IMPACT OF LOCKDOWN ON AIR QUALITY IN BELGRADE DURING COVID-19 PANDEMIC

by

Biljana S. VUČIĆEVIĆ, Marija M. ŽIVKOVIĆ**, Valentina M. TURANJANIN, Vukman V. BAKIĆ, and Marina P. JOVANOVIĆ

Laboratory for Thermal Engineering and Energy, VINČA Institute of Nuclear Sciences, National Institute of the Republic of Serbia, University of Belgrade, Belgrade, Serbia

Original scientific paper
https://doi.org/10.2298/TSCI230706212V

The Environmental Protection Agency of the Republic of Serbia continuously monitors and collects air quality parameters at numerous measuring points throughout the country. The results revealed that the levels of air pollution recorded during the lockdown differed from those recorded during the same period the previous years. In this paper, we examined pollutant concentration trends in 2020 and a few previous years to determine the underlying causes of these trends. Pollutants are measured at five stations in Belgrade from the beginning of March to the end of July between 2015 and 2020. Because no hourly data were available, NO_2, SO_2, and suspended particles PM_{10} and $PM_{2.5}$ are average daily values, whereas CO and ozone are daily 8-hour maximums. Concentrations were compared and averaged only when data for the same period over time was available, i.e. when comparing 2020 to previous years.

The results were compared to the annual and daily limit values (for ozone and CO 8 hours maximum, respectively), as well as the variations in concentrations over time. The goal of calculating and displaying these values is to specifically identify a change in air pollution during the COVID-19 virus pandemic isolation period.

In general, for Belgrade in 2020, NO_2 concentrations are lower at four stations, $PM_{2.5}$ concentrations are lower at two stations, PM_{10} concentrations are higher at one station and lower at another, and SO_2 concentrations are higher than in previous years (2015-2019).

Key words: *air pollution, COVID-19, lockdown*

Introduction

The most common air pollutants in ambient air include particulate matter (PM_{10} and $PM_{2.5}$), O_3, NO_2, CO, and SO_2. Particulate matter (PM), tiny airborne particles that adsorb polycyclic aromatic hydrocarbons, heavy metals, and other volatile organic fragments, can be inhaled into the human lungs and cause lung disease, but can also enter the bloodstream and cause cardiovascular disease. Black carbon is a part of PM produced by incomplete combustion and has been associated with carcinogenic effects in humans [1]. The NO_2 is a gaseous air pollutant composed of nitrogen and oxygen that is formed when fossil fuels such as coal, oil, gas, or

*Corresponding author, e-mail: marijaz@vin.bg.ac.rs

diesel are burned at high temperatures. The NO_2 damages the lungs in several ways, including by aggravating coughing and wheezing, limiting lung function, increasing asthma attacks, and increasing the likelihood of emergency room and hospital visits. According to recent research, NO_2 is likely a contributing factor to asthma in children. Sulfur and oxygen combine to form SO_2, a gaseous air pollutant. The SO_2 is formed when fuels containing sulfur, such as coal, oil, or diesel, are burned. Sulfates, which contribute significantly to particulate pollution, are also produced by SO_2 in the atmosphere. Electricity generation, commercial boilers, and other industrial processes such as metal processing and petroleum refining are the main sources of SO_2 emissions. Another major source of diesel emissions is from aging busses and trucks, locomotives, ships, and off-road diesel machinery. The SO_2 has a number of harmful effects on the lungs, including wheezing, shortness of breath, chest tightness, and other problems, especially during physical exertion [2].

Air pollution comes from mobile (cars, buses, planes, trucks, and trains), stationary (power plants, oil refineries, industrial plants, and factories), spatial (agricultural land, cities, and wood-burning sites), and natural (windblown dust, forest fires, and volcanoes) sources. It is a global health and environmental problem, and one of the biggest problems in the world that seriously threatens human health. According to the World Health Organisation (WHO), more than 7 million deaths are attributed to air pollutants each year [1]. The trend of increasing urban population and energy consumption as well as traffic volume has led to a significant increase in air pollution. For this reason, air pollution is being studied in many countries and various solutions are being sought to reduce it.

The emergence of the Sars Cov2 virus in the world has caused significant disruptions in the operations of many countries and cities. On March 11, 2020, the WHO declared a global coronavirus pandemic (Sars Cov2) [3]. The high number of infections and deaths compelled many governments to implement drastic locking measures to prevent virus spread, particularly at the start of the pandemic, until the first vaccines became available. During the lockdown, traffic density was greatly reduced, and human activities were greatly restricted. The emergency rules reduced human activities but provided a new perspective for studying air pollutants and understanding how human activities contribute to them.

This study was conducted primarily by comparing the values of the major pollutant concentrations during the lockdown and in previous periods: immediately before, during, and after closure, or by comparison with previous years in the same period.

