The effect of COVID-19 pandemic on air quality caused by traffic in Istanbul

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Abstract

The COVID-19 pandemic has become global public health concern and the first death due to COVID-19 in Turkey occurred on 16 March 2020. Therefore, the Turkish governments took some precautions such as curfew, travel restriction, social isolation and shut down the schools and the universities within the scope of the fight of COVID-19. These precautions may cause a decrease in mobility, which in turn expectation to decrease in traffic-related emissions. In this study, the change in the amount of PM_{10} and NO_2 pollutants were evaluated by dividing them in two periods before and after the virus in 2016 and 2020. Traffic-induced PM_{10} and NO_2 concentrations were monitored at 4 stations located close to road traffic in Istanbul. As a result of the study, it was observed that there was no significant difference in PM_{10} concentration, however NO_2 concentrations decreased by 11.8 percent in the after-virus period.

Highlights

- The effect of COVID-19 pandemic on traffic induced- PM_{10} and NO_2 concentrations in Istanbul was studied.
- The pollutants concentrations were examined using the SPSS program as two independent groups during the BV and the AV.
- There was no effect of precautions taken for COVID-19 on PM_{10} concentrations between the BV and the AV.
- The significant difference of NO_2 concentrations was observed statistically between the BV and the AV.

Introduction

A virus from the coronavirus family was detected on people in Wuhan, China in December 2019. This corona virus type has spread to Asia-Pacific region countries, North America and Europe within one month (**Fig.1**) [1]. A disease caused by this new coronavirus was temporarily called the 2019 new coronavirus (2019-nCoV) disease before 11 February 2020. The disease was renamed as COVID-19 by the World Health Organization, and the virus was classified as SARS-CoV-2 by the International Committee on Taxonomy of Viruses (ICTV) on February 11, 2020.

The virus, causing COVID-19 infectious in humans, has become a global epidemic by now. It was reported that 2,397,216 people worldwide were diagnosed with COVID-19 and 162,956 people died from this disease, while 95,591 people were put to Covid-19 diagnosis and 2017 people died in Turkey until 21 April 2020 (**Fig.2**) [1-2].

There are different approaches to prevent COVID-19 pandemic in different countries and prevent the further spread of this disease. Some of the more common approaches have seen governments COVID-19 recommendations on stay home for part or all of the country, while others have acted to limit all non-essential movement, curfew, shot down the schools cafes and universities, etc. In Turkey, curfew is only applied to those under the age of 20 or over 65. Also, the curfew between 11-12.04.2020 and 18-19.04.2020 was applied to all citizens in 30 major cities and Zonguldak province in Turkey.

Due to COVID-19 outbreak, the mobility has decreased considerably, a parallel decrease can be observed in air pollution from fossil fuel burning vehicles. Since the fossil fuels supply most of the energy requirements, especially the use of gasoline and diesel fuel in transportation, constitutes the basis of air pollution [3-5]. It was stated at the 1st Global Air Pollution and Health Conference, which was organized for the first time in the world in 2018, that air pollution caused more than 7 million people died prematurely every year [6]. These situations reveal a strong relationship between air pollution and health. Moreover, air pollution can weaken the immune system, causes people to be easily infected from the virus [7-9]. Therefore, increased air pollution may trigger an increase in the number of Covid-19 patients.

Air pollution parameters are measured in four categories as urban, rural, traffic and industry throughout the world. Particulate matter (PM_{10} and $PM_{2.5}$), Nitrogen dioxide (NO_2), NO_x , O_3 and CO are mainly measured in accordance with international standards. The size of the particulate matter (PM) effects on human health and its processes in the atmosphere varies [10]. While large particles can be kept mostly in the upper respiratory tract, thin and ultra-thin particles can reach the lower respiratory tract, lungs and alveolus [11]. Many studies on atmospheric particulate matter show that prolonged exposure to particulate matter of different sizes such as $PM_{2.5}$, PM_{10} and PM_1 has negative effects on human health and causes an increase in mortality rates [12-16]. These effects vary depending on the chemical composition of PM_{10} . Chemical components of PM_{10} include dissolved salts, metals, organic compounds, carbon products, and acids. The negative health effects of chemical components are caused by the composition of many compounds [17]. Potential health effects of pollutants in PM_{10} content depend on many factors such as toxicity, bioavailability and total pollutant content of PM_{10} . [18]. Especially, the exposure to PM_{10} concentrations may cause various chronic diseases such as lung cancer [19] asthma [20-21] and kidney disorders [22]. Furthermore, trace elements such as arsenic, beryllium, cadmium, chromium and nickel in the content of PM_{10} are classified as carcinogens by the International Cancer Research Center (IARC). On the other hand, non-cancer negative health effects of many other trace elements have also been revealed [23]. It has been demonstrated sulphate, nitrate, organic and elemental carbon components, permanent organic pollutants such as PAH and PCBs which leads serious health effects such as cancer on human health, cardiovascular and respiratory diseases can be found in the content of anthropogenic PM_{10} [24-25].

