extension of the period it took to the acute allergic airway inflammation (AAI) for the 10-year-old children.

Ma, Chang-Jin, and Gong-Unn Kang. "Air Quality Variation in Wuhan, Daegu, and Tokyo during the Explosive Outbreak of COVID-19 and Its Health Effects." International Journal of Environmental Research and Public Health 17.11 (2020): 4119.

Significant changes in the chemical compositions and sources of PM2.5 in Wuhan since the city lockdown as COVID-19

Wuhan was the first city to adopt the lockdown measures to prevent COVID-19 spreading, which improved the air quality accordingly This study investigated the variations in chemical compositions, source contributions, and regional transport of fine particles (PM2 5) during January 23–February 22 of 2020, compared with the same period in 2019 The average mass concentration of PM2 5 decreased from 72 9 μ g m-3 (2019) to 45 9 μg m-3 (2020), by 27 0 μg m-3 It was predominantly contributed by the emission reduction (92 0%), retrieved from a random forest tree approach The main chemical species of PM2 5 all decreased with the reductions ranging from 0 85 μg m-3 (chloride) to 9 86 μg m-3 (nitrate) ($p < 0$ 01) Positive matrix factorization model indicated that the mass contributions of seven PM2 5 sources all decreased However, their contribution percentages varied from -11 0% (industrial processes) to 8 70% (secondary inorganic aerosol) Source contributions of PM2 5 transported from potential geographical

regions showed reductions with mean values ranging from 0 22 to 4 36 μg m-3 However, increased contributions of firework burning, secondary inorganic aerosol, road dust and vehicle emissions from transboundary transport were observed This study highlighted the complex and nonlinear response of chemical compositions and sources of PM2 5 to air pollution control measures, suggesting the importance of regional-joint control

Zheng, Huang, et al. "Significant changes in the chemical compositions and sources of PM2. 5 in Wuhan since the city lockdown as COVID-19." Science of The Total Environment (2020): 140000.

Changes in U.S. air pollution during the COVID-19 pandemic

The COVID-19 global pandemic has likely affected air quality due to extreme changes in human behavior. We assessed air quality during the COVID-19 pandemic for fine particulate matter (PM2.5) and nitrogen dioxide (NO2) in the continental United States from January 8th-April 21st in 2017–2020. We considered pollution during the COVID-19 period (March 13–April 21st) and the pre-COVID-19 period (January 8th-March 12th) with 2020 representing 'current' data and 2017–2019 representing 'historical' data. County-level pollution concentrations were compared between historical versus current periods, and counties were stratified by institution of early or late non-essential business closures. Statistically significant NO2 declines were observed during the current COVID-19 period compared to historical data: a 25.5% reduction with absolute decrease of 4.8 ppb. PM2.5 also showed decreases during the COVID-19 period, and the reduction is statistically significant in urban counties and counties from states instituting early non-essential business closures. Understanding how air pollution is affected during COVID-19 pandemic will provide important clues regarding health effects and control of emissions. Further investigation is warranted to link this finding with health implications.

Berman, Jesse D., and Keita Ebisu. "Changes in US air pollution during the COVID-19 pandemic." Science of The Total Environment (2020): 139864.

21-Day Lockdown in India Dramatically Reduced Air Pollution Indices in Lucknow and New Delhi, India

In December 2019, the outbreak of viral disease labeled as Novel Coronavirus started in Wuhan, China, which later came to be known as Covid-19. The disease has spread in almost every part of the world and has been declared a global pandemic in March 2020 by World Health Organization (WHO). The corona virus outbreak has emerged as one of the deadliest pandemics of all time in human history. The ongoing pandemic of COVID-19 has forced several countries of the world to observe complete lockdown forcing people to live in their homes. India also faced the phase of total lockdown for 21 days (in first phase) to avoid the spread of coronavirus to the maximum possible extent. This lockdown impacted the pollution levels of environment and improved air and water quality in the short span owing to very less human activities. The present work scientifically analyzed the available data for primary air pollutants (PM2.5, NO2, SO2 and CO) from two major Indian cities, Lucknow and New Delhi. The analysis was based on air quality data for before lockdown and after lockdown (first phase of 21 days) periods of 21 days each. The results showed significant decline in the studied air pollution indices and demonstrated improvement of air quality in both the cities. The major impact was seen in the levels of PM2.5, NO2 and CO. The levels of SO2 showed less significant decline during the lockdown period. The results are presented with future perspectives to mitigate air pollution in near future by adopting the short and periodical lockdown as a tool.

