How environmental pollution could influence COVID-19 morbidity and spreading? A focus on Particulate Matter

Field: Ecology
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Abstract

The World Health Organization (WHO) declared COVID-19 a Public Health Emergency of International concern. There is evidence that atmospheric pollution might influence the spreading, morbidity and mortality rate of COVID-19. Exposure to air pollution may represent an important risk co-factor for viral infection outcomes. COVID-19 appears to have a higher incidence in industrialized areas well known high concentrations of pollutants as per Particulate Matter (PM). Some studies suggest PM could play a crucial role in virus spreading and morbidity even if more research is needed to corroborate this hypothesis.

Discussion

SARS-CoV-2 (Severe acute respiratory syndrome coronavirus 2) is the pathogen of the COVID-19 disease. COVID-19 was firstly reported in December 2019 in a small cluster in Wuhan (Hubei Province, China), successively it has spread all over the world and it has been declared as a global pandemic by the WHO. Many hypotheses have been proposed by the scientific community in order to understand possible correlations between pollution and COVID-19 spreading and morbidity, however the complexity of the problem is far from being solved, with several urgent aspects still requiring further investigations [1]. Air pollution could be an important risk factor in respiratory infections by carrying microorganisms, making pathogens more invasive or let people be more susceptible to them [2], both as for long-term and short-term exposure [3][4].

Air pollution is defined by WHO as a *"[…] contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere. Household combustion devices, motor vehicles, industrial facilities and forest fires are common sources of air pollution. Pollutants of major public health concern include:*

- *Particulate matter (ex. $PM_{2.5}$, PM_{10})*

- *Carbon monoxide (CO)*

- *Ozone (O_3)*

- *Nitrogen dioxide (NO_2)*

- *Sulphur dioxide (SO_2)*

Outdoor and indoor air pollution cause respiratory and other diseases, which can be fatal" (https://www.afro.who.int/health-topics/air-pollution).

Particulate matter (PM) is defined as a mixture of several chemical compounds particles with aerodynamic diameters less than 2.5 µm ($PM_{2.5}$) or less than 10 µm (PM_{10}) and is considered one of

the leading environmental health risk factor, causing several million deaths per year. PM can be classified by its origin as primary and secondary. Primary PM is directly emitted from their sources, on the other hand, secondary PM origins from chemical reactions and physical processes involving emission of precursor gases. Urban industrialized areas are characterized by high concentrations of PM, as a consequence, for example, of domestic heating, transports and industrial activities [5]. PM's aerosol features could be associated with potentially adverse cellular effects, such as cytotoxicity through oxidative stress, resulting in the production of oxygen-free radicals-generating activity, DNA oxidative damage, mutagenicity, and the stimulation of pro-inflammatory responses which may damage the respiratory system and reducing host resistance [3][6].

A recent study on COVID-19 diffusion, conducted in China (Figure 1) in 120 cities (4 municipalities and 116 prefecture- level city), considered daily concentration of six air pollutants as $PM_{2.5}$, PM_{10}, SO_2, NO_2, O_3 and the meteorological conditions [2].

