Journal of research in Atmospheric science

Research Article

Journal of Research in Atmospheric Science
Vol. 3, No. 1, pp.1-7, June 2021

ISSN:2687-6418
http://resatmsci.com/

Impact of the COVID-19 Event on PM_{10} Air Pollution in Istanbul and Ankara

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Abstract

The quality of the air we breathe is important for a healthy life. The use of fossil fuels has increased continuously since the second half of the 19th century. Gases or dusts released into the atmosphere during overproduction, increased consumption waste can reduce air quality on a global scale. In order to reduce the spread of the coronavirus epidemic that emerged towards the end of 2019 and spread around the world, restrictions began to be imposed on human activities. With the announcement of the COVID-19 case on March 11, 2020 in Turkey, a series of measures restricting human activities started to be taken starting from March 16, 2020. On the basis of restriction, it is aimed to prevent the spread of the virus, which has the ability to spread through contact, and to slow the rate of spread. The change in air pollution values due to different restrictions of human activities has been a subject of curiosity. The results of the study showed that the reduction of human activities significantly affects air pollution. In this study, the changes in PM_{10} pollutant concentrations in Istanbul and Ankara in the months when more measures were not taken and in the months when more measures were taken in 2019 and 2020 were examined. As a result of the restrictions applied, the use of vehicles, industrial activities, fuel consumption, etc. It was observed that the change caused a decrease in PM_{10} pollutant concentrations.

Keywords: PM_{10}, COVID-19, Air Pollution, Istanbul, Ankara

COVID-19'un İstanbul ve Ankara'da PM_{10} Hava Kirliliği Üzerine Etkisi

Özet

Sağlıklı bir hayat için soluduğumuz havanın kalitesi önemlidir. 19. yüzyılın 2. yarısından itibaren fosil yakıtları kullanımı sürekli artmıştır. Aşırı üretim, tüketim israfların artması sırasında atmosfere salınan gazlar veya tozlar küresel ölçekte hava kalitesini düşürebilmektedir. 2019 yılının sonlarına doğru ortaya çıkan ve dünya geneline yayılan koronavirüs salgınının yayılımını azaltmak amacıyla insan faaliyetlerinde kısıtlamalar uygulanmaya başlanmıştır. Türkiye'de de 11 Mart 2020 tarihinde COVID-19 vakasının duyurulmasıyla birlikte 16 Mart 2020 tarihinden başlamak üzere insan faaliyetlerini kısıtlayıcı bir dizi tedbirler alınmaya başlamıştır. Kısıtlamaya gidilmesinin temelinde temas yoluyla yayılma özelliği gösteren virüsün yayılımının önüne geçilmesi ve yayılım hızının yavaşlatılması hedeflenmiştir. İnsan faaliyetlerinin farklı şekilde kısıtlanmasına bağlı olarak hava kirliliği değerlerindeki değişim merak konusu olmuştur. Çalışma sonuçları insan faaliyetlerinin azalmasının hava kirliliğini önemli derecede etkilediğini göstermiştir. Bu çalışmada İstanbul ve Ankara'da PM_{10} kirletici yoğunlukları 2019 ve 2020 yılında daha çok tedbir alınmayan aylarda ve daha çok tedbir alınan aylardaki değişimi incelenmiştir. Uygulanan kısıtlamalar sonucunda taşıt kullanımı, sanayi faaliyetleri, yakıt tüketimi vs. de değişimin PM_{10} kirletici yoğunluklarında düşüşe sebep olduğu görülmüştür.

Anahtar Kelimeler: PM_{10}, COVