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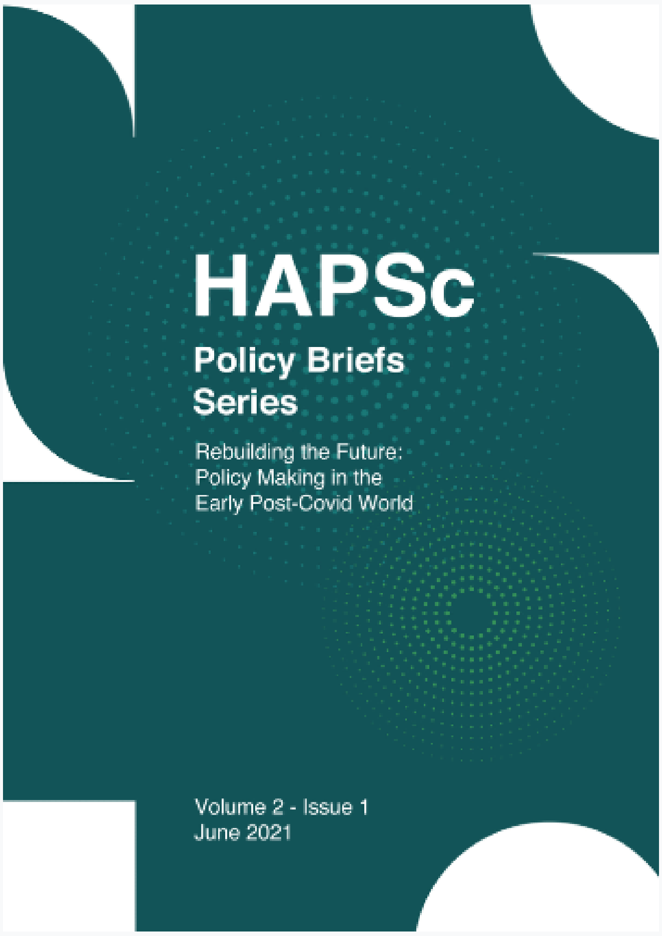

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Assessing Air Quality in Greece in Times of a Global Pandemic[1]

Michail Melidis[2] & Stylianos Ioannis Tzagkarakis[3]

Abstract

The transformation of the world in a matter of months evinced the magnitude of the pandemic worldwide with a rising death toll and rapid spreading of infections from a previously unknown virus that appeared in Wuhan (China) in December 2019. Aside from the severe health and economic effects of the coronavirus, the environment has seen a few considerable improvements. Amongst others, air pollution and greenhouse gas emissions have dropped at a global level as countries struggled to contain the spread of the coronavirus. Although Greece has a long record of problems and challenges in its environmental policy, the pandemic seemed to have caused a significant decline in its air pollution levels. This is mostly manifested in the reduced average monthly concentrations of three air pollutants (NO2, PM2.5, and PM10) in 2020 compared to pre-pandemic levels. The aim of this paper is to assess Greece's air quality by looking at three cities (Athens, Thessaloniki, and Patra) and comparing the average concentrations of NO2, PM2.5, and PM10 over the period 2019-2020.

Keywords: Air quality; Greece; COVID-19; Nitrogen Dioxide; Particulate Matter.

Introduction

Many rural areas and cities across the world are seriously impacted by increased levels of air pollution (Melidis and Tzagkarakis, 2020; Saadat et al., 2020; Zambrano-Monserrate et al., 2020). Indicatively, most people in Europe dwell in cities in which EU air quality limits are often found to exceed (EEA, 2020). According to a recent report of EEA (2020), air pollution in Europe's urban centers causes severe effects on the health of Europeans, raises medical costs, decreases productivity, and affects the economy. Generally, implementing EU environmental policy in times of crisis has not been an easy task for many EU Member states (Melidis and Russel, 2020). A policy sector that has traditionally felt various problems in its implementation is air quality (EC, 2019). In this sense, air pollution seems to have a significant impact on Greece's population (Klein K. et al., 2019). For example, high levels of ozone concentrations are often reported in Athens compounded by its topography as a basin surrounded by mountains and weather conditions with high temperatures, low

