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COVID-19 Kontrol Önlemleri Hava Kalitesi Parametrelerini Etkiledi mi? 35 Ülkede Hava Kirleticileri Değerlendirmesi

Have Quarantine Measures Affected the Air Quality Parameters? Condition Assessment in 35 Countries

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ÖZ

Amaç: Çalışmada, COVID-19 salgını nedeniyle dünya çapında hükümetler tarafından oluşturulan geçici insan hareketliliği kısıtlamalarının hava kirleticileri değerleri üzerindeki etkilerini değerlendirmek amaçlanmıştır.
Materyal ve Metot: Çalışma ekolojik tipte tasarlanmıştır. 2019 ve 2020 Ocak-Mayıs tarihleri arasında "Hava Kalitesi Açık Veri Platformu" web sitesinde bulunan 35 ülke için dört hava kirletici (CO, NO2, O3, SO2) ölçümleri çalışmanın verileri oluşturmaktadır.
Bulgular: Tüm ülkeler için medyan NO2 seviyeleri 2019'a göre 1-3,6 µg/m³ arasında azalmıştır. Azalma her ay için istatistiksel olarak anlamlı olarak bulunmuştur (Ocak, p=0,024; Şubat, p=0,001; Mart, Nisan ve Mayıs, p<0,001). Ayrıca, 35 ülkenin medyan O3 seviyelerinin 2020 Nisan ayının 2019 Nisan ayına göre değişimi değerlendirildiğinde istatistiksel olarak anlamlı bir artış gözlenmiştir (medyan fark: 1,80 µg/m³; p=0,017).
Sonuç: Mevcut bulgularımız ışığında, insan faaliyetlerinin hava kalitesi üzerinde önemli bir etkiye sahip olduğu sonucuna varılabilir. İleride yapılacak çalışmalarda ülkelerin hava kirletici seviyeleri meteorolojik koşulları dikkate alınarak daha detaylı değerlendirilebilir.
Anahtar Kelimeler: COVID-19, karbonmonoksit, kükürtdioksit, nitrik oksit, ozon

ABSTRACT

Objective: This study was conducted to assess the effects of the temporary human mobility restrictions established worldwide by governments due to the COVID-19 pandemic on criteria air pollutants.
Materials and Methods: Our study is designed in an ecological type measurements of four air pollutants (CO, NO2, O3, SO2) for 35 countries collected between January-May in 2019 and 2020 and available in the Air "Quality Open Data Platform" website were included.
Results: Median NO2 levels for all countries decreased between 1-3.6 µg/m³ compared to 2019, and this decrease was statistically significant in each month (January, p=0.024; February, p=0.001; March, April and May, p<0.001). Furthermore, a statistically significant increase was observed in median O3 levels for all 35 countries between April 2020 and April 2019 (median difference: 1.80 µg/m³; p=0,017).
Conclusion: Based on the findings reported here, it can be concluded that human activities have a significant influence on air quality. In future studies, air pollutants levels of countries may be evaluated in more detail considering their meteorological conditions.
Keywords: Carbon monoxide, COVID-19, nitric oxide, sulphur dioxide, ozone

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INTRODUCTION

new coronavirus strain was first named by the International Committee on Taxonomy of Viruses as 2019-nCoV (2019, novel coronavirus), and then as Severe Acute Respiratory Syndrome-2 (SARS-CoV-2).[2] After the appearance of the first case in Wuhan, the disease caused by SARS-CoV-2, Coronavirus-2019 (COVID)-19, was characterized as a pandemic in March 11 2020 by the World Health Organization (WHO) due to its rapid spread.[3,4]

During the on-going pandemic and to prevent the rapid spread of COVID-19, governments worldwide have brought into effect several control and prevention measures, including mandatory or voluntary lockdowns, where the general population was asked to stay at home except for urgent situations, and only going out for supplying basic necessities, human mobility restrictions, such as shutting down non-essential businesses and promoting telecommuting when possible, restricting industrial activities, reducing public transportation rounds, shutting down all entertainment venues and places of mass-gathering (e.g., sanctuaries, schools and gyms). These measures, besides controlling the spread of the pandemic and its effects on the general population, have also had unexpected and positive effects on the environment: decreased air pollution levels.[5-8]

