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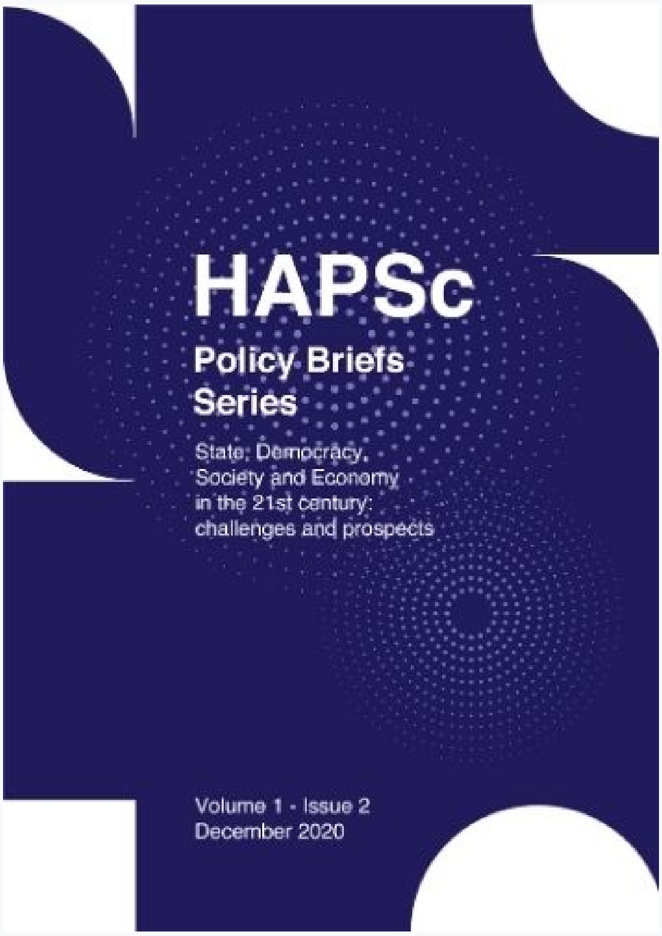

A Comparative Analysis of COVID-19 Effects on air Pollution in Ten EU Cities in 2020

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A Comparative Analysis of COVID-19 Effects on Air Pollution in Ten EU Cities in 2020[1]

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Abstract

The global pandemic has arguably induced many dramatic changes at all levels worldwide. The occurrence of some silver linings on the environment brought about a glimmer of hope and optimism. However, these are seen as rather short-lived and temporary mainly linked to lower economic output and the imposition of restrictive measures by the national governments to contain the spreading of the coronavirus. In such a context, the restart of the economy plausibly raises many concerns about the durability of those in the long run. An environmental sector that has attracted particular attention is air pollution which has seen significant improvements in urban centers and most polluted cities during the pandemic. Evidence shows that air pollution in the EU has decreased in 2020 as a result of reduced consumption of fossil fuels, road transport, lower economic output, and industrial activity, however, strong signs of retreat to pre-coronavirus levels are observed. The aim of this policy brief is to examine the effects of COVID-19 on air pollution by breaking down and comparing the average concentrations of three pollutants, nitrogen dioxide (NO2), and particulate matter (PM2.5), and (PM10), per month in ten major European cities in 2020 with the use of data from the European Environment Agency.

Keywords: Air pollution; COVID-19; Environmental effects; Lockdown; Nitrogen Dioxide; Particulate Matter.

Introduction

Since the outbreak of the global pandemic, a plethora of studies have embarked on assessing the effects of the coronavirus on the environment at the international level (Helm, 2020). The pandemic could be argued that apart from the serious negative effects has generated some environmental benefits (Zambrano et al., 2020). Indicatively, these can be identified in the lower consumption of fossil fuels and the decrease of GHG emissions due to lower economic and industrial activity which, in turn, led to improved air quality, clearer skies, and a cleaner atmosphere in the world's most polluted cities. Likewise, the fall of tourism affected the quality and clarity of waters and beaches around the world while nature and wildlife in the absence of human presence seemed to bounce back

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(Melidis, 2020). On the other hand, some of the negative effects are met in the increased use of single-use plastics, the rise in household and medical waste and waste management (Saadat et al., 2020). In this regard, an environmental sector that lends itself to an interesting analysis and constitutes the centerpiece of this paper is air pollution which has seen significant improvements during the pandemic. The focus of this article is to look into and compare the levels of air pollution in ten major European cities by analysing the NO_2, $PM_{2.5}$, and PM_{10} pollutants and their monthly average concentrations in 2020, a year of several restrictive measures, national and local lockdowns. In a nutshell, the article demonstrates the significant reductions in emissions in ten EU cities and improved air quality, however, there are clear indications of a possible setback to the pre-pandemic levels. The structure of the article is as follows. Initially, it introduces the research methodology and key definitions then goes on to outline air quality in the EU followed by an analysis of air pollutants in a sample of ten EU cities, and lastly draws some conclusions and policy recommendations.

Methodology and Definitions

The article is drawn on a range of academic articles, environmental studies, and reports from environmental agencies and international organisations. The data for the statistical analyses were compiled by the official European Environment Agency datasets (EEA, 2020a). Specifically, we used the EEA’s Air quality and Covid-19 viewer to track the average concentrations of nitrogen dioxide (NO_2) and particulate matter (PM_{10} and $PM_{2.5}$) per month in 2020. Here we provide some definitions of the key terms included in our research. Emission is the release of a pollutant directly into the atmosphere. The first pollutant examined is nitrogen dioxide (NO_2). NO_2 is a gaseous air pollutant principally generated during the combustion processes such as the burning of fossil fuels from vehicles, trucks, buses, powerplants, diesel-powered heavy construction, industrial boilers, and off-road equipment in combination with nitric oxide (NO) (EPA, 2020). Certain gases when reacting with NO in the atmosphere may result in the formation of NO_2. These reactions are characterized by rapidity and reversibility. Therefore, the two gases are reported together as nitrogen oxides (NOx). Nitrogen oxides play a crucial role in the formation of acid rain and smog with harmful effects on the environment (DEFRA, 2019). Road transport and energy production are the largest sources of NO_2 emissions. Exposure to NO_2 poses health and safety hazards such as coughing, irritation of the eyes, nose, and throat, congestion, chest pain, breathing difficulties, blood loss, lung damage, and ultimately death (WHO, 2017).

Subsequently, the term ‘PM’ refers to particulate matter (particles in the air) – a mix of extremely small solid particles and liquid droplets in the atmosphere (DEFRA, 2020). PM_{10} and $PM_{2.5}$ are inhalable and often come from different emissions sources bearing different chemical compositions. Particle pollution can emanate from the combustion of liquid and solid fuels for domestic heating, power generation, wood-burning stoves, forest fires, diesel engines, road traffic emissions, industry, agricultural burning, and dust (DEFRA, 2019). It can also be composed of a variety of sources such as sulphates, nitrates, ammonia, carbon, lead, organics, soil, dust, sea salt, and bioaerosols. A difference between these two is size where particles have a diameter of less than 10 and 2.5 micrometers respectively. According to World Health Organisation (2020), PM_{10} and $PM_{2.5}$ are the two types of pollution that affect more people than any other pollutant. $PM_{2.5}$ is also known as fine particulate matter. Exposure to particle pollution may have serious effects on health such as lung and cardiovascular diseases, respiratory problems, and premature deaths. Fine particles are also linked to reduced visibility (haze) and adversely impact climate, ecosystems, and materials. Their limit values can be frequently found in exceedance in many European cities (WHO, 2017).