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wind speed, and temperature inversions. Based on the latest environmental performance review of OECD (2020) on Greece, two of its major cities, Athens and Thessaloniki are situated at the top 20% of the highest polluted areas in OECD countries. Unexpectedly, the advent of the pandemic appears to have left a positive footprint thus resulting in a reduction of GHG (Greenhouse Gas) emissions, a cleaner atmosphere, and improved air quality (Melidis, 2020; Melidis and Tzagkarakis, 2020). The aim of this paper is to investigate, compare and analyse air quality in three Greek cities focusing on the average monthly concentrations of three air pollutants (NO2, PM2.5, and PM10) across two years, pre (2019) and during (2020) the pandemic. The article presents that 2020 compared to 2019 has seen significant improvements in air quality with the imposed restrictions and measures by the Greek government to contain the spread of the coronavirus. The paper is structured as follows. First, we set out the scene by outlining some basic definitions, then we go on to explain the methodology of our research followed by an analysis of the three air pollutants, and finally provide some broader conclusions.

Definitions

According to the definition of Britannica encyclopedia, air pollution is ‘’the release into the atmosphere of various gases, finely divided solids, or finely dispersed liquid aerosols at rates that exceed the natural capacity of the environment to dissipate and dilute or absorb them. These substances may reach concentrations in the air that cause undesirable health, economic, or aesthetic effects’’. ‘Exposure to air pollution may generate adverse health issues such as breathing problems, chronic diseases, premature mortality, and increased hospitalization primarily for the most vulnerable groups and those living in highly polluted areas. In this regard, there are short and long-term health risks (WHO, 2013). Particularly, as short-term effects are irritated or itchy eyes, nose, and throat, skin rashes, asthma, coughing, shortness of breath, headaches, nausea, and chest infections. As long-term effects are the development of lung cancer, the aggravation of existing lung diseases, and other chronic respiratory illnesses, such as bronchitis, emphysema and pneumonia, cardiovascular disease, and allergies. Some of the most harmful pollutants to human health are PM, NO2, and ground-level O3 (WHO, 2018). For the purposes of this research, we focus solely on PM2,5, PM10, and NO2. PM represents particulate matter and is also known as particle pollution. It is a term for the mixture of tiny solid particles and liquid droplets in the air. Particle pollution encompasses PM10 inhalable particles with a diameter of equivalent to or less than 10 micrometers and PM2.5 fine inhalable particles, with a diameter equivalent to or less than 2.5 micrometers (EPA, 2021). PM’s main sources include construction sites, vehicular emissions, powerplants, industries, dust, and fires. Subsequently, nitrogen dioxide (NO2) is defined as a gaseous air pollutant composed of nitrogen and oxygen which constitutes one of a group of highly reactive gases called nitrogen oxides, or NOx (EPA, 2021). It is mainly formed and released in the atmosphere with the burning of fossil fuels such as diesel, coal, oil, and gas. It can also be formed indoors with the burning of wood and natural gas (WHO, 2018). Key sources of NO2 emissions comprise power plants, buses, trucks, and off-road equipment. Other NOx and NO2 can conduce to particle pollution and to the chemical reactions that form ozone (EEA, 2020; EPA, 2020).

Methodology

For the purposes of this study, three air pollutants NO2, PM2.5, and PM10, are examined on a monthly basis over a two-year period. The main source of data derives from the official European Environment Agency datasets and, particularly, EEA's Air quality and Covid-19 viewer that traces the average monthly concentrations of nitrogen dioxide (NO2) and particulate matter (PM10 and PM2.5). The pollutants are presented in micrograms per cubic meter of air (μg/m3). The above-mentioned cities are representative of the high level of economic activity and population density. For example, almost half of the population of Greece currently resides and works in Athens followed by Thessaloniki and Patra. Although the sample is limited, it does offer though a clear picture of air quality in the main urban areas after the imposition of restrictions and lockdowns.

