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# Assessment of Air Pollution in Trabzon During COVID-19 Measures

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## Abstract

*The COVID-19 pandemic has radically changed many routines in everyday life, usually in cities. In this period, most of the people consciously tried to isolate themselves in their homes. With the lockdowns and restrictions, human activities have significantly decreased. Also,* according *to in-situation and satellite observations; it has been found that emissions of pollutant gases in most countries have decreased significantly because of a decline in activities forming pollutants such as transportation, mining. In coronavirus and air pollution-related studies, it is seen that generally large metropolises or city centers are considered. But, this study focuses on analyzing air pollution in Trabzon which is a semi-rural city.* $PM_{10}$, $PM_{2.5}$, $SO_2$, $NO_2$, *and CO,* $O_3$ *pollutant datasets are taken into consideration as three periods which represent before (1 Jan-15 March), during (16 March-31 May), after (1 June-30 June) lockdowns. It is found that during the period of lockdown, air pollution generally decreased by 20%, while pollutant concentrations increased by 30% during the normalization period in Trabzon.*

***Keywords:*** *Covid-19, Lockdown, Air Pollution, Trabzon, Semi-Rural*

## 1. Introduction

The Coronavirus disease (COVID-19) is an infection that was first distinguished on January 13, 2020, because of exploration led in a gathering of patients who was seen respiratory manifestations (fever, cough, windedness) in Wuhan Province in late December, (Türkiye Cumhuriyeti Sağlık Bakanlığı. 2020). Most countries around the world have temporarily closed various government intuitions to prevent the spread of COVID-19. For instance, in China, Chinese specialists shut down transportation and travel all through Wuhan. They additionally tried to decrease local travel, shut down schools and universities, established various quarantines, and declared lockdowns in order to lessen the spread of the illness, (Dutheil et al. 2020). In Turkey, the first case was seen on March 11. First, the government banned going out over the age of 65 and then under the age of 20 on March 16. On April 10, an inclusive lockdown was announced by the Ministry of Interior. While the Lockdowns periodically applied, generally on weekends, special bans were imposed by local governments in areas where the number of cases could not be controlled in Turkey. Also, pollution emissions have declined noticeably in this period which the industry had to temporarily pause, transportation came to a halt, and people had to change their daily routines. For example, according to the findings from ESA's Sentinel-5P satellite, nitrogen dioxide ($NO_2$) levels over China have decreased significantly compared to last year, (National Aeronautics and Space Administration, 2020). In addition, there are many studies examining the relationship between this pandemic period and air quality in various countries. In Rio de Janeiro, Brazil, low traffic and suspended economies give rise to the decline of 37.0–43.6% of the concentration of NOx and CO compared to the same period in 2019 (Dantas et al., 2020). Also, In the US, there is a significant decrease in the concentration of $NO_2$ were observed as 25.5% during the COVID-19 period (March 13–April 21st) (Berman and Ebisu, 2020) In a study in Turkey, it was shown on map difference of maximum values of nitrogen dioxide in two periods differ each other as 95 µg/m³. This value corresponds to an approximately 57% reduction of $NO_2$ in some parts of the working area, (Kaplan and Yiğit, 2020). In another study in Konya, Turkey it is seen that with the reduction of traffic and industrial activities; air quality has been improved. It is also observed that the concentration of $PM_{10}$ decreased by 40% compared to the first period (1 January- 15 March) (Shayia et al., 2020). On the other hand, the aim of this study is to reveal the effect of lockdowns caused by the COVID-19 outbreak on air quality which is determined by the presence of pollutants ($PM_{10}$, $PM_{2.5}$, $SO_2$, $NO_2$, and $O_3$) in a semi-rural province such as Trabzon. In addition, to our knowledge, this is the first study that evaluates the COVID-19 outbreak and air pollution relationship for the province of Trabzon. The difference of this study from other conducted studies in the literature is that not only includes the lockdown but also the normalization period and 6 different pollutants were analyzed.

## 2. Materials and Methods

### 2.1. Study Area

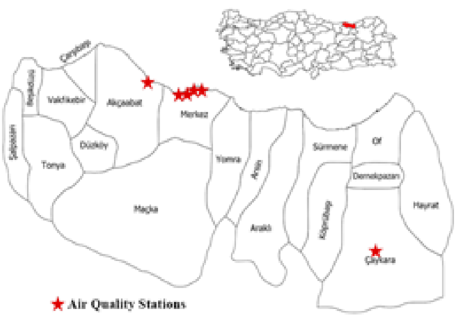


*Figure 1. Map of Air Quality Station in Trabzon*

Trabzon (41.0027° N, 39.7168° E) which is located in the Eastern Black Sea part of the Black Sea Region has an area of 4685 km2 (Figure 1) (Türkiye Cumhuriyeti Kültür ve Turizm Bakanlığı, 2020). It is surrounded by Gümüşhane and Bayburt in the south, Giresun in the west, Rize in the east, and the Black Sea in the north. Trabzon, one of the most important port cities of the Black Sea, has a population of 808,974, (Eastern Blacksea Development Agency, 2020). More than half of the population (56%) live in city centers, while 44% live in rural areas. On account of its closeness to significant locales, for example, the Caucasus, Russia, the Middle East, and Central Asia, Trabzon is an intersection point and is much of the time referenced in intercontinental transportation projects. With international highway connections and mountain passes, easy access is provided to both neighboring countries and inner regions (Türkiye İstatistik Kurumu, 2019). The altitude starting from sea level increasing towards the south reaches 3000 meters in the region. In the higher parts, there are generally mountains, hills, and plateaus. The province of Trabzon is located on the transition area of polar air masses in the north and tropical air masses in the south. Due to the presence of the Black Sea in the north and the presence of the Eastern Black Sea Mountains that stretch like a set close to the coast, Trabzon becomes quite temperate compared to other areas at the same latitudes, (Türkiye Cumhuriyeti Trabzon Valiliği, 2020.).

### 2.2. Data

In order to determine how the lockdown imposed in the province of Trabzon due to coronavirus affects local air quality, the air quality stations belong to the Ministry of Environment and Urbanization were examined. According to Figure 1 it is clearly seen that, these stations are Akçaabat (39,5923°N, 41,0143°E), Beşirli (39,6682 °N, 40,9938 °E), Fatih (39,6943° N, 40,9992°E), Meydan (39,7316° N, 41,0045°E), Uzungöl (40,3060° N, 40,6227°E), Valilik (39,7123° N, 41,0059°E) (Figure 2). In addition, $PM_{10}$, $PM_{2.5}$, $SO_2$, $NO_2$, $O_3$, and CO hourly measurement data of the stations before, during, after the COVID-19 Lockdown period in 2018, 2019, 2020 were used. The data count threshold for the pollutant in each station was taken as 75%. And the data were analyzed separately in each period according to this threshold. In other words, pollutant data whose data percentage does not exceed 75% are not included in the calculation.

### 2.3. Methods

All graphics and calculations were made with the R programming language (RStudio Version 1.2.5033) and MS Excel. Quality control was applied to the data before it was calculated and plotted. Extreme points, negative values, and repeating values were examined in the data. While applying the correction process, Pearson correlation analysis was applied.

While applying this, a high value such as 0.80 (r >0.80) was determined as the correlation coefficient threshold. Stations that are close or exposed to similar meteorological influences (winds, precipitation) are included in the correlation calculation and only the lockdown period taken in order to obtain high representativeness of stations. The provincial averages and daily means from the stations' data were calculated using the arithmetic average.

## 3. Results and Discussion

### 3.1 Overview of Stations Pollution Data

According to the dataset belongs to Akçaabat Air Quality station (Figure 2), the average values of $PM_{10}$, $NO_2$, $SO_2$, $O_3$, CO were measured as 37.7, 29.7, 29.7, 44.8, and 790.5 µg/m³ respectively. Also, the extreme values were measured maximum (max) - minimum (min) as 126.08 - 11.31 µg/m³, 90.40 - 5.70 µg/m³, 30.839 - 0.264 µg/m³, 94.562- 8.732 µg/m³, 2123.7- 346.4 µg/m³ respectively. For $NO_2$, there is 115 (12.6%) missing data belongs to April. Lastly, it is found that the skewness of all pollutants is positive.

According to the dataset belongs to Beşirli Air Quality station (Figure 3), the average values of $PM_{10}$, $NO_2$, CO, $PM_{2.5}$ were measured as 42.11, 42.261, 534.6, and 22.060 µg/m³ respectively. Also, the extreme values were measured maximum (max) - minimum (min) as 124.80 - 0.43 µg/m³, 81.950 - 9.384 µg/m³, 1318.0 - 161.1 µg/m³, 58.239 - 4.444 µg/m³ respectively. For $PM_{10}$, there are 85 (9.3%) missing data belongs to January and May. Also, there is 40 (4.4%) missing $NO_2$ data belongs to April and May. And, 42 (%4.6) missing data are seen in July and August in CO dataset. Lastly, it is found that the skewness of all pollutants is positive. But $NO_2$ shows an almost symmetrical data feature.

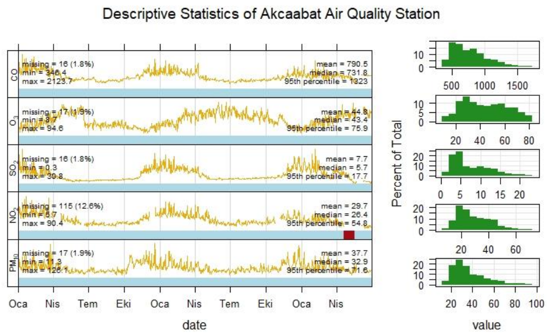


*Figure 2. Descriptive Statistics of Akçaabat Air Quality Station*

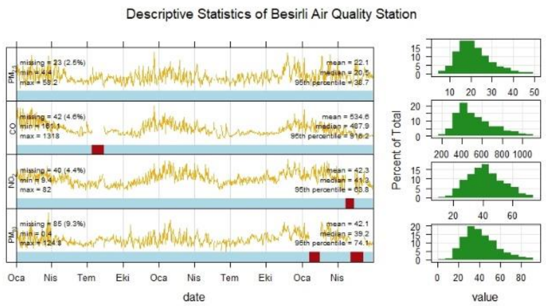


*Figure 3. Descriptive Statistics of Beşirli Air Quality Station*

According to the dataset belongs to the Fatih Air Quality station (Figure 4), the average values of $PM_{10}$, $NO_2$, $SO_2$, CO were measured as 44.52, 42.74, 5.505, and 769.0 µg/m³ respectively. Also, the extreme values were measured maximum (max) - minimum (min) as 181.265 - 9.959 µg/m³, 124.425 - 6.896 µg/m³, 26.4861 - 0.8063 µg/m³, 2527.1 - 246.5 µg/m³ respectively. For $NO_2$, there is 30 (3.3%) missing data belongs to May. Also, there are 105 (11.6%) missing $SO_2$ data belongs February, March, April, and May. And, 98 (10.7%) missing data were seen in July and August in CO dataset. Lastly, it is found that the skewness of all pollutants is positive.

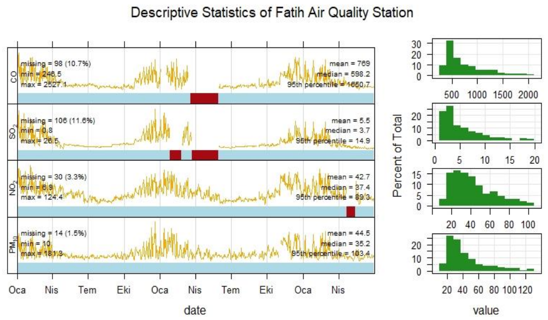


*Figure 4. Descriptive Statistics of Fatih Air Quality Station*

According to the dataset belongs to Meydan Air Quality station (Figure 5), the average values of $PM_{10}$, $NO_2$, $SO_2$, were measured as 37.546, 43.08, and 12.4512 µg/m³ respectively. Also, the extreme values were measured maximum (max) - minimum (min) as 165.728 - 2.637 µg/m³, 164.00 - 10.70 µg/m³, 72.9267 - 0.1171 µg/m³ respectively. For $PM_{10}$, there are 262 (28.7%) missing data belongs to September, October, November, December, January, February, March. Also, there is 230 (25.2%) missing $SO_2$ data belongs to the same months as $PM_{10}$. Lastly, it is found that the skewness of all pollutants is positive.

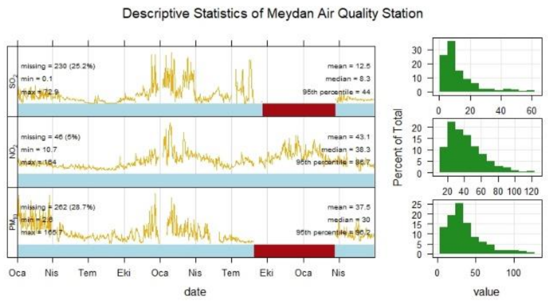


*Figure 5. Descriptive Statistics of Meydan Air Quality Station*

According to the dataset belongs to Uzungöl Air Quality station (Figure 6), the average values of $PM_{10}$, $NO_2$, $SO_2$, $O_3$ were measured as 15.470, 5.988, 2.7408, and 49.09 µg/m³ respectively. Also, the extreme values were measured maximum (max) - minimum (min) as 104.980 - 0.550 µg/m³, 22.070 - 1.898 µg/m³, 9.9092 - 0.3129 µg/m³, 95.85 - 12.77 µg/m³ respectively. For $PM_{10}$, there are 662 (72.6%) missing data belongs to the May-March period. Also, there is 352 (38.6%) missing $NO_2$ data belongs March and August – June period. And, 67 (7.3%) missing values were seen in March and April in the $SO_2$ dataset. For $O_3$, there are 63 (6.9%) missing data belongs to the same months as $SO_2$ data. Lastly, it is found that the skewness of all pollutants is positive. But $SO_2$ and $O_3$ show almost symmetrical data feature.

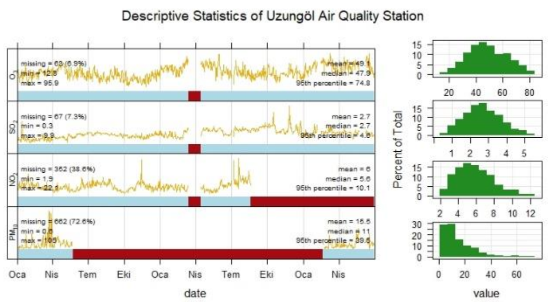


*Figure 6. Descriptive Statistics of Uzungöl Air Quality Station*

According to the dataset belongs to Valilik Air Quality station (Figure 7), the average values of $PM_{10}$, $NO_2$, $SO_2$, and $O_3$ were measured as 20.528, 24.442, 7.5573, and 45.666 µg/m³ respectively. Also, the extreme values were measured maximum (max) - minimum (min) as 85.093 - 3.837 µg/m³, 100.460 - 3.078 µg/m³, 53.3717 - 0.1173 µg/m³, 129.400 - 4.288 µg/m³ respectively. For $PM_{10}$, there are 284 (31.1%) missing data belongs to June, July, and August - March period. Also, there is 363 (39.8%) missing $NO_2$ data belongs June – April periods. And, 668 (73.2%) missing values were seen in April – June, and September – March period in the $SO_2$ dataset. For $O_3$, there are 110 (12.1%) missing data belongs to June, July, February, March. Lastly, it is found that the skewness of all pollutants is positive.

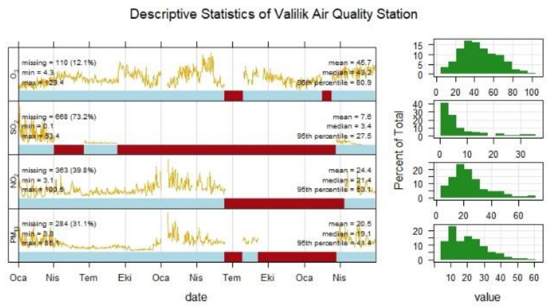


*Figure 7. Descriptive Statistics of Uzungöl Air Quality Station*

### 3.2 Pollutant Concentrations by Periods

Pollutant concentration changes were examined in terms of years and periods. The first period represents the interval before the coronavirus epidemic (January 1 - March 15), the second period to the during lockdown (March 16 - May 31), and the third to after the lockdowns. (June 1 - June 30).

**a) $PM_{10}$**

According to Table 1 and Figure 8, There is a decline in the concentration of $PM_{10}$ between the First and third period gradually for both years of 2018 and 2019. In contrast, there is a little or no decrease in $PM_{10}$ concentration in 2020 in the third period because, with the lifting of lockdowns or bans, people continued their everyday life. In Trabzon, the concentration of pollutants in the first period of all years was higher compared to other periods. This is thought to be due to domestic warming as it is included in the March warming season. In addition, the difference between $PM_{10}$ concentrations in 2018 and 2019 is very small in the second period when compared to each other. In contrast, 16% percent of the decline was observed in the same period in 2020 because of the effects of lockdown. After the lockdown, due to the danger that the virus could spread, people preferred using private cars instead of public transportation. In addition, suspended factories, especially cement and timber, which are located in Trabzon started up again. Mostly, this caused a 13% increase in $PM_{10}$ in 2020.

*Table 1. Annual mean $PM_{10}$ concentrations by periods*

| | $PM_{10}$ (µg/m3) | | | |
|---|---|---|---|---|
| Period | 2018 | 2019 | 2020 | Change (%) |
| First | 43 | 52 | 48 | 2 |

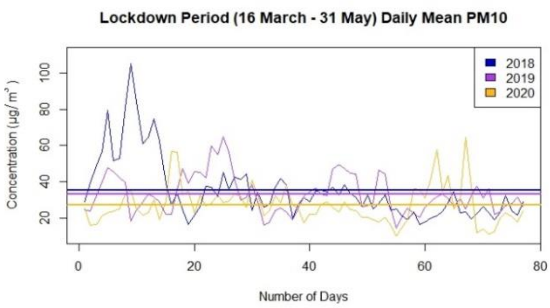


*Figure 8. Second period daily mean $PM_{10}$ by years*

**b) $NO_2$**

According to Table 2 and Figure 10, there is a decrease in the concentration of $NO_2$ between the periods. However, the biggest decrease was observed in the last period with sunnier days. Because UV lights affect $NO_2$ concentrations by turning it into $O_3$ via chemical reactions. In addition, the effects of the lockdown can be seen clearly; There is a %10 percent decrease of pollutant concentration was observed in the second period similar to $PM_{10}$. After lockdown, a decrease in pollution concentration (8 µg/m3) has been observed, but that decrease is not as great as in 2018 or 2019. Because some of the human activities played a major role in increasing pollutant emissions such as the end of the transportation ban. Also, it is found that the concentration of $NO_2$ is higher than in the first and third periods compared to 2018 and 2019.