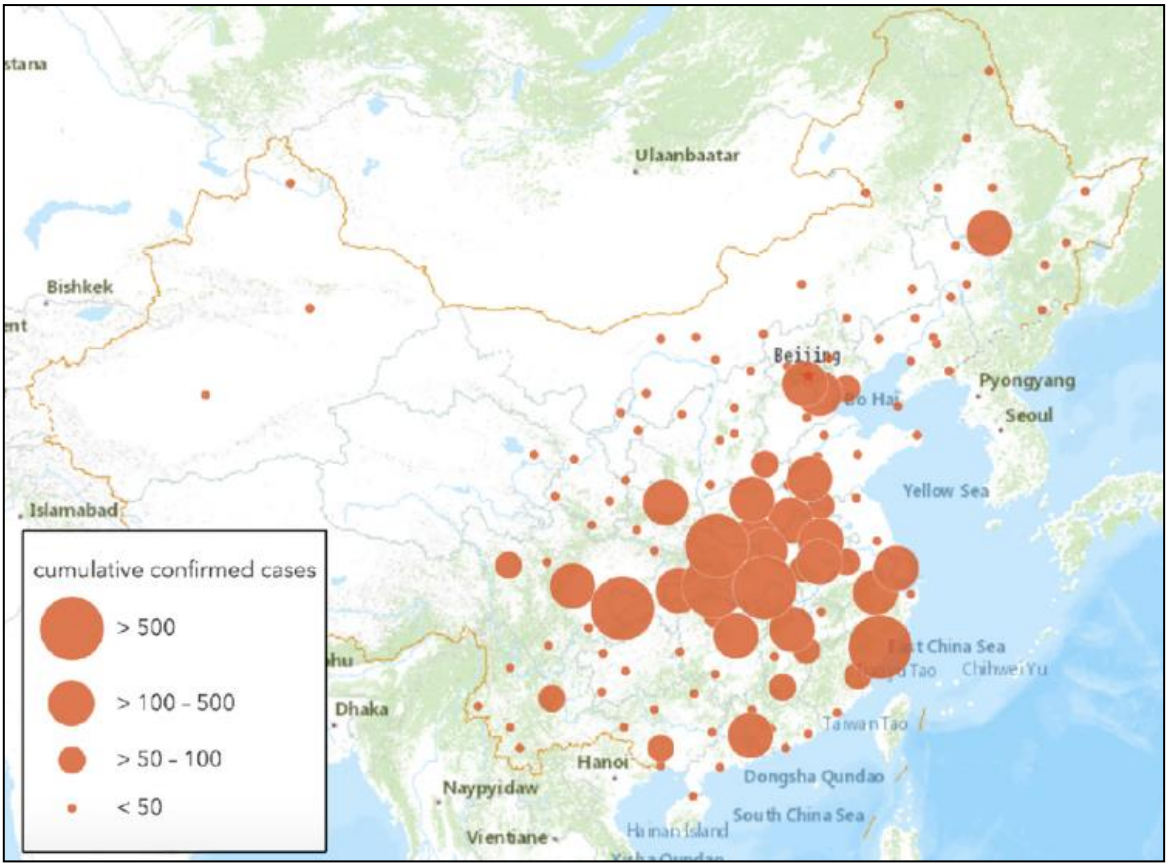

Figure 1. *"Location of 120 cities and cumulative COVID-19 confirmed cases in each city as of 29 February 2020"* [2]

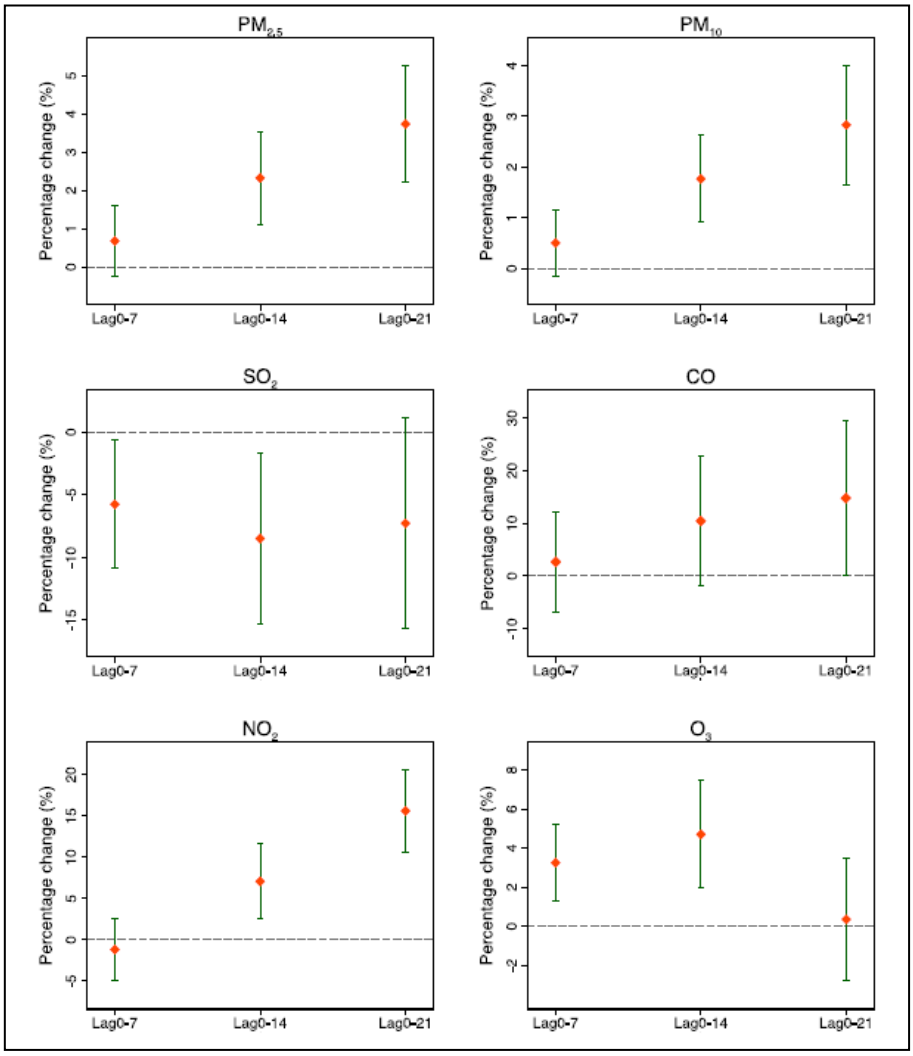

Figure 2. *"Percentage change (%) and 95% CI of daily COVID-19 confirmed cases associated with a unit increase in pollutant concentration using single-pollutant models after excluding Wuhan. Units are 10 μg/m³ increase in $PM_{2.5}$, PM_{10}, SO_2, NO_2, O_3 and 1 mg/m³ in CO"* [2]