Air pollution is a global threat that has negative effects on people and ecosystems.[9,10] Nine out of 10 people on earth breathe polluted air, and although the WHO works together with its Member States to monitor air pollution levels and improve air quality worldwide, limit values for air pollution originating from transportation, heating and industrial activities are still exceeded in many countries.[11-14]

Although a limited number of studies on this topic have been conducted, some of them have reported that air pollution in different countries has decreased during the confinement and mobility restriction periods implemented to slow down the spread of COVID-19.[15-18] Taking this into account, this study aims to assess the effects of the temporary human mobility restrictions established worldwide by governments due to the COVID-19 pandemic on criteria air pollutants.

MATERIALS AND METHODS

Our study was approved by the Istanbul University Ethics Committee (Date: 16.10.2020, decision no: 25)

An ecological study was conducted using data obtained from the “Air Quality Open Data Platform” website.[19] This website contains the measurement values of air quality parameters of countries around the world collected in several periods. Air pollution was assessed using CO, NO_2, O_3, and SO_2 parameters, and measurements of the first five months (January, February, March, April, May) of 2019 and 2020 were considered in this study.

Also, in the data set used in the study, there were 66 countries with measurements for at least one air pollution parameter and 511.435 measurements in total. However, in only 35 countries, there were measurements for the four air pollutants. Thus, the total number of measurements used in this study was 431,983, that is, 84.46% of all data in the data set.

The variables of the study were, on the one hand, the countries with measurements for all four air pollution parameters (n=35) and the CO, NO_2, O_3 and SO_2 median values of these countries measured between January-May 2019 and 2020. The five-month CO, NO_2, O_3, SO_2 median values for each country for both years were calculated based on their monthly median measurements. On the other hand, monthly CO, NO_2, O_3, SO_2 median values for the 35 countries (2019 and 2020) were determined using the monthly median levels of each country.

Statistical Analysis: Statistical analyses of the study findings were performed with the Statistical Package for the Social Sciences software (SPSS), version 25.0. Categorical variables were described using frequency distributions and percentages, and continuous variables, using medians and the minimum, the maximum and the first (Q1) and third (Q3) quartile. Continuous variables data distribution was determined using the Kolmogorov-Smirnov test, histogram and probability graphics. Due to the non-normality of continuous variables, the Wilcoxon signed-rank test was performed to compare dependent data. Dependent groups consisted of the 35 countries with air parameters measurements (monthly median CO, NO_2, O_3 and SO_2 levels) for the first five months of 2019 and 2020. A statistically alpha margin of error of 0.05 was considered.

RESULTS

The 35 countries included in this study were: Australia, Argentine, Belgium, Bosnia Herzegovina, Bulgaria, Brazil, Canada, China, Chile, Colombia, Croatia, Denmark, England, France, Germany, Hong Kong, Hungary, India, Italy, Israel, Japan, Korea, Macedonia, Mexico, Netherlands, Poland, Peru, Reunion, Russia, Spain, Serbia, South Africa, Thailand, Turkey, and United States of America) (Figure 1). The regional distribution of the countries was as follows: Europe (n:17; 48.6%), Asia (n:8; 22.9%), America (n:8; 22.9%), Australia (n:1; 2.9%), and Africa (n:1; 2.9%), respectively. In total, there were 431.983 measurements of CO, NO_2, O_3, and SO_2 levels in these countries during the first five months of 2019 and 2020. The distribution of said measurements according to the four parameters was as fol-