*Table 2. Annual mean $NO_2$ concentrations by periods*

| **$NO_2$ (µg/m3)** | | | | |
|---|---|---|---|---|
| Period | 2018 | 2019 | 2020 | Change (%) |
| First | 40 | 48 | 51 | 15 |
| Second | 36 | 42 | 35 | -10 |
| Third | 21 | 19 | 27 | 31 |

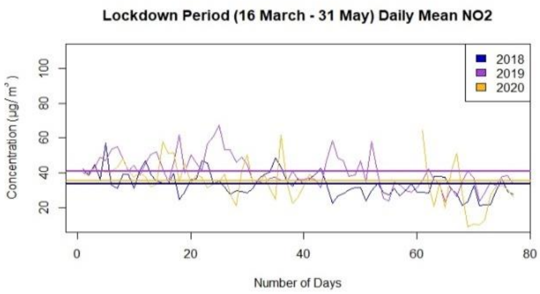


*Figure 9. Second period daily mean $PM_{10}$ by years*

**c) $SO_2$**

According to Table 3 and Figure 11, it is clearly seen that, concentration has dropped continuously by the years. In general, $SO_2$ concentration was observed to be low due to the lack of a significant number of industrial facilities and low use of poor quality coal thanks to the support of using natural gas by the provincial administration in Trabzon. In addition, It has been observed that the sulfur dioxide concentration resulting from the use of poor quality coal in Trabzon tends to decrease in the transition from winter to summer months. Also, it is found that air pollution caused by sulfur dioxide is very low in Trabzon. During the lockdown, it can be seen that the decrease in pollutant concentration has the biggest rate (-%49). After the lockdown period the drop rate that found lowest as -25%. The reason for this is that factories, which were temporarily closed during the pandemic period when the rate of pollution reduction was too high, reopened in the third period.

*Table 3. Annual mean $SO_2$ concentrations by periods*

| **$SO_2$ (µg/m3)** | | | | |
|---|---|---|---|---|
| Period | 2018 | 2019 | 2020 | Change (%) |
| First | 10 | 15 | 8 | -38 |
| Second | 6 | 11 | 5 | -49 |
| Third | 3 | 5 | 3 | -25 |
| Second | 34 | 33 | 28 | -16 |
| Third | 21 | 26 | 27 | 13 |

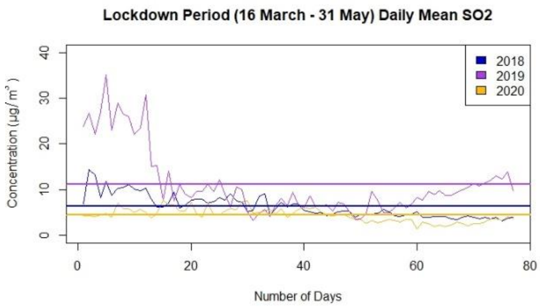


*Figure 10. Second period daily mean $SO_2$ by years*

**d) $O_3$**

According to Table 5 and Figure 12, it is observed that the concentration of $O_3$ has increased especially in the third period belonging to 2020 because of solar radiation and lifting the lockdown. The concentration of ozone is increased by 32% compared to 2018 and 2019. The reason for this increase is the increase in harmful gas emissions from vehicles especially chemicals that can react with the effect of sunlight, as mentioned in previous pollutants. During lockdown, the concentration of ozone is also increased because of incoming solar radiation by %3 via Chapman Process.

Table 4. Annual mean $O_3$ concentrations by periods

| **$O_3$ (µg/m3)** | | | | |
|---|---|---|---|---|
| Period | 2018 | 2019 | 2020 | Change (%) |
| First | 32 | 49 | 44 | 9 |
| Second | 52 | 64 | 60 | 3 |
| Third | 49 | 51 | 66 | 32 |

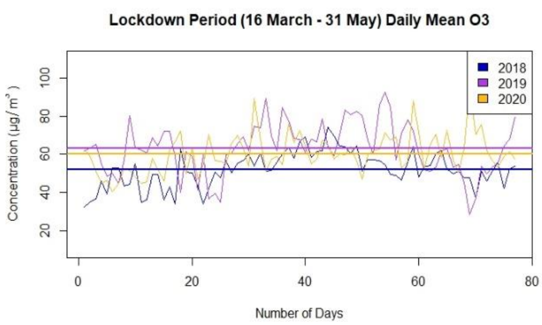


*Figure 11. Second period daily Mean $PM_{10}$ by years*

**e) CO**

According to Table 5 and Figure 12, it is seen that there is a decrease in the concentration of CO by years. In 2020 the third period is 5% higher than in the same period in 2019. In other words, the decreasing trend has deteriorated in 2020. The cause of this can be explained the same as the $NO_2$ emission increased: The increase in the use of private vehicles and the resumption of wood, lumber, and cement factories in various locations of the Trabzon province. These factories were also operating in 2018 and 2019, but due to the increasing demand started to operate at full capacity. In addition, a decreasing trend is observed when pollutant concentrations are compared over the years.

*Table 5. Annual CO concentrations by periods*

| CO (µg/m3) | | | | |
|---|---|---|---|---|
| Period | 2018 | 2019 | 2020 | Change (%) |
| First | 1125 | 930 | 838 | -18 |
| Second | 686 | 638 | 573 | -14 |
| Third | 519 | 438 | 504 | 5 |

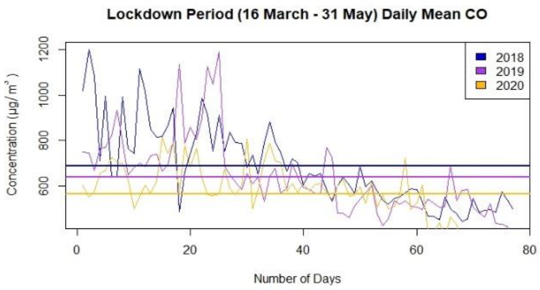


*Figure 12. Second period daily Mean CO by years*

**f) $PM_{2.5}$**

According to Table 6 and Figure 14, although there was no visible change in the first and second periods, the pollution increased by 51% in the third period. The reason for this is the release of some human activities as seen other pollutants'. Considering the trend, there is a decrease in concentration from winter to summer months. So, it can be interpreted that one of the reasons for $PM_{2.5}$ pollutions is heating.

***Table 6.*** *Annual CO concentrations by periods*

| $PM_{2.5}$ (µg/m$^3$) | | | | |
|---|---|---|---|---|
| Period | 2018 | 2019 | 2020 | Change (%) |
| First | 26 | 24 | 24 | -4 |
| Second | 26 | 20 | 23 | -1 |
| Third | 15 | 17 | 24 | 51 |

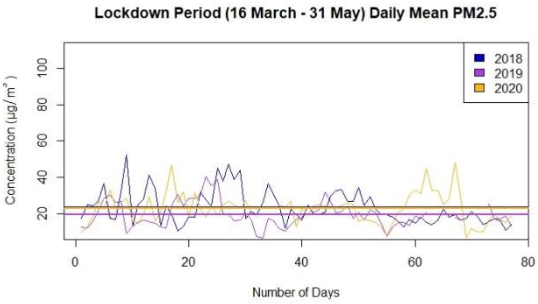


*Figure 13. Second period daily Mean $PM_{2.5}$ by years*

## 4. Conclusion

It is known that pollutants that form air pollution, which damage organic and inorganic substances are dependent on many natural and anthropogenic factors. With the declaration of the lockdown during the coronavirus epidemic period, most of the anthropogenic pollution sources have decreased in Trabzon. The number of vehicles in traffic was very low, factories were temporarily closed and people have started to isolate themselves during the lockdown.

The primary reason for the formation of air pollution in the period before the epidemic is heating. January, February, and March are the winter months, and even though the winter is not harsh in Trabzon, the air temperature drops below 15 C frequently. Also, the concentration of $SO_2$ and CO decrease can be mentioned (38% and 18%) for the first period compared to 2018 and 2019 because of the efforts of local governments to improve air quality including usage of low-quality coal ban.

In Second Period (16 March-31 May), it is clearly seen lockdown effects on air pollution. It is observed that concentration of $PM_{10}$, $NO_2$, $SO_2$, CO has decreased by 16%, 10%, 49%, 14% accordingly thanks to measures such as the prohibition of transportation to big cities, curfews, and stopping of flights. The closure of businesses such as cafes, restaurants, coffee shops, shopping centers, and the suspension of the operations of cement and wood factories in Trabzon has a great role in increasing air quality especially.

In the Third Period (1 June-30 June), with the normalization process, there has been a noticeable increase in pollutant concentrations due to the reopening of the commercial enterprises, the resumption of suspended industrial mining activities, and the people returning to their old life habits. Also, it has been recorded that many people came from different provinces, especially Istanbul. In this period concentrations of $PM_{10}$, $NO_2$, $O_3$, $PM_{2.5}$ increased by 13%, 31%, 32%, 51% accordingly compared to the same period in 2018 and 2019.

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# The Effect of COVID-19 outbreak on Air Quality of Istanbul city centre

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## Abstract

Air pollution, which is one of the biggest problems of humanity from past to present, has a permanent negative effect on life and human health. The most important role in the increasing concentration of air pollution along with human activities is in the use of fossil fuels. The exhaust fumes from vehicle use, industrial activities and the fumes that emerge as a result of the use of fuel for heating are caused by the burning of fossil fuels. These fumes are released into the atmosphere and play an important role in the increase of air pollution concentration. Recently, an outbreak of the Covid-19 virus, which has spread worldwide and has become a major threat to human health, has been able to make a major spread through contact. March May 16, 2020 – May 31, 2020, which is considered a pandemic process in Turkey, human activities were restricted and the public was urged to stay at home because Covid-19 virus posed a huge risk. With the reduction of human activities known as the biggest source of air pollution with the covid-19 pandemic process, changes in air pollution values were observed. The year 2020, which includes 2018, 2019 and the pandemic process, in order to observe this change and to compare it with other years, January 1 - March 15, considered the pre-pandemic process; March 16 - May 31, considered the pandemic process; June 1 - June 30, considered the normalization process. According to these 3 different period, the effect of human activities on air pollution has been studied.

**Keywords: Air pollution, Covid-19, Istanbul, Fossil fuels, PM, sulphur dioxide, NOx, O3**

## 1. Introduction

Covid-19 is a virus that can cause acute respiratory syndrome and result in death, which emerged on December 31, 2019 in Wuhan, China. In a short period of time, the virus spread rapidly throughout the world through human interaction, causing it to become a pandemic. The first case of Covid-19 in Turkey occurred in mid-March 2020, and several measures were required by the government to prevent the spread of virus in Turket (TMMOB, 2020). In line with the measures taken, due to the pandemic process, people have started to continue their education and working lives in their homes. As people start to stay at home, social activities decrease with the formation of substances that will cause air pollution and this process has resulted in significant decreases for air pollution (Aktan,2020).

Air pollution is the presence of pollutants such as ozone (O3), particulate matter (PM), sulphur dioxide (SO2), nitrogen oxides (NOX) in the atmosphere at a level that will have a negative effect on human health and the environment. Air pollution arises from industrial facilities, exhausts from vehicles, fuel consumption resulting from the need for residential heating. Air pollution generally occurs as a result of human activities. Therefore, air pollution is high in places where human activities are high compared to places where human activities are low. The effect of air pollution on human health is quite large. This effect depends on similar characteristics of airborne pollutants such as time, location, and concentration (URL-1). Research has shown that people who live and are exposed to air pollution in countries such as Italy, the US and the UK are worse affected by the Covid-19 virus(URL-2). Air pollution has affected human health not only during Covid-19, but at all times of life. A notable example of this is air pollution, which occurred in London in 1952 as a result of fossil fuel use, resulting in the deaths of about 12,000 people (Üzümoğlu, 2020).

The population of Istanbul was determined as 15.52 million according to the data in 2019. Along with the large human population, the use of fuel to meet the need for industrial activities, vehicle use and heating, which have the biggest roles in air pollution, is also high. According to 2011 data, approximately 52% of the industrial sector assets are in Marmara region. Istanbul has the largest share both in the region and in the country. 32% of total establishments in the country, 24.4% of employees and 33.8% of investment incentive certificates are located in Istanbul. Furthermore, 23% of the added value created, 49% of imports and 45% of exports are realized by ide Istanbul (Doğan, 2013). Industrial air pollution is mainly seen as a result of wrong location selection and disposal of waste gases into the atmosphere without adequate technical measures. The quality and quantity of the fuel used is often able to determine the pollutant potential of industrial establishments (URL-3). At the same time, the increase in vehicle usage as a result of the increasing need for transportation in direct proportion to the population increases the amount of air pollution that occurs as a result of exhaust in the atmosphere. In the traffic density index of TomTom, Europe's largest navigation systems company; Istanbul ranked 9th as a result of the study measuring traffic density in 416 cities in 57 countries spread over six continents (URL-4). Especially in large cities, motor vehicle-induced air pollution has been shown to exceed 70% of total pollution and warming-induced air pollution causes at least 2 times more of this pollution. As the number of vehicles in traffic and traffic congestion increases, the emission of air pollutants from transportation increases at that rate. The main source of volatile organic substances, nitrous oxide, PM 2.5 and PAH pollutants are diesel vehicles. In our country, there are significant increases in the number of motor vehicles. According to TurkStat data, the number of vehicles, which was 8,655,170 in 2002, has increased to 21,940,757 as of September 2017. The number of Motor Vehicles has increased 2.5-fold in the last 15 years. Air pollution also causes twice as many deaths from road accidents, according to the UK study (Öztürk, 2017). Finally, air pollution caused by heating, which is another important factor in air pollution, reaches high values with the increase in the use of heating devices due to the cooling of the weather in winterHeavy metals such as arsenic and mercury in coal, which are one of the fuels used for heating, are also emitted into the atmosphere in the stove smoke as a result of the coal burning. In addition, airborne pollutants can be transformed into other pollutants or cause different environmental problems by atmospheric reactions and removal from the atmosphere (Özen, 2016). Efforts to reduce the share of pollutants in the air by disseminating natural gas from fuels used to meet the need for heating are very important in this case. The measurement of the pollutants that cause the air pollution is carried out by measuring devices in stations, especially in places where the public, plants, trees, animals, vehicles, structures and materials are exposed to air pollution. The number of stations required to be set up for various air pollutants and the minimum measurement frequency vary. The number of measuring stations shows an increase or decrease depending on the population number. As a result of the measurements made at these stations, it is aimed to increase air quality by reducing air pollution by taking the necessary measures to improve air quality in the investigations carried out. Thus, the ratio of pollutants that are harmful to both the environment and human health is reduced in the atmosphere. The aim of this study is to examine the effect of the COVID-19 pandemic process on air quality and compare the air quality values of the period before and after the outbreak measures were taken, as well as the previous years of the same periods.

## 2. Material and Method

### *2.1. Research Area*

Istanbul, as the subject of the article, is composed of two peninsulas that serve as a bridge between Europe and Asia. Its latitude is 41°00” 16”and its longitude is 28°58’59". It is located in a region where the transition from the Mediterranean climate, which is hot and dry in summers and warm and rainy in winters, to the Black Sea climate, which is hot in summers and warm in winters but rainy in all seasons. It is the most populous province in Turkey and has significant value both historically and economically. The fact that there is a lot of human activities due to the large population also brings the effect of air pollution.

### *2.1. Supply of Air Quality Data for Research Area*

NO2 and O3 data for 2018, 2019 and 2020 for the province of Istanbul are T.C. Provided in Excel file format from the website of the Ministry of Environment and Urbanization(URL-5).

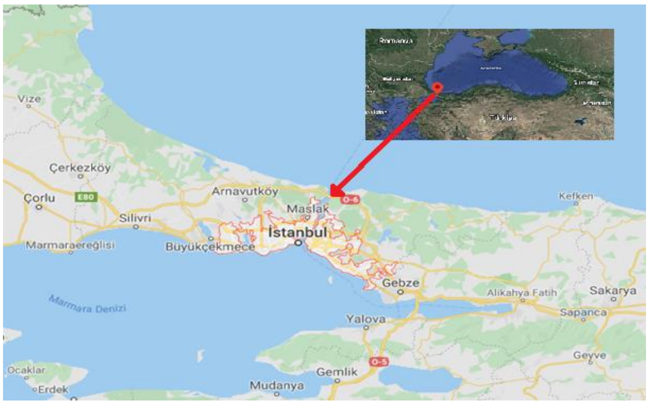


*Figure 1. Investigation Location of the Istanbul.*

### *2.2. Method*

By using the data obtained in Excel format from the Ministry of Environment and Urbanization in order to see any positive or negative change in air quality with the COVID19 process in Istanbul;

- By analysing the NO2 concentration, which is one of the important components of air pollution, the effect of human activities on air pollution will be examined,
- The effect of ozone, whose most important source is the sun, on air pollution and its relationship with NO2 will be examined,
- The connection of air temperatures with O3 values will be discussed,
- The pandemic process that started in 2020 and the data of 2018 and 2019 covering the old normal will be compared, so that the effect of the pandemic process on air pollution will be clearly seen,
- With meteorological data, it will be clearly seen how much air pollution depends on human activities.

## 3. Result and Discussion

The main pollutants of air pollution are $SO_2$, $NO_X$, CO, lead, hydrocarbons, particulate matter and $O_3$. Along with the rapid population growth in cities, improper location in cities according to topographic and meteorological conditions, the type of fuel used to meet the heating need in houses, air pollution problem is experienced depending on the compatibility of the combustion system with the fuels used. Although the main source of the heating-induced air pollution problem is the fuel used, the emissions that will occur vary according to the type of fuel; these are carbon monoxide (CO), sulphur dioxide ($SO_2$), nitrogen dioxides ($NO_X$) and particulate matter. In addition, air pollution from industrial plants, depending on the type of fuel used carbon monoxide (CO), sulphur dioxide (SO2), nitrogen dioxides (NOx) and particulate matter such as pollutant parameters emerge. Finally, transportation vehicles, which are another factor in the formation of air pollution, are a part of our daily life. These motorized road vehicles, which we use every day in different ways, pollute our environment and the air we breathe with the pollutant gas and particles they give to the air (URL-6). Nitrogen dioxide ($NO_2$), one of the major pollutants of air pollution, is formed by the combustion reaction of fossil fuels such as gas, coal and oil. Nitrogen, which makes up 78% of the air we breathe, creates $NO_X$ by performing a combustion reaction and is evaluated as the sum of NO and $NO_2$. In the presence of sunlight, as a result of photolysis of nitrogen dioxide ($NO_2$), ozone ($O_3$) is formed as a result of various reactions. This reaction needs sunlight in the UV band (300-390 nm). On sunny days, it starts at noon, leading to the rapid depletion of $NO_2$. This reaction rate is very variable according to the hours of the day and reaches its maximum value at noon on summer days. As mentioned earlier, fuel use and transportation vehicles in residential and industrial facilities, which are the main reasons for the formation of $NO_2$, cause gas to be converted to $NO_2$ by a chemical reaction in the atmosphere after it is sent into the air through the flue or exhaust. Furthermore, the presence of $O_3$ in the air accelerates this transformation even further(Cindoruk,2018).

