



(RESEARCH ARTICLE)



Evaluation of air pollutants (PM₁₀ and SO₂) in the first year of the COVID-19: A city sample from Turkey

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Abstract

The aim of this study is to evaluate the change of air pollutants in the province of Van compared to the previous year during the COVID-19 pandemic. The study is a cross-sectional study conducted in Van where is a city in eastern Turkey. PM₁₀ and SO₂ values obtained from the National Air Quality Monitoring Network website. The lockdowns imposed in the province of Van within the scope of combating COVID-19 have been recorded by examining the decisions of the Sanitary Board on the Van Governorship's official website. The mean of PM₁₀ measurement values in the period before and after COVID-19 were 40.89±19.6 µg/m³ and 41.3±20.39 µg/m³, respectively. The mean of SO₂ measurement values were 17.76±18.48 µg/m³ and 23.49±20.96 µg/m³ before and after COVID-19, respectively. When one year after and before COVID-19 was evaluated, there was no difference in PM₁₀ values in terms of year averages, while SO₂ value was found to be increased compared to the previous year. However, when analyzed by months, there were months when PM₁₀ values were found to be increased (March, September and October) and decreased (July, August and November) compared to the previous year.

Keywords: Air pollution; Coronavirus disease; Particulate matter; Sulfur dioxide

1. Introduction

Coronavirus Disease (COVID-19) first appeared in Wuhan province of China in late 2019 and was identified as a pandemic by World Health Organization (WHO) on March 11, 2020 [1]. In the past year, the number of confirmed cases in the world is 120,915,219 and the number of confirmed deaths is 2,674,078 [2]. Country governments around the world have had to take some measures to prevent the spread of the disease. Also in Turkey, the spread of the pandemic was tried to be prevented by taking measures such as obligation to wear masks, closure of schools, restrictions on travel between provinces, curfews on certain days and hours, prohibition of age groups over 65 from leaving their homes and postponing collective organizations. These measures may have some secondary benefits/harms. Changes in air pollutants are one of these secondary benefits/harms.

Air pollution is an important public health problem defined as the pollution of the air with smoke, solid substances or chemicals that harm the ecological system and human health in the environment [3]. Air pollution, considered by WHO as the most important environmental risk to health, is responsible for more than 7 million premature deaths per year worldwide [4]. Primary pollutants that form air pollution are substances which are released directly to the atmosphere during the fossil fuel combustion process such as sulfur dioxide (SO₂), carbon monoxide (CO), volatile organic compounds (VOCs), nitrogen oxides (NO_x) and particulate matter (PM) [5].

PM is a common air pollutant that consists of a mixture of solid and liquid particles suspended in the air. General chemical components of PM include sulfates, nitrates, ammonium, sodium, potassium calcium, magnesium, chlorine,

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carbon, particle-bound water, metals (cadmium, copper, nickel, zinc) and polycyclic aromatic hydrocarbons [6,7]. Outdoor PM sources vary depending on specific locations and particle sizes, and generally consist of sources such as traffic-related emissions, power plants, factories, constructions, wood combustion products, and wind-borne dust [5,8]. Particulate matter has been reported to play a role in the transport of COVID-19 [9].

SO₂ is a pungent, colorless gas that emerges as the primary combustion product of fossil fuels. Especially kerosene heaters are the main source of sulphate aerosols and sulfur dioxide in the indoor environment. It is associated with a wide variety of adverse health effects, including acute respiratory morbidity and mortality [10,11].

In Turkey, 24-hour limit values of PM₁₀ (particulate matter less than 10 µm in diameter) and SO₂ contaminants are 50 µg/m³ and 125 µg/m³, respectively [12].

As a result of the measures taken due to the COVID-19 pandemic, the reduction of traffic as a result of curfews and the reduction of pollutants emitted due to the decrease in industrial production may cause a decrease in air pollution while spending more time in the homes may have caused more energy use for home heating especially in winter, and therefore an increase in the release of air pollutants [13].

The aim of this study is to evaluate the change of air pollutants in the province of Van compared to the previous year during the COVID-19 pandemic.