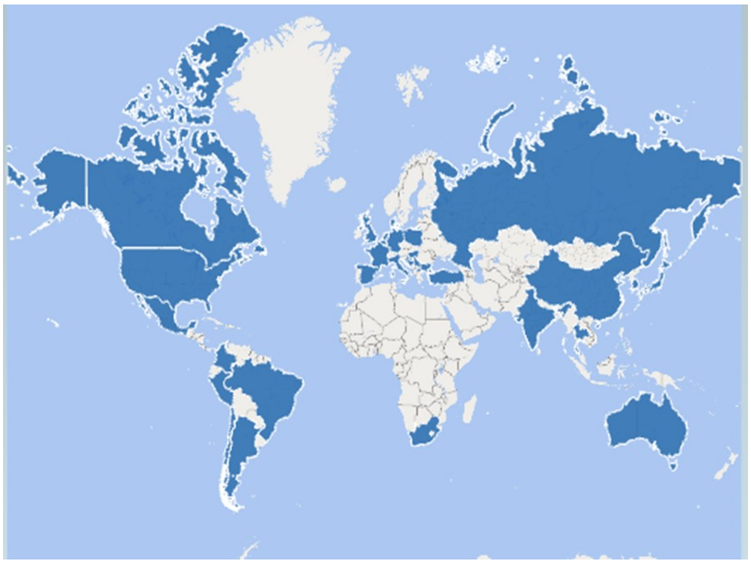

Figure 1. Countries included in the study (dark blue).

lows: 96,759 for CO, 118,432 for NO_2, 117,590 for O_3, and 99,202 for SO_2.

CO median values for all countries by month (in both years) are compared. When compared to the 2019 data, in 2020 there was a slight increase, although not statistically significant, in CO median concentrations for all countries in March, April and May; on the other hand, there was a slight decrease in January and February, though not statistically significant.

NO_2 median values of all countries for the first five months of 2019 and 2020 are summarized (Table 1). In 2020, NO_2 median levels for all countries decreased between 1-3.6 µg/m³ decreased in comparison to 2019, and said increase was statistically significant in each month.

The highest decrease in median NO_2 levels per country compared to 2019 was observed in Peru (54.89%), Brazil (47.13%), Spain (38.46%), Croatia (38.18%) and Serbia (35.75%).

Table 1. NO_2 measurement distributions of the countries from the first five months of 2019-2020 and their relevance.

Month	Year	Median	Q1	Q3	Min.	Max.	Z Value	P
January	2019	10.70	8.20	13.50	2.00	24.70	-2.264	0.024
	2020	9.50	6.90	12.30	2.45	27.90		
February	2019	11.10	7.70	14.03	2.50	29.80	-3.292	0.001
	2020	7.50	6.10	11.45	1.85	27.90		
March	2019	8.00	6.50	11.40	2.20	24.30	-4.745	<0.001
	2020	6.40	4.90	8.90	1.40	17.70		
April	2019	7.90	6.30	10.00	2.60	18.60	-5.144	<0.001
	2020	5.50	4.10	6.90	1.00	16.75		
May	2019	6.90	5.60	9.30	2.80	19.30	-4.768	<0.001
	2020	5.90	4.20	7.35	2.20	15.50		

NO_2: Nitrogen dioxide; Based on the data available at Air Quality Open Data Platform.[19]

SO_2 median levels for all countries in the first five months of 2019 and 2020 are presented (Table 2). In January, February, March and May 2020, SO_2 levels increased compared to these months in 2019, being the increase statistically significant in March (p=0.035), yet in April, they slightly decreased compared to 2019, although said decrease was not significant.

O_3 median levels for all countries during the first five months of 2019 and 2020 are presented (Table 3). When compared to 2019, O_3 levels were lower in January and March, although the decrease was not statistically significant, and higher in February, April and May, being the increase statistically significant in April (p=0.017).

The highest increase in median O_3 levels per country compared to 2019 was observed in Canada (87.25%), Bosnia Herzegovina (41.94%), Colombia (40.21%), Australia (30.56%) and Thailand (21.98%), respectively.

DISCUSSION AND CONCLUSION

According to the findings of the present study, median NO_2 levels for all 35 countries decreased significantly during the first five months of 2020 in comparison to 2019 (1-3.6 µg/m³; January p=0.024 February p=0.001; March-April-May p<0.001). Similarly, Sicard et al., [14] in a study conducted to determine the effect of lockdown due to COVID-19 pandemic on air pollution in Rome (Italy), Turin (Italy), Nice (France), Valencia (Spain) and Wuhan (China) and in which air pollution data from January 1 to April 18, 2020 was compared with measurements made during the same period in 2017,2018 and 2019, describe that NO_2 mean concentrations decreased in all five cities during the restriction period (NO_2: 45.6%, 30.4%, 62.8%, 69.0%, and 57.2%, respectively) and

Table 2. SO_2 measurement (µg/m³) distributions of the countries from the first five months of 2019- 2020 and their relevance .