Within the scope of the study, daily average $NO_2$ and $O_3$ concentrations measured at 32 stations in Istanbul from January 2018 to July 2020 were evaluated.

Figure 2 shows the average $O_3$ values obtained from each station in Istanbul. As seen from the chart on January 2018 – June 2020 if the measured average O3 concentration values in Istanbul are examined, the winter months December from February experiencing declines in values of O3, while the O3 peak was reached in the summer months of the year (Figure 2).

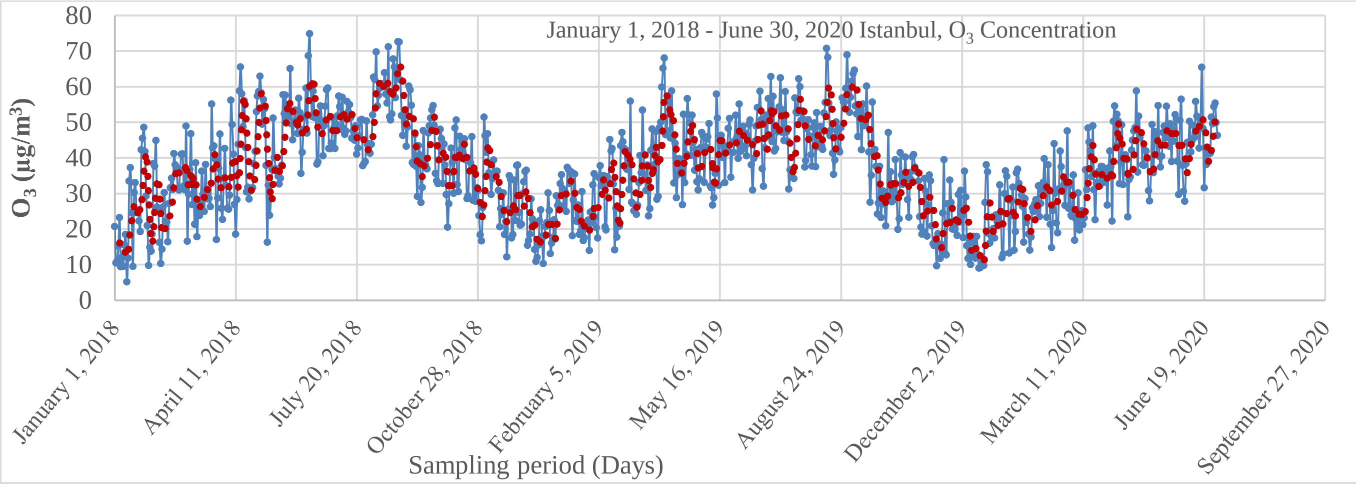


*Figure 2. O3 values Istanbul city between 1.1.2018 and 6.30.2020.*

In addition, as can be seen in Table 1, the average temperature values in June, which is one of the months in which the average O3 value in the examined periods peak, increases compared to the other months. This increase rate was 44,053 in 2018; 62,549 in 2019; In 2020, it was 67.03. Within this information, it is observed that the average ozone concentration value is proportional to temperature as well as human activities. During the pandemic process in which human activities have been significantly reduced, there is no significant change in O3 concentration compared to other years in the face of increasing temperatures.

*Table 1. Average temperature data of Istanbul, (°C)*

| Reviewed Period | 2018 | 2019 | 2020 | 2020/(2018;2019)(%) |
|---|---|---|---|---|
| January 1 - March 15 | 8,91 | 8,06 | 9,05 | 7 |
| March 16 - May 31 | 16,48 | 15,3 | 13,8 | -13 |
| Jun 1 - Jun 30 | 24 | 24,9 | 23,1 | -5 |
| Jun /March 16 - May 31 | 44,1 | 62,5 | 67 | |

Figure 3 shows the daily average distribution of average O3 values for Istanbul between January 2020 - June 2020. If Table 1 and Figure 2 are examined together, it is observed that the air starts to get warmer with the effect of sunlight, which is an important source of O3, and therefore an increase in the amount of ozone in Istanbul is observed.

Figure 4 shows the average NO2 values obtained from each station in Istanbul. If the average NO2 concentration values measured in Istanbul between January 2018 and June 2020, which are indicated in the graphic, are examined; referred to as the pandemic process in Turkey, between dates of March 16, 2020 - June 30, 2020, NO2 reached its minimum value. As it is known that processes such as burning fossil fuels that cause the formation of NO2 cause NO to turn into NO2 by a chemical reaction in the atmosphere, With Figure 4 in mind, the amount of fuel use and exhaust fumes from transportation vehicles that will cause No2 formation in the context of the pandemic process has decreased. As can be seen, the amount of NO2 in the atmosphere exhibits a change in proportion to human activities. In addition, if the values given in Table 2 are examined, the lowest $NO_2$ level of the last 3 years is in the pandemic process. In addition, during the 2020 pandemic period, the average NO2 concentration decreased by 43% compared to the values in previous years. As a result of other studies, it is stated that the research results in a way to support the above explanations, and that the rate of air pollution in Istanbul decreased and the air quality increased during the pandemic process. (URL-7). At the same time, there was a 15% increase in the NO2 concentration between 1 June - 30 June 2020, which covers the normalization process, compared to the time period covering the pandemic process. Due to the normalization process, the concentration of NO2 in the atmosphere has increased with the increase of human activities and the return to normal in areas where fossil fuels are used.

$NO_2$ concentration values for the first 6 months of 2020 are given in Figure 5. Figure 4 and Table 2 indicated that there was a 43% reduction in the value of NO2 during the pandemic process. In Figure 5, a decrease in the date ranges covering the pandemic process draws attention. It can be seen clearly, ıt fell to the minimum values for the first 6 months of 2020, and an increase was observed again with the normalization process. At the same time, other studies on the air pollution concentration in Istanbul, taking into account the pandemic process and its aftermath, support the above explanations. Prof. Dr.Hüseyin Toros as a result of his studies, explained that NO2 concentration increased by 38% in the time frame covering the normalization process compared to the pandemic process. (URL-8).

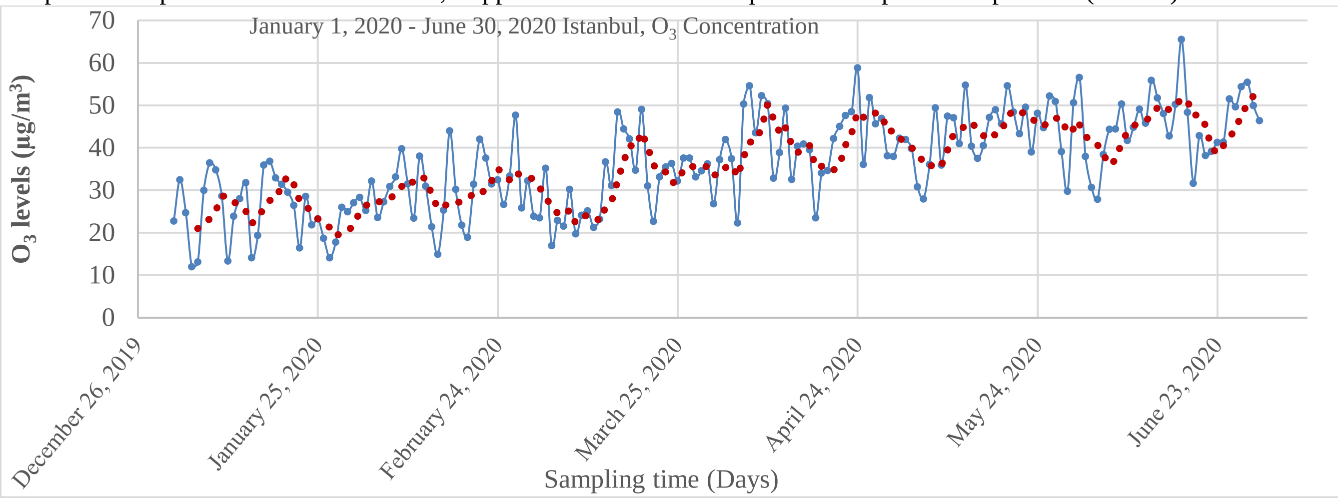


*Figure 3. O3 values Istanbul city between 1.1.2020 and 6.30.2020.*

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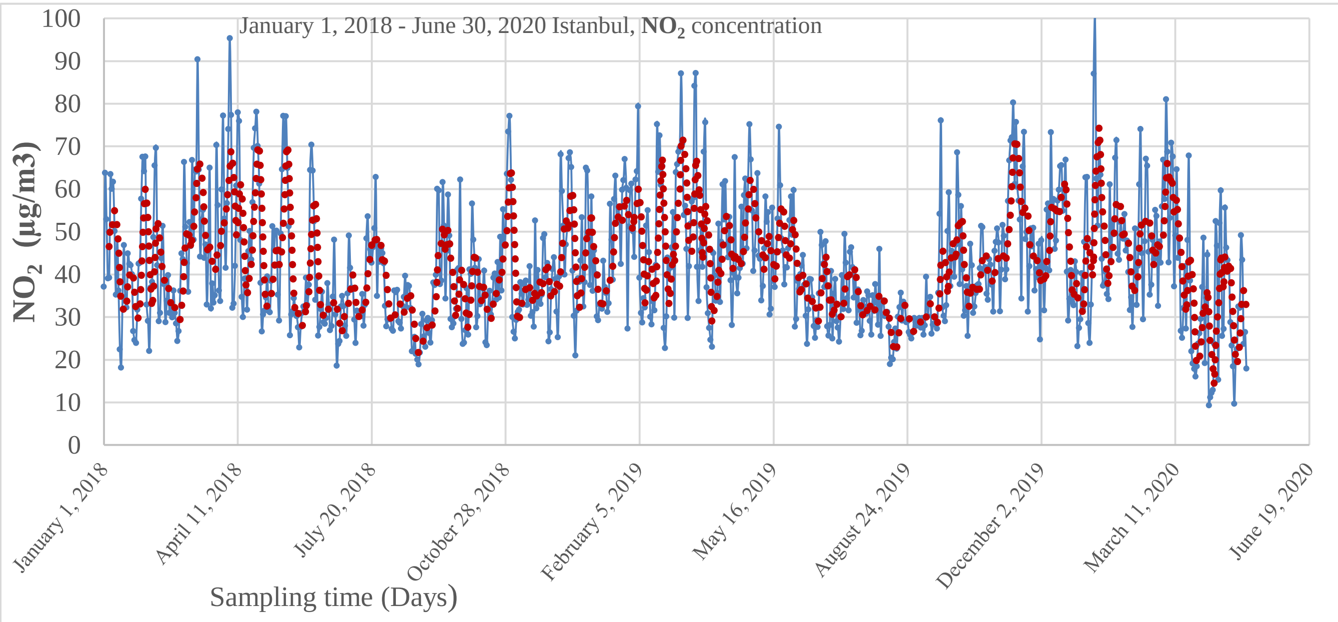


*Figure 4. $NO_2$ values Istanbul city between 1.1.2018 and 6.30.2020.*

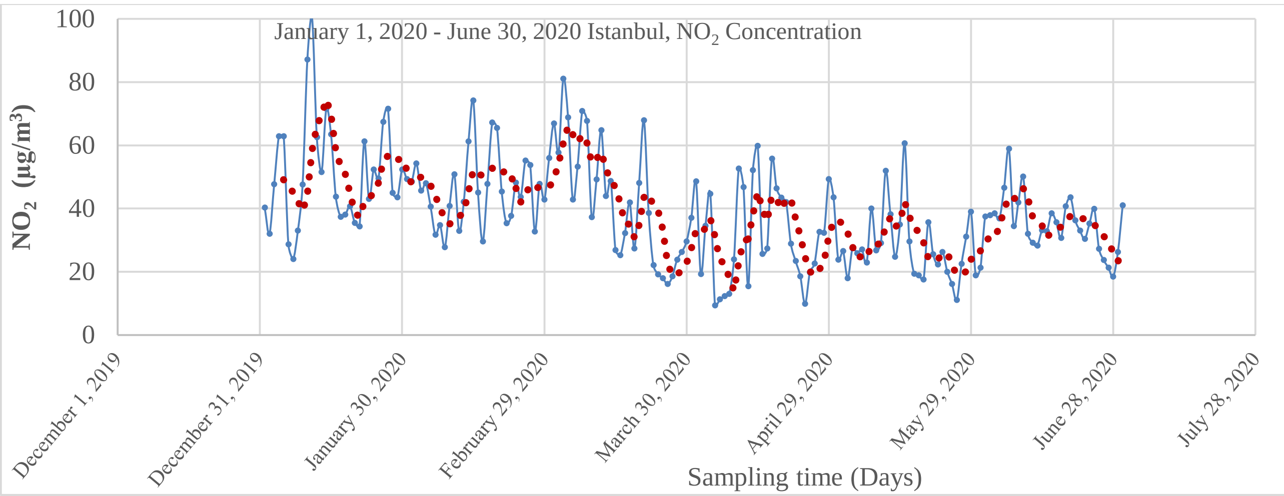


*Figure 5. $NO_2$ values Istanbul city between 1.1.2020 and 6.30.2020.*

*Table 2. Average NO2 (µg/m3) data of Istanbul city centre*

| Reviewed Period | 2018 | 2019 | 2020 | 2020/(2018;2019) (%) |
|---|---|---|---|---|
| January 1 - March 15 | 44 | 48 | 51 | 12 |
| March 16 - May 31 | 52 | 48 | 29 | -43 |
| Jun 1 - Jun 30 | 36 | 36 | 33 | -7 |
| Jun /March 16 - May 31 | -31,50 | -26,4 | 15 | |

## 4. Conclusion and Recommendations

Covidien-19, threatening human health, in addition in Turkey, between dates of 16 March, - May 31, 2020, is the virus that causes the declaration of a pandemic process. To prevent the spread of the virus, the government restricted human activities between these dates. With the introduction of restrictions, there has been a decrease in air pollution concentrations in Istanbul. As of June 1, 2020, the normalization process has resulted in the return of human activities to normal, and has led to the rise of declining values to their normal values. In short, as a result of the investigations and comparisons, reduced vehicle use as a result of the restriction of human activities, the decrease in smoke generated by fossil fuels used for industrial work and other purposes caused reductions in air pollution values. This has shown that human activities have an important role in the concentration of air pollution. Considering this result, people should know that the well-being and future of the atmospheric condition they are in depend on them and act accordingly. The use of fossil fuels should be reduced as much as possible, and the formation of air pollution should be prevented by using public transport instead of individual vehicles. In addition, in order to provide clean air circulation and to have better atmospheric conditions, every part of the world should be greened with trees that are oxygen sources.

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# Overall Evaluation of $NO_x$, NO, $NO_2$ Gasses in Turkey and Their Data Quality Control

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## Abstract

Air pollution has been increasing rapidly because of the human-based activities, such as mining, construction, industrial work, which have accelerated since the industrial revolution. This acceleration is caused by not only the high demand for vehicles but also the existence of a high quantity of factories in order to meet people's requirements. As a result, the concentration of pollutants, such as particular matter (PM10), nitrogen monoxide (NO), nitrogen dioxide (NO2), sulfur dioxide (SO2), carbon dioxide (CO2), and ozone (O3), in the atmosphere have been increased by the consumption of fossil fuels. The presence of these pollutants in the atmosphere provides valuable information about air pollution. It is revealed by studies that air pollution has negative impacts on both the species and their habitat in terms of health and sustainability. In addition, the high rise of global mean temperature and acidic rains are related to air pollution directly. The purpose of this study to examine, analyze and provide graphical data about the level of NO, NO2, NOx on the scale of Turkey by separating into regions : Black Sea region, Marmara region, Aegean region, Mediterranean region, Central Anatolia region, East Anatolia region and Southeast Anatolia region. In this study, 2010-2018 was taken as a period, and the evaluation was made on the basis of Turkey's provinces. According to this study, it has been revealed that the quantity of nitrogen dioxide and their variations (NOx's) has been decreasing over the years on the scale of Turkey.

**Keywords:** Air pollution, Nitrogen oxides, Regions, Turkey.

## 1. Introduction

Exhaust gasses that are originated from conventional vehicles cause air pollution which is one of the most significant pollution problems especially in provinces of Turkey [1]. Nitrogen oxide and its variations, some of the exhaust gasses, have negative impacts on both the environment and human health. For example, Lethal risks in cardiovascular and respiratory failures have also been shown to be associated with a 10 ppb increment in 24-h NO2 exposure [2]. Also, there is a significant decrease in the growth of plants that remain under the effect of low nitrogen oxide concentrations (0.05 ppm) for a long time. Severe damage occurs in plants exposed to concentrations of 2-10 ppm for a few hours. In addition, NO2 has negative impacts on plants in terms of reduction in root development, respiration and photosynthesis [3]. Air pollutants with various damages to the environment and living creatures should be monitored and controlled. The policy about protecting air quality is important for not only governments but organizations in order to continue the sustainability of the environment. Air quality standards are determined by many organizations like EPA (Environmental Protection Agency), WHO (World Health Organization) [4]. In Turkey, the National Air Quality Monitoring Network having 355 monitoring stations scattered throughout the country was founded in order to improve air quality by Ministry of Environment and Urbanization in 2005. The main sources of nitrogen oxides are vehicles and power stations. One of its natural sources is organic decay in the soil. Natural sources of NOx include forest fires, lightning and microbiological processes in soil. Most of the NOx is produced as NO. Nitrogen oxides which are important in terms of air pollution as a pollutant is a colorless and odorless, highly harmless gas. When nitrogen dioxide is oxidized, its color turns yellow brown and becomes a pungent and harmful gas. The combined value of atmospheric concentrations NO and NO2 is represented by NOx. The retention time in the atmosphere is approximately 1 day. It has a corrosive effect on materials and toxic impacts on human health. When the water vapor in the clouds condenses in the form of water droplets or snow particles, it merges with nitrogen dioxide as it descends from the atmosphere to the ground and forms a very corrosive nitric acid rain. Moreover, the NO, NO2 concentrations show a variety by place and time. It is observed that in previous studies, places with a high population and traffic have higher NO2 level than optimal value. However, even cities with low population traffic and industrial density like Bilecik, the average NO concentration in autumn and winter due to temperature is over 30 µg / m3 [4]. Moreover, SO2, NOx, CO, and other pollutants formed from factories and power plants play a significant role in air quality in Serbia, particularly in the winter [5]. The aim of this study is to apply quality control in order to fix wrong data and to determine, analyze and examine the concentrations of nitrogen oxide pollution by producing graphs about all the regions of Turkey.