Concentrations of $PM_{2.5}$ and PM_{10}, and CO were measured at six stations in the Victoria, Mexico [4] area, four weeks before and twelve weeks after partial closure. There was a significant decrease in concentrations. The air quality in Poland as a whole was investigated [5]. The NO_2 was measured using satellite data, and NO_2, PM, and SO_2 were measured using station data. Three months were observed: March, April, and May, with significant reductions compared to 2018 and 2019. The concentrations of $PM_{2.5}$, PM_{10}, and NO_2 were compared during the lockdown period to previous data from four Indian megacities (Delhi, Pune, Mumbai, and Ahmedabad) [6]. Significant reductions in NO_2 concentrations (60-65%) and relatively lower reductions in $PM_{2.5}$ (25-50%) and PM_{10} (36-50%) were observed.

During March-May 2020, a combination of aerosol ($PM_{2.5}$) and gases (NO_2, SO_2, CO, and O_3) data, as well as meteorological datasets (mean temperature-MT, relative humidity-RH, absolute pressure-AP, wind speed-WS, and rainfall-RainF), were collected from ground and satellite-based stations in Dhaka, Bangladesh [7]. The $PM_{2.5}$ and NO_2 levels fell by 26-54.2% and 20.4-55.5% in the urban city area during full and partial lockdowns, respectively, when compared to the pre-lockdown period.

The review of lockdown measures in 19 countries (South and Southeast Asia region) [8], as well as a spatial-temporal analysis of the effect of pandemic mitigation measures on regional-scale air quality. Overall air quality in the study area improved significantly during the lockdown, with at least 50% of the study area experiencing a significant reduction in atmospheric NO_2, SO_2, and $PM_{2.5}$. In 80% of the study area, the concentration of O_3 increased unexpectedly.

Kumari and Toshniwal [9] investigates air pollution data from 162 monitoring stations in 12 cities from COVID-19 affected countries: concentrations of $PM_{2.5}$ and PM_{10}, NO_2, SO_2, and O_3 were analysed during March, April, and May of 2020 and compared to the same time frame in 2019. Because of the restricted emissions during the lockdown phase, the major pollutants, including $PM_{2.5}$, PM_{10}, and NO_2, have shown a remarkable reduction in the post-lockdown period compared to the pre-lockdown period for all selected locations. Similarly, the concentrations of these pollutants were significantly lower in March, April, and May of 2020 compared to the same months in 2019. During the lockdown phase, the SO_2 concentration level showed a mixed trend. In a few cities, such as Lima, Madrid, Moscow, Rome, Sao Paulo, and Wuhan, SO_2 concentrations remained unchanged during the lockdown period because the main source of SO_2 emissions is power plants, which remained operational in most cases. Many locations' O_3 concentration levels increased during the lockdown phase, which could be attributed to a reduction in O_3 consumption during the titration process and changes in meteorological conditions over time. Similar findings have been reported in Saudi Arabia [10], northern India [11], Wuhan, China [12], Rio de Janeiro [13], and Sao Paulo, Brazil [14].

In Portugal [15], data from 24 air quality monitoring stations, including rural, urban background, and 11 urban traffic air quality monitoring stations, were considered for NO_2 and PM_{10}. The NO_2 and PM_{10} had average reductions of 41% and 18%, respectively. The authors concluded that NO_2 and PM_{10} reductions occurred primarily in urban areas, with traffic contributing more than 60% of NO_2 concentrations.

Measuring was done at 15 monitoring air quality stations in New York City [16]. There are no significant differences in NO_2 and $PM_{2.5}$ concentrations between the first 17 weeks of 2015 and 2020. The analysis could account for both short- and long-term changes in air quality, and New York City has lower baseline concentrations of air pollutants than the other locations under consideration. Similar findings were obtained in Northern South America [17], Madrid and Barcelona, Spain [18], and the continental USA [19]. Some authors [20-24] also addressed the impact of meteorological conditions on air pollution during the pandemic. The question arises whether the COVID-19 pandemic contributed to the reduction of air pollution in Belgrade and thus made a positive contribution.

The declaration of a COVID-19 epidemic in Serbia on March 20, 2020, has had a significant impact on the operation of many systems. To prevent the spread of the infection, the Government of the Republic of Serbia imposed and lifted a number of restrictions, including complete bans on the movement of people over the age of 65, restrictions during specific times, closures of restaurants, cafes, shopping malls, and markets, restrictions on passenger bus transportation, restrictions on domestic and international passenger rail traffic, and so on. Kindergartens, schools, and colleges were also closed. Public organizations now handle emergencies and conduct business online (*e.g.* social services). The majority of companies now allow employees to work from home. As a result of all of this, there has been significantly less human movement and consumption across a variety of industries.

This study's objective is to demonstrate how the concentrations of major pollutants changed from 2015 to 2019 to the locking period. The results obtained can serve as a guide for decision-makers to implement specific measures in order to accomplish the objectives related to the reduction of air pollution.

Methodology

The Environment Protection Agency (SEPA) of the Republic of Serbia [25] continuously monitors air quality parameters throughout the country and collects data from the local network monitoring system. For this paper, we used data from SEPA measuring stations in Belgrade, Serbia, fig. 1. By analysing all data available from the local SEPA network monitoring system, measurement periods with or without data are classified, tab. 1. The analysis includes data from automatic monitoring stations for major pollutants (CO, NO_2, O_3, $PM_{2.5}$, PM_{10}, SO_2) and meteorological parameters (*t*, RH, wind speed, wind direction) collected in Belgrade from the five automatic monitoring stations: Mostar, Novi Beograd, Stari grad, Vračar, and Zeleno brdo.