The selection of our EU cases (cities) rests on two criteria, high population, and high economic activity. To measure air pollution, we broke down the concentrations of air pollutants, NO_2, PM_{10}, and $PM_{2.5}$, and categorized them by month from January to December to show the variations in air pollution throughout 2020. Importantly, the concentrations of air pollutants are given in micrograms per cubic meter of air (ug/m3). With regard to data analysis, it is worth noting that the first lockdown in the EU came into force from mid-March to early May 2020. However, even after this period containment measures in many EU Member states continued to be in place but in a laxer form, particularly over the summer and in autumn. In November and December, many EU Member states imposed a second lockdown. Some states adopted strict restrictive measures and others either local or/and national lockdowns to contain the coronavirus cases and death toll. Lastly, some of the limitations of our research have to do with the lack of available data from the official European Environment Agency datasets, particularly in the concentrations of $PM_{2.5}$ regarding Paris, Barcelona, Berlin, and Rome (only for January - NO_2, $PM_{2.5}$, and PM_{10}) and the inclusion of a greater sample of air pollutants due to space restrictions.

Air quality

In a broader context, there has been observed a drop in economic and industrial activities resulting in a reduction in emissions of air pollution. This is manifested in the area of transport where the private use of vehicles diminished during the period of lockdowns. In essence, this translates into lower NO_2 concentrations in many densely populated areas and cities. Based on EEA's Air quality and COVID-19 viewer that tracks the average monthly concentrations of NO_2 and PM_{10} and $PM_{2.5}$, the concentrations of NO_2 – a pollutant emitted by road transport – had a sharp drop in many EU cities where lockdown measures came into effect during the spring of 2020 (EEA, 2020a). The resume of economic and social activities seems to have contributed to the increase of the above-mentioned pollutants and in some cases, a strong tendency to go back to pre-pandemic levels is noted. In general, PM concentrations are caused by emissions from natural resources and man-made sources such as industry, agriculture, and residential heating and lockdown measures are less likely to have influenced them (EEA, 2020b). Particularly, PM_{10} concentrations dropped in EU cities but not eminently. Although it may be anticipated a decline in concentrations of fine particulate matter ($PM_{2.5}$), a steady decrease in many European cities has not yet been observed. A reason for this could be that this pollutant's main sources are more diversified, encompassing, for example, the fuel combustion for the heating of institutional, commercial, and residential buildings, road traffic, and industrial activities. Furthermore, a considerable proportion of particulate matter is shaped in the atmosphere when reacting with other air pollutants such as ammonia – a pollutant attributable to the use of agricultural fertilisers at this time of year. Additional factors such as weather conditions can play a key role in the decrease of pollutants' concentration. On the contrary, meteorology variations may also result in increased air pollution and combined with frequent non-sequential relationships between changes in emissions and concentrations can give an explanation about the reason for the non-occurrence of lower pollution in all areas (EEA, 2020c).

Breakdown of NO2, PM2.5 & PM10 Average concentrations per month in 2020

In this section, an analysis of the average concentrations of three pollutants on a monthly basis is provided in a tabular form for 10 highly populated cities with high economic activity below.

Figure 1: NO_2 Average concentrations (ug/m3) in 2020

	January	February	March	April	May	June	July	August	September	October	November	December	Average
Milan	69.8	54.0	33.3	23.7	20.6	23.9	23.5	20.9	34.1	39.2	47.9	43.0	36.17
Rome	No data	44.6	25.4	17.9	19.9	23.2	25.7	21.6	32.1	34.0	36.2	34.9	28.68
London	34.0	28.0	25.8	24.2	19.8	19.9	17.5	21.8	25.6	23.6	31.4	39.9	25.95
Paris	39.7	29.9	28.2	22.3	22.8	25.2	22.3	27.2	36.0	27.4	35.0	33.4	29.11
Madrid	47.1	45.4	23.0	12.2	12.9	16.0	20.2	22.2	27.9	29.8	40.4	24.6	26.80
Barcelona	36.2	35.2	21.5	14.4	15.8	17.2	21.6	17.6	25.9	27.6	30.7	26.5	24.18
Lisbon	31.0	34.7	16.8	11.7	13.0	10.6	17.3	11.2	23.2	23.4	27.5	22.1	20.20
Berlin	33.3	25.9	26.4	22.7	20.0	18.9	21.5	24.6	30.7	24.3	26.4	27	25.14
Brusells	26.2	18.7	19.3	17.6	16.7	15.5	13.2	16.3	23.5	17.3	25.3	27.6	19.77
Athens	40.8	40.8	34.3	23.7	39.0	34.9	33.9	33.1	32.7	37.7	26.6	31.7	34.10