NO_2 , another most important air pollutants, reacts with volatile organic components within a photochemical reaction, forming ozone which is one of the secondary air pollutants [26]. The main sources of NO_2 are road traffic, power generation, industries and residential heating. NO_2 may cause lung

damages because of its limited solubility and high oxidative potential but it is not possible to find out whether this is due to NO₂ itself or to the secondary pollutants [27-28]. So, exposures to high concentrations of NO₂ may promote severe diseases such as colds, flu and bronchitis. Moreover, NO₂ is related with mortality from cardiovascular, ischemic heart, cerebrovascular, respiratory disease, and cancer [29-32]. According to the recent research, exposure to high concentration of NO₂ may increase the death from COVID-19, especially in cities with high air pollution [33].

In this study, the effects of COVID-19 epidemic on air pollution in Istanbul which has a population of over 15 million, were examined. The difference in PM₁₀ and NO₂ concentrations were monitored by dividing them in two periods: before and after the virus in 2016 and 2020. Traffic-induced PM₁₀ and NO₂ concentrations were evaluated at all traffic stations in Istanbul. It is also thought that gas emission from transportation will decrease due to the decrease in mobility rate.

Materials And Methods

In the study, the effects of the precautions to minimise negative effects of COVID-19 pandemic on air quality were assessed. PM₁₀ and NO₂ concentrations were monitored 79 days from 4 air quality monitoring station in Istanbul between 01.02-19.04 in 2016-2020. This period was evaluated based on all years in the two periods: before virus (BV) for 01.02-15.03 and after virus (AV) for 16.03-14.04 considering of precaution taken for covid-19. Graphic models were developed to show PM₁₀ and NO₂ concentrations which were provided by Ministry of Environment and Urbanization/Turkey National Air Quality Monitoring Network [34]. The assessment was made according to the data of 4 stations Uskudar (41° 01' 37"-29° 01' 29"), Umraniye (41° 01' 27"-29° 05' 59"), Mecidiyekoy (41° 03' 57", 28° 59' 40") and Sirinevler (41° 00' 08", 28° 50' 19") stations having high potential traffic and human density, in the traffic category in Istanbul. TURKSTAT's 2019 data shows that, the total population is 1,519,267 and the number of motor vehicles is 4,187,776 in 2019 in Istanbul [35].

PM₁₀, NO₂ concentrations and temperature were calculated daily and monthly as a result of hourly measurements at the stations. The PM₁₀ and NO₂ concentrations in the AV and in the BV were evaluated in the study period. Also, general trends of the pollutants in the study period were assessed for 2016-2020. Within the scope of European Union harmonization process, evaluation of air quality data is carried out according to the provisions of Regulation on Air Quality Assessment and Management and NO₂ and PM₁₀ have become compatible with EU limit concentrations, since 2019. According to the regulation which was published by the Ministry of Environment and Urbanization in 2008, the limit concentration for NO₂ was determined as 250µg/m³ hourly and 40µg/m³ annually (with 18 exceedances permitted per year). Also, PM₁₀ concentration was set as 40µg/m³ annually (with 35 exceedances permitted per year) and 50µg/m³ daily in order to protect human health. The concentrations of the pollutants were evaluated according to EU Directive and Regulation on Air Quality Assessment and Management (RAQAM). The measurements were made by air quality monitoring stations, according to RAQAM, the determination of

mass concentrations, in the outdoor air for NO₂ analyse, was made with chemi-luminescence as ISO 7996 the reference method. EN 12341 "Air Quality-PM₁₀ fraction determination method of suspended particulate matter" was used as reference method for measurement of PM₁₀. The measurement principle is based on collecting the PM₁₀ fraction of the particulate matter in the medium on the filter and gravimetric mass determination.