Month	Year	Median	Q1	Q3	Min.	Max.	Z Value	P
January	2019	1.80	1.10	4.60	0.40	37.00	-1.147	0.251
	2020	1.90	1.10	3.10	0.30	50.10		
February	2019	1.85	1.10	4.40	0.40	27.15	-1.830	0.067
	2020	2.05	0.88	4.08	0.25	27.40		
March	2019	1.60	0.90	4.20	0.30	23.65	-2.110	0.035
	2020	1.90	1.00	4.10	0.30	20.70		
April	2019	1.80	1.00	3.60	0.30	17.30	-1.037	0.300
	2020	1.70	1.00	3.40	0.30	21.25		
May	2019	1.50	0.90	3.10	0.30	24.55	-0.963	0.336
	2020	1.60	0.80	3.40	0.40	14.70		

SO_2: Sulphur dioxide; Based on the data available at Air Quality Open Data Platform.[19]

Table 3. O_3 measurement distributions of the countries from the first five months of 2019- 2020 and their relevance .

Month	Year	Median	Q1	Q3	Min.	Max.	Z Value	P
January	2019	13.70	10.10	16.40	4.20	25.90	-1.683	0.092
	2020	12.00	7.40	16.00	2.80	21.60		
February	2019	12.20	9.30	18.28	4.40	27.90	-1.783	0.075
	2020	16.48	11.13	23.13	3.80	26.10		
March	2019	19.98	12.51	26.13	3.20	32.00	-0.570	0.568
	2020	19.45	11.20	25.20	3.40	33.95		
April	2019	24.50	12.76	28.60	4.85	34.50	-2.377	0.017
	2020	26.30	14.30	29.50	5.10	37.15		
May	2019	22.00	10.35	28.56	1.90	38.40	-1.225	0.221
	2020	23.30	12.20	28.40	4.20	35.00		

O_3: Ozone; Based on the data available at Air Quality Open Data Platform.[19]

NO mean concentrations decreased in Rome (68.5%), Turin (52.6%), Nice (70.7%) and Valencia (61.9%), respectively. Also, they report that O_3 mean levels increased during the lockdown in all five cities: 24.0% in Nice, 13.6% in Rome, 27.0% in Turin, 2.4% in Valencia, and 36.4% in Wuhan, and that this increase was associated with the NO_2 levels decline observed during the restriction period.[14] In this regard, in our study it was also determined that O_3 mean concentrations for all 35 countries increased in February, April, and May 2020 compared to 2019, being the increase in April statistically significant (p=0.017).

CO is a colourless, odourless, tasteless toxic gas. It usually emerges as a product of incomplete combustion and reduces the oxygen-carrying capacity of haemoglobin.[12] In the present study, it was found that CO median concentrations for all 35 countries decreased in January, February and March 2020, period in which the quarantine was initiated in most of these countries; however, in April and May, an insignificant increase was observed. In addition, the increase in Israel CO median levels in January 2020, when it was in the maximum quartile (38.9 µg/m³), could be explained by the new air quality stations built in the cities of Netanya, Ashdod, and Ashkelon during said period.

In addition, in another study conducted in China, by Chen et al.,[17] air quality parameters were compared in 366 regions of the country at the beginning of the pandemic and after the COVID-19 control measures had been implemented, finding that in 322 regions air quality improved, since CO, SO_2 and NO_2 concentrations decreased in average 0.23 µg/m^3, 2.2 µg/m^3, and 19.4 µg/m^3, respectively during the human mobility restrictions period. Moreover, a positive correlation between decreased emissions from motor vehicles and industrial activities and decreased CO and NO_2 levels was found (CO $R^2 = 0.17$, $p < 0.05$; $R^2 = 0.29$, $p< 0.01$) (NO_2 $R^2 =0.44$, $p< 0.001$; $R^2=0.36$, $p < 0.01$).[17]