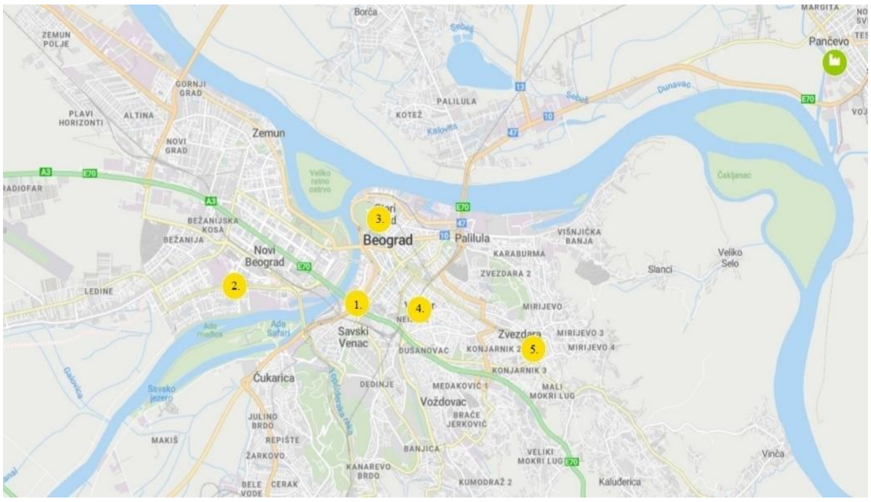

Figure 1. The SEPA measuring stations in Belgrade used for this paper

In this section, we compare ambient NO_2, SO_2, PM_{10}, and $PM_{2.5}$ air pollutant concentrations during COVID-19 lockdown between May and July 2020, compared to concentrations in Belgrade from the previous five years for the same period.

There were significantly fewer measurements taken in 2017 and 2018 than in 2019 and 2020, both by pollutants and by stations. As a result, some pollutants were unable to compare measuring results from 2020 during the lockdown period to previous years during the same time period.

Results and discussion

– Nitrogen dioxide

At all monitoring stations in Belgrade, the annual limit value for NO_2 of 40 μg/m^3, as well as the daily limit value for NO_2 of 85 μg/m^3 [26] has not been exceeded during the observed period in 2020. Due to a lack of data, it is not possible to analyse the NO_2 concentration for the observed period in earlier years in some stations. It has been noticed that the average value of NO_2 for the observed period from March the 1st to June the 30th in 2020 is 38% lower compared to 2019 and for years 2018/2017/2016/2015, respectively, by 41%/16%/54%/38%.

Table 1. Data availability pollutants and years for each measuring station

Measuring station/National Code	Year	Pollutant					
1. Mostar (urban/traffic) RS0028A		CO	NO_2	O_3	$PM_{2.5}$	PM_{10}	SO_2
	2015	–	√	√	–	–	√
	2016	–	√	–	–	–	√
	2017	–	√	–	–	–	√
	2018	√	√	–	–	√	√
	2019	√	√	–	√	√	√
	2020	√	√	–	√	√	√
2. Novi Beograd (urban/background) RS0036A		CO	NO_2	O_3	$PM_{2.5}$	PM_{10}	SO_2
	2015	√	√	–	–	–	√
	2016	–	√	–	√	√	–
	2017	√	–	–	–	–	√
	2018	√	–	√	–	–	√
	2019	√	√	√	√	√	√
	2020	√	√	√	√	√	√
3. Stari grad (urban/background) RS0032A		CO	NO_2	O_3	$PM_{2.5}$	PM_{10}	SO_2
	2015	√	√	–	–	–	–
	2016	√	√	–	√	√	–
	2017	√	–	√	–	–	–
	2018	√	-	√	√	√	–
	2019	√	√	√	√	√	–
	2020	√	√	√	√	√	–
4. Vračar (urban/background) RS0037A		CO	NO_2	O_3	$PM_{2.5}$	PM_{10}	SO_2
	2015	√	√	–	–	√	–
	2016	√	√	–	–	–	–
	2017	–	√	–	–	√	–
	2018	–	√	√	–	√	√
	2019	–	√	√	–	–	√
	2020	–	√	√	√	√	√
5. Zeleno brdo (suburban/background) RS1027A		CO	NO_2	O_3	$PM_{2.5}$	PM_{10}	SO_2
	2015	–	√	√	–	√	√
	2016	–	√	–	–	–	√
	2017	–	√	–	–	–	√
	2018	–	√	√	–	–	√
	2019	√	√	√	–	–	√
	2020	√	√	√	–	–	√

In fig. 2, presented graphs show difference between NO_2 concentration daily values averaged for five years 2015-2019 and values in 2020. Comparing NO_2 concentration average value for five years from 2015 to 2019 (each year period from 1st March to 30th June) with concentration in 2020 (the same period of year), decrease of 41% is recorded. Similar results have been confirmed also by several studies worldwide [27-29]. The obtained results are expected considering the reduced intensity of traffic in the city during lockdown. The differences are more pronounced in urban measuring stations, with the smallest difference observed at Station 5, which is located in a suburban area with low traffic.