Source: EEA (2020a)

As shown in Figure 1, the NO_2 average concentrations per month have dropped in most cities (Milan, Rome, Paris, Madrid, Barcelona, Lisbon, Berlin, and Athens) in 2020 but, towards the end of the year, there is a tendency to reach the pre-pandemic levels. In some cases (London and Brussels) these are seen in exceedance. The reductions are also clearly mirrored in the yearly average. Specifically, during the first lockdown (March-May) a significant decline is manifested almost everywhere. Similarly, these seem to remain relatively stable over the summer. However, in the following months until December, there has been a noticeable ramp-up. Interestingly, the variations in NO_2 average concentrations during the two lockdown periods (March-May and November-December) cannot be overlooked. Last but not least, cities such as Milan, Madrid, Paris, and Athens exhibited by far the highest concentrations in the pre-pandemic era and continue to do so throughout 2020 with the addition of London just before the advent of the new year.

Figure 2: $PM_{2.5}$ Average concentrations (ug/m3) in 2020

	January	February	March	April	May	June	July	August	September	October	November	December	Average
Milan	51.1	34.7	21.1	16.4	9.7	8.2	11.3	10.5	13.5	18.2	42.8	23.0	21.71
Rome	No data	16.0	13.4	12.8	8.9	7.4	9.6	11.1	11.3	9.3	19.5	11.7	11.90
London	10.6	7.3	8.8	14.8	8.7	7.9	5.3	10.8	9.0	6.4	15.1	11.5	9.68
Paris	No available data												
Madrid	14.1	14.8	6.9	6.6	7.4	7.9	10.7	8.6	7.5	7.3	12.5	4.4	9.05
Barcelona	No available data												
Lisbon	15.9	14.1	10.2	7.3	9.0	6.5	11.6	6.3	10.2	6.9	9.9	8.4	9.69
Berlin	No available data												
Brusells	11.0	6.8	9.4	13.0	8.9	7.9	5.9	9.2	10.3	6.3	13.3	14.0	9.66
Athens	21.7	16.6	14.6	12.8	13.4	10.1	12.6	12.6	12.1	11.0	14.0	14.8	13.86

Source: EEA (2020a)

More clearly, in Figure 2 a rather sharp decline in $PM_{2.5}$ average concentrations in all cases is demonstrated compared to pre-pandemic levels. Only London and Brussels seem to diverge significantly. A reflection of this decline is also met in the yearly average. Similar trends to the above pollutant (NO_2) are also observed here especially with the apparent increase in $PM_{2.5}$ average concentrations towards the end of the year (mainly November). Along these lines, the first (March-May) and second (November-December) lockdown do not seem to have a very strong impact on $PM_{2.5}$ average concentrations. Nor is it plainly observed a constant decline of those throughout. An interesting remark is that while periods of less restrictive measures such as the summer and early autumn would be expected to experience a significant and rapid increase of the average concentrations, this is hardly seen. Lastly, cities with high scores pre-pandemic such as Milan, Athens, and Lisbon are now amongst those with a remarkable decrease at the end of the year.