Srivastava, Sudhakar, et al. "21-Day Lockdown in India Dramatically Reduced Air Pollution Indices in Lucknow and New Delhi, India." Bulletin of Environmental Contamination and Toxicology (2020): 1.

AIR POLLUTION COVID-19 HEALTH LINK

Exposure to air pollution and COVID-19 mortality in the United States

Background: United States government scientists estimate that COVID-19 may kill between 100,000 and 240,000 Americans. The majority of the pre-existing conditions that increase the risk of death for COVID-19 are the same diseases that are affected by long-term exposure to air pollution. We investigate whether long-term average exposure to fine particulate matter (PM2.5) increases the risk of COVID-19 deaths in the United States. Methods: Data was collected for approximately 3,000 counties in the United States (98% of the population) up to April 04, 2020. We fit zero-inflated negative binomial mixed models using county-level COVID-19 deaths as the outcome and county level long-term average of PM2.5 as the exposure. We adjust by population size, hospital beds, number of individuals tested, weather, and socioeconomic and behavioral variables including, but not limited to obesity and smoking. We include a random intercept by state to account for potential correlation in counties within the same state.

Results: We found that an increase of only 1 µg/m3 in PM2.5 is associated with a 15% increase in the COVID-19 death rate, 95% confidence interval (CI) (5%, 25%). Results are statistically significant and robust to secondary and sensitivity analyses.

Conclusions: A small increase in long-term exposure to PM2.5 leads to a large increase in COVID-19 death rate, with the magnitude of increase 20 times that observed for PM2.5 and all-cause mortality. The study results underscore the importance of continuing to enforce existing air pollution regulations to protect human health both during and after the COVID-19 crisis.

Xiao Wu, Rachel C. Nethery, Benjamin M. Sabath, Danielle Braun, Francesca Dominici, "Exposure to air pollution and COVID-19 mortality in the United States." medRxiv (2020). https://www.medrxiv.org/content/10.1101/2020.04.05.20054502v1

Can atmospheric pollution be considered a co-factor in extremely high level of SARS-CoV-2 lethality in Northern Italy?

This paper investigates the correlation between the high level of Severe Acute Respiratory Syndrome CoronaVirus 2 (SARS-CoV-2) lethality and the atmospheric pollution in Northern Italy. Indeed, Lombardy and Emilia Romagna are Italian regions with both the highest level of virus lethality in the world and one of Europe's most polluted area. Based on this correlation, this paper analyzes the possible link between pollution and the development of acute respiratory distress syndrome and eventually death. We provide evidence that people living in an area with high levels of pollutant are more prone to develop chronic respiratory conditions and suitable to any infective agent. Moreover, a prolonged exposure to air pollution leads to a chronic inflammatory stimulus, even in young and healthy subjects. We conclude that the high level of pollution in Northern Italy should be considered an additional co-factor of the high level of lethality recorded in that area.

Conticini, Edoardo, Bruno Frediani, and Dario Caro. "Can atmospheric pollution be considered a co-factor in extremely high level of SARS-CoV-2 lethality in Northern Italy?." Environmental Pollution (2020): 114465.

Does Air Pollution Influence COVID-19 Outbreaks?

SARS-CoV-2 is highly transmissible (with more than 1.3 million people infected in the world at the time of this writing) and lethal (more than 76,000 reported deaths at present). Exposure to air pollution could increase vulnerability and have detrimental effects on the prognosis of patients affected by the COVID-19. However, the relative weight of air pollution, compared to other confounders, is still to be determined.

Caution should be used in translating high values of conventional metrics, such as PM2.5 and PM10 concentrations, into a direct measure of vulnerability. Airborne transmission mediated by virus-laden aerosols emitted during expiration and speech is plausible in specific environments. Current knowledge indicates a low probability in outdoor environments and an increase in probability in specific indoor environments, like hospitals and areas where patients are quarantined. In these environments, it is advisable to mitigate the risk for vulnerable people via using periodic ventilation of environments, decontaminations of surfaces and air conditioning systems, and appropriate technologies for mechanical ventilation/conditioning in order to limit the circulation of virus-laden bioaerosols in air.