– Sulfur dioxide

The SO_2 concentrations were measured at four stations in Belgrade. During the observation period, no station in Belgrade exceeded the annual limit value for SO_2 of 50 μg/m^3

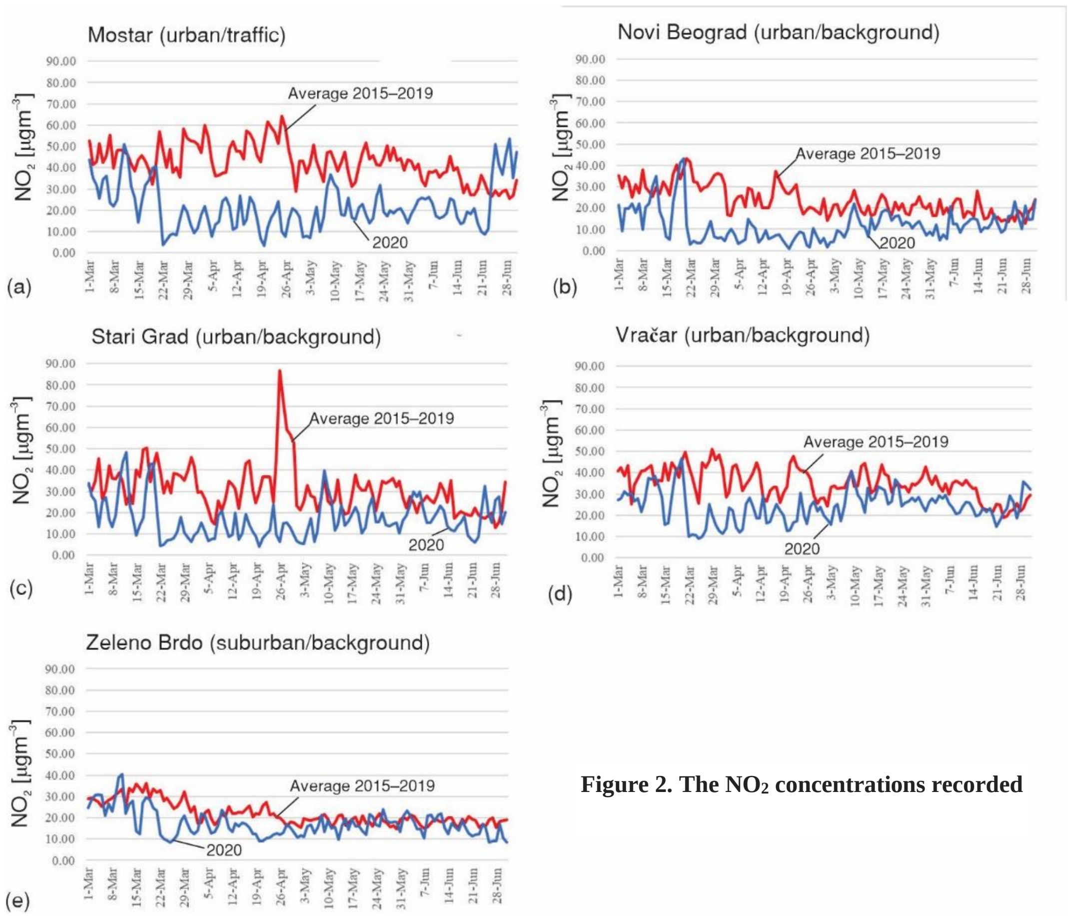

Figure 2. The NO_2 concentrations recorded

and daily limit value of 125 μg/m^3 [26]. The highest SO_2 concentrations were recorded in 2020, compared to previous years, at all Belgrade stations except Station 1, but they are below the allowable limit values. It is believed that the cause of the increased value of SO_2 concentration in 2020 compared to previous years comes from coal used in a nearby thermal power plant. The highest average annual SO_2 concentration was measured at Station 5 in 2020 when compared to other years in the observed period. There are numerous private house individual furnaces in the vicinity of this station. It is assumed that during the lockdown, the burning of coal and biomass increased the concentration of SO_2 at this location significantly.

In comparison with the same period of time (2015-2019), daily average SO_2 concentrations shown in fig. 3 recorded an increase of 32%, 42% and 103% at the Stations 2, 4, and 5, respectively. Only at Station 1 was recorded a decrease of 18% in concentration to the previous years.