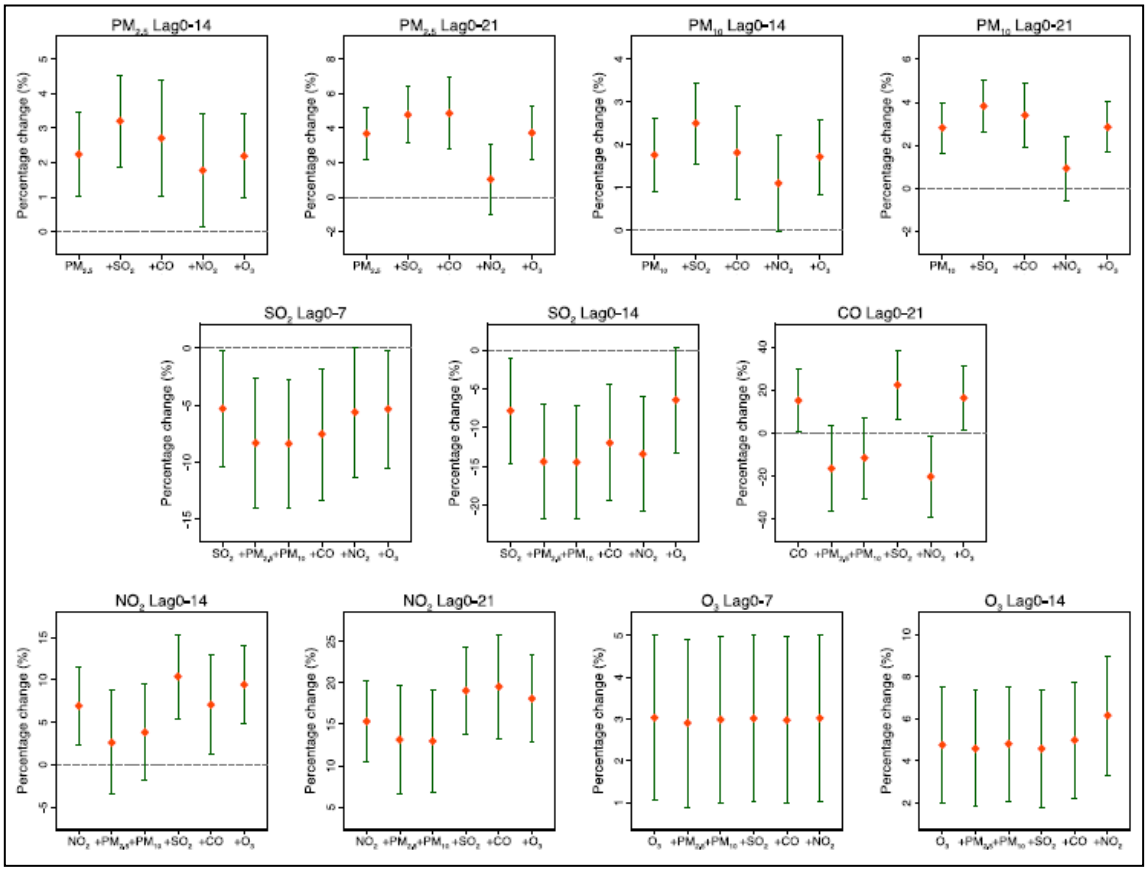

Figure 3. *"Percentage change (%) and 95% CI of daily COVID-19 confirmed cases associated with a unit increase in pollutant concentration using single and two-pollutant models. Units are 10 µg/m3 increase in $PM_{2.5}$, PM_{10}, SO_2, NO_2, O_3 and 1 mg/m^3 in CO"* [2]

Authors observed significantly positive associations with short-term exposure to high concentrations of $PM_{2.5}$, PM_{10}, CO, NO_2, O_3 with COVID-19 confirmed cases. A short-term exposure to higher concentrations of SO_2 results to have a negative correlation with the number of daily confirmed cases. This approach, based on the relationship with pollutants air concentrations and daily confirmed cases of COVID-19, give a first positive response to the possible connection between concentration of air pollutants in China and confirmed cases of COVID-19 [2].