The stakes for the world are enormous, and the results of robust research studies are urgently needed in order to provide information that could help in developing strategies for facing the current pandemic as well as future pandemics. Our recommendations for future research focus on (but are no limited to) the investigation, both outdoors and indoors, of airborne transmission routes, lifetimes and dynamics, dosimetry and infection thresholds within the human body, and the physical, chemical, biological, toxicological, virological properties of virus-laden bioaerosol particles, with all of these factors properly adjusted for a wide number of potential confounders. This research should come from a multidisciplinary approach involving a strong collaboration between traditionally distinct disciplines of science, and in particular, virologists, epidemiologists, toxicologists, physicians, aerobiologists, aerosol scientists, and meteorologists.

Contini, D.; Costabile, F. Does Air Pollution Influence COVID-19 Outbreaks? Atmosphere 2020, 11, 377.

Evaluation of the potential relationship between Particulate Matter (PM) pollution and COVID-19 infection spread in Italy

In conclusion, the rapid COVID-19 infection spread observed in selected regions of Northern Italy is supposed be related to PM10 pollution due to airborne particles able to serve as carrier of pathogens. As already highlighted in previous studies, it is recommended to take into account PM10 contribution and make policymakers aware of the need to take direct actions for pollution control.

Piazzalunga-Expert, Andrea. Evaluation of the potential relationship between Particulate Matter (PM) pollution and COVID-19 infection spread in Italy. mimeo, 2020.

Assessing nitrogen dioxide (NO2) levels as a contributing factor to coronavirus (COVID-19) fatality

Nitrogen dioxide (NO2) is an ambient trace-gas result of both natural and anthropogenic processes. Long-term exposure to NO2 may cause a wide spectrum of severe health problems such as hypertension, diabetes, heart and cardiovascular diseases and even death. The objective of this study is to examine the relationship between long-term exposure to NO2 and coronavirus fatality. The Sentinel-5P is used for mapping the tropospheric NO2 distribution and the NCEP/NCAR reanalysis for evaluating the atmospheric capability to disperse the pollution. The spatial analysis has been conducted on a regional scale and combined with the number of death cases taken from 66 administrative regions in Italy, Spain, France and Germany. Results show that out of the 4443 fatality cases, 3487 (78%) were in five regions located in north Italy and central Spain. Additionally, the same five regions show the highest NO2 concentrations combined with downwards airflow which prevent an efficient dispersion of air pollution. These results indicate that the long-term exposure to this pollutant may be one of the most important contributors to fatality caused by the COVID-19 virus in these regions and maybe across the whole world.

Ogen, Yaron. "Assessing nitrogen dioxide (NO2) levels as a contributing factor to the coronavirus (COVID-19) fatality rate." Science of The Total Environment (2020): 138605.

Association between short-term exposure to air pollution and COVID-19 infection: Evidence from China

The novel coronavirus pneumonia, namely COVID-19, has become a global public health problem. Previous studies have found that air pollution is a risk factor for respiratory infection by carrying microorganisms and affecting body's immunity. This study aimed to explore the relationship between ambient air pollutants and the infection caused by the novel coronavirus. Daily confirmed cases, air pollution concentration and meteorological variables in 120 cities were obtained from January 23, 2020 to February 29, 2020 in China. We applied a generalized additive model to investigate the associations of six air pollutants (PM2.5, PM10, SO2, CO, NO2 and O3) with COVID-19 confirmed cases. We observed significantly positive associations of PM2.5, PM10, NO2 and O3 in the last two weeks with newly COVID-19 confirmed cases. A 10-μg/m3 increase (lag0–14) in PM2.5, PM10, NO2, and O3 was associated with a 2.24% (95% CI: 1.02 to 3.46), 1.76% (95% CI: 0.89 to 2.63), 6.94% (95% CI: 2.38 to 11.51), and 4.76% (95% CI: 1.99 to 7.52) increase in the daily counts of confirmed cases, respectively. However, a 10-μg/m3 increase (lag0–14) in SO2 was associated with a 7.79% decrease (95% CI: −14.57 to −1.01) in COVID-19 confirmed cases. Our results indicate that there is a significant relationship between air pollution and COVID-19 infection, which could partially explain the effect of national lockdown and provide implications for the control and prevention of this novel disease.