Then, the changes on the pollutants during the BV and the AV were examined for the statistical analysis using the Statistical package for the social sciences, (SPSS) program as two independent groups. IBM SPSS Statistics 22 (SPSS IBM, Turkey) programs were used for statistical analysis to evaluate the data in the study. Descriptive statistical methods (mean, standard deviation, median, minimum, maximum) were used for the data assessment. The suitability of quantitative data for normal distribution was tested within Kolmogorov-Smirnov, Shapiro-Wilk test and graphical evaluations. Mann Whitney U test was used to compare two groups of non-normally distributed data. Also, Kruskal Wallis test was used for comparisons of three or more groups that did not show normal distribution, and Bonferroni-Dunn test was used for binary comparisons. Significance was evaluated at the level of $p < 0.05$.

Result And Discussion

The average PM₁₀ concentration was $36.71 \pm 19.72 \mu\text{g}/\text{m}^3$ during the study period in Uskudar station in 2020 (**Fig.4**). The average PM₁₀ concentrations were $40.18 \pm 18.43 \mu\text{g}/\text{m}^3$ and $31.56 \pm 20.75 \mu\text{g}/\text{m}^3$ during the BV and the AV respectively. PM₁₀ concentration during the AV was lower than the BV for all years except 2016 and 2018. Also, the minimum PM₁₀ concentration was obtained in 2020. Although the minimum temperature was seen, which in turn expectation of high PM₁₀ concentration, the minimum PM₁₀ concentration was observed during the AV in 2020. Thanks to precautions taken for COVID-19 epidemic, there was statistically significant difference for PM₁₀ concentration between the BV and the AV in 2020, statistically ($p = 0.019$; $p < 0.05$) (**Table 1**).

The average PM₁₀ concentration was $46.85 \pm 21.32 \mu\text{g}/\text{m}^3$ for the study period at Sirinevler station in 2020 (**Fig.5**). As it was expected, the average PM₁₀ concentration during the AV ($45.58 \pm 23.57 \mu\text{g}/\text{m}^3$) was lower than the BV ($47.85 \pm 19.56 \mu\text{g}/\text{m}^3$). Except 2018, the PM₁₀ concentration during the BV was higher than the AV for all years. However, the differences between the BV and the AV were not attributed to positive affect on air quality in terms of PM₁₀ concentration. Although 2016 has the lowest value for PM₁₀ concentration, there was no meaningful difference for PM₁₀ concentrations between the BV and the AV, statistically ($p = 0.388$; $p > 0.05$) (**Table 1**).

The average PM₁₀ concentration was $57.31 \pm 28.40 \mu\text{g}/\text{m}^3$ in the study period and PM₁₀ concentration during the BV ($56.25 \pm 20.31 \mu\text{g}/\text{m}^3$) and the AV ($58.47 \pm 35.55 \mu\text{g}/\text{m}^3$) were seen very close to each other at Mecidiyekoy station in 2020 (**Fig.6**). Unfortunately, there was no significant difference for PM₁₀ concentrations between the AV and the BV, while expecting the AV to be lower than the BV. This indicates the importance of other emission sources for PM pollutant, such as commercial and institutional

buildings, household heating, etc. Contrary to expectations it was not seen positive effect of COVID-19 pandemic related to mobility on air quality at Mecidiyekoy station in the study period. Consequently, the statistically significant difference could not be seen for the PM₁₀ concentrations regarding to Mecidiyekoy stations ($p=0,608$; $p>0.05$) (Table 1) during the BV and the AV.

The average PM₁₀ concentration was $32.35\pm13.20\text{ }\mu\text{g}/\text{m}^3$ at Umraniye station for the study period in 2020 (**Fig.7**). There was approximately equality for PM₁₀ concentrations between the BV (32.49 ± 9.80) and the AV ($32.18\pm16.56\text{ }\mu\text{g}/\text{m}^3$) in 2020. Although the PM₁₀ concentration during the AV was higher than the BV between 2016 and 2018, the PM₁₀ concentrations during the AV were lower than the BV in 2019 and 2020. However, it cannot be seen the positive effect of the prevention taken for COVID-19 pandemic on air quality in the manner of PM10 concentration between the BV and the AV. Hence, there was no statistically significant difference for PM₁₀ concentration during the BV and the AV ($p=0.395$; $p>0.05$) (Table 1). Interestingly, for PM10 higher exceedances were recorded during the AV more than the BV only at Umraniye Station in Istanbul.