Sources of poor air quality and pollution in Greece

Sources such as vehicular fumes and emissions to natural events such as forest fires comprise some of the main causes of air pollution in Greece (OECD, 2020). Vehicular pollution is not only found in Greece but is generally seen as the main contributor that impacts all the countries in the world (AQI, 2020). Combustion sources such as vehicle engines, industrial sites, and the burning of wood and other materials have been also accused of contributing to large amounts of pollution. Against this backdrop, large amounts of fine particulate matter are identified in the atmosphere such as black carbon including the soot that bears carcinogenic potency after inhalation. The release of chemicals such as nitrogen dioxide (NO2) and sulfur dioxide (SO2) - linked to vehicular emissions - are found in zones of high traffic. Likewise, volatile organic compounds (VOCs) such as methylene chloride, toluene, and benzene as well as finely ground particulate matter such as silica and gravel dust are emitted with metals such as lead or mercury from industrial zones or construction sites (AQI, 2020). Despite the reduction in the average exposure to small particulates, from the outset of the decade, premature deaths ascribed to ozone and PM2.5 appear to be steady overall except for variations related to weather conditions. Natural sources, such as the Saharan dust is regarded as a determinant, particularly in Southern Greece, for particulate pollution (OECD, 2020). Other sources include the extensive use and large numbers of heavy-duty vehicles including buses, trucks, cars, and motorbikes (OECD, 2020). The consumption of fossil fuels such as diesel is another offender. It is also observed in provincial zones a greater use of diesel-fueled vehicles (i.e., older motorbikes and cars) that contribute to a higher release of noxious fumes and oil vapors (AQI, 2020). Additional sources of pollution are power plants, factories, and industrial sites (OECD, 2020). For instance, coal-fired power plants may experience sharp increases in energy demand during the winter period in some areas of Northern Greece due to severe climate conditions (AQI, 2020). To respond to the increasing energy demands for the heating of businesses and households, power plants may increase the use of coal and thus the pollution on the whole. Similarly, to meet their own energy needs, the use of diesel and coal-based heavy machinery for a large number of manufacturing facilities and factories across the country can cause high pollution with the release of industrial chemicals (OECD, 2020).

Breakdown of NO2, PM2.5 & PM10 Average concentrations per month in 2019 & 2020

In this section, we will present an analysis of the three pollutants in a tabular form with a view to illustrating the main trends and variations of the average concentrations on a monthly basis over the period 2019-2020. That said, apart from the monthly values for each city, we calculated the average for each year and the overall difference in order to see more clearly the changes that occurred as a result of the lockdowns and various restrictions.

NO2 Average concentration (μg/m3)															
City	Year	January	February	March	April	May	June	July	August	September	October	November	December	Average	Difference
Athens	2019	35	37.1	38.1	39.6	43.5	39.3	36.0	27.5	37.4	39.5	34.8	34.9	36.88	3.07
	2020	40.5	40.8	34.3	23.7	39.0	34.9	33.9	33.1	32.7	37.7	26.6	28.6	33.81	
Thessalonik	2019	36.9	34.6	30.9	23.7	20.1	21.3	19.3	20.1	22.5	36.0	30.9	26.3	25.44	4.18
	2020	29.3	29.8	21.8	16.5	14.2	16.4	17.4	19.7	21.4	23.2	24.7	20.8	21.25	
Patra	2019	35.6	33.0	32.5	31.1	25.0	25.8	26.1	28.9	28.3	36.6	37.1	34.2	30.20	3.9
	2020	37.5	34.8	25.9	14.3	19.9	18.6	25.0	20.0	30.1	31.7	28.7	28.9	26.30	

Regarding nitrogen dioxide (NO2), the table above exhibits high concentration levels before the first lockdown in all three cities. A closer look shows that the highest concentrations are recorded in Athens as the most populated city with the highest economic activity. Surprisingly, while Patra is the least populated city among the three, its overall NO2 concentrations are in excess concerning those of Thessaloniki while reaching those of Athens. The comparison between 2019 and 2020 reveals that a significant drop in NO2 emissions took place in April 2020 as a result of the first lockdown. However, since then, there has been a steady rise until October 2020. The second coronavirus surge in November 2020 brought about a second nationwide lockdown which led to a mixed picture in terms of NO2 emissions.

PM 2.5 Average concentration (μg/m3)															
City	Year	January	February	March	April	May	June	July	August	September	October	November	December	Average	Difference
Athens	2019	20	19.1	17.2	17.8	12.9	15.3	13.7	13.5	14.1	18.6	15.8	18.3	16.37	2.46
	2020	22.1	16.6	14.6	12.8	13.4	10.1	12.6	12.6	12.1	11.0	14.0	14.9	13.90	
Thessalonik	2019	34.6	26.9	24.4	17.6	14.3	15.4	15.3	17.1	16.5	22.2	17.3	24.8	19.46	0.71
	2020	33.3	24.0	18.6	15.1	12.9	10.7	12.9	13.4	14.0	16.4	26.3	27.5	18.75	
Patra	2019	20.1	19.6	22.2	15.5	10.9	12.9	12.0	11.5	12.3	14.3	15.1	22.3	15.21	1.41
	2020	28.7	19.5	15.2	10.7	7.3	7.5	10.4	10.1	9.8	10.8	16.0	19.6	13.80	