Yongjian, Zhu, et al. "Association between short-term exposure to air pollution and COVID-19 infection: Evidence from China." Science of The Total Environment (2020): 138704.

Factors determining the diffusion of COVID-19 and suggested strategy to prevent future accelerated viral infectivity similar to COVID

This study has two goals. The first is to explain the geo-environmental determinants of the accelerated diffusion of COVID-19 in Italy that is generating a high level of deaths. The second is to suggest a strategy to cope with future epidemic threats having accelerated viral infectivity in society. Using data on N = 55 Italian province capitals, and data of infected individuals at as of April 7th, 2020, results reveal that the accelerate and vast diffusion of COVID-19 in North Italy has a high association with air pollution of cities measured with days exceeding the limits set for PM10 (particulate matter 10 μm or less in diameter) or ozone in previous years. In particular, hinterland cities with average higher number of days exceeding the limits set for PM10 (and a low intensity of wind speed) have a very high number of infected people on 7th April 2020 (arithmetic mean about 2200 infected, with average polluted days greater than 80), than coastal cities also having days of exceeding the limits set for PM10 or ozone but with high intensity of wind speed (arithmetic mean about 944.70 infected individuals, with about 60 average polluted days); moreover, cities having more than 100 days of air pollution (exceeding the limits set for PM10), they have a very high average number of infected people (about 3350 infected individuals, 7th April 2020), whereas cities having less than 100 days of air pollution, they have a lower average number of infected individuals (about 1014). The findings here also suggest that to minimize the impact of future epidemics similar to COVID-19, the max number of days per year in which Italian provincial capitals can exceed the limits set for PM10 or for ozone, considering their meteorological conditions, is about 48 days. Moreover, results here reveal that the explanatory variable of air pollution in cities under study seems to be a more important predictor in the initial phase of diffusion (on 17th March 2020, $b1 = 1.27$, $p < 0.001$) than interpersonal contacts ($b2 = 0.31$, $p < 0.05$). In the second phase of maturity of the transmission dynamics of COVID-19, air pollution reduces intensity (on 7th April 2020 with $b'1 = 0.81$, $p < 0.001$) also because of indirect effect of lockdown, whereas coefficient of transmission by interpersonal contacts has stability ($b'2 = 0.31$, $p < 0.01$). This result reveals that accelerated transmissions dynamics of COVID-19 is due to mainly to the mechanism of “air pollution-to-human transmission” rather than “human-to-human transmission”. Overall, then, transmission dynamics of viral infectivity, such as COVID-19, is due to systemic causes: general factors that are the same for all regions (e.g., biological characteristics of virus, incubation period, etc.) and specific factors which are

different for each region (e.g., complex interaction between air pollution, meteorological conditions and biological characteristics of viral infectivity) and health level of individuals (habits, immune system, age, sex, etc.). Lessons learned for COVID-19 in the case study of Italy suggest that a proactive strategy to cope with future epidemics is to also apply especially an environmental and sustainable policy based on reduction of levels of air pollution mainly in hinterland and polluting cities- having low wind speed, high percentage of moisture and fog days-that seem to have an environment that may damage immune system of people and foster a fast transmission dynamics of viral infectivity in society. Hence, in the presence of polluting industrialization in regions that can trigger the mechanism of air pollution-to-human transmission dynamics of viral infectivity, this study must conclude that a comprehensive strategy to prevent future epidemics similar to COVID-19 has to be also designed in environmental and socioeconomic terms, that is also based on sustainability science and environmental science, and not only in terms of biology, healthcare and health sector.

Coccia, Mario. "Factors determining the diffusion of COVID-19 and suggested strategy to prevent future accelerated viral infectivity similar to COVID." Science of The Total Environment (2020): 138474.