2. Material and methods

The study is a cross-sectional study conducted between February 15 and March 15, 2021. Van is a city in eastern Turkey with a population of 1 million 150 thousand located on the eastern shore of the largest lake in Turkey, Lake Van, it is approximately 1700 meters above sea level, has a continental climate. Its economy is based on agriculture and animal husbandry.

The data of the study were obtained from the National Air Quality Monitoring Network website [14]. PM₁₀ and SO₂ values measured between 1 March 2019-28 February 2021 at the station in the province of Van under the Southeastern Anatolia Clean Air Center Directorate of the Ministry of Environment and Urbanization were evaluated. As of March 1, 2020, it was considered the post-COVID-19 period. The lockdowns imposed in the province of Van within the scope of combating COVID-19 have been recorded by examining the decisions of the Sanitary Board on the Van Governorship's official website [15]. Ethics committee approval was not obtained, as publicly available data was used.

2.1. Statistical Analysis

Statistical analysis were performed using the SPSS software version 25. Mean, median, standard deviation, minimum and maximum values were given for descriptive data. The variables were investigated using visual (histograms, probability plots) and analytical methods (Kolmogorov-Smirnov/Saphiro-Wilk's test) to determine whether or not they are normally distributed. Mann-Whitney U test was used for comparisons for independent variables that did not conform to normal distribution, McNemar test and Wilcoxon test were used for comparisons for dependent variables. A p-value of less than 0.05 was considered to show a statistically significant results.

3. Results

In the study, the mean of PM₁₀ measurement values in the period before and after COVID-19 were 40.89±19.6 µg/m³ and 41.3±20.39 µg/m³, respectively (p=0.969). The mean of SO₂ measurement values were 17.76±18.48 µg/m³ and 23.49±20.96 µg/m³ before and after COVID-19, respectively (p<0.001).

When the effect of weekend lockdowns on air pollution is examined; in the pre-COVID-19 period, weekday and weekend average measurement values were 41.08±19.22 µg/m³ and 40.83±20.37 µg/m³ for PM₁₀, respectively (p=0.773); for SO₂, it was 18.43±18.96 µg/m³ and 17.16±17.47 µg/m³ (p=0.500), respectively. In the post-COVID-19 period, mean values for PM₁₀ were 41.56±20.66 µg/m³ on weekdays and 39.69±19.76 µg/m³ on weekends (p=0.459); mean values for SO₂ were 23.32±21.14 µg/m³ on weekdays and 24.06±20.10 µg/m³ on weekends (p=0.437) (Table 1).

Table 1 Comparison of weekday and weekend measurement values for PM₁₀ and SO₂

		Weekdays		Weekend		Mann-Whitney U test	
		Mean ±SD	Median (min-max)	Mean ±SD	Median (min-max)	Z	p
Before COVID-19	PM ₁₀	41.08 ±19.22	38 (10-140)	40.83 ±20.37	37 (10-134)	-0.288	0.773
	SO ₂	18.43 ±18.96	8 (2-85)	17.16 ±17.47	6,5 (3-70)	-0.674	0.500
After COVID-19	PM ₁₀	41.56 ±20.66	36.5 (5-115)	39.69 ±19.76	38 (10-97)	-0.741	0.459
	SO ₂	23.32 ±21.14	12 (7-103)	24.06 ±20.10	13 (7-81)	-0.777	0.437

When the PM₁₀ monthly measurement values were examined before and after COVID-19, a significant increase was observed in March (p=0.004), September (p=0.001) and October (p=0.016) compared to the period before COVID-19; a significant decrease was found in July (p=0.011), August (p<0.001) and November (p=0.003)(Table 2)(Figure 1).