The average PM₁₀ concentrations of Istanbul, were calculated using the data from Uskudar, Sirinevler, Mecidiyekoy and Umraniye stations, were seen in **Fig. 8**. The average PM₁₀ concentration was $43.22\pm19.76\text{ }\mu\text{g}/\text{m}^3$ for the study period in Istanbul. There was approximately equality for PM₁₀ concentrations between the BV ($43.79\pm15.37\text{ }\mu\text{g}/\text{m}^3$) and the AV ($42.50\pm24.41\text{ }\mu\text{g}/\text{m}^3$) in 2020. Although PM₁₀ concentrations during the AV was lower than the BV comparing to all years except 2017, there was no statistically significant difference for PM₁₀ concentration between the BV and the AV ($p=0.215$; $p>0.05$) (**Table 1**). Hence, the precaution taken for COVID-19 pandemic on air quality was not effective. This indicates the importance of other emission sources for PM₁₀ pollutant, such as commercial and institutional buildings, household heating, etc.

When considering to all station, it was not seen statistically significant difference according to all stations ($p>0.05$) except Uskudar station ($p=0.019$; $p<0.05$) (Table 3.) for PM₁₀ concentrations between the BV and the AV. Therefore, the binary comparison was made to identify the group that creates the difference between all stations for PM₁₀ concentration. According to the binary comparison, there was statistically significant difference for PM₁₀ concentrations between the BV and the AV: Uskudar-Mecidiyekoy, Sirinevler-Umraniye, Mecidiyekoy-Umraniye stations ($p<0.01$); Uskudar-Sirinevler, Uskudar-Mecidiyekoy, Sirinevler-Umraniye, Mecidiyekoy-Umraniye stations ($p<0.05$) respectively (Table 1).

Table 1: Evaluations of PM₁₀ concentrations during the BV and during the AV at all Stations.

Stations		PM ₁₀ concentrations in 2020		^a p
		BV (n=44)	AV (n=35)	
¹ Uskudar	Min.-Max. (Median)	10,4-77,2 (40,7)	12,9-116,2 (27)	0,019*
	Avrg.±SD	40,18±18,43	31,56±20,75	
² Sirinevler	Min.-Max. (Median)	19,9-116,1 (43,8)	22,3-131,7 (41,8)	0,388
	Avrg.±SD	47,85±19,56	45,58±23,57	
³ Mecidiyeköy	Min.-Max. (Median)	22,3-125,5 (53,4)	26,6-185,1 (51,7)	0,608
	Avrg.±SD	56,25±20,31	58,47±35,55	
⁴ Umraniye	Min.-Max. (Median)	15,6-55,9 (30,1)	12,8-83,2 (29)	0,395
	Avrg.±SD	32,49±9,80	32,18±16,56	
^b p		0,001**	0,001**	
Binary evaluations between stations	^c p ₁₋₂	0,321	0,010*	
	^c p ₁₋₃	0,001**	0,001**	
	^c p ₁₋₄	0,200	1,000	
	^c p ₂₋₃	0,263	0,810	
	^c p ₂₋₄	0,001**	0,024*	
	^c p ₃₋₄	0,001**	0,001**	

^aMann Whitney U Test

^bKruskal Wallis Test

^cBonferroni Dunn Test

**p<0.01

*p<0.05

The average NO₂ concentration was 41.90±18.79 µg/m³ during the study period at Uskudar station in 2020 (**Fig.9**). The average NO₂ concentrations were 48.12±18.06 µg/m³ and 33.34±16.47 µg/m³ during the BV and the AV respectively. Considering to all years the NO₂ concentration during the AV was higher than the BV, except 2020. In addition, the minimum temperature was observed in 2020, which in turn expectation of high NO₂ concentration, the minimum NO₂ concentration was seen during the AV in 2020. This result exhibits that precautions taken for COVID-19 epidemic had positive effects on air quality. Hence, significant difference was seen for NO₂ concentrations between the BV and the AV in 2020, statistically (p=0.001; p<0.01) (**Table 2**).

The average NO₂ concentration was 62.96±23.71 µg/m³ during the study period at Sirinevler station in 2020 (**Fig.10**). The average concentration was identified as 50.05±21.13 µg/m³ during the AV, while it was 72.94±20.75 µg/m³ during the BV. Except 2018, the NO₂ concentration during the BV was higher than the AV among all years. Although 2020 had the minimum temperature in five years, the difference of NO₂ concentrations between the BV and the AV was maximum level in 2020. The positive contribution of precautions taken for COVID-19 was clearly seen. Statistically significant difference for this pollutant during the BV and the AV (p=0.001; p <0.01) supports these comments (**Table 2**).