Role of the chronic air pollution levels in the Covid-19 outbreak risk in Italy

After the initial outbreak in China, the diffusion in Italy of SARS-CoV-2 is exhibiting a clear regional trend with more elevated frequency and severity of cases in Northern areas. Among multiple factors possibly involved in such geographical differences, a role has been hypothesized for atmospheric pollution. We provide additional evidence on the possible influence of air quality, particularly in terms of chronicity of exposure on the spread viral infection in Italian regions. Actual data on Covid-19 outbreak in Italian provinces and corresponding long-term air quality evaluations, were obtained from Italian and European agencies, elaborated and tested for possible interactions. Our elaborations reveal that, beside concentrations, the chronicity of exposure may influence the anomalous variability of SARS-CoV-2 in Italy. Data on distribution of atmospheric pollutants (NO2, O3, PM2.5 and PM10) in Italian regions during the last 4 years, days exceeding regulatory limits, and years of the last decade (2010–2019) in which the limits have been exceeded for at least 35 days, highlight that Northern Italy has been constantly exposed to chronic air pollution. Long-term air-quality data significantly correlated with cases of Covid-19 in up to 71 Italian provinces (updated April 27, 2020) providing further evidence that chronic exposure to atmospheric contamination may represent a favourable context for the spread of the virus. Pro-inflammatory responses and high incidence of respiratory and cardiac affections are well known, while the capability of this coronavirus to bind particulate matters remains to be established. Atmospheric and environmental pollution should be considered as part of an integrated approach for sustainable development, human health protection and prevention of epidemic spreads but in a long-term and chronic perspective, since adoption of mitigation actions during a viral outbreak could be of limited utility.

Fattorini, Daniele, and Francesco Regoli. "Role of the chronic air pollution levels in the Covid-19 outbreak risk in Italy." Environmental Pollution (2020): 114732.

Severe air pollution links to higher mortality in COVID-19 patients: the “double-hit” hypothesis

In areas of SARS-CoV-2 outbreak worldwide mean air pollutants concentrations vastly exceed the maximum limits. Chronic exposure to air pollutants have been associated with lung ACE-2 over-expression which is known to be the main receptor for SARS-coV2. The aim of this study was to analyse the relationship between air pollutants concentration (PM 2.5 and NO2) and COVID-19 outbreak, in terms of transmission, number of patients, severity of presentation and number of deaths. COVID-19 cases, ICU admissions and mortality rate were correlated with severity of air pollution in the Italian regions. The highest number of COVID-19 cases were recorded in the most polluted regions with patients presenting with more severe forms of the disease requiring ICU admission. In these regions, mortality was two-fold

higher than the other regions. From the data available we propose a “double-hit hypothesis”: chronic exposure to PM 2.5 causes alveolar ACE-2 receptor overexpression. This may increase viral load in patients exposed to pollutants in turn depleting ACE-2 receptors and impairing host defences. High atmospheric NO2 may provide a second hit causing a severe form of SARS-CoV-19 in ACE-2 depleted lungs resulting in a worse outcome.

Frontera, Antonio, et al. "Severe air pollution links to higher mortality in COVID-19 patients: the “double-hit” hypothesis." Journal of Infection (2020).

First data analysis about possible COVID-19 virus airborne diffusion due to air particulate matter (PM): The case of Lombardy (Italy)

The severe cases of COVID-19 infections in Italy, and notably in Lombardy (mainly in Brescia and Bergamo areas), registered at the beginning of March 2020, occurred after a period of PM10 pollution, that exceeded the concentration of 50 µg/m3 (the attention limit) for several days. The two events were supposed to be correlated, also based on the limited information available about the new virus. Despite that clear indications about the role of particulate matter (PM) in the virus mechanism dispersion cannot be found in literature, some researchers supposed that PM can act as virus carrier, promoting its diffusion through the air.

This paper, for the first time, analyses the PM10 situation in Lombardy (from 10th February to March 27, 2020), several days before the sanitary emergency explosion. The data of the detected infection cases are reported and discussed parallelly. As a comparison, the situation of Piedmont, located near to the Lombardy is also presented. Data are reported for Brescia, Bergamo, Cremona, Lodi, Milano, Monza-Brianza, Pavia (Lombardy), Alessandria, Vercelli, Novara, Biella, Asti, and Torino (Piedmont). The results show that it is not possible to conclude that COVID-19 diffusion mechanism also occurs through the air, by using PM10 as a carrier. In particular, it is shown that Piedmont cities, presenting lower detected infections cases in comparison to Brescia and Bergamo in the investigated period, had most sever PM10 pollution events in comparison to Lombardy cities. This first study may serve as a reference to better understand and predict the factors affecting the COVID-19 diffusion and transmission routes, focusing on the role of air particulate matter in the atmosphere.