Table 2 Comparison of PM₁₀ measurement values before and after COVID-19

Months	PM ₁₀ Values (µg/m ³)				Wilcoxon Test	
	March 2019 – February 2020		March 2020 – February 2021			
	Mean ±SD	Median (min-max)	Mean ±SD	Median (min-max)	Z	p
March	32.57 ±17.08	28.6 (13.1-84.6)	49.06 ±32.25	36.1 (8.7-114)	-2.881	0.004
April	25.38 ±13.29	24.25 (9.8-72.5)	23.40 ±10.27	20.85 (9.3-49.6)	-0.74	0.459
May	30.2 ±12.38	28.3 (11.7-64.4)	27.57 ±12.55	25.8 (5.1-56.8)	-0.627	0.530
June	38.19 ±8.288	35.75 (20.5-55.8)	32.48 ±10.21	31.2 (15-51.2)	-1.795	0.073
July	42.75 ±13.38	40.1 (21.5-71.2)	36.73 ±11.85	33.4 (19.5-62)	-2.541	0.011
August	45.85 ±9.872	44.1 (27.1-72.3)	33.92 ±11.02	33.8 (9.9-53)	-3.88	<0.001
September	36.43 ±9.446	35.85 (19.6-55.8)	47.77 ±10.05	50 (26.7-64.9)	-3.198	0.001
October	40.71 ±11.40	41.4 (20.4-61.3)	52.64 ±18.08	50.6 (20-89.7)	-2.41	0.016
November	57.55 ±20.68	61.65 (19.9-94.7)	39.58 ±14.41	39.8 (13-74.9)	-2.952	0.003
December	49.27 ±28.35	40.2 (19.5-133.5)	43.74 ±17.17	42.3 (20.4-83.2)	-0.539	0.590
January	48.31 ±21.68	44.9 (15.6-97.3)	54.40 ±29.27	60.2 (10.4-114.8)	-0.941	0.347
February	44.15 ±32.74	35.85 (9.8-139.9)	50.33 ±21.68	45.75 (16-100.1)	-1.612	0.107
Total	40.87 ±19.6	37.6 (9.8-139.9)	41.3 ±20.39	37.9 (5.1-114.8)	-0.038	0.969

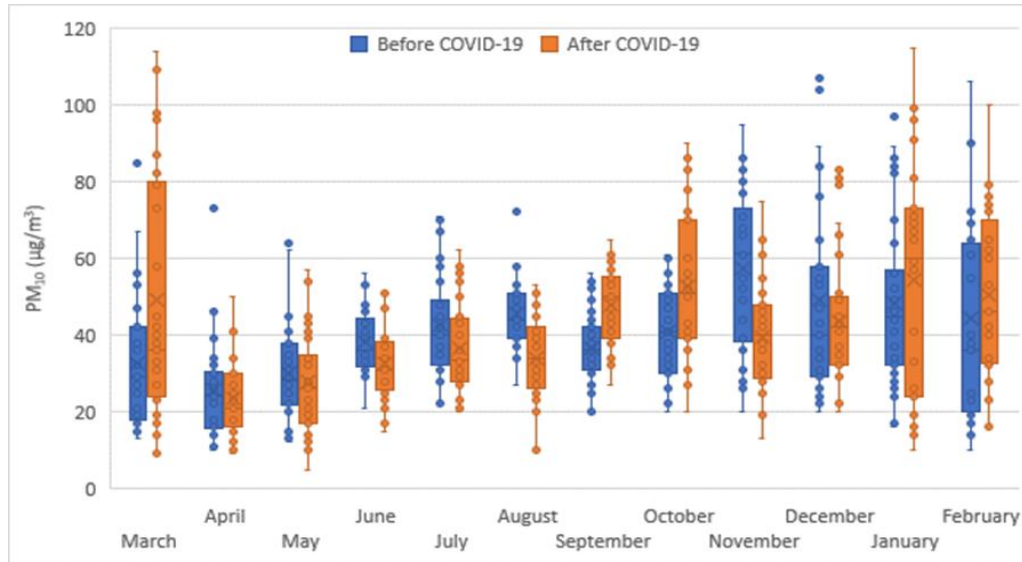


Figure 1 Change of PM₁₀ values by months

When SO₂ measurement values are examined; a significant increase was detected, except for November (p=0.417) and December (p=0.203) in the COVID-19 period, compared to the period before COVID-19 (p<0.05)(Table 3)(Figure 2).