Figure 3: PM_{10} Average concentrations (ug/m3) in 2020

	January	February	March	April	May	June	July	August	September	October	November	December	Average
Milan	68.9	45.0	31.4	24.4	16.9	14.5	18.9	18.0	23.1	27.5	56.6	26.2	30.96
Rome	No data	28.2	26.4	20.5	20.5	17.4	20.7	23.5	23.0	20.4	31.3	18.8	22.80
London	15.8	13.6	15.5	22.5	14.1	12.1	8.6	16.8	13.9	9.5	20.9	14.6	14.81
Paris	20.9	15.2	20.0	20.9	17.2	15.5	16.5	17.0	21.6	14.1	22.9	19.2	18.42
Madrid	21.6	26.6	12.7	9.1	12.7	15.0	23.0	17.0	16.1	14.2	20.0	7.7	16.31
Barcelona	24.8	27.4	19.5	14.6	17.7	18.5	22.4	21.0	19.3	22.4	24.4	13.5	20.46
Lisbon	23.8	24.5	20.0	12.6	16.2	11.9	20.7	13.1	19.3	15.7	19.3	15.7	17.73
Berlin	20.4	13.6	20.2	22.4	14.1	17.0	15.0	20.5	19.7	16.5	20.8	34.7	19.57
Brusells	14.2	11.9	14.9	22.8	16.6	14.6	11.0	15.8	18.5	10.3	18.3	17.0	15.49
Athens	32.9	27.1	24.9	20.5	28.2	19.8	24.3	22.2	25.9	22.4	21.0	23.7	24.42

Source: EEA (2020a)

In the same line with the above analyses (NO_2 and $PM_{2.5}$), PM_{10} average concentrations note considerable reductions throughout the year and in almost all cities excluding Berlin and Brussels. Interestingly, the monthly average concentrations of PM_{10} are by far higher in relation to $PM_{2.5}$. The contribution of the first and second lockdown measures to the overall decline of average concentrations while is not contested, however, raises some doubts about their efficiency given that a rather mixed picture is presented. As we drill down into the data, we observe that PM_{10} average concentrations do not show a steady decline. Rather, it appears a quite strong tendency to bounce back to pre-pandemic levels compared to NO_2 and $PM_{2.5}$.

Conclusion

The article did provide a comparative analysis based on the latest available data about the effects of COVID-19 on air pollution in ten selected EU cities with high population and economic activity in 2020. With such a comparative approach and in spite of the limitations mentioned in the methodology, we aimed to illuminate and explain the variations in air pollution levels in a dramatic year featured by the imposition of two lockdowns and a generally stunted economy. What we can conclude from the above is that, first, there has been an overall reduction in average concentrations of the three pollutants but these reductions vary significantly among them. Second, the effect of lockdown measures in the decrease of NO_2 average concentrations appears to be important, but not that much with regards to the other two ($PM_{2.5}$ and PM_{10}). To some extent, it could be argued that their impact may be overstated. Third, reduced consumption of fossil fuels, road transport, lower economic output, and industrial activity constitute the main reasons for the overall decline in air pollution in our cases. Fourth, it is evidenced that the decline in emissions has not been steady and continuous particularly for the particulate matter ($PM_{2.5}$ and PM_{10}). Fifth, despite the significant decline in air pollution, a strong tendency to return to pre-pandemic levels based on the increasing average concentrations towards the end of 2020 cannot be ignored. In a sense, this is a clear indication that the full opening of the economy and resume of various activities post-pandemic will reverse this picture and some of the silver linings that emerged during this period would be seriously compromised if no coordinated action is taken. While the numbers speak for themselves, some useful lessons can be drawn about possible improvements in the aftermath of the pandemic. Knowingly that the economic and social challenges will overwhelm the government agenda, a more targeted approach would be required. Our suggestions for improving air quality in urban centers and polluted areas would include wider use of technology to reduce unnecessary traveling, the development of an advanced urban transportation system, the phasing out of combustion engines in tandem with a provision of economic and fiscal incentives for the use of electric vehicles, further decoupling from fossil fuels and increased use of renewables to drive down energy costs for the industry. Considering the needs of the contemporary economy and citizens post-pandemic these suggestions could be seen as a leap forward to green growth and the transition to a carbon-free economy.

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