– Particulate matter (PM_{10})

In Belgrade, the annual limit value for PM_{10} (40 g/m^3) was not exceeded at any of the monitoring stations during the observed period in 2020. The analysis of average annual concentration data for PM_{10} revealed that the highest concentration was recorded in 2020 (except for the Station 4), which is 12% higher than in 2018 and 15% higher than in 2019 at Station 3. On the other hand, the average annual values of PM_{10} in 2020 were 3% higher than in 2019 and

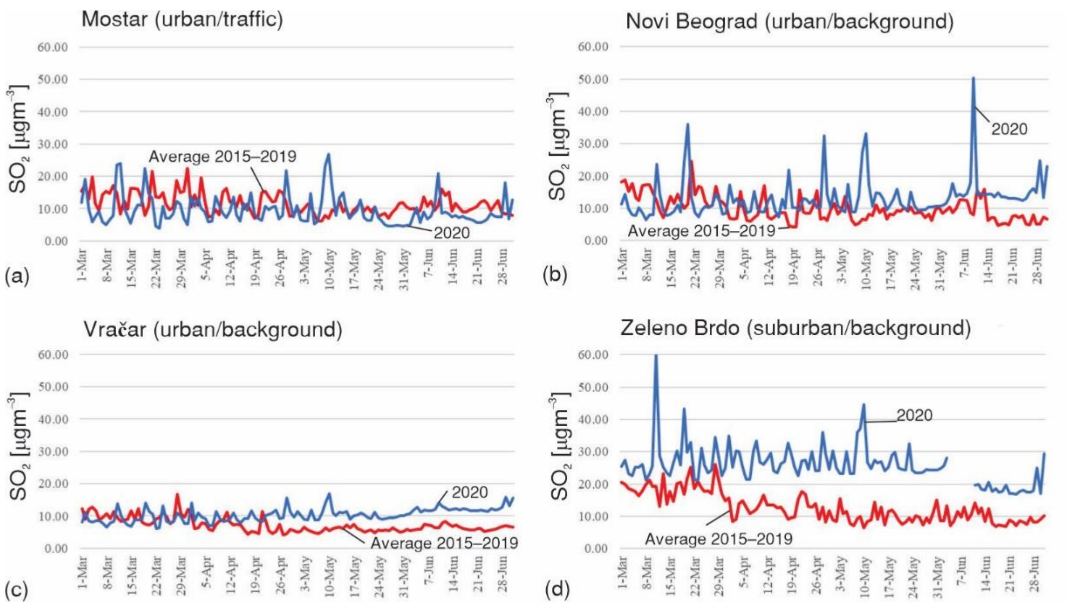

Figure 3. The SO_2 concentrations recorded

29% higher than in 2018 at Station 1, which is located in a traffic-heavy area. The daily limit value of PM_{10} concentration (50 µg/m^3) [26] was exceeded for the observed period in earlier years and in 2020 also, fig. 4.

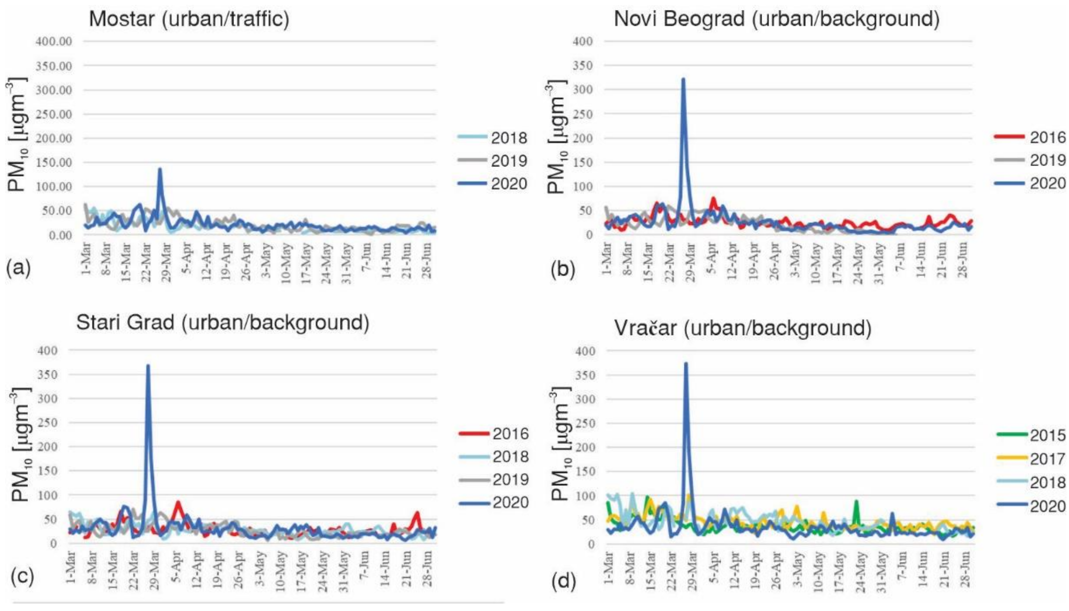

Figure 4. The PM_{10} concentrations recorded

At the end of March (the 27th March 2020) a sudden increase of PM_{10} concentration has been recorded at all stations. The following text provides an explanation for this phenomenon.