Table 3 Comparison of SO₂ measurement values before and after COVID-19

Months	SO ₂ Values (µg/m ³)				Wilcoxon Test	
	March 2019 – February 2020		March 2020 – February 2021			
	Mean ±SD	Median (min-max)	Mean ±SD	Median (min-max)	Z	p
March	21.07 ±10.40	19.6 (8.8-52.4)	30.58 ±15.77	24.6 (12-65.9)	-3.243	0.001
April	9.55 ±3.83	8.6 (5-20.7)	12.59 ±2.83	12.3 (8.2-20.1)	-3.188	0.001
May	5.09 ±1.09	5.1 (3.5-7.3)	8.91 ±0.86	9 (7-10.9)	-4.784	<0.001
June	4.29 ±0.86	4.1 (3.3-7.2)	7.75 ±0.66	7.6 (6.7-9.3)	-4.625	<0.001
July	4.93 ±1.87	4.7 (1.7-8.9)	9.01 ±1.19	9.05 (6.8-10.8)	-4.763	<0.001
August	5.08 ±1.53	4.6 (2.9-8.5)	9.61 ±1.54	9.4 (7.4-14.9)	-4.842	<0.001
September	5.39 ±1.82	5.25 (2.7-10.8)	9.91 ±1.42	10.25 (6.9-12.9)	-4.618	<0.001
October	6.1 ±1.13	5.9 (4.3-8)	14.29 ±6.04	11.8 (8.1-30.3)	-4.861	<0.001
November	29.49 ±16.13	24.6 (6.3-63.8)	27.19 ±11.69	25.4 (9.3-54.1)	-0.812	0.417
December	36.7 ±17.04	31.5 (13.5-70)	41.95 ±15.33	37.9 (23.1-78.7)	-1.274	0.203
January	51.39 ±15.35	45 (25.9-85.1)	61.73 ±23.71	70.1 (24.3-103.3)	-1.695	0.090
February	37.48 ±12.79	37.6 (16.9-67)	48.3 ±16.18	50.25 (19.6-76.6)	-2.254	0.024
Total	17.76 ±18.48	7.5 (1.7-85.1)	23.49 ±20.96	12 (6.7-103.3)	-9.679	<0.001

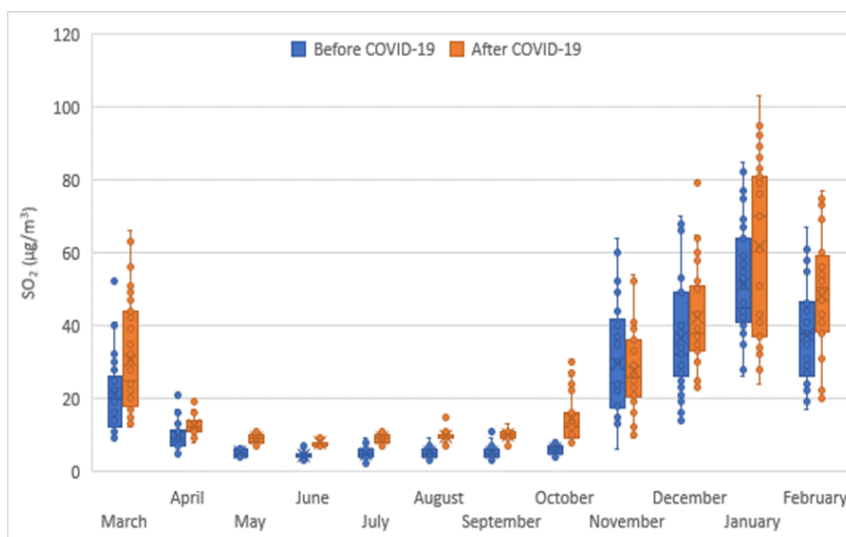


Figure 2 Change of SO₂ values by months

When the 24-hour average measurement values for PM₁₀ above the specified limit (50 µg/m³) are examined by months, while in the period after COVID-19 in September, significantly more days were above the limit values than before; in August and November, significantly more days were above the limit values in the pre-COVID-19 period compared to the post-COVID-19 period (Figure 3). For SO₂, there were no days above the 24-hour average limit value.