## 2. Study Area, Data and Methodology

 

### 2.1. Study Area

A large part of Turkey's territory is located in Asia Minor, which is 790.200 km$^2$. The other small part located in the Balkans is 24.378 km$^2$. Turkey's land area, which is 770,760 km$^2$, stretches over 1,600 km from west to east but almost less than 800 km from north to south. The complete region (about 783,562 km$^2$) covers of about 756,816 km$^2$ in Western Asia (Anatolia) and about 23,764 km$^2$ in Southeastern Europe [6]. In addition, Climate, human habitat, location, transportation, topography have been determinative parameters for separating its geographical regions. Four lateral three internal areas were named according to their neighboring four seas of Turkey and their positions as The Marmara Region, The Aegean Region, The Black Sea Region, The Mediterranean Region, The Central Anatolia Region, The Eastern Anatolia Region, The Southeastern Anatolia Region.

Turkey is located between the subtropical zone and temperate zone. The climate of Turkey shows variety by the place because of the diversity of the mountains and landforms. The coastal regions of Turkey have more mild climate characteristics due to the effects of the seas. The North Anatolian Mountains and Taurus mountain range prevents entering marine effect to interior regions. Therefore, continental climate characteristics are seen in the inner locations of Turkey [7].

### 2.2 Data

Maps of the air quality data collected stations are given in Figure 1. Clean Air Center was founded in 7 provinces: Istanbul, Samsun, Erzurum, Izmir, Adana, Konya and Ankara. In all installed air pollution measurement stations, Sulfur Dioxide ($SO_2$), Nitrogen Oxides (NO, $NO_2$, $NO_x$), Carbon Monoxide (CO) and Ozone ($O_3$) and Particulate Matter ($PM_{10}$) parameters are being measured automatically.


***Figure 1.*** *Maps of the air quality data collected stations [8]*

The data used in this study is taken from T.C Ministry of Environment and Urbanization Air Quality Monitoring Stations' Web Site 'http://mobil.havaizleme.gov.tr'. This data consists of 8 years (2010-2018) of NO, $NO_2$, $NO_x$ data.

### 2.3 Methodology

Since the data from the measuring instruments at the stations are raw data, they were subjected to a quality control test. Negative data, repeating data, local and global extremes that have a very large absolute value were examined and deleted. In addition, datasets with less than 80% data on a monthly and yearly basis were not included in the calculation, since they would mislead the overall result. Using the arithmetic average method, provincial average was calculated with station's pollutant values. Region averages were also calculated from the calculated province average.

## 3. Results and Discussion

### a) Marmara Region

Marmara region has the most developed cities in Turkey. For instance, Istanbul, Bursa, Kocaeli has several advanced factory sites and sophisticated transportations systems. In addition, the population in this area is increasing rapidly. With this population growth, the number of transportation vehicles on the roads are climbing proportionally. However, the quantity of NO, $NO_2$ and $NO_x$ in the Marmara region is high in 2010, there is a steady decrease in the years between 2010 and 2018 thanks to the developing technology, the widespread use of natural gas, advanced factory and vehicle air filters. However, Mean concentration of $NO_x$ is 136.27 in 2010 has dropped to 45 µg/m³ until 2018 (Figure 2). According to monthly data, it is clearly seen that, at winter season the quantity of NO, $NO_2$, $NO_x$ gasses are higher than the summer season's because of heating (Figure 3). So, the extremum values of $NO_x$ were measured in winter: Kocaeli 612.1 µg/m³ in 14.12.2011, İstanbul 404.273 µg/m³ in 07.12.2015, Bursa 392.836 µg/m³ in 26.11.2016. Also, the cleanest cities were Çanakkale (25.41 µg/m³), Yalova (22.99 µg/m³) and Kırklareli (23.42 µg/m³) in Marmara region.

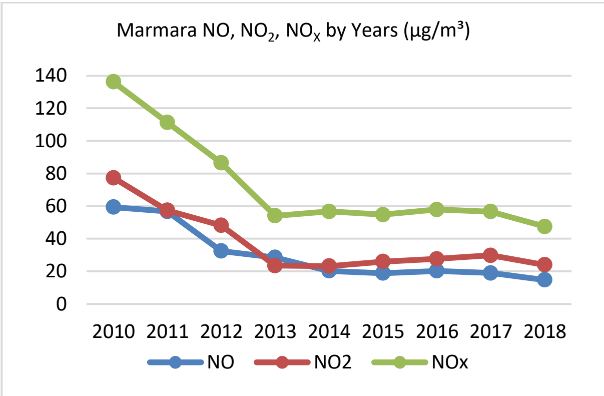


*Figure 2. Marmara Region NOX by years*

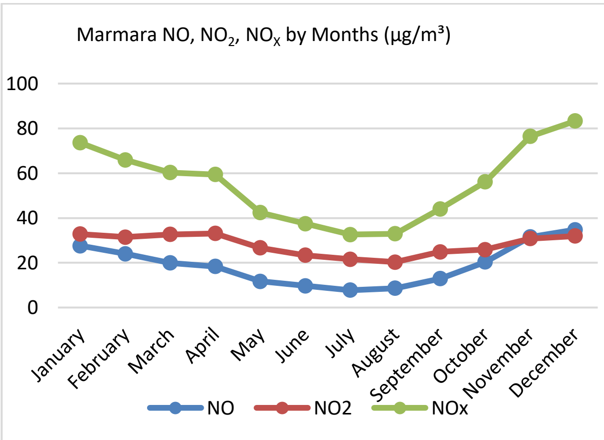


*Figure 3. Marmara Region NOX by moths*

### b) Blacksea Region

The Blacksea Region has a number of huge woodland and mountainous areas. City centers usually located near the sea and the cities that are located in this region are mostly under-developed. Scattered the population by location can be seen due to geographical characteristics. Since the weather is rainy and windy, the polluted air disintegrates and circulates easily. Especially the east of Blacksea Region's air is cleaner than the west parts'. By the years, pollution is usually decreased except in 2015 (Figure 4-5). Because until 2015 there were only Samsun's data exist, but after the year of 2015 the quantity of $NO_x$ has been begun to be measured by the other stations located at different cities. The most polluted cities are Çorum (84.25 µg/m³) and Ordu (99.27 µg/m³) in terms of measured NOx. In Samsun between 29.04.2010 and 17.05.2010, the values have shown that there is an anomaly caused by dust transportation. The extremum values of $NO_x$ : Samsun 808.86 µg/m³ in 09.05.2010, Ordu 797.28 µg/m³ in 05.01.2017 and Giresun 530.47 µg/m³ of $NO_x$ was measured in 01.03.2016. Also, the cleanest cities in that region are Rize (10.91 µg/m³), Zonguldak (19.17 µg/m³) and Artvin (13.58 µg/m³ ).

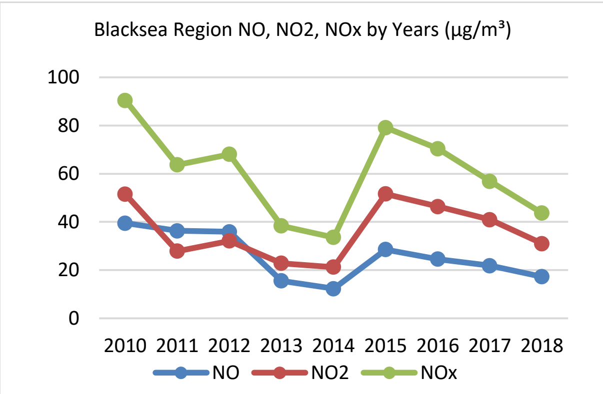


*Figure 4. Blacksea Region NOX by years*

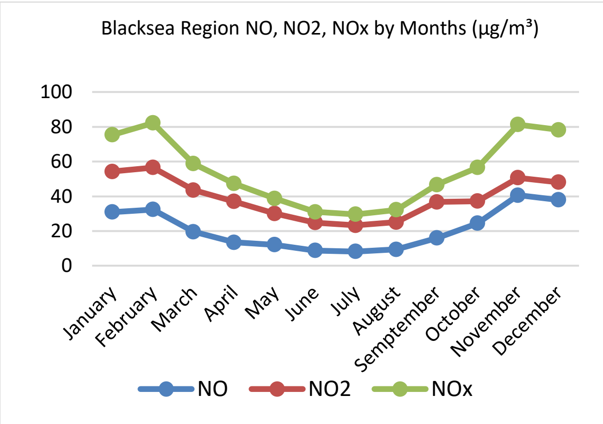


*Figure 5. Blacksea Region NOX by months*

### c) Central Anatolia Region

Central Anatolia Region is the second largest region and has the second highest population in Turkey. Developing cities like Ankara, which is the capital of Turkey, Kayseri and Konya are located in this region. Central Anatolia has continental climate and many city centers located in plains. Since the cities are located in the plains, polluted air cannot be circulated effectively. These factors cause the rising of pollutant concentrations especially in winter seasons. For example, the average value of July is 61.68 µg/m³ and the average value of November is 167.88 µg/m³ in Ankara. By the years, the pollutant concentration has not changed significantly. However, with the inclusion of undeveloped cities into the calculation the average of NO, $NO_2$ and $NO_x$ are decreased in 2018 (Figure 6-7). The quantity of NO was reduced slightly with the years in Ankara. By the values in 2018, it is clearly shown that the undeveloped cities have less NO, $NO_2$ and $NO_x$ than developing cities like Ankara and Kayseri. The extremum values $NO_x$ were measured at usually between October and November: Ankara (471.74 µg/m³) in 01.21.2011 and Kayseri (906.96 µg/m³) in 05.10.2011.

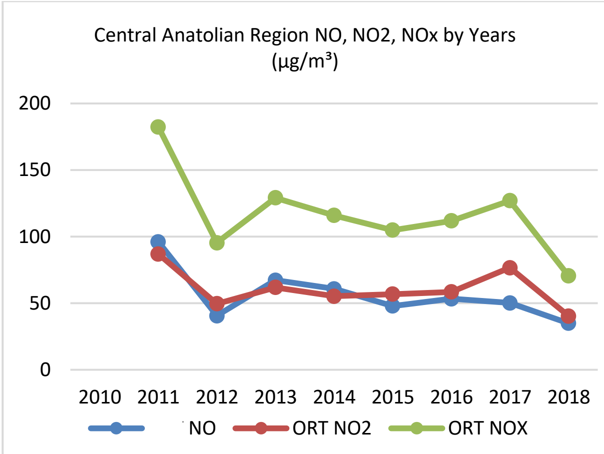


*Figure 6. Central Anatolia Region NOX by years*

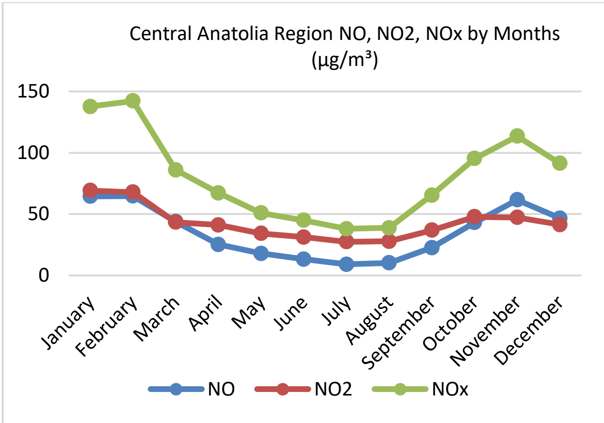


*Figure 7. Central Anatolia Region NOX by months*

### d) Mediterranean Region

There are only two stations in the Mediterranean Region. These are Adana and İskenderun stations (Figure 8-9). Because of the warm climate, differences between winter and summer season is not high. In addition, their climate and wind patterns are similar. For example, İskenderun NOx average in August was 14.92 µg/m³ and average in February was 27.28 µg/m³. Moreover, because of Adana is more developed than İskenderun has more polluted air. The extremum values of Adana were 496 µg/m³ in 22.11.2011 and İskenderun was 373 µg/m³ in 16.11.2011.

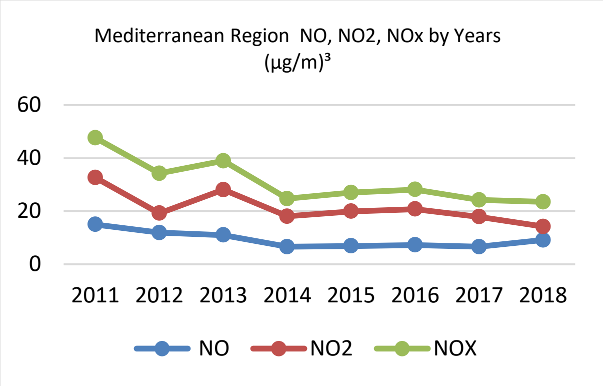


*Figure 8. Mediterranean Region NOX by years*

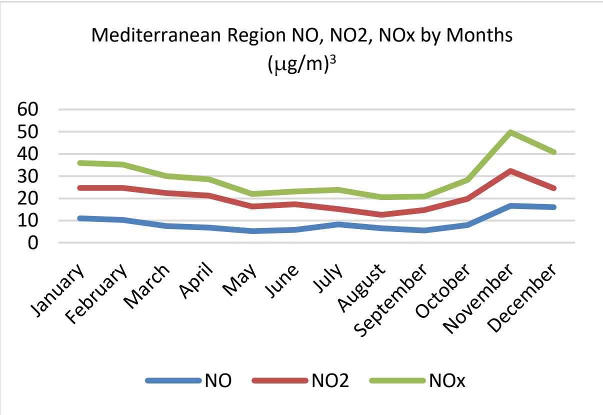


*Figure 9. Mediterranean Region NOX by months*

### *e) Eastern Anatolian Region*

Plains, plateaus and mountain ranges from the Eastern Anatolia Region. The population in this region is the least populated region in Turkey and population density is less than in other regions. There are only a few developed cities: Erzurum and Erzincan. These cities are the most polluted in the region in terms of quantity of NO, $NO_2$, $NO_x$. For example, mean $NO_x$ in Erzincan is 76.74 µg/m³ and in Erzurum is 60.54 µg/m³. The maximum $NO_x$ value in Erzincan observed as 276.825 µg/m³ in 14.12.2017. In addition, the maximum $NO_x$ value in Erzurum is 271.55 µg/m³ in 14.12.2017. The values were obtained according to the last three years because of lack of data. It has been seen that the cleanest city is Iğdır (28.39 µg/m³) in that region (Figure 10-11).

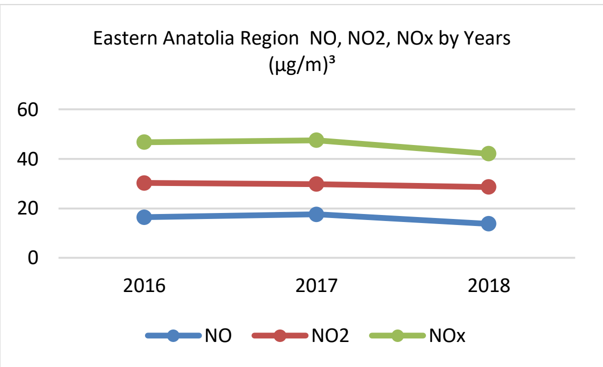


*Figure 10. Eastern Anatolia $NO_X$ by years*

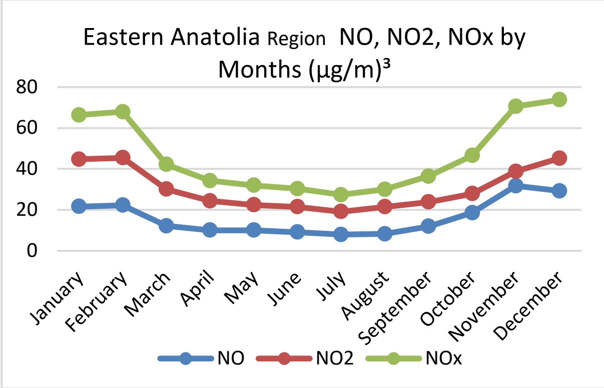


*Figure 11. Eastern Anatolia NOX by months*

### *f) Aegean Region*

The Aegean region measurement data were gathered from the stations belonging to 3 cities named İzmir, Kütahya and Manisa. Due to the region's temperate and windy weather; It is seen that NO, $NO_2$ and $NO_x$ values are much lower than other regions. in İzmir $NO_x$ average was 34.37 µg/m³ and Manisa was 56.36 µg/m³. Furthermore, the extremum values of Aegean Region: İzmir 256.14 µg/m³ in 10.12.2013 and Manisa 265.43 µg/m³ in 26.11. 2016. Also, Because of lack of data in Kütahya was not be included in calculation in order to avoid wrong interpret (Figure 12-13).

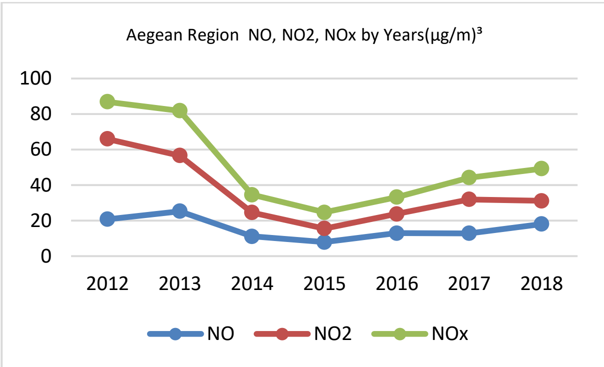


*Figure 12. Aegean Region NOX by years*

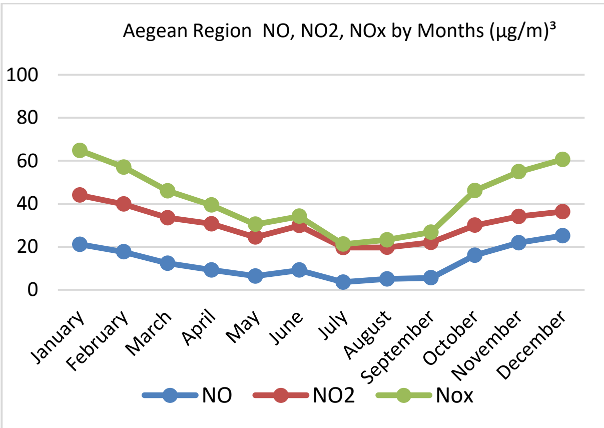


*Figure 13. Aegean Region NOX by months*

### *g) General Evaluation*

When the average of NO, NO2 and NOx in Turkey is examined in general, there is a regular decrease in pollutant concentration (113.34 µg/m³ to 46.11 µg/m³) between the years of 2010 and 2018(Fig. 15). The reasons for this decrease are the widespread use of natural gas instead of coal, the development of technology and the decrease in the amount of gas released from the factories thanks to the increasing chimney emission controls. In addition, the widespread use of public transport, the increase in the usage of renewable energy sources and the number of new model vehicles, having much better version of catalytic compared to the old models, can be count as causes of that decrease. Mediterranean Region (31.06 µg/m³) which has only two cities that can be obtained data, is considered cleanest region on the scale of Turkey. The years of maximum NOx concentration in the 6 regions where the values are; Marmara Region 136.27µg / m³ in 2010, Black Sea Region 90.41µg / m³ in 2010, Mediterranean Region 47.62µg / m³ in 2011, Central Anatolia 182.34µg / m³ in 2011, Eastern Anatolia 47.53µg in 2017 and 2012 in the Aegean Region 86.87µg / m³. Southeast Anatolian pollutant data was not included in the calculations because the number of data does not exceed the specified threshold (80% annually) (Figure 14-15).