– Fine particulate matter ($PM_{2.5}$)

The annual limit value for $PM_{2.5}$ concentration (25 μg/m^3) has not been exceeded over the observed period in earlier years and in 2020 as well. Average annual concentration data analysis has shown slightly lower concentration of $PM_{2.5}$ in 2020, which is 0.4%, 0.3%, and 3% lower compared to 2019 at the Stations 1-3, respectively. At the end of March, similar to the PM_{10} concentrations, two peaks have been recorded, fig. 5.

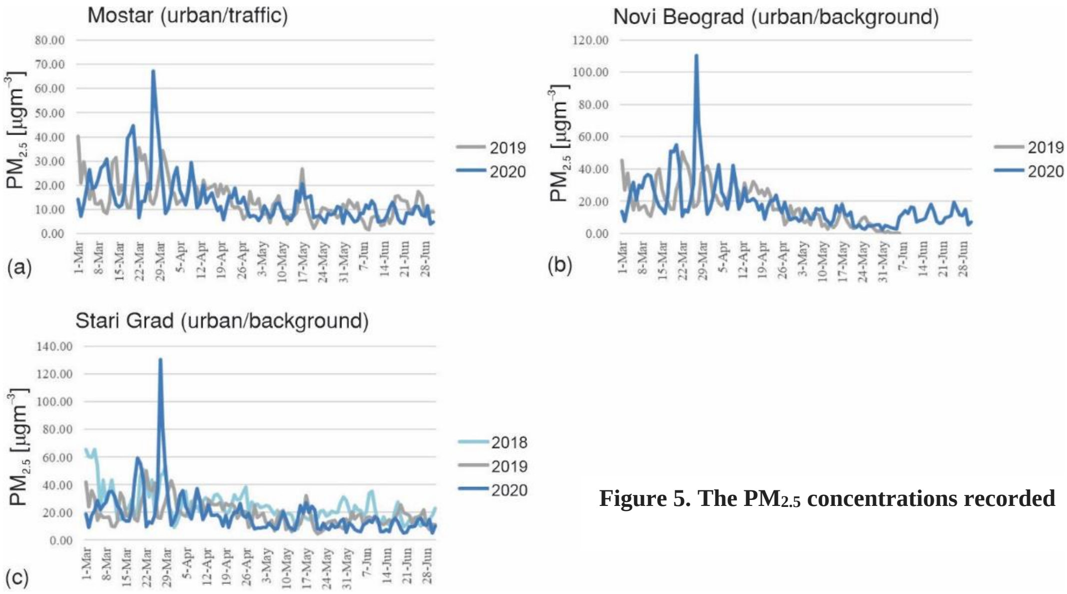

Figure 5. The $PM_{2.5}$ concentrations recorded

During the observed period, daily limits were exceeded at the majority of stations. On March 27, 2020, the Aralkum desert was identified as the external source of a significant increase in PM in Serbia and other countries in South-East Europe [30].

In 2020, the lowest concentrations of suspended $PM_{2.5}$ and PM_{10} particles were recorded at all Belgrade stations, compared to previous years. PM_{10} and $PM_{2.5}$ are two of the most common air pollutants in cities, both of which are produced by combustion processes (exhaust gases from internal combustion engines, fly ash from thermal power plants, and individual combustion furnaces). The higher measured average values in 2020 for all stations are thought to be due to traffic in central city municipalities and busy roads.

It was assumed that the restriction of movement would primarily result in a change in pollution caused by traffic. That is why nitrogen dioxide concentrations were analysed. Suspended particles, which are constantly present in the atmosphere and are the leading cause of pollution in the Republic of Serbia, were also studied.

Other sources of emissions, such as agricultural activity and heating during the winter, are certainly significant when it comes to emissions, and the state of emergency was mostly during the heating season.

Significant differences occurred in the mean daily values, which showed a drop when compared to 2019. The most noticeable differences were at Stations 3 and 2, as well as at Station 1, which monitors pollution caused by traffic. The percentage drop in mean concentrations ranged from 52% to 65% at the stations listed.

During the state of emergency, suspended PM_{10} particles exceeded the daily limit value of 50 μg/m^3 at the following Stations: 1 (20 days) and Station 3 (16 days).

By comparing the mean values of PM_{10} during the entire period of the state of emergency with the same period in 2019, there is an increase in the average value in 2020, which is insignificant at the Station 1, and for Stations 2 and 3 significant difference was recorded.

In contrast to concentrations of NO_2, concentrations of PM_{10} increased during the state of emergency compared to the same period in 2019. An episode of high PM_{10} concentrations occurred in the period 26th-29th March in Hungary, Bulgaria, Serbia, Croatia, Slovenia, and part of Italy when, as mentioned in some sources, the analysis of HYSPLIT images showed that the source of pollution was a sandstorm in the Aralkum desert, on the border of Kazakhstan and Uzbekistan, fig. 6.

The day with the highest recorded concentrations was March the 27th.