The average NO₂ concentration was 44.41±15.35 µg/m³ during the study period at Mecidiyekoy station in 2020 (**Fig.11**). While the average NO₂ concentration was 48.79±16.05 µg/m³ during the BV, it was 39.52±13.09 µg/m³ during the AV. Contrary to other years, the average NO₂ concentration during the AV was lower than the BV in 2020. This situation indicates the results of the prevention taken for COVID-19

on air quality are positive. In addition, there was statistically significant difference for NO₂ concentration between the BV and the AV ($p=0.02$; $p<0.05$) supports this comment (**Table 2**).

The average NO₂ concentration was 53.36 ± 14.04 µg/m³ during the study period in 2020. While the average NO₂ concentration during the AV (47.08 ± 11.58 µg/m³) was lower than the BV (57.99 ± 14.01 µg/m³) (**Fig.12**). Although, the average NO₂ concentration during the BV was higher than the AV comparing to all years. Due to COVID-19 outbreak, NO₂ concentration during the AV was lower than the BV in 2020. This situation shows the success of social isolation to prevent COVID-19 pandemic, also statistically supported ($p=0.002$; $p<0.01$) (**Table 2**).

The average NO₂ concentrations of Istanbul were detected using the data from Uskudar, Sirinevler, Mecidiyekoy and Umraniye stations, in **Fig. 13**. The average NO₂ concentration was 50.82 ± 15.65 µg/m³ during the study period in 2020. Unlike other years, the average NO₂ concentration during the BV (57.61 ± 13.20 µg/m³) was higher than the AV (42.03 ± 14.68 µg/m³), in 2020. This result illustrates the positive effect of COVID-19 pandemic on air quality, also statistically supported ($p=0.001$; $p<0.01$) (**Table 2**).

The statistically significant difference was seen in the NO₂ concentrations at all stations (for Uskudar, Sirinevler and Umraniye $p<0.01$; for Mecidiyekoy $p<0.05$) during the BV and the AV. The group that creates the difference of NO₂ concentration between the BV and AV were detected by binary comparison. According to binary comparison, there was statistically significant difference between Uskudar-Sirinevler, Sirinevler-Mecidiyekoy, Mecidiyekoy-Umraniye ($p<0.01$); Uskudar-Sirinevler, Uskudar-Umraniye stations ($p<0.01$) during the BV and the AV, respectively (**Table 2**).

Table 2: Evaluation of NO₂ Concentrations in the BV and in the AV at all Stations.

Stations		NO ₂ concentrations in 2020		^a <i>p</i>
		BV (n=44)	AV (n=35)	
¹ Uskudar	<i>Min.-Max. (Median)</i>	15,9-92,8 (46,3)	9-67,6 (25,7)	0,001**
	<i>Avrg.±SD</i>	48,12±18,06	33,34±16,47	
² Sirinevler	<i>Min.-Max. (Median)</i>	33,9-122 (68,6)	18,9-99,4 (41,6)	0,001**
	<i>Avrg.±SD</i>	72,94±20,75	50,05±21,13	
³ Mecidiyekoy	<i>Min.-Max. (Median)</i>	20,7-75,9 (53,1)	16,9-67,5 (35,4)	0,020*
	<i>Avrg.±SD</i>	48,79±16,05	39,52±13,09	
⁴ Umraniye	<i>Min.-Max. (Median)</i>	29,4-86,3 (55,3)	23,2-69,3 (47,8)	0,002**
	<i>Avrg.±SD</i>	57,99±14,01	47,08±11,58	
		^b <i>p</i>	0,001**	0,001**
<i>Binary evaluations between stations</i>		^c <i>p</i> ₁₋₂	0,001**	0,003**
		^c <i>p</i> ₁₋₃	1,000	0,815
		^c <i>p</i> ₁₋₄	0,099	0,003**
		^c <i>p</i> ₂₋₃	0,001**	0,254
		^c <i>p</i> ₂₋₄	0,009**	1,000
		^c <i>p</i> ₃₋₄	0,371	0,214