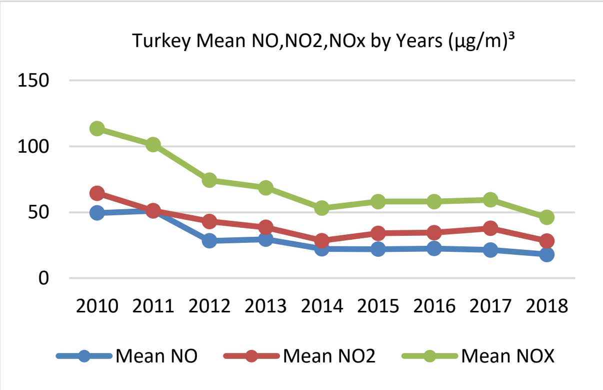


*Figure 14. Turkey mean $NO_X$ by years*

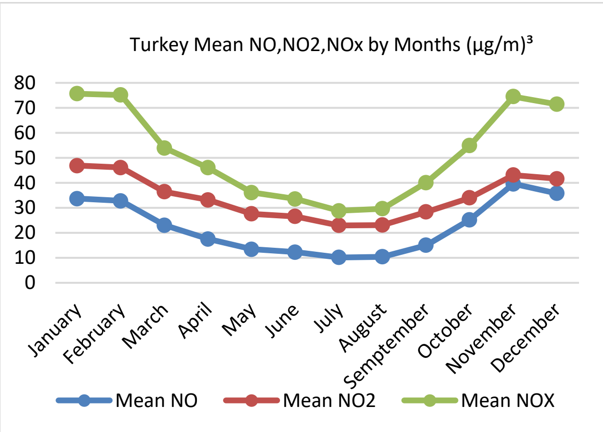


*Figure 15. Turkey mean NOX by years*

## 4. Recommendations

Air quality, which determines the sustainability of cities, has a significant impact on the quality of human life. Factors such as Factorization, Transportation, Mining, Industry, which result in the decrease in air quality and the formation of toxic gases and pollutants should be kept under control and reported periodically. To ensure sustainability in cities and to create a livable environment, the following items should be applied:

- ✔ High quality fuels should be preferred.
- ✔ Public transportation should be preferred instead of using personal vehicles.
- ✔ Renewable energy sources should be used instead of fossil fuels.
- ✔ Greening activities should be increased.
- ✔ Filtration system should be used in structures where pollutant gas is emitted from the chimney (factory, power stations etc.).
- ✔ Electric motors should be preferred instead of internal combustion engines.
- ✔ Industrial settlements should be located as far away from the dwellings as possible.

## Acknowledgements

The authors are grateful to Ministry of Environment and Urbanism of Turkey for the air quality data.

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# Relationship Between Particulate Air Pollution and Meteorological Variables in Kocaeli

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## Abstract

Air pollution is really important problem in recent years. Many other factors are related with air pollution that increasing population and industrialisation also main factors on air pollution. Usage of fossil fuels for energy production forced emission to atmosphere. Meteorological factors are also having important effect on local environment. In recent time, Covid-19 pandemic has effect on worldwide, and outbreaks are also role on the environmental condition. Recent studies have given some improvement on environmental condition during pandemic outbreak. In this, it study was aimed to research effect of Covid-19 outbreak in Kocaeli city centre air quality. The daily air quality data between January 1, 2018 and June 30, 2020 were analysed for this purpose. In order to investigate the effects of the measures taken during the epidemic period on air pollution, 3 different periods belonging to the last 3 years have been compared. These periods were compared between January 1 - March 15 before the pandemic measures of March 16, May 31 2020, when intensive measures were taken, and June, when measures were reduced passed to normal life.

**Keywords:** Air pollution in Turkey's Kocaeli region, Covid-19 outbreak.

## 1. Introduction

The primary factors assigning air quality in the past; industrial period fuel consumption for activities and heating aims, today especially as a result of the fast increase of transportation systems traffic has become one of the primary drivers (Borrego et al., 2000). Air pollution is increased when one or more materials are present in the air at a concentration higher than their natural level or for a certain period of time and have the potential to produce side effects (Seinfeld & Pandis, 2006). It is the air pollution that adversely affects the health of people and living things, pollutants that can be found in the form of dust, smoke, gas, odour and impure water vapour in the atmosphere. Heating and traffic, which are significant sources of air pollution, adverse weather reason by some meteorological events consideration when determining the city's air quality must be taken (Mayer, 1999). Sources of air pollution: natural resources, volcano, volcano, forest fires and destruction of vegetation and nature can be given as examples. Artificial resources: These are the resources created by human activities. Rapidly increasing population, improper urbanization, noticeable increase in the use of pesticides, chemicals used, we can count many reasons for air pollution. Gaseous pollutants contribute greatly to the composition changes of the atmosphere and are primarily caused by the combustion of fossil fuels. (Katsouyanni, 2003). There is a wide range in traffic, from the exhaust gases of motor vehicles to the smoke emitted from factory chimneys. Especially in winter, fuels whose content is not fully known can have an adverse effect on air pollution (Taşdemir, 2002). The particulate matter is primarily injected through diesel engine fuel combustion transport, industrial processes, agriculture and coal combustion for different purposes (Unal et al., 2011). In a world where at least 50% of the population lives in urban environments, air pollution and particulate matter (PM) in particular has become one of the most critical problems for human health. (Ozdemir et al, 2010). Everyday increases in air pollutants reason a variety of acute health problems. For instance, an increase in pollutant concentration cause an increase in asthma attacks. Chronic health effects occur with long-term exposure to pollutants (URL-1).

Air pollution is a greater danger to human health in the long term than the Corona virus (Greenstone, 2020). With the decrease in air, sea, land transportation and industrial production, the amount of oil, natural gas, electricity consumption and carbon emissions decreased, and the air pollution was reduced by around 20 percent (Yurtman, 2020) (URL-2). Energy demands have decreased as a result of people spending more time at home, less travel, facilities closure or limited work. This has reduced air pollution and resulted in improved air quality (Toros,2020) (URL-3). It is necessary to have a good air quality in order to eliminate these negativities (Samsunlu, 2020) (URL-4). Vehicle exhausts in traffic and industry are other important sources of air pollution in the city centre. The aim of this study is primarily to examine the air quality of Kocaeli city center; secondly, the interaction between corona virus pandemic measures and the effect on air quality in Kocaeli.

## 2. Study Area, Data and Methodology

Kocaeli was municipality city centre was selected for the study and the air quality data have been collected from the website of the Ministry of Environment and Urbanization and analysed by transferring the necessary studies to an Excel file. In this study, daily air pollution and meteorological data were used during 2018-2020.

### *2.1. Study area*

Study area may be explained in 5 sections as follow:

**Kocaeli -** A province of Turkey, and is the tenth most populous city. As of 2019, it has a population of 1.953.035. It is neighbours with Istanbul, Bursa, Sakarya and Yalova. Kocaeli province is located in the Çatalca-Kocaeli Section of the Marmara Region, between 29 ° 22 '—30 ° 21' east longitude and 40 ° 31 '- 41 ° 13' north latitude. It is surrounded by Sakarya in the east and southeast, Bursa in the south, Yalova in the west, Izmit Bay, Marmara Sea and Istanbul province, and the Black Sea in the north. Passing to the east of the city center of Sacramento and 30 ° east longitude, time is considered essential for Turkey. The area of Kocaeli province was 3,397 km². While sometimes sweltering heat is experienced on the coves of the bay in summer, the Black Sea coast is cooler. The highest air temperature measured in the city center is 44.1 ° C (13 July 2000), the lowest air temperature is -8.3 ° C (23 February 1985), and the annual average temperature is 14.8 ° C. The average annual rainfall on the Black Sea coast exceeds 1,000 mm (URL-5).

**Dilovası** - Dilovası district of Kocaeli province is located in the east of Gebze district in the west of Körfez district, İzmit Bay in the south and Gebze district in the north. The sea, land and railways connecting the Anatolian side to the European side pass through the district. Studies have found high doses of heavy metals, including cadmium and aluminum, in the milk of mothers who gave birth in the district. The geographical location of Dilovası is 40 ° 47 ′ 20 ″ North and 29 ° 32 ′ 31 ″ East. It was noted that air pollution in Dilovasi was 3.7 times higher than the limit value set by the World Health Organization in 2009, 3.9 in 2010, 3.6 in 2011, 4.6 in 2013 and about 4.0 times in 2014. Its area is 125 km² and its population is 47,948 (URL-6).

**İzmit -** Izmit is a city located in the east of Marmara Sea and Marmara Region, which connects Asia and Europe. Kandıra to the north, Adapazarı to the east, Kartepe and Başiskele to the south, İzmit Bay to the southwest and Derince to the west. Road, rail, sea and air routes to be considered one of Turkey's most important transition point. Turkey time (UTC + 2) for the principles adopted at 30 ° east longitude passes to the east of Izmit. It can be said that the climate of Izmit creates a transition between the Mediterranean climate and the Black Sea climate. Hot summers in Izmit, with little rain; Winters are rainy and generally warm. Izmit population is 360,409 as of the end of 2017. Izmit is located at the intersection of many highways. In addition, sea traffic is very high. In addition, Kocaeli Metropolitan Municipality provides sea transportation between districts (URL-7).

**Gölcük** - Gölcük is located in the Marmara Region, where the Izmit Bay gets the narrowest, on the south coast of the Gulf, on 40 degrees - 40 seconds North latitude, 29 degrees - 50 seconds East longitude. Izmit is in the east of the district, Karamürsel in the west, Iznik districts in the south, and Izmit Bay in the north. Its area is 199 km2. Its climate is Mediterranean climate (URL-8).

**Yeniköy** - *Yeniköy is located at latitude 40.692619 and longitude 29.877363. It is connected to Gölcük district. Its altitude (above sea level) is 183 meters* (URL-9).

**Kandıra -** Kandira is the district of Kocaeli and is located in the north of Kocaeli Peninsula. Its population was recorded as 49.221 in 2016. Kandira is the only district of Kocaeli whose industry has not developed (URL-10).

## *2.2. Data Collection*

In order to determine the level of air quality with measurement data, the data of Kocaeli - measurement station from the Marmara Clean Air Center air quality measurement stations of the Ministry of Environment and Urbanization were examined. The daily measurement values of $PM_{10}$, $PM_{2.5}$, $SO_2$, $NO_2$, $O_3$ and CO for 2018 and 2020 of the station were used. In order to see the majority distribution in the data, outliers of 5% from the top and bottom were not included in the study. If 75 percent of the data was available in the relevant periods, it was examined in that period (URL-11).

## *2.3. Method*

To see air quality change in study region, the air quality data were analysed using some calculation in Excel Packet program

- Temporal variation of each pollutant (according to density and index values)
- Groups and distribution by data ranges
- Relationships between pollutants
- Relationships between meteorological data and pollutants
- In order to determine potential sources that cause air pollution, evaluations were made by taking into account meteorological variables.

## 3. Results and Discussion

In order to improve the quality of our air, we must first use resources efficiently, end all kinds of waste, and prefer clean energies (Toros, 2020). The analysis focused on the spatial and temporal variations of pollutants and their probable sources in urban areas of the city. PM10 concentrations in Istanbul differ important across the city, with current PM10 grades at various traffic points and industrial areas exceeding the EC air limit class (Unal et al, 2011). Particulate materials can include heavy metals like mercury, lead, cadmium and carcinogenic chemicals, and can pose an important threat to health. These toxic and cancer-causing chemicals combine with moisture and turn into acid. Particulate Matter ($PM_{10}$) and other particles smaller than 10 micrometres in diameter can reach the lungs and cause inflammation or heart and lung diseases that will affect people very negatively. In Figure 1, emerged by making the necessary investigations for the province of Kocaeli, there were increases in January 2020, and decreases were seen on some days during the Covid-19 period. Regular increases and decreases occurred in $PM_{10}$ this year (Figure 1). In this period, $PM_{10}$ increased as a result of people not controlling the type of fuel used for heating, not improving combustion systems, sheathing in buildings, training of firemen and the increase in pollution loads caused by motor vehicles. As can be seen in Figure 2, periodic increases have occurred. Rises occurred during the transition from winter to spring in 2018. The increase in values is associated with the use of more motor vehicles at that time and the burning of coal or forest fires. There was an increase in February and March of 2019. In 2020, less increases occurred in this period. Straight lines in the Figure 2 indicate no value or zero (URL-12; URL-13).

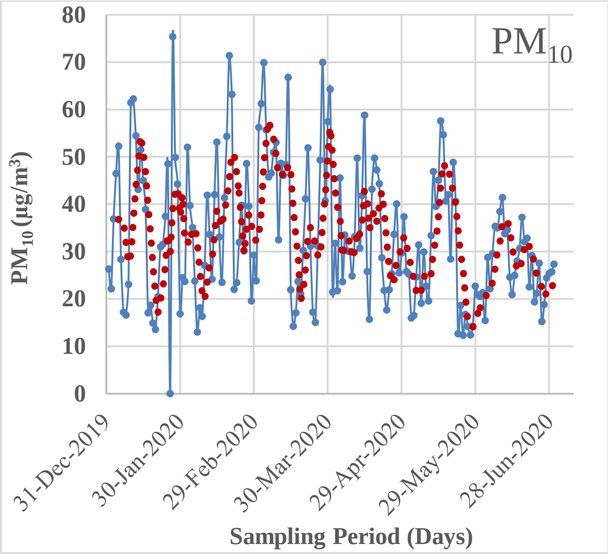


**Figure 1.** $PM_{10}$ values for Kocaeli city centre between 1 January 2020 and 30 June 2020

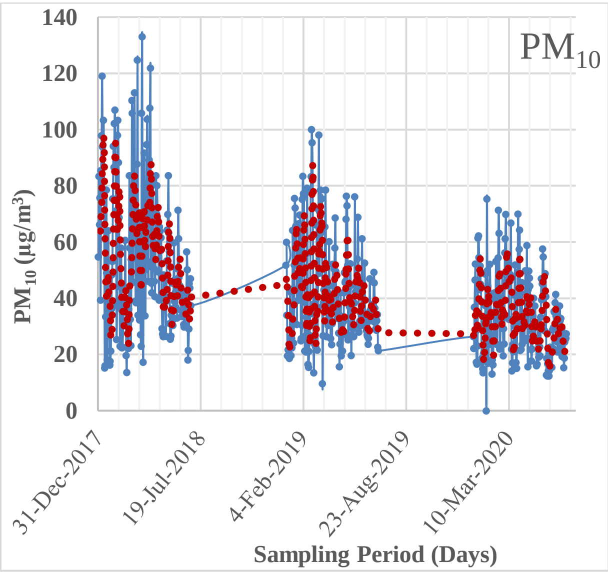


**Figure 2:** $PM_{10}$ values for Kocaeli city centre between 1 January 2018 and 30 June 2020

It is noteworthy that measurements are not made in some of the stations in regions such as Yatağan and Kangal where there are coal-fired thermal power plants, which are a risk for human health and nature, and not all pollution parameters ($PM_{2.5}$) are measured at stations that need to detect the impact of these plants (Bozoğlu, 2020). While some particles are emitted directly from a particular source, some are formed by chemically interacting with gases and particles in the atmosphere. For example, gaseous sulphur dioxide from power plants reacts with oxygen and water drops in the air to form a secondary particle, sulphuric acid. $PM_{2.5}$ fine particles are found in power plants, factories, motor vehicles, coal use, dust storms. In Figure 3, before Covid-19 started, the particles increased in February, then gradually decreased. The decline is the period when people are prohibited from going out due to the pandemic and motor vehicles are scarce. Figure 4 shows increases in certain periods. For example, it rose with the highest values in April 2018, February 2019 and early 2020 periods. Straight lines in this table indicate that there is no data for that period or it is zero.

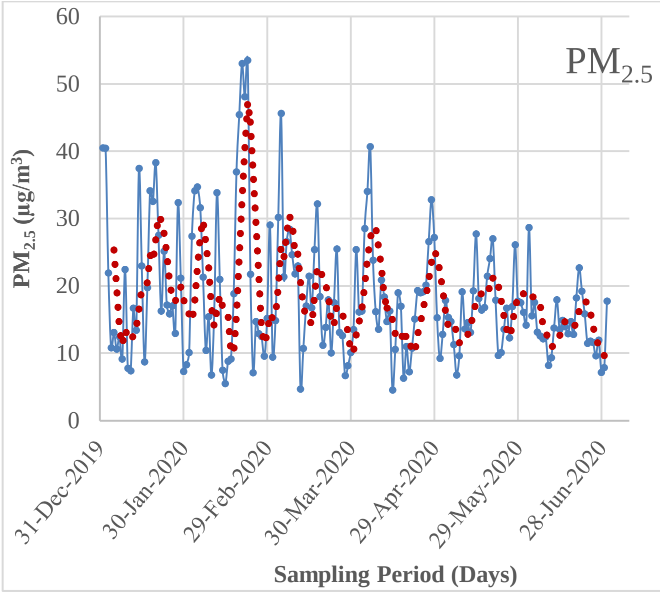


***Figure 3:*** *$PM_{2.5}$ values for Kocaeli city centre between 1 January 2020 and30 June 2020*

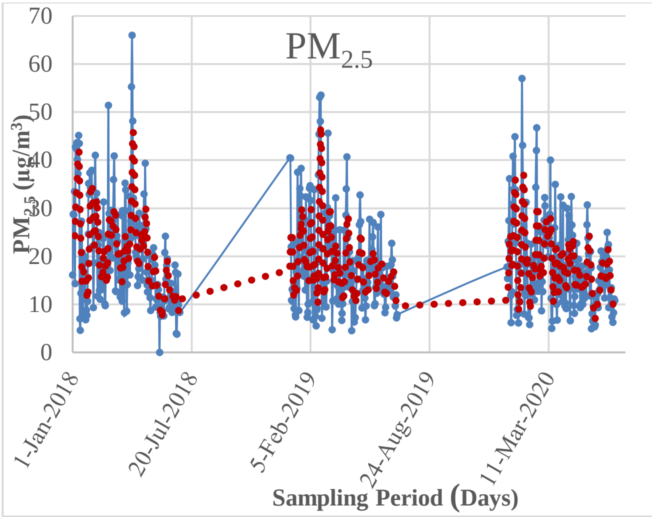


***Figure 4:*** *$PM_{2.5}$ values for Kocaeli city centre between 1 January 2018 and 30 June 2020*

Nitrogen oxides ($NO_x$) are extremely reactive gases formed at high temperatures (1200 °C). This gas is colorless, odorless and insoluble in water. Nitrogen monoxide (NO) and a small amount of nitrogen dioxide ($NO_2$) are formed as a result of burning at high temperatures. NO released into the atmosphere turns into $NO_2$ as a result of oxidation, and this gas is a powerful oxidizer. $NO_x$ are formed when solid or liquid fuels are burned at high temperatures (URL-14). Two important sources are motor vehicles and thermal power plants. $NO_2$ emissions are increasing due to the increasing number of vehicles and industrialization. As seen in Figure 5, there is an increase in Kocaeli province in May 2020. Then the decrease occurred, the reason for this shows that the use of motor vehicles has decreased considerably. Before the start of Covid-19 in Kocaeli province, there were upsurges. This is due to the greater use of anthropogenic resources. Considering the averages in the previous periods in Figure 6, quite high values have occurred. In the spring months of 2018, quite high values are seen. High values are again seen in the winter of 2019, due to the excessive use of stoves or coal.