A similar trend is also observed for particulate matter (PM2,5). Broadly, PM2,5 concentrations were generally seen higher in Thessaloniki in relation to Athens and Patra respectively. From a comparative perspective, no stark differences were noticed in 2019 and 2020 as all the cities experienced reductions. Indicatively, the period from February to October featured by the first lockdown was favourable for constant reductions. As mentioned earlier with NO2, we do note a reversal of this trend towards the end of the year (November and December) with some increases amidst the second lockdown.

PM 10 Average concentration (μg/m3)															
City	Year	January	February	March	April	May	June	July	August	September	October	November	December	Average	Difference
Athens	2019	34.1	29.5	28.6	31.2	26.0	28.7	23.6	25.9	28.1	31.0	30.2	33.1	29.17	4.49
	2020	33.5	27.1	24.9	20.5	28.2	19.8	24.3	22.2	25.9	22.4	21.0	26.1	24.67	
Thessalonik	2019	54.1	47.6	45.3	33.9	30.6	32.7	30.1	34.2	34.8	56.3	59.4	45.1	39.50	3.11
	2020	52.7	43.6	34.4	28.4	34.9	28.5	29.0	28.0	34.0	34.9	44.0	44.2	36.38	
Patra	2019	29.8	33.2	36.1	28.7	23.6	28.8	26.4	28.8	27.2	29.8	29.9	33.3	29.32	3.69
	2020	38.5	31.0	24.6	20.0	19.4	19.4	23.8	22.8	25.0	24.2	27.5	31.3	25.63	

With regards to PM10, the average concentrations in terms of value across 2019 and 2020 are significantly higher than those of PM2.5. Thessaloniki once more shows the highest records during the stated period. It should be mentioned that all the three cases demonstrated a decline in concentrations for most of the period of 2020 and noticeable increases over the last months of 2020.

Conclusions

To wrap up, the above data demonstrated that NO2, PM2,5, and PM10 emissions in Athens, Thessaloniki, and Patra in 2020 saw a reduction overall. It may be argued that this decrease in emissions was a reflection of the reduced economic activity and vehicular use particularly during the first lockdown which contributed to a cleaner atmosphere. On the other hand, the second lockdown in November 2020 emerged as a brake which reversed the dominant trend inducing some increases and a mixed picture towards the last months of 2020. In such a context, the various restrictions and the first lockdown seemed to have played a pivotal role in the emission reduction. Reasonably, this fall in emissions gives a glimmer of hope but at the same time, the easing of restrictions and the expected rapid economic recovery to pre-pandemic levels as seen by the average concentrations in November and December 2020 witnessed that the overall emission reductions could be viewed as a temporary and short-lived phenomenon. This trend arguably raises some doubts about the next day after the pandemic and the actions that should be foregrounded. Drawing on that, policymakers should focus their efforts on reducing vehicular use or replacing it with alternative sources (i.e., electric cars) to improve air quality in urban centers. In this regard, strategic and long-term planning assisted by the latest technological advancements for the reduction of industrial, construction, and energy emissions in the run-up to a zero-carbon economy are more than necessary. In the midst of a climate emergency, the increasing use of alternative energy sources and the provision of economic incentives to industries to adopt innovative strategies that are successful in other countries could largely offer useful solutions and lessons on how to improve the state of the environment and citizens' health and well-being (Lee, 2013). Although such initiatives and strategies imply bold decisions, it can generally be inferred that national governments should consider policies with a greener footprint. Advocates of a more sustainable economic model are the new generation (youth) and generally, the public opinion in many EU Member states, as well as the strong scientific community whose contributions to finding efficient ways and tackling environmental problems, are of utmost importance. In this setting, no retreats are allowed to policies that proved harmful for the development, the environment, and people. Instead, tapping into the momentum, desire, and pledge of many EU states to curb GHG emissions and transition to a more sustainable future can give a new vision of the next day. Greece should step up its efforts and harness all the best practices and means offered by the EU to proceed to the essential changes in its transportation networks, and energy and construction plans. Although the above mentioned provide a strong base for reflection, the challenges that lie in their implementation may muddy the waters given the strong voices and pressures from a part of the society and industry to prioritize quick growth over the environment with the known consequences.

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