Bontempi, E. "First data analysis about possible COVID-19 virus airborne diffusion due to air particulate matter (PM): the case of Lombardy (Italy)." Environmental Research (2020): 109639.

Short-Term Effects of Ambient Ozone, PM2.5, and Meteorological Factors on COVID-19 Confirmed Cases and Deaths in Queens, New York.

The outbreak of coronavirus disease 2019 (COVID-19), caused by the virus SARS-CoV-2, has been rapidly increasing in the United States. Boroughs of New York City, including Queens county, turn out to be the epicenters of this infection. According to the data provided by the New York State Department of Health, most of the cases of new COVID-19 infections in New York City have been found in the Queens county where 42,023 people have tested positive, and 3221 people have died as of 20 April 2020. Person-to-person transmission and travels were implicated in the initial spread of the outbreaks, but factors related to the late phase of rapidly spreading outbreaks in March and April are still uncertain. A few previous studies have explored the links between air pollution and COVID-19 infections, but more data is needed to understand the effects of short-term exposures of air pollutants and meteorological factors on the spread of COVID-19 infections, particularly in the U.S. disease epicenters. In this study, we have focused on ozone and PM2.5, two major air pollutants in New York City, which were previously found to be associated with respiratory viral infections. The aim of our regression modeling was to explore the associations among ozone, PM2.5, daily meteorological variables (wind speed, temperature, relative humidity, absolute

humidity, cloud percentages, and precipitation levels), and COVID-19 confirmed new cases and new deaths in Queens county, New York during March and April 2020. The results from these analyses showed that daily average temperature, daily maximum eight-hour ozone concentration, average relative humidity, and cloud percentages were significantly and positively associated with new confirmed cases related to COVID-19; none of these variables showed significant associations with new deaths related to COVID-19. The findings indicate that short-term exposures to ozone and other meteorological factors can influence COVID-19 transmission and initiation of the disease, but disease aggravation and mortality depend on other factors.

Adhikari, Atin, and Jingjing Yin. "Short-Term Effects of Ambient Ozone, PM2. 5, and Meteorological Factors on COVID-19 Confirmed Cases and Deaths in Queens, New York." International Journal of Environmental Research and Public Health 17.11 (2020): 4047.

Air pollution and COVID-19: Is the connect worth its weight?

Primary route of transmission of SARS-CoV-2 among humans is droplets and direct contact. Airborne transmission of this virus is not established conclusively and so is the role of airborne particulate matter. This commentary examines the existing evidence about the role of particulate matter pollutants in SARS-CoV-2 transmission. PM2.5and other small particulate matter have been shown to carry viable virus particles in the air and incriminated in spread of measles and SARS coronavirus. Empirical evidence has been provided regarding role of air pollution in accelerated transmission of SARS-CoV-2 in Italy as well as Wuhan. Lockdown-related reduction in PM2.5levels in ambient air may have contributed to reduce transmission of SARS-CoV-2. High PM2.5levels in the past might have added to SARS-CoV-2 related mortality due to air pollution relate comorbidities. Post-lockdown increase in PM2.5levels may accelerate covid-19 transmission and can add to the burden of COVID-19 morbidity and mortality.

Sharma, Arun Kumar, and Palak Balyan. "Air pollution and COVID-19: Is the connect worth its weight?." Indian Journal of Public Health 64.6 (2020): 132.