Also, Kanniah et al.,[18] in a study where air pollution data from Malaysia and several South Asian countries collected during the implementation of partial and full human mobility and activities restriction measures due to the COVID-19 pandemic was compared to 2015-2019 average air quality parameters, report that as of April 17 2020, NO_2 concentrations had decreased 34%, 30%, 27% and 22% in Manila, Kuala Lumpur, Singapore and Bangkok, respectively compared to baseline levels, and that said decrease was caused by the shutting down of businesses and the reduction of emissions from factories and motor vehicle traffic, both due to the partial or full lockdown measures.[18]

O_3 is an air pollutant that forms as a result of the interaction of sunlight with NOx and volatile organic compounds (VOC). O_3 has a complex chemical structures and its levels depend on factors such as the VOC/NOx ratio, meteorological conditions, and whether it is emitted in urban or rural areas. In stable VOC concentrations, decreased NOx levels cause increased O_3 concentrations. In addition, solar radiation, which increases during the spring months, may also cause increased O_3 concentrations.[14,20]

In this sense, in the present study, median O_3 concentrations for all 35 countries during the five-month period in 2020 increased in February, April and May, being the increase statistically significant in April (p=0.017) compared to the same period in 2019. Similar to this finding, Dantas et al., [21] in a study conducted using data on air quality data collected by three monitoring stations (Irajá, Bangu and Tijuca districts) from March 2 to April 16, 2020 (so that the period in which partial lockdown measures were brought into force were included) in Rio de Janeiro, Brazil, report that, compared to the same period in 2019, in the Irajá and Bangu stations, median NO_2 and CO2 levels decreased between 24.1% to 32.9%, and between 37.0% to 43.6%, respectively, and that O_3 levels increased, which was probably caused by the decrease of NO_x levels.

SO_2 is an air pollutant produced by the burning of fossil fuels containing sulphur compounds that causes respiratory disorders in humans. In our study, median SO_2 levels in all the 35 countries considered increased in January, February, March and May 2020, being the increase in March significant (p=0.035), and they slightly decreased in April, which is a finding similar to what is described by Kerimay et al.[22] in a study where air pollution parameters collected in Almaty (Kazakhstan) before the lockdown period and during the quarantine were compared, since they report that mean SO_2 concentrations increased 7% during the lockdown, being said increase not statistically significant, concluding that SO_2 levels were not affected by traffic emission, but instead by the burning of coal in the city.[22]

Likewise, Sharma et al.,[9] in a study conducted using data of six criteria pollutants collected in 22 cities in India during from 2017 to 2020, report a similar increase of O_3 levels (17%), as well as a slight increase in SO_2 concentrations, which, according to these authors, could have been caused by the fact that no restrictions were implemented in powered plants in northern India, and the extensive burning of coal in the country as an essential commodity (heating) during the lockdown period. Also, Sharma et al[9]. describe that CO and NO_2 levels decreased approximately 10% and 18%, respectively.

Regarding the limitations of the study, these include the fact that we could not regulate several meteorological and other conditions that may affect the air quality parameters of the countries considered in the study, such as solar radiation, rainfall, wind level, temperature, and humidity, conditions that took place while the restriction measures were implemented in these countries, since we did not have access to these data. Also, we were able to make a relative estimation of how much factory and power generation activities, motor vehicle transportation decreased during the periods in which precaution and restriction measures were implemented differently in each country; however, we were unable to support this estimation with data, which could also be considered a limitation.

In our study, an apparent decrease in NO_2 values and a decrease and increase in CO values together were observed. It was determined that the rise in ozone concentrations is getting attention, and in addition to this, there is a slight increase in SO_2 levels. It is clearly observed that human activities have an influence on air pollution. In future studies, detailed analyses may be conducted using the data regarding the quarantine histories of countries and meteorological conditions.

Ethics Committee Approval: The study was approved by the Istanbul University Ethics Committee (Date: 16.10.2020, decision no: 25)

Conflict of Interest: No conflict of interest was declared by the authors.

Author Contributions: Concept - SPY, CB; Supervision - SPY, CB, AEÖ; Materials SPY, CB, AEÖ; Data Collection and/or Processing - SPY, CB Analysis and/or Interpretation - SPY, CB; Writing - SPY, CB.

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