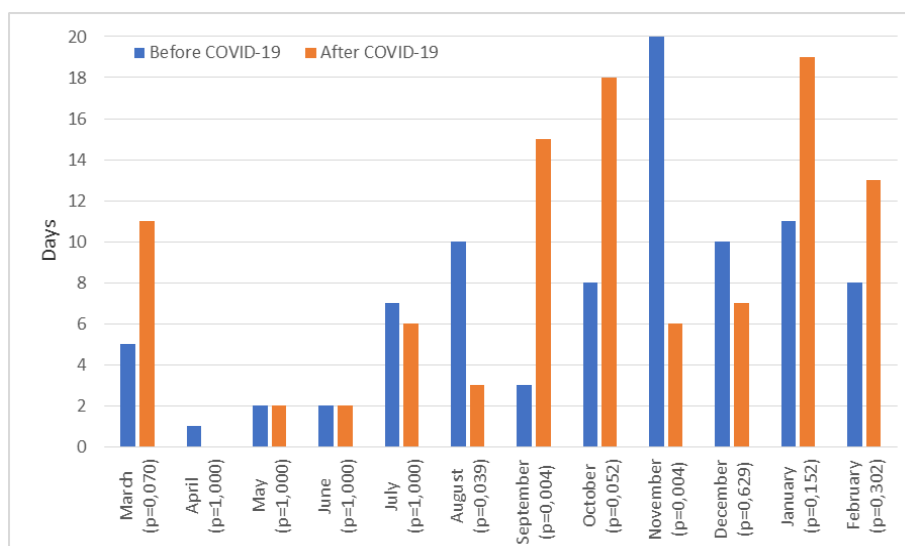


Figure 3 Comparison of the number of days when the 24-hour average PM₁₀ measurement values exceeded the limit value (>50 µg/m³) with the McNemar test.

4. Discussion

In the study, after COVID-19, while no difference was found from the PM₁₀ values of the previous year, it was observed that SO₂ values increased. It has been reported that with the COVID-19 lockdowns, air pollution from industrial activities and traffic will decrease, but the contribution of domestic pollutants to air pollution will continue [16]. The fact that the industry is not developed in Van, may have prevented a decrease due to lockdowns especially in air pollution due to PM₁₀. SO₂, which emerges primarily as a coal combustion product, was reported to be minimally affected by COVID-19 lockdowns in a study [17]. In a study conducted in England, SO₂ levels were found to be increased in the lockdown period compared to the previous year, similar to this study [18]. The reason for this has been stated that the decrease in relative humidity is associated with the increase in SO₂ levels [18]. In this study the reason for higher SO₂ in the post-COVID-19 period may be the increase in personal vehicle use due to the decrease in public transportation, and temperature, relative humidity and pressure differences.

It was observed that weekend lockdowns did not cause a change in the air pollution parameters of the province of Van. In a study comparing the data of five cities in Europe and Asia after the COVID-19 period, it was shown that there was no significant difference when the weekend and weekday values were compared for PM_{2.5} and PM₁₀ [16]. Weekend lockdowns are considered not to have a sufficient impact on air pollution parameters.

In a study conducted in 11 cities in Spain, it was reported that PM₁₀ and SO₂ values decreased in some cities during the lockdown periods, and no significant difference was found in some cities [19]. In our study, an increase was observed in PM₁₀ values in March and September in the period after COVID-19 compared to the previous year. It can be thought that the reason for the increase in March may be due to the fact that, although the restrictions have not fully started, the industry, considering the possibility of lockdown, has increased its production activities or that individuals give up the habit of using public transportation. In September, it may be thought that schools may be opened, but school buses are not preferred, personal vehicles are used, and energy consumption increases by those who spend more time in homes due to lockdowns.

There are many air pollutants other than PM₁₀ and SO₂. It is an important limitation that only PM₁₀ and SO₂ measurement values are present in the area where the study was conducted. Another limitation is that due to the underdeveloped industrial facilities of the city where the study was conducted, a relationship could not be established with the pollution in this area for the post-COVID-19 period.

5. Conclusion

When one year after and before COVID-19 was evaluated, there was no difference in PM₁₀ values in terms of year averages, while SO₂ value was found to be increased compared to the previous year. However, when analyzed by months, there were months when PM₁₀ values were found to be increased (March, September and October) and decreased (July, August and November) compared to the previous year. The effects of COVID-19 lockdowns on air pollutants have not been clearly determined. More detailed studies involving other pollutants can provide a more accurate perspective on this issue. Air pollution, which is extremely important in terms of health, should be prevented with more permanent solutions and valid policies, rather than situations with limited sustainability such as lockdowns.

Compliance with ethical standards

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Disclosure of conflict of interest

The author declare no conflicts of interest.

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