Assessing the relationship between ground levels of ozone (O3) and nitrogen dioxide (NO2) with coronavirus (COVID-19) in Milan, Italy

This paper investigates the correlation between the high level of coronavirus SARS-CoV-2 infection accelerated transmission and lethality, and surface air pollution in Milan metropolitan area, Lombardy region in Italy. For January–April 2020 period, time series of daily average inhalable gaseous pollutants ozone (O3) and nitrogen dioxide (NO2), together climate variables (air temperature, relative humidity, wind speed, precipitation rate, atmospheric pressure field and Planetary Boundary Layer) were analyzed. In spite of being considered primarily transmitted by indoor bioaerosols droplets and infected surfaces or direct human-to-human personal contacts, it seems that high levels of urban air pollution, and climate conditions have a significant impact on SARS-CoV-2 diffusion. Exhibited positive correlations of ambient ozone levels and negative correlations of NO2 with the increased rates of COVID-19 infections (Total number, Daily New positive and Total Deaths cases), can be attributed to airborne bioaerosols distribution. The results show positive correlation of daily averaged O3 with air temperature and inversely correlations with relative humidity and precipitation rates. Viral genome contains distinctive features, including a unique N-terminal fragment within the spike protein, which allows coronavirus attachment on ambient air pollutants. At this moment it is not clear if through airborne diffusion, in the presence of outdoor and indoor aerosols, this protein “spike” of the new COVID-19 is involved in the infectious agent transmission from a reservoir to a susceptible host during the highest nosocomial outbreak in some agglomerated industrialized urban areas like Milan is. Also, in spite of collected data for cold season (winter-early spring) period, when usually ozone levels have lower values than in summer, the findings of this study support possibility as O3 can acts as a COVID-19 virus incubator. Being a novel pandemic coronavirus version, it

might be ongoing during summer conditions associated with higher air temperatures, low relative humidity and precipitation levels.

Zoran, Maria A., et al. "Assessing the relationship between ground levels of ozone (O3) and nitrogen dioxide (NO2) with coronavirus (COVID-19) in Milan, Italy." Science of The Total Environment (2020): 140005.

SOCIO-ECONOMIC IMPACTS, CLIMATE IMPACTS AND OTHER RELEVANT TOPICS ABOUT COVID-19

Navigating the Clean Energy Transition in the COVID-19 Crisis

Conclusion: What does the COVID-19 crisis imply for the energy transition required to keep global warming at bay? Many commentators and advocates have been quick to provide answers and ready-made solutions. We take a step back and pursue a different approach. In our view, structuring the challenges that arise in different time horizons and offering guiding principles for responses are most useful at this stage. We recommend three principles: (1) avoid overreacting in the short term. (2) Make use of new opportunities for the energy transition in the mid-term. (3) Develop new policy designs that can withstand future shocks. While now the policy attention is rightfully focused on the public health crisis and mitigating its immediate effects, it is important to navigate the new situation without jeopardizing the imperative clean energy transition.

Steffen, Bjarne, et al. "Navigating the Clean Energy Transition in the COVID-19 Crisis." Joule (2020).

Valuation of air pollution externalities: comparative assessment of economic damage and emission reduction under COVID-19 lockdown

Air pollution (AP) is one of the major causes of health risks as it leads to widespread morbidity and mortality each year. Its environmental impacts include acid rains, reduced visibility, but more importantly and significantly, it affects human health. The price tag of not managing AP is seen in the rise of chronic obstructive pulmonary disease (COPD), cardiovascular disease, and respiratory ailments like asthma and chronic bronchitis. But as the world battles the corona pandemic, COVID-19 lockdown has abruptly halted human activity, leading to a significant reduction in AP levels. The effect of this reduction is captured by reduced cases of morbidity and mortality associated with air pollution. The current study aims to monetarily quantify the decline in health impacts due to reduced AP levels under lockdown scenario, as against business as usual, for four cities—Delhi, London, Paris, and Wuhan. The exposure assessment with respect to pollutants like particulate matter (PM2.5 and PM10), NO2, and SO2 are evaluated. Value of statistical life (VSL), cost of illness (CoI), and per capita income (PCI) for disability-adjusted life years (DALY) are used to monetize the health impacts for the year 2019 and 2020, considering the respective period of COVID-19 lockdown of four cities. The preventive benefits related to reduced AP due to lockdown is evaluated in comparison to economic damage sustained by these four cities. This helps in understanding the magnitude of actual damage and brings out a more holistic picture of the damages related to lockdown.