^aMann Whitney U Test ^bKruskal Wallis Test ^cBonferroni Dunn Test

**** $p<0.01$**

*** $p<0.05$**

According to the related regulation (RAQAM) in Turkey and EU Directive, 24h averages of PM_{10} and 1 h averages of NO_2 limit values are $50\mu g/m^3$ and $200\mu g/m^3$ respectively. 24 h averages PM_{10} limit was exceeded 3 times during the AV-9 times during the BV at Uskudar station, 10 times during the AV-12 times during the BV at Sirinevler station, 16 times during the AV-21 times during the AV at Mecidiyekoy station, 4 times during the AV-2 times during the BV at Umraniye station. The number of days that cannot be measured PM_{10} concentration were 6, 0, 4, 1 day during the AV and 1, 0, 10, 3 during the BV at Uskudar, Sirinevler, Mecidiyekoy and Umraniye stations respectively. The NO_2 concentrations 1 h averages were exceeded only once at Sirinevler station among all stations. The number of days that cannot be measured for NO_2 concentration were 3, 1, 1, 4 days during the AV and 0, 0, 6, 2 during the BV at Uskudar, Sirinevler, Mecidiyekoy and Umraniye stations respectively.

Conclusion

In this study, the effect of social isolation due to the COVID-19 pandemic at monitoring 4 stations located close to road traffic on air quality was examined between the period of 01.02-19.04 in 2016-2020. Air quality assessment for Istanbul was carried out in two period: before and after the date of the first death from COVID-19 in Turkey. Also, PM_{10} and NO_2 concentrations in these periods were compared within 2016-2020.

Results obtained from the presents study can be aligned in the following:

- There was no significant decrease for the average PM_{10} concentration in İstanbul between the BV and AV in 2020. However, the PM_{10} concentrations remained either constant or even slightly increased during the study period at these stations. Hence, it can be stated that PM_{10} concentration is not only affected by the traffic, but also affected by fossil-fuel heating, agriculture, landfills, wildfires and industrial sources.
- There was no statistically significant difference between PM_{10} concentration and temperature at all stations during the AV and the BV in 2020.
- While a significant difference for PM_{10} concentration was observed only at Uskudar station, a significant difference was observed at all stations for NO_2 pollutants between the BV and the AV (PM_{10} and NO_2 concentration during the AV<BV) in 2020.
- NO_2 concentration in the AV are much lower than the BV in 2020, among all years. The observed decline in NO_2 is in agreement with the reduction of NO_2 emissions from COVID-19 outbreak.

As a result of the precaution taken for COVID-19, the concentration of NO_2 , one of the most important air pollutants, decreased by 11.8 percent. If NO_2 concentration which was obtained during the AV, can be kept constant in the future, the rate of deaths and diseases caused by air pollution may decrease by 10

percent. Hence, it is necessary to supply continuity of the measures taken for COVID-19, to increase the level of air quality for a healthy future and avoiding new pandemic.

Declarations

Conflicts of interest/Competing interests:

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Figures

Figure 1

Countries, territories or areas with reported confirmed cases of COVID-19, 21 April 2020 [1]. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

Figure 2

The numerical information COVID-19 in Turkey, 16.03-19.04.2020 [2].

Figure 3

Location of Air Quality Monitoring Stations.

Figure 4

Average Temperature (T), PM10 concentrations and Standard Deviation (SD) (indicated by error bars) during the BV, in the study period and during the AV at Uskudar station.

Figure 5

Average Temperature (T), PM10 concentrations and SD (indicated by error bars) in the BV, in the study period and in the AV at Sirinevler station.

Figure 6

Average Temperature (T), PM10 concentrations and SD (indicated by error bars) during the BV, in the study period and during the AV at Mecidiyekoy station.

Figure 7

Average Temperature (T), PM10 concentrations and SD (indicated by error bars) during the BV, in the study period and during the AV at Umraniye station.

Figure 8

Average Temperature (T), PM10 concentrations and SD (indicated by error bars) in the BV, in the study period and in the AV for Istanbul.

Figure 9

Average Temperature (T), NO2 concentrations and SD (indicated by error bars) during the BV, in the study period and during the AV at Uskudar station.

Figure 10

Average Temperature (T), NO2 concentrations and SD (indicated by error bars) in the BV, in the study period and in the AV at Sirinevler station.

Figure 11

Average Temperature (T), NO2 concentrations and SD (indicated by error bars) during the BV, in the study period and during the AV at Sirinevler station.

Figure 12

Average Temperature (T), NO2 concentrations and SD (indicated by error bars) during the BV, in the study period and during the AV at Umraniye station.

Figure 13

Average Temperature (T), NO₂ concentrations and SD (indicated by error bars) during the BV, in the study period and during the AV for Istanbul.