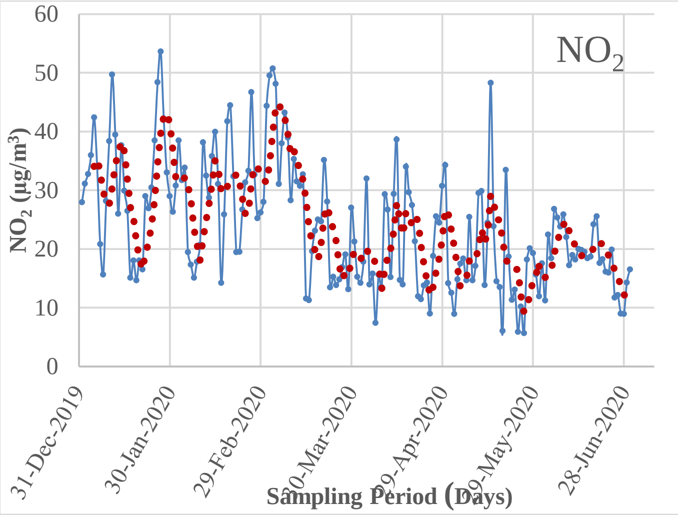


***Figure 5:*** *$NO_2$ values for Kocaeli city centre between 1 January 2020 and 30 June 2020*

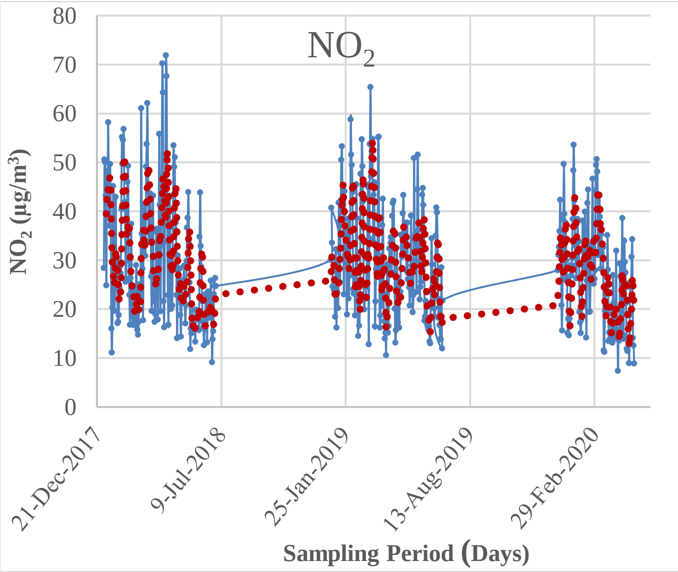


***Figure 6:*** *$NO_2$ values for Kocaeli city centre between 1 January 2018 and 30 June 2020*

The ozone layer is a protective shield in the Earth stratosphere that absorbs most of the ultraviolet radiation from the sun. Ozone is an extremely reactive gas found in the natural composition of the atmosphere that reaches peak concentrations in the stratosphere. Since ozone does not dissolve in water, it reaches the depths of the respiratory system and demonstrate its negative effects on the lungs. It is produced as a result of anthropogenic activities in the troposphere. Ozone consists of photochemical processes that take place in the presence of sunlight. Ozone pollution occurs when pollutants from industrial facilities, motor vehicles and thermal power plants react under sunlight in hot weather (URL-15). In traffic, diesel vehicles cause more nitrogen oxides, gasoline vehicles release more volatile organic compounds and carbon monoxide from the pollutants that cause ozone pollution to the air. Ozone started to heal during the Covid-19 period in Kocaeli province. As seen in Figure 7, during the Covid-19 period, the ozone layer started to improve and the values started to decrease. This table shows the changes towards improvement of the ozone layer. In the periods shown in Figure 8, we see that the ozone layer is for thinning. The reason for this is human-induced factors. Smoke from motor vehicles, smoke from stoves or coal burning, and deodorants or sprays used by people are among the biggest effects of ozone damage.

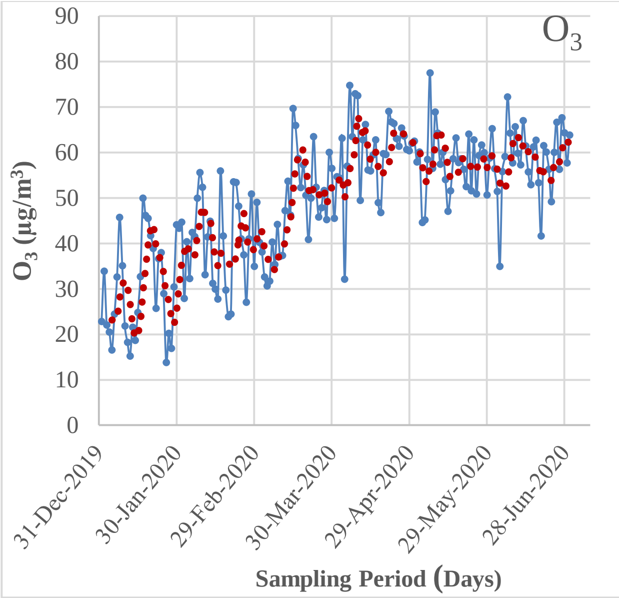


***Figure 7:*** *$O_3$ values for Kocaeli city centre between 1 January 2020 and 30 June 2020*

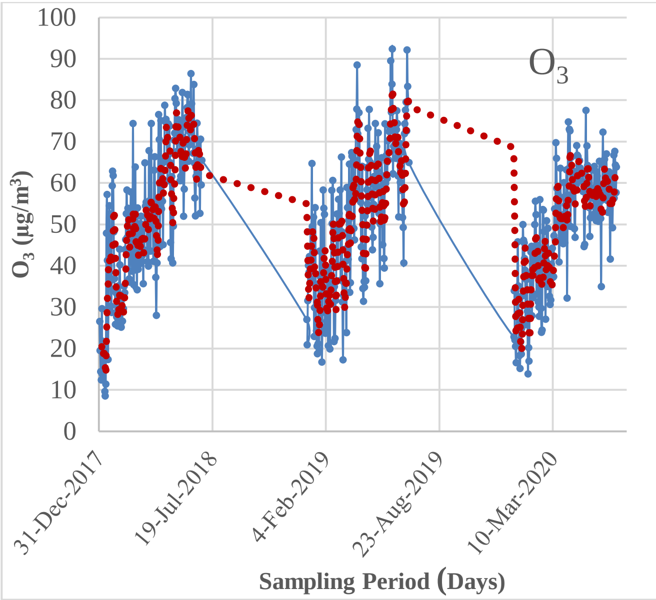


***Figure 8:*** *$O_3$ values for Kocaeli city centre between 1 January 2018 and 30 June 2020*

CO is a uncoloured, scentless gas and is formed when the carbon in fuels is not fully combusted. The main source of internal combustion engines, industry, wood burning and forest fires are sources of CO emissions. The increase occurred in February before Covid-19 started in Kocaeli province. Then the decrease is seen. As can be seen in Figure 9, during the Covid-19 period, CO gas decreased and air pollution decreased. As can be seen in Figure 10, increases and decreases occurred in 2018 in the same year. There was a slight increase in the table in 2019 and an increase occurred again in the winter months of 2020.

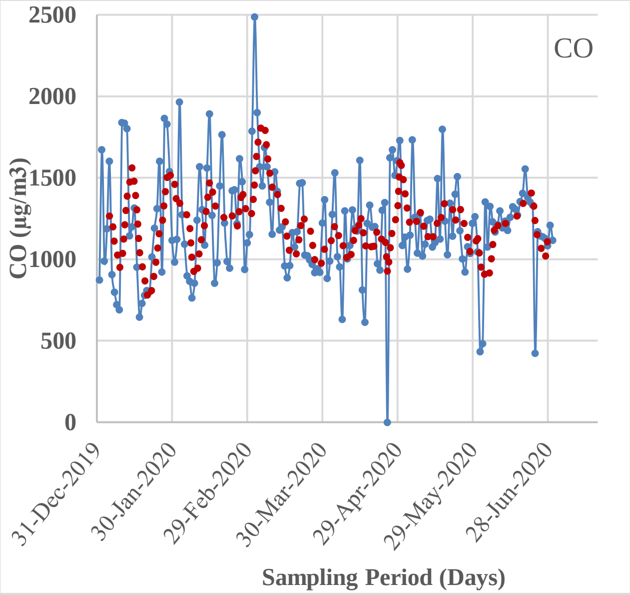


***Figure 9:*** *CO values for Kocaeli city centre between 1 January 2020 and 30 June 2020*

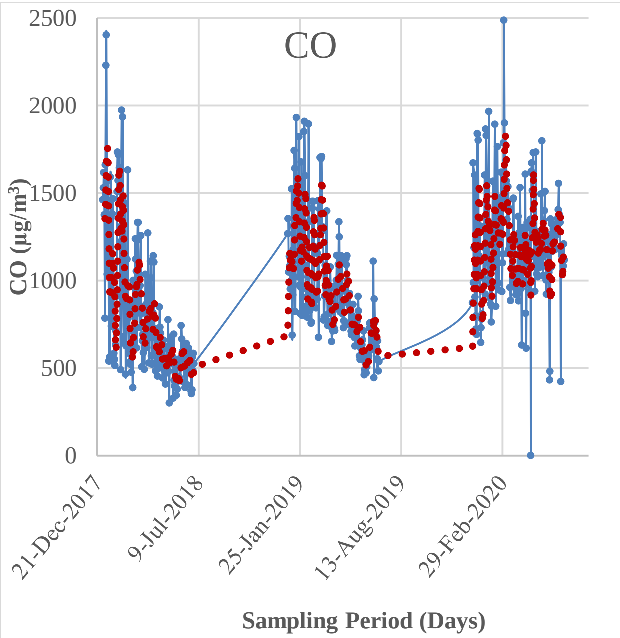


***Figure 10:*** *CO values for Kocaeli city centre between 1 January 2018 and 30 June 2020*

$SO_2$ is a colorless, non-flammable and not shining gas. Approximately 60% of the sulfur oxides released every year are formed by burning coal. Especially, thermal power plants where coal is used as fuel are the biggest sources of $SO_2$ emission. It is also found in natural resources such as forest fires, volcanic activities. It forms sulfate aerosols and particles in the atmosphere. These particles can be carried over long distances by winds. It forms sulfuric acid when dissolved in moisture, sunlight and the presence of certain chemicals. It has an important contribution to the formation of acid rain. Before the Covid-19 period started in Kocaeli province, an increase occurred in the winter months, as seen in Figure 11. A serious increase occurred in April, and these increases decreased after May. Figure 12 shows an increase in the transition from winter to spring in the previous periods. In the following period, there were increases in early 2019. The reason for this is due to the higher use of coal in the winter months.

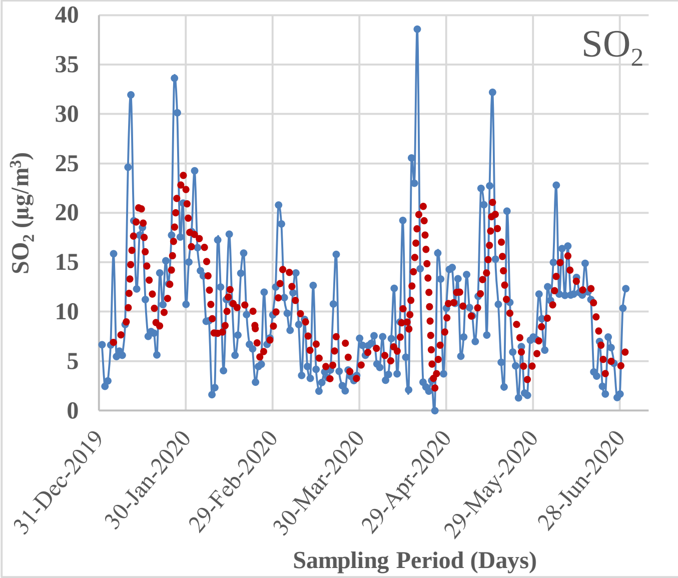


***Figure 11:*** *$SO_2$ values for Kocaeli city centre between 1 January 2020 and 30 June 2020*

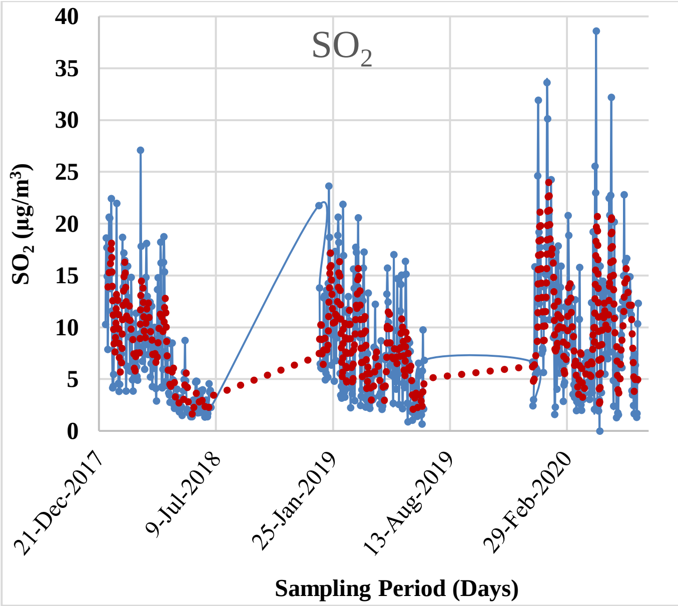


***Figure 12:*** *$SO_2$ values for Kocaeli city centre between 1 January, 2018 and 30 June, 2020*

This table was made to understand how many changes occurred before the pandemic period, how much it reflected on the averages. Three periods were examined in this table, and while the averages were close to each other in the previous periods, these values decreased significantly during the pandemic period. For example, PM10 pollutant values are almost close between 2018-2019, but a significant decrease is seen in 2020. In June, when hot weather increased and turbulence was more, air pollution decreased. When the June and pandemic period are compared in $NO_2$ gas, it decreased to 1%. It is understood that during this period, people in Kocaeli province did not go out on the streets, motor vehicles were almost never used and there was no loading in the industry.

***Table:1.*** *$PM_{10}$, $NO_2$, $O_3$ concentration changes in investigation periods of 2018, 2019 and 2020 for Kocaeli city centre*

| $PM_{10}$ (µg/m3) | | | | |
|---|---|---|---|---|
| Period under study | 2018 | 2019 | 2020 | 2020/(2018;2019) |
| 1 January - 15 March | 58 | 47 | 34 | -35 |
| 16 March - 31 May | 57 | 42 | 34 | -31 |
| 1 June - 30 June | 41 | 34 | 28 | -26 |
| June /16 March - 31 May | -29 | -18 | -19 | |
| $NO_2$ (µg/m3) | | | | |
| Period under study | 2018 | 2019 | 2020 | 2020/(2018;2019) |
| 1 January - 15 March | 34 | 34 | 31 | -9 |
| 16 March - 31 May | 30 | 30 | 19 | -37 |
| 1 June - 30 June | 21 | 23 | 19 | -14 |
| June /16 March - 31 May | -31 | -24 | -1 | |
| $O_3$ (µg/m3) | | | | |
| Period under study | 2018 | 2019 | 2020 | 2020/(2018;2019) |
| 1 January - 15 March | 38 | 38 | 37 | -3 |
| 16 March - 31 May | 61 | 59 | 58 | -3 |
| 1 June - 30 June | 70 | 69 | 58 | -16 |
| June /16 March - 31 May | 13,6 | 16,9 | 1 | |

***Table:2.*** *$PM_{2.5}$, $SO_2$, CO concentration changes in investigation periods of 2018, 2019 and 2020 for Kocaeli city centre*

| $PM_{2.5}$ (µg/m3) | | | | |
|---|---|---|---|---|
| Period under study | 2018 | 2019 | 2020 | 2020/(2018;2019) |
| 1 January - 15 March | 24 | 22 | 20 | -10 |
| 16 March - 31 May | 20 | 17 | 16 | -15 |
| 1 June - 30 June | 12 | 13 | 15 | 19 |
| June /16 March - 31 May | -40,1 | -22,8 | -5 | |
| $SO_2$ (µg/m3) | | | | |
| Period under study | 2018 | 2019 | 2020 | 2020/(2018;2019) |
| 1 January - 15 March | 11 | 10 | 6 | -47 |
| 16 March - 31 May | 6 | 7 | 8 | 23 |
| 1 June - 30 June | 3 | 3 | 5 | 48 |
| June /16 March - 31 May | -53 | -51,2 | -42 | |
| CO (µg/m3) | | | | |
| Period under study | 2018 | 2019 | 2020 | 2020/(2018;2019) |
| 1 January - 15 March | 1137 | 1199 | 1272 | 9 |
| 16 March - 31 May | 640 | 856 | 1153 | 54 |
| 1 June - 30 June | 519 | 628 | 1245 | 117 |
| June /16 March - 31 May | -18,9 | -26,7 | 8 | |

## 4. Conclusion and Recommendation

Looking at the values in the Figures 1-20, it can be seen a higher proportion of pollutants in 2018, but after in late 2019 and early 2020. It can be seen that the value rates were decreased. The reason for the decrease in these rates may be explained by the people used less motor vehicles due to the Covid-19 pandemic outbreak, factories and industries did not work like as before period, and people did not go out for activity, which provided a very important effect for the atmospheric quality. As it seen in Tables 1 and 2, there are almost similar values in 2018 and 2019, but there are significant decreases for some air pollution parameters in 2020. For example, $PM_{10}$ pollutant has very close values in 2018-2019 period, and this value decreased by 35% in 2020. Ozone concentration has decreased by 16%. $SO_2$ concentration decreased by 47%. The atmospheric quality concentration was decreased during the Covid-19 pandemic measures. In order for the virus pandemic not to spread further and to have less pollutants in the atmosphere, attention should be paid to the personal cleaning of people first and then to the environmental cleaning. It is necessary to make legal changes to encourage public transport and bicycle transportation in cities, to protect and increase forests, to reproduce trees, to reduce pollutant emissions from motor vehicles, to spread alternative resources instead of coal for heating homes. Finally, attention should be paid to mask, distance and cleanliness and we should use motor vehicles less, we should protect it by respecting the atmosphere.

## Acknowledgements

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# Air Pollution in Ankara During COVID-19

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## Abstract

Turkey's capital of Ankara, is located in the center of Turkey's Central Anatolia Region. Due to rapid population growth, improper urbanization and increasing industrialization in Ankara in recent years, air pollution has reached serious levels especially in winter months. According to the research, it has been observed that there is a significant increase in the number of vehicle use in Ankara, which causes a decrease in air quality. It is known that the effects of air pollutants on the environment and human health depend on time, place, duration of action, concentration and other characteristics. While air pollution increases the mortality rate due to heart and lung diseases, it also increases hospital admissions due to these diseases. In this study, the relationship of the covid-19 virus with air pollution in Ankara was divided into three periods (before the Covid-19 measures, during the Covid-19 fight and the Covid-19 struggle is in the decline process). Effect of factors such as a decrease in vehicle use due to curfews on air parameters is being studied. Daily data of $PM_{10}$, $PM_{2.5}$, $NO_2$, $SO_2$, $O_3$, CO parameters were analyzed for Bahçelievler, Çankaya, Demetevler, Kayaş, Keçiören, Sincan, Siteler, Sıhhiye stations in Ankara. In the improvement of air quality, entry and exit bans, quarantines imposed in areas where the epidemic was detected, travel restrictions and interruption of education have contributed to a great extent.

**Keywords:** Ankara, Covid-19, health, emission, air quality.

## 1. Introduction

Air pollution is a mixture of multiple pollutants originating from a myriad of natural and anthropogenic sources. Transport, power generation, industrial activity, biomass burning, and domestic heating and cooking are the predominant anthropogenic sources in many locations and they cause air pollution increase. Pollution levels in western Europe and North America have generally declined since the late 20th century, but they are increasing in some rapidly industrializing countries, notably in Asia. In many areas, WHO and national air quality guidelines for air pollutants are routinely and substantially exceeded (Samet et al. 2013). Air pollution in Turkey, emerged in the second half of the 20th century, has been particularly severe problem in the winter months. There are two major causes of air pollution in Turkey. These are urbanization and industrialization. Because Turkey in the period in which concentrations of air pollution with an increase in levels of urbanization and industrialization breakthrough was observed that the increase in the serious level (Sümer, 2014).

The criteria we examine in this study are air pollutants carbon monoxide (CO), nitrogen dioxide ($NO_2$), sulphur dioxide ($SO_2$), ozone ($O_3$) and particulate matter (PM). Particulate matter is a heterogeneous mixture varying in physicochemical properties depending on meteorological conditions and emission sources [World Health Organization (WHO) 2006]. In urban regions, road traffic is a significant wellspring of burning PM [Health Effects Institute (HEI) 2010]. The use of vehicles also affects the increase of many air pollutants like $NO_2$, $SO_2$ or $O_3$. Krzyzanowski et al. (2005) concluded that transport-related air contamination adds to an expanded danger of death, especially from cardiopulmonary causes, and that it builds the danger of respiratory side effects and infections that are not identified with hypersensitivities.

SARS-CoV-2 is phylogenetically identified with extreme intense respiratory condition like (SARS-like) bat infections, hence bats could be the conceivable essential supply. The moderate wellspring of source and move to people isn't known, nonetheless, the quick human to human exchange has been affirmed broadly. This process is shown in Figure 1. There is no clinically affirmed antiviral medication or antibody accessible to be utilized against COVID-19. However, few broad-spectrum antiviral drugs have been evaluated against COVID-19 in clinical trials, resulted in clinical recovery (Shereen et al. 2020 ).

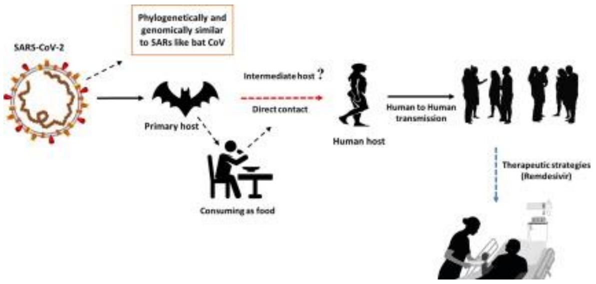


*Figure 1. Coronavirus disease process (URL-1)*

The World Health Organization (WHO) classified the COVID-19 outbreak as an "international public health emergency" on January 30, and the global epidemic (pandemic) on March 11 due to the spread and severity of the virus, the occurrence of COVID-19 cases in 113 countries outside China, where the first epidemic started. (TC Ministry of Health Covid-19 Guide, 2020).Whether there is a positive correlation between pandemic process and air pollution is important in how it affects air quality.

 

Today, air pollution that occurs as a result of industrialization and urbanization is an environmental problem that we breathe, smell, visible or invisible, physically, biologically or chemically growing every day. It is relatively easy to see or smell poor food and water quality, but air quality is not easily recognized. This problem harms the ecosystem by causing changes in the air compounds in the atmosphere, global climate change, acid precipitation, dilution of the ozone layer, negative effects on wildlife and humans. The effects of foreign substances released into the atmosphere may increase depending on the meteorological factors such as pressure, temperature, wind, humidity, precipitation and solar radiation, location and topographic structure (Toros and Bağış , 2017).

The aim of the study is to analyze the positive change in air quality in Ankara during covid 19 and to see whether the temperature change has an effect on this change.

## 2. Material and Method

### *2.1 Research Area*

It is located in the northwest of Ankara Central Anatolia Region, between 39º and 57´ north latitudes and 32º and 53´ east longitudes (Figure 2). There are Kırşehir and Kırıkkale in the east of Ankara, Eskişehir in the west and Çankırı in the north. Village-to-city migration and rapid urbanization, which started in the 1950s in our country, started with the declaration of Ankara as the capital. Its height above sea level is 938 meters. Its surface area is 25 706 km². The city of Ankara is located on the 800-850 meters high Ankara Plain formed by the Ankara Stream and its tributaries. Around the plain, there is a mountainous, hilly area with an average altitude of 1250 - 1500 meters. The plain is open in the west direction and is connected to the Mürtet Plain. Accordingly, the city center is located in a bowl-like area. While these topographical features determine the distribution of settlement areas in Ankara on the one hand, they are effective on the prevailing continental climate on the other hand (Çicek et al., 2004). The green area per person in Ankara city is 4m² (within the scope of parks, sports and recreation areas) (ABB, 2007). This value is well below the minimum 10m² per person standard specified in the 3194 Development Law. At the same time, the green areas in the city do not show a systematic and homogeneous distribution. When the amount of green areas per capita is examined by district; 0.6m² in Altındağ, 2.8m² in Çankaya, 2.9m² in Etimesgut, 1.1m² in Gölbaşı, 1.6m² in Keçiören, 1.3m² in Mamak, 1.6 m² in Yenimahalle and It appears to be 6.0m² in Sincan (Yeşil 2006). The amount of green areas per capita differentiating in the districts reveals that there is no homogeneous distribution and the green areas in the city are not sufficient. The city of Ankara is geographically located on the Hatip Plain in a basin surrounded by hills. The city grew over time and spread over the ridges around it. For this reason, the city is both a plain settlement and a slope settlement. In the report of the IPCC (2001) it is stated that the vulnerability of coastal settlements to climate change is high, and it states that slope settlements are less vulnerable.

According to TUIK (2017) data, the population of Ankara is 5 445 026 (URL-3), and the total number of automobiles is 1 376 928 (URL-4). While there was one vehicle per 4 people in 2017, there was one vehicle per 3 people in 2018. It has been analyzed that the increase in the number of vehicles is much higher than the population. However, when the number of deaths is considered, it was 25 611 in 2017 and 26 115 in 2018 (URL-5). The increase in death rates may be due to air pollution.

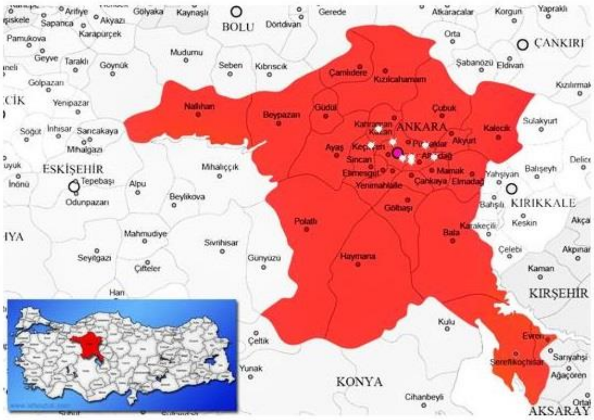


*Figure 2. Location of investigation area Ankara city centre (URL-2)*

In Ankara and its surroundings, "BSk" climate type is seen according to the Köppen climate classification. According to this, the climate in Ankara with an annual average temperature lower than 18.0 ºC, a semi-arid climate with summer drought and a low annual rainfall (250-400 mm) prevails (Akman 1990).

### *2.2. Data*

Air quality values were analyzed for eight sampling stations in Ankara, which are Bahçelievler, Çankaya, Demetevler, Kayaş, Keçiören, Sincan, Siteler and Sıhhiye. For this analysis, daily data of $PM_{10}$, $PM_{2.5}$, $NO_2$, $SO_2, O_3$, CO parameters at eight stations were examined. If the data is less than 75%, it was considered unsuitable for the study and ignored. Measurement data in the form of hourly averages obtained from the stations are monitored through a special network by transferring them to the Data Management Center located in Gölbaşı/Ankara of the Laboratory, Measurement and Monitoring Department under the General Directorate of EIA Permitting and Inspection of the Ministry of Environment and Urbanization. In this center, a validation study is carried out on the data, taking into account the calibration and alarm information of the devices. Accordingly, monthly and annual reports are prepared with the evaluated data and the raw data obtained from the monitoring network are published simultaneously on www.havaizleme.gov.tr. After the data validation studies carried out at the end of each month, the verified data are transferred to the website (URL-6).

Environment SA MP101M, Thermo 5014i, Metone Bam 1020 for the measurement of particulate matter ($PM_{10}$, $PM_{2.5}$), Environnement SA CO12M - CO12e for the measurement of carbon monoxide (CO), Environment SA AF22M for the measurement of sulfur dioxide ($SO_2$) - AF22e, Ozone (Environnement 0341M - O342M - O342e is used for $O_3$) measurement, Environnement SA AC32M - AC32e instrument is used for measurement of nitrogen oxides (NO, NOX) (URL-7).

Temperature data taken from Turkish state meteorological service and daily mean values of Temperature are given in Figure 15.

### *2.3. Data Period*

In addition to the comparison of the 2020 epidemic period and before, the effect of seasonal conditions on air quality, the data of the 2020 epidemic period and the normal periods of 2018 and 2019 were also compared to understand the effect of the seasonal period of any relationship with air pollution. Period 1, before the Covid-19 measures (from January 1 to March 15). Period 2, during the Covid-19 fight (from March 16 to May 31). Period 3, Covid-19 struggle is in the decline process (from June 1 to June 30). Temperature data of January 2018-June 2020 were also analyzed and its effect on air pollution was investigated. MS Excel was used for the analysis and graphics of the data.

## 3. Results and Discussion

Humans can be negatively influenced by exposure to air pollutants in ambient air. Accordingly, the European Union has built up a broad assemblage of enactment which builds up wellbeing based principles and goals for various contaminations present noticeable all around. These apply over differing periods of time because the observed health impacts associated with the various pollutants occur over different exposure times.

When looking at the composition of PMs, it consists of more than one pollutant, such as aerosol, smoke, soot, combustion products, dust, sea salt and pollen. It appears to consist of substances. More than 10µM of the PM taken into the respiratory tract is retained in the nose and nasopharynx, less than 10 microns accumulates in the bronchi, 1-2 micron diameter particles are collected in the alveoli, and particles of 0.5 micron diameter diffuse from the alveoli to the intracapillary space. While $SO_2$ from gaseous pollutants is eliminated in the nose and pharynx, $O_3$ and $NO_2$ from non-water soluble gases can reach deep into the respiratory system. Carbon Monoxide (CO) diffuses in the alveolar capillary membrane and binds to hemoglobin (Bayram et al. 2006).

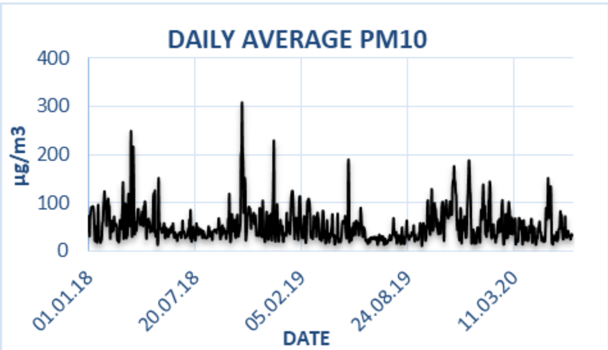


*Figure 3. $PM_{10}$ values Ankara between 01.01.2018 and 30.06.2020*

Figure 3 shows the daily mean values of $PM_{10}$ Ankara city sampling eight station for time period from beginning of January 2018 to middle of June 2020. $PM_{10}$ values of Ankara city centre generally less than 100 µg/m$^3$. Annual mean values 53.21 µg/m$^3$ that were higher than national air quality limits of Turkey. The daily maximum value is 309.18 µg/m$^3$ on 18 October 2018, while the daily minimum value is 12.55 µg/m$^3$ on 21 September 2019. At the point when the taking a gander at the Figure 3, it isn't exceptionally simple to assemble the all information, that numerous elements might be viewed as compelling. While the measure of fuel assumes a significant job in the winter season, PM from all vehicle debilitates covers the whole season. Nonetheless, meteorological components changing during the time are as powerful as emission sources.

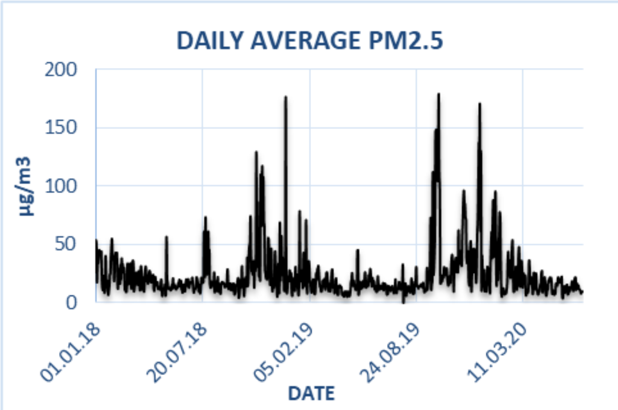


*Figure 4. $PM_{2.5}$ values Ankara between 01.01.2018 and 30.06.2020*

Figure 4 shows the daily mean values of $PM_{2.5}$ Ankara city sampling eight station for time period from beginning of January 2018 to middle of June 2020. $PM_{10}$ values of Ankara city centre generally less than 50 µg/m$^3$. Annual mean values 23.61 µg/m$^3$ that were lower than national air quality limits of Turkey. The daily maximum value is 178.56 µg/m$^3$ on 5 October 2019, while the daily minimum value is 3.4 µg/m$^3$ on 24 May 2020. When the looking at the figure 4, it isn't exceptionally simple to assemble the all information, that numerous elements might be viewed as compelling. While the measure of fuel assumes a significant job in the winter season, PM from all vehicle debilitates covers the whole season. Nonetheless, meteorological components changing during the time are as powerful as emission sources.

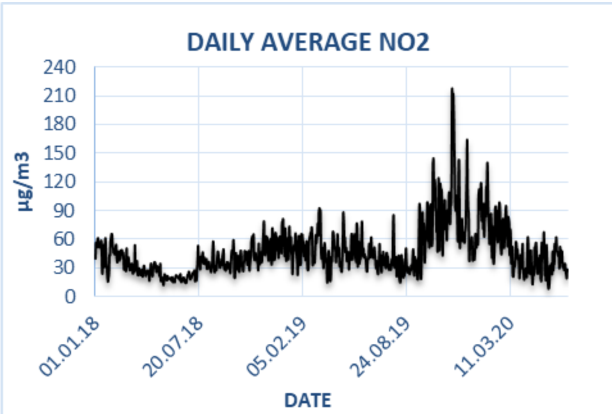


*Figure 5. $NO_2$ values Ankara between 01.01.2018 and 30.06.2020*

Daily average data about $NO_2$, which is the 3rd parameter measured as air pollutants in Ankara for eight station, can be seen in Figure 5. $NO_2$ values of Ankara city generally less than 50 µg/m$^3$. Annual mean values 47.42 µg/m$^3$ that were lower than national air quality limits of Turkey. The daily maximum value is 216.73 µg/m$^3$ on 20 November 2019, while the daily minimum value is 8.6 µg/m$^3$ on 24 May 2020 on the same date as in $PM_{2.5}$. Exhaust gases of vehicles in traffic can be cited as the main source of $NO_X$ for the research area. With reference to to the available data, $NO_2$ change according to the seasons and increased significantly in the winter of 2019.