Bherwani, H., Nair, M., Musugu, K. et al. Valuation of air pollution externalities: comparative assessment of economic damage and emission reduction under COVID-19 lockdown. Air Qual Atmos Health (2020). https://doi.org/10.1007/s11869-020-00845-3

Global assessment of environment, health and economic impact of the novel coronavirus (COVID-19)

The institution of social distancing and punitive measures to contain the spread of COVID-19 through human-to-human transmission has environmental, health and economic impact. While the global pandemic has led to the enhancement of the health system and decline of emissions, economic development appears deteriorating. Here, we present the global environmental, health and economic dimension of the effect of COVID-19 using qualitative and empirical assessments. We report the health system policies, environmental sustainability issues, and fiscal, monetary and exchange rate measures introduced during lockdown across countries. While air pollution is reported to have declined, municipal and medical waste is increasing. The COVID-19 global pandemic uncertainty ranks the UK as the country with the highest uncertainty level among 143 countries. The USA has introduced 100% of pre-COVID-19 crisis level GDP, the highest policy cut-rate among 162 countries. Science, innovation, research and development underpin COVID-19 containment measures implemented across countries. Our study demonstrates the need for future research to focus on environment-health-economic nexus—a trilemma that has a potential trade-off.

Sarkodie, Samuel Asumadu, and Phebe Asantewaa Owusu. "Global assessment of environment, health and economic impact of the novel coronavirus (COVID-19)." Environment, Development and Sustainability (2020): 1-11.

The dramatic impact of Coronavirus outbreak on air quality: Has it saved as much as it has killed so far?

The outbreak of coronavirus disease (COVID-19) was first reported from Wuhan, China, on December 31st, 2019. As the number of coronavirus infections has exceeded 100,000 with toll deaths of about 5000 worldwide as of early March, 2020, scientists and researchers are racing to investigate the nature of this virus and evaluate the short and long term effects of this disease. Despite its negative impacts that obliged the World Health Organization to declare COVID-19 epidemic as a Public Health Emergency of International Concern, the rate of mortality of this infection has not exceeded 3.4% globally. On the other hand, the mortality rate caused by ambient air pollution has contributed to 7.6% of all deaths in 2016 worldwide. The outbreak of COVID-19 has forced China to lockdown its industrial activities and hence dropped its NO_2 and carbon emissions by 30 and 25%, respectively. This work reports on the first case study that compares the air quality status before and after the crisis. It sheds light on the facts related to the demographics of deaths by gender, age and health status before infection. The historical data on air quality, estimates of annual deaths and its economic burden have been presented and analyzed. The actual daily deaths due to COVID-19 have been obtained from the official records of the daily Situation Reports published by World Health Organization as of March 11th. The rate of mortality due to COVID-19 was impacted by two factors: age and health status. Results show that 75% of deaths were related to cases that had underlying present diseases with the majority aged of 80+ years. The reported figures were compared with the average daily mortality due to poor air quality which reached up to 3287 deaths due to high levels of NO_2, O_3 and PM. The air quality status before the crisis was compared with the current situation showing that COVID-19 forced-industrial and anthropogenic activities lockdown may have saved more lives by preventing ambient air pollution than by preventing infection.

Isaifan, R. J. "The dramatic impact of Coronavirus outbreak on air quality: Has it saved as much as it has killed so far?." Global Journal of Environmental Science and Management 6.3 (2020): 275-288.

Environmental impact of the COVID-19 pandemic – a lesson for the future

The environment is an integral component of human and animal health. COVID-19 is a global health challenge in the twenty-first century. The emergence of SARS-CoV-2 in Wuhan, China in December 2019, and its spread to regional countries and nowadays affecting more than 210 countries worldwide represents the first pandemic in history to be caused by a coronavirus. The COVID-19 pandemic has huge impacts on most aspects of human activities, as well as on the economy and health care systems. Lock-downs, quarantines and border closures in the wake of the pandemic have led to reductions in air pollution through decreased travel and production. These positive environmental effects are likely mostly temporary, but may serve as an example that changes in our way of life can have prompt positive effects for the environment and demonstrate the usefulness of travel-reducing measures such as teleconferencing. Thus, acknowledging that COVID-19 is first and foremost a global disaster, the pandemic may inspire to future behavioral changes with positive environmental effects.

El Zowalaty, Mohamed E., Sean G. Young, and Josef D. Järhult. "Environmental impact of the COVID-19 pandemic–a lesson for the future." (2020): 1768023.