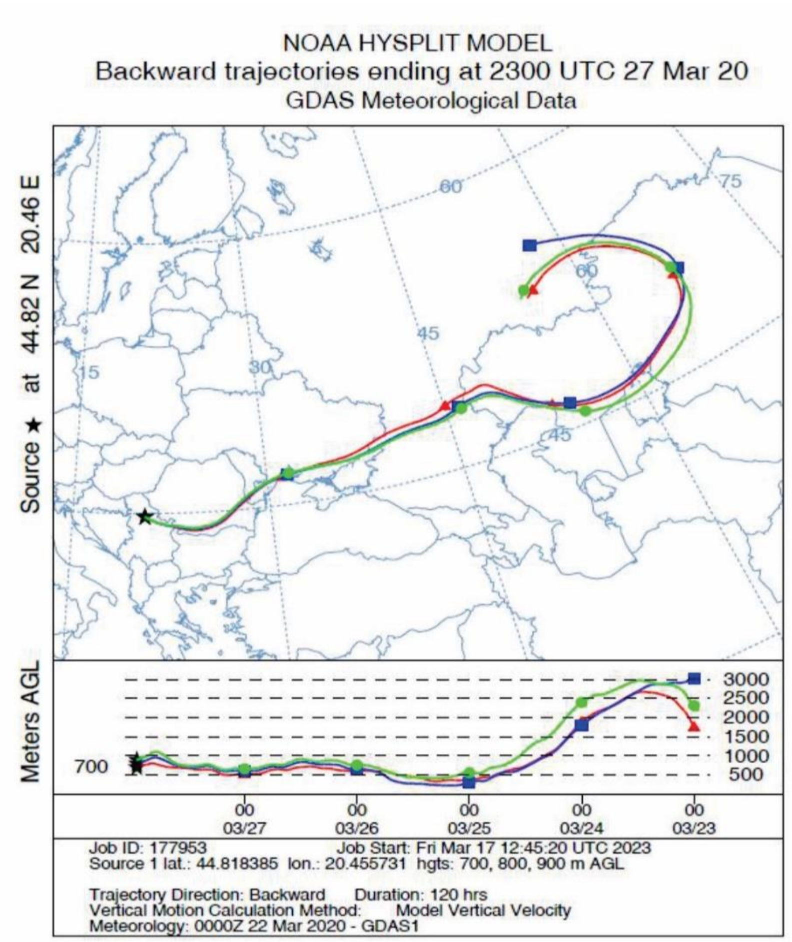

Figure 6. The NOAA Hysplit backward model

Conclusions

The impact of declining human activity during the COVID-19 pandemic on air pollution is investigated in this paper. The measured values of ambient air pollutant concentrations in Belgrade during the COVID-19 lockdown (data obtained from the Environmental Protection Agency of Serbia) were analysed between May and July 2020. The analysis was carried out by comparing the measured concentrations of pollutants NO_2, SO_2, PM_{10}, and $PM_{2.5}$ for the period May-June 2020 to previous years' concentrations for the same period.

The main causes of pollution are local combustion plants, heating and thermal power plants that use coal and fuel oil as the primary fuel for combustion. The state of emergency caused by the emergence of the COVID-19 infection undoubtedly had an impact on NO_2 concentrations, which fell, but the cause of pollution by suspended particles is far more complex, so a clear picture of the impact was not obtained. Furthermore, an unusual sandstorm in the Aralkum desert, which was attributed to a spike in the concentration of suspended particles in Kazakhstan, Uzbekistan, Hungary, Serbia, Croatia, and Slovenia on March 27 at the most, contributed to the increase in mean PM_{10} concentrations for the observed period.

Apart from heat and power generation, there are no large industrial areas in Belgrade that could contribute to increased pollution in the city. It can be concluded that the greatest pollution comes from nitrogen dioxide caused by urban traffic, and that this is the sector where measures to reduce pollution would achieve the best results.

Acknowledgment

The research was funded by the Ministry of Education, Science and Technological Development of the Republic of Serbia (contract number 451-03-47/2023-01/ 200017) and under Contract for Goods and/or Services Between the United Nations Development Programme (UNDP) and Vinca Institute for Nuclear Sciences.