Considering United States, one of the most affected country in the world, a nationwide study has been carried out in order to evaluate the relationship between long-term exposure to $PM_{2.5}$ and COVID-19 death rates. Results underline the relationship between long-term exposure to air pollution and an increase of vulnerability to the most severe COVID-19 outcomes. Wo et al. (2020) observed a statistical significant evidence that an increase of 1 μg/m^3 in long-term $PM_{2.5}$ exposure is directly related to an 8% growth in the COVID-19 mortality rate. Even if mechanisms at the basis of the relationship between $PM_{2.5}$ and COVID-19 mortality are still not clear, hypothesis suggests that it might be mediated mostly by cardiovascular and respiratory comorbidities and pre-existing PM-related inflammation and cellular damage [7]. Other researchers suggest that exposure to air-pollution can suppress early immune responses to COVID-19 infection, leading to later increases in inflammation and worse prognosis [8].

Since the presence of comorbidities appeared determinant for the aetiology and severity of the COVID-19 symptoms [8][9], the role of atmospheric pollution in contributing to the high levels of SARS-CoV-2 lethality has been hypothesized for Northern Italy as well. Indeed, the outbreak of the virus in Italy and its fatal outcome has been more important in the northern and most industrialized regions, such as Lombardy. Actually, North Italy is considered one of the Europe's most polluted areas in terms of smog and air pollution due to its climate and geography which leads to a pollutants stagnation, particularly for Lombardy and the Po Valley [7].

Bergamo is one of the most stricken Italian city by COVID-19 pandemic and for the first time "traces" of SARS-CoV-2 RNA has been detected in outdoor PM in this area. *Setti et al.* found that in conditions of atmospheric stability and high concentrations of PM, SARS-CoV-2 could create clusters with outdoor PM10 and reducing their diffusion coefficient, enhancing the persistence of the virus in the atmosphere. Confirmation studies are ongoing in Italy (Milan and Naples), Spain (Madrid and Barcelona), Belgium (Brussels), and U.S. (New York) under the RESCOP (Research group on COVID-19 and Particulate Matter) International Research Initiative, promoted by the Italian/International Society of Environmental Medicine (SIMA/ISEM). The main target is to understand and then to use the presence of SARS-COV-2 on PM_{10} as early indicator of epidemic recurrence. Moreover, it is still unclear if SARS-CoV-2 remains viable as per the ratio of its virulence when adsorbed on particulate matter [10]. It will be necessary to understand the correlation between PM and virus in other large polluted areas as in Latin America in particular in Brazil and Mexico (where right now COVID-19 is hitting population and sanitary systems very hard) and compare this data with other parts of the world.

The evidences are not set on yet in the meaning if the air pollution could have an active role in the epidemic diffusion. Although hypotheses made by the scientific community about the relationship between exposure to PM high concentrations and COVID-19 data are not adequately supported, the possibility that exposure to pollutants could influence the vulnerability of a population to COVID-19 seems plausible [10].

To avoid a possible faster COVID-19 diffusion and a worse disease course (as per other future pandemics), limiting as much as possible the air pollution, represents a mandatory commitment for the global community.

How can we achieve this?

There are several tools available, first of all decreasing our coal and oil consumption and at the same time increasing the energy fraction produced by renewable sources, as solar, wind power or geothermic. These targets could be reached by changing our habits, decreasing the use of cars (i.d. promoting smart-working for all workers' category, where possible) preferring green mobility for commercial transport as well, and in our daily routine, assuming "little but fundamental" new habits (i.e. avoiding the waste of our heating or cooling).

A second choice could be to turn our economy to green, although it is not an easy goal to achieve because industries all over the word have been hit harder than ever by the pandemic and investments on the "green new deal" are often, in the short run, not very remunerative and rather expensive. Until nowadays, green and sustainable ecological politics could be considered as "inversely proportional"

to economic sustainability. The big challenge of the near future will lie actually in the effort to convert this equation, supporting green research from the basis, both from economics choices and from a different educational approach at all school levels.

None of these paths will be easy to undertake. However, pursuing these solutions could be fundamental to avoid “apocalyptic future scenarios” similar to the current COVID-19 emergency, in a more sustainable way. There is no “magical formula” to make things easier, however, with different degree of effort from each member of the society it will be possible to achieve great results.

Glossary

CI	*Confidence interval (statistics)*
CO	*Carbon monoxide*
COVID-19	*Coronavirus disease 2019*
NO_2	*Nitrogen dioxide*
O_3	*Ozone*
PM	*Particulate matter*
RESCOP	*Research group on COVID-19 and Particulate Matter*
SARS-CoV-2	*Severe acute respiratory syndrome coronavirus 2*
SIMA/ISEM	*Italian/International Society of Environmental Medicine*
SO_2	*Sulfur dioxide*
WHO	*World Health Organisation*

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