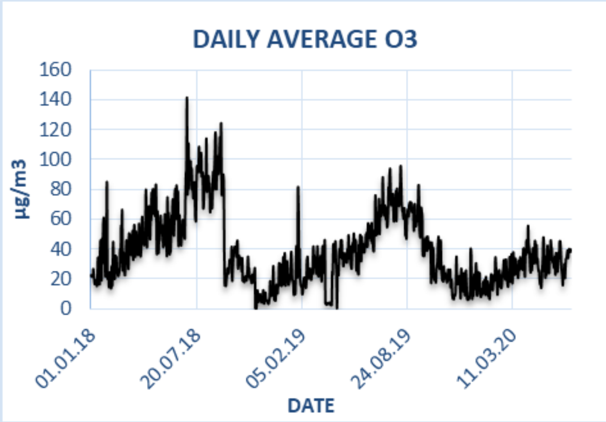


*Figure 6. $O_3$ values Ankara between 01.01.2018 and 30.06.2020*

$O_3$ values as air quality values were summarised in Figure 6 for Ankara city sampling eight station for time period from beginning of January 2018 to middle of June 2020. $O_3$ values of Ankara generally less than 40 µg/m$^3$. Annual mean values 38.66 µg/m$^3$, daily maximum value is 141.19 µg/m$^3$ on 2 July 2018, while the daily minimum value is 2.15 µg/m$^3$ on 3 April 2019. Looking at the Figure 6, there is an increase in ozone in the summer months and a decrease in the winter months. Ozone is a highly reactive gas that reaches peak concentrations in the stratosphere. Since ozone is insoluble in water, it reaches the depths of the respiratory system and shows its negative effects in the lungs. It is produced as a result of anthropogenic activities in the troposphere. The main anthropogenic sources can be listed as transportation (airplanes, motor vehicles, railways and ships), industry (thermal power plants, industrial processes and solid waste incinerators) and heating (solid, liquid, gas fuel stoves and heating boilers) (Müezzinoglu, 1987). Although the transport from the stratosphere also contributes to the increase of $O_3$ in the atmosphere we live in, it is mostly produced from anthropogenic sources.

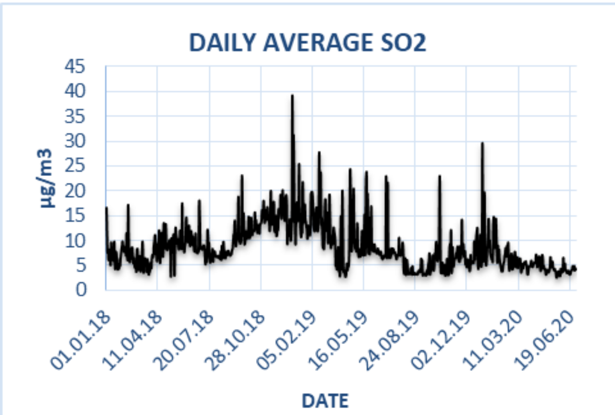


*Figure 7. $SO_2$ values Ankara between 01.01.2018 and 30.06.2020*

Figure 7 shows the daily mean values of $SO_2$ Ankara city sampling eight station for time period from beginning of January 2018 to middle of June 2020. $SO_2$ values of Ankara generally less than 10 µg/m$^3$. Annual mean values 8.66 µg/m$^3$ that were lower than national air quality limits of Turkey. The daily maximum value is 39.3 µg/m$^3$ on 28 December 2018, while the daily minimum value is 2.63 µg/m$^3$ on 10 April 2019. Among the gaseous pollutants, sulfur oxides, a colorless non-flammable gas, are the most well-known primary air pollutants. The permanence period in the atmosphere reaches 40 days (Agren, 1991). They are mostly formed as a result of burning fossil fuels. According to Figure 7, using of fossil fuels increased during the winter months.

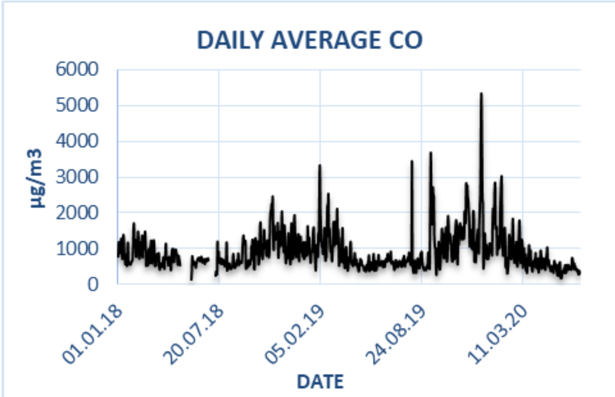


*Figure 8. CO values Ankara between 01.01.2018 and 30.06.2020*

Daily average data about CO, which is the 3rd parameter measured as air pollutants in Ankara for eight station, can be seen in Figure 8. CO values of Ankara city generally less than 1000 µg/m$^3$. Annual mean values 899.21 µg/m$^3$ that were lower than national air quality limits of Turkey. The daily maximum value is 5326.86 µg/m$^3$ on 19 December 2019, while the daily minimum value is 119.4 µg/m$^3$ on 26 May 2018. It is known that more than 70% of the carbon monoxide production in the world comes from the transportation sector and the number of vehicles in the Ankara have a great importance in the formation of this graphic. Its main source is internal combustion engines (85-95%). Industry, wood burning and forest fires cause CO emissions.

| PM10 (µg/m3) | | | | |
|---|---|---|---|---|
| Period studied | 2018 | 2019 | 2020 | Change (%) |
| 1 January- 15 March | 62 | 52 | 58 | -1 |
| 16 March - 31 May | 66 | 44 | 44 | 19 |
| 1 Jun - 30 Jun | 39 | 28 | 40 | -20 |

*Table 1. $PM_{10}$ three period averages by years*

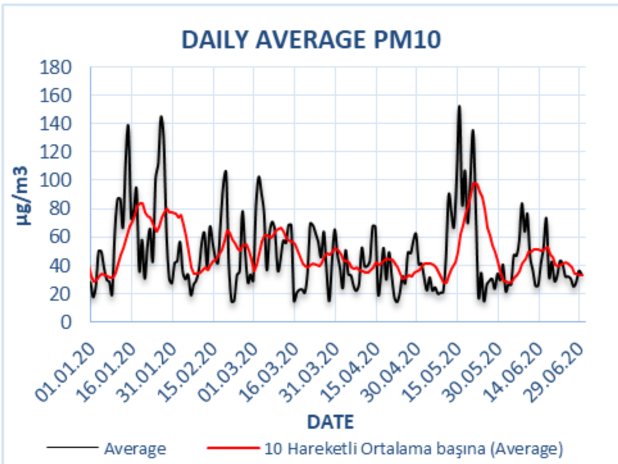


*Figure 9. $PM_{10}$ values Ankara between 01.01.2020 and 30.06.2020*

 

Table 2. $PM_{2.5}$ three period averages by years

| PM2.5 (µg/m3) | | | | |
|---|---|---|---|---|
| Period studied | 2018 | 2019 | 2020 | Change(%) |
| 1 January- 15 March | 27 | 19 | 30 | -29 |
| 16 March - 31 May | 17 | 15 | 15 | 4 |
| 1 Jun - 30 Jun | 15 | 14 | 12 | 16 |

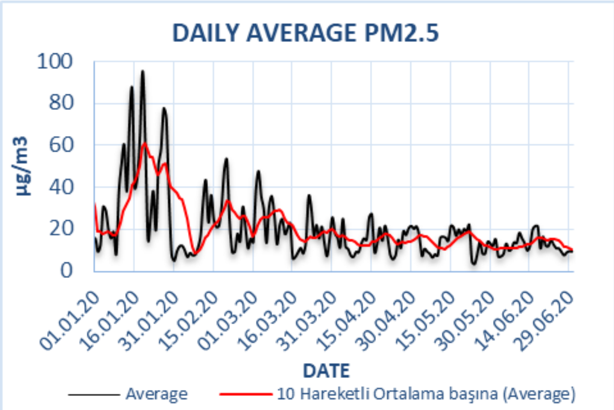


*Figure 10 $PM_{2,5}$ values Ankara between 01.01.2020 and 30.06.2020*

Figure 10 and Table 2 shows the $PM_{2.5}$ values in as air quality values for Ankara eight sampling station during first 6 months of 2020. Figure 10 indicate that $PM_{2.5}$values are mostly lower than 30 µg/m³. While the rate of decrease is high in the 1st period, it is less than the 1st period in the 2nd and 3rd periods. Comparing between before and after pandemic outbreak measures, it is difficult to see significant differences. It is known that the main sources of particles are the metal industry and vehicles and in Figure 10, it can be said that the decreased use of vehicles during the pandemic ban is effective. In Table 2, 2020 $PM_{10}$ values decreased in general compared to 2018 and increased compared to 2019.

*Table 3. NO2 three period averages by years*

| NO2 (µg/m3) | | | | |
|---|---|---|---|---|
| Period studied | 2018 | 2019 | 2020 | Change (%) |
| 1 January- 15 March | 43 | 52 | 75 | -56 |
| 16 March - 31 May | 22 | 43 | 34 | -3 |
| 1 Jun - 30 Jun | 19 | 41 | 39 | -27 |

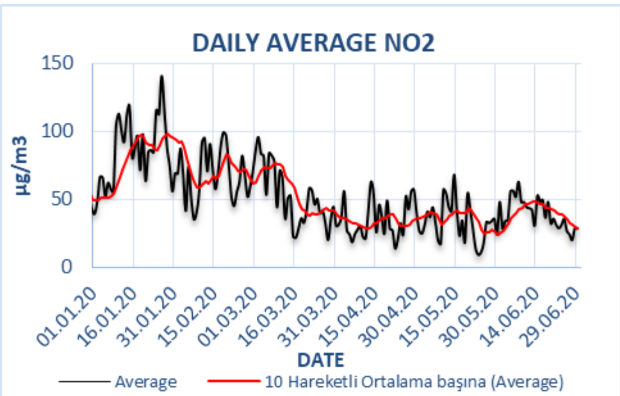


*Figure 11. $NO_2$ values Ankara between 01.01.2020 and 30.06.2020*

$NO_2$ values are included in Figure 11 and Table 3 as air quality values for eight sampling stations in Ankara. Sources of $NO_2$ can generally be listed as exhaust gases, fossil fuels and organic substances. Accordingly Figure 11 shows that, there was a decrease in the 2nd period(16 March - 31 May 2020) in the pandemic process compared to the 1st period(1 January-15 March 2020). In Table 3, 2020 $NO_2$ values for each period increased compared to 2018, and decreased compared to the 2nd and 3rd period of 2019.

*Table 4. $O_3$ three period averages by years*

| O3 (µg/m3) | | | | |
|---|---|---|---|---|
| Period studied | 2018 | 2019 | 2020 | Change (%) |
| 1 January- 15 March | 30 | 26 | 18 | 34,8 |
| 16 March - 31 May | 53 | 4 | 33 | -14,3 |
| 1 Jun - 30 Jun | 74 | 49 | 31 | 49,9 |

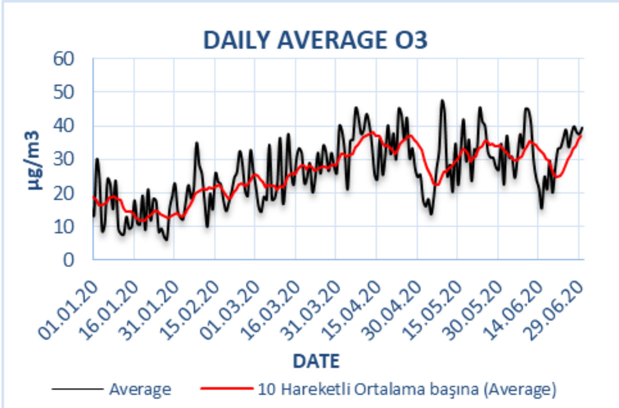


*Figure 12. $O_3$ values Ankara between 01.01.2020 and 30.06.2020*

$O_3$ values are shows Figure 12 and Table 4 as air quality values for eight testing stations in Ankara. Tropospheric ozone ranks fourth among greenhouse gases that play a role in global climate change and is mostly produced from atropogenic sources (URL-8). Accordingly Figure 12 shows that, there was a increase in the 2nd period(16 March - 31 May 2020) in the pandemic process compared to the 1st period(1 January-15 March 2020).Accordingly, it is understood that the ozone layer, which protects the world from harmful sun rays that cause cancer, begins to thicken again. Period 3 showed approximately the same values as period 2. In Table 4, 2020 ozone values for every periods decreased in compared to 2018 and increased only 2 nd period compared to 2019. In Table 4, 2020 ozone values for every period decreased compared to 2018, and increased only 2 nd period compared to 2019.

*Table 5. $SO_2$ three period averages by years*

| SO2 (µg/m3) | | | | |
|---|---|---|---|---|
| Period studied | 2018 | 2019 | 2020 | Change (%) |
| 1 January- 15 March | 7 | 13 | 8 | 22 |
| 16 March - 31 May | 10 | 9 | 5 | 48 |
| 1 Jun - 30 Jun | 10 | 8 | 4 | 54 |

 

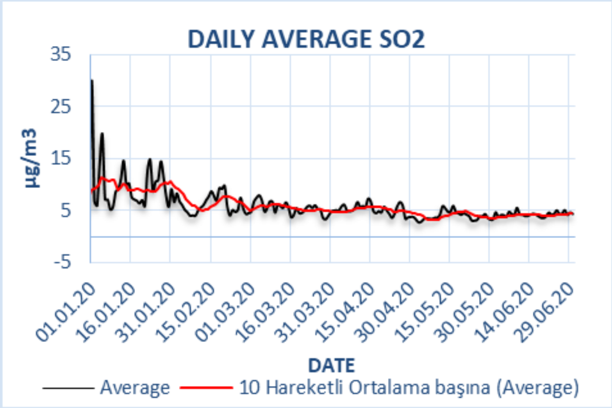


*Figure 13. $SO_2$ values Ankara between 01.01.2020 and 30.06.2020*

Air quality $SO_2$ values for the first 6 months of 2020 for eight sample stations in Ankara are shown in Figure 13 and Table 5. Figure 13 indicate that $SO_2$ values are mostly lower than 10 µg/m³. While the rate of decrease is high in the 1st period, it is less than the 1st period in the 2nd and 3rd periods. Comparing between before and after pandemic outbreak measures, it is difficult to see significant differences.It is realized that the principle wellsprings of particles are the metal industry and vehicles. Accordingly in Figure 13, decreased use of vehicles during the pandemic ban is effectiv In Table 5, 2020 $SO_2$ values decreased in general compared to 2018 and decreased for each period compared to 2019.

*Table 6. CO three period averages by years*

| CO (µg/m3) | | | | |
|---|---|---|---|---|
| Period studied | 2018 | 2019 | 2020 | Change (%) |
| 1 January- 15 March | 911 | 990 | 1208 | -27 |
| 16 March - 31 May | | 718 | 536 | 25 |
| 1 Jun - 30 Jun | | 615 | 439 | 29 |

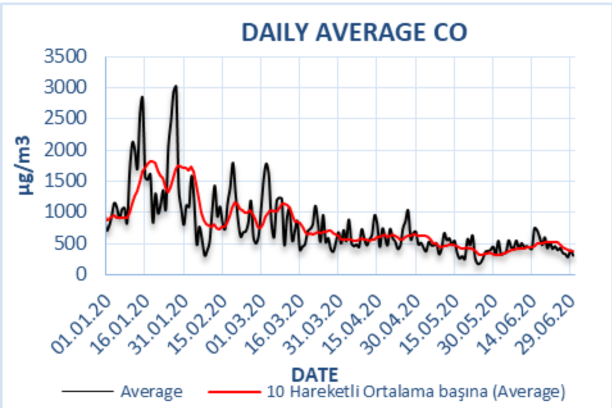


*Figure 14. CO values Ankara between 01.01.2020 and 30.06.2020*

Figure 14 and Table 6 shows the CO values in as air quality values for Ankara eight sampling station during first 6 months of 2020. Carbon monoxide in the city air has extremely important effects on human health. The most important of these effects is that carbon monoxide reduces the ability of body cells in the blood to carry oxygen. As a result, this situation can lead to death by severely reducing the amount of oxygen in the body. Since it is known that more than 70% of the carbon monoxide production in the world comes from the transportation sector (İncecik, 1994), the decrease in CO that occurs in the 2nd period in Figure 14 can be said due to the decrease in vehicle use. When we look at Table 6, which occurred thanks to the pandemic, the 672 µg / m3 decrease between the 1st and 2nd periods and the following 97 µg / m3 decrease is very important for human life. Due to the lack of data in 2018, there are gaps in Table 6 and interpretation is not possible.

Carbon monoxide, which is a primary air pollutant, occurs instead of CO2 as a result of incomplete combustion in the absence of one of the factors such as lack of oxygen, ignition temperature, persistence time of high temperature gas and combustion chamber turbulence (Masters, 1991). Nitrogen oxides ($NO_X$) are highly reactive gases formed at high temperatures (1200 °C). Many types of nitrogen oxides are colorless and odorless and do not dissolve in water. Therefore, they are inhaled to the very ends of the respiratory tract without being eliminated in the upper respiratory tract and show negative effects there. Nitrogen monoxide (NO) and a small amount of nitrogen dioxide ($NO_2$) are formed as a result of burning at high temperatures. NO released into the atmosphere turns into $NO_2$ as a result of oxidation (URL-9). Formation of carbon monoxide and nitrogen oxides are among the air pollutants harmful to human health as a result of high temperatures.

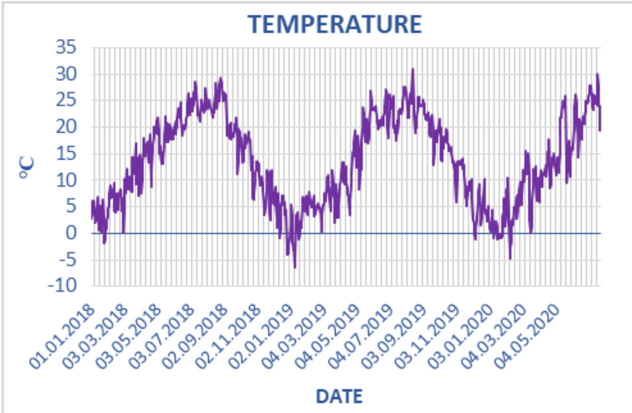


*Figure 15. Temperatures between 01.01.2018-30.06.2020*

Figure 15 shows the daily mean values of temperature Ankara from beginning of January 2018 to middle of June 2020. The average temperature between January 1 and June 30 was 12.44 °C in 2018, 10.92 °C in 2019 and 10.71 °C in 2020. The highest temperature occurred on 14 August 2019 at 31.05 °C. There is no excess in these temperature values for formation of carbon monoxide and nitrogen oxides.

## 4. Conclusion

The outputs obtained will be a very important step in terms of air quality evaluations in Ankara, raising awareness of the public, especially local administrators, about air quality. In line with the instructions of the World Health Organization against this new epidemic that spreads from China and threatens international public health, various measures have been taken by national administrations to protect public health and get rid of the epidemic with minimal damage. Implementations such as increased border security and entry and exit bans to countries, quarantines imposed in areas where the epidemic was detected, curfews, travel restrictions, and interruption of education have greatly affected the improvement of air quality and the positive reduction of air pollutants.

### *4.1. Future Recommendations*

In order for the meteorological devices to be measured to make the most accurate measurement, the station locations should be selected well and the necessary maintenance and calibration should be done, thus eliminating the problem of missing data. Popularizing the use of bicycles and reducing the use of motor vehicles are among the factors that help prevent air pollution. In addition, legal changes aimed at protecting and increasing forests and reducing pollutant emissions from vehicles will also be effective in increasing air quality.

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