References

[1] Cao, X., *et al*., Investigation of COVID-19-Related Lockdowns on the Air Pollution Changes in Augsburg in 2020, Germany, *Atmospheric Pollution Research*, *13* (2022), 9, 101536
[2] ***, American Lung Association, https://www.lung.org/clean-air/outdoors/what-makes-air-unhealthy
[3] ***, World Health Organization, Coronavirus disease (COVID-19) pandemic https://www.who.int/europe/emergencies/situations/covid-19
[4] Tello-Leal, E., *et al*., Association of Environmental and Meteorological Factors on the Spread of COVID-19 in Victoria, Mexico, and Air Quality During the Lockdown, *Environmental Research*, *196* (2021), 110442
[5] Filonchyk, M., *et al.*, Impact of Covid-19 Lockdown on Air Quality in the Poland, Eastern Europe, *Environmental Research*, *198* (2021), 110454
[6] Yadav, R. *et al.*, COVID-19 Lockdown and Air Quality of SAFAR-India Metro Cities, *Urban Climate*, *34* (2020), 100729
[7] Rahman, M. S., *et al.*, How Air Quality and COVID-19 Transmission Change Under Different Lockdown Scenarios? A Case from Dhaka City, Bangladesh, *Science of The Total Environment*, *762* (2021), 143161
[8] Roy, S., *et al.*, Geospatial analysis of COVID-19 lockdown effects on air quality in the South and Southeast Asian region, *Science of The Total Environment*, 756 (2021), 144009
[9] Kumari, P., Toshniwal, D., Impact of Lockdown on Air Quality Over Major Cities Across the Globe During COVID-19 Pandemic, *Urban Climate*, *34* (2020), 100719
[10] Aljahdali, M. O., *et al.*, Impact of Novel Coronavirus Disease (COVID-19) Lockdown on Ambient Air Quality of Saudi Arabia, *Saudi Journal of Biological Sciences*, *28* (2021), 2, pp. 1356-1364
[11] Saxena, A., Raj, S., Impact of Lockdown During COVID-19 Pandemic on the Air Quality of North Indian Cities, *Urban Climate*, *35* (2021), 100754
[12] Sulaymon, I. D., *et al.*, COVID-19 Pandemic in Wuhan: Ambient Air Quality and the Relationships Between Criteria Air Pollutants and Meteorological Variables Before, During, and After Lockdown, *Atmospheric Research*, *250* (2021), 105362
[13] Dantas, G., *et al.*, The Impact of COVID-19 Partial Lockdown on the Air Quality of the City of Rio de Janeiro, Brazil, *Science of the Total Environment*, *729* (2020), 139085

[14] Nakada, L. Y. K., Urban, R. C., COVID-19 Pandemic: Impacts on the Air Quality During the Partial Lockdown in Sao Paulo State, Brazil, *Science of The Total Environment*, *730* (2020), 139087
[15] Gama, C., *et al.*, The Impact of COVID-19 on Air Quality Levels in Portugal: A Way to Assess Traffic Contribution, *Environmental Research*, *193* (2021), 110515
[16] Zangari, S., *et al.*, Air Quality Changes in New York City during the COVID-19 Pandemic, *Science of The Total Environment*, *742* (2020), 140496
[17] Mendez-Espinosa, J. F., *et al.*, Air Quality Variations in Northern South America during the COVID-19 Lockdown, *Science of The Total Environment*, *749* (2020), 141621
[18] Jose M. Baldasano, COVID-19 Lockdown Effects on Air Quality by NO_2 in the Cities of Barcelona and Madrid (Spain), *Science of the Total Environment*, *741* (2020), 140353
[19] Berman, J. D., Ebisu, K., Changes in U.S. Air Pollution during the COVID-19 Pandemic, *Science of the Total Environment*, *739* (2020), 139864
[20] Coccia, M., How do Low Wind Speeds and High Levels of Air Pollution Support the Spread of COVID-19?, *Atmospheric Pollution Research*, *12* (2021), 1, pp. 437-445
[21] Li, H., *et al.*, Air Pollution and Temperature are Associated with Increased COVID-19 Incidence: A Time Series Study, *International Journal of Infectious Diseases*, *97* (2020), Aug., pp. 278–282
[22] Liu, Q., *et al*., Spatiotemporal Impacts of COVID-19 on Air Pollution in California, USA, *Science of the Total Environment*, *750* (2021), 141592
[23] Srivastava, A., COVID-19 and Air Pollution and Meteorology-An Intricate Relationship: A Review, *Chemosphere*, *263* (2021), 128297
[24] Azuma, K., *et al*., Impact of Climate and Ambient Air Pollution on the Epidemic Growth During COVID-19 Outbreak in Japan, *Environmental Research*, *190* (2020), 110042
[25] ***, Regulation on Conditions for Monitoring and Air Quality Requirements ("Official Gazette of the Republic of Serbia ", No, 11/2010, 75/2010 and 63/2013), http://www.sepa.gov.rs/
[26] ***, National Network of Automatic Stations for Air Quality Monitoring, http://www.amskv.sepa.gov.rs/kriterijumi.php?lng=en, *(in Serbian)*
[27] Guevara, M., *et al.*, Time-Resolved Emission Reductions for Atmospheric Chemistry Modelling in Europe During the COVID-19 Lockdowns, *Atmospheric Chemistry and Physics*, *21* (2021), 2, pp. 773-797
[28] Biswal, A., *et al.*, COVID-19 Lockdown-Induced Changes in NO_2 Levels Across India Observed by Multi-Satellite and Surface Observations, *Atmospheric Chemistry and Physics*, *21* (2021), 6, pp. 5235-5251
[29] Bontempi, E., *et al*., The Europe Second Wave of COVID-19 Infection and the Italy "Strange" Situation, *Environmental Research*, *193* (2021), 110476
[30] Knežević, J., *at al.*, Annual Report on the State of Air Quality in the Republic of Serbia for 2020, Ministry of Environmental Protection (in Serbian), Environmental Protection Agency, Belgrade, 2021

Paper submitted: July 6, 2023
Paper revised: August 20, 2023
Paper accepted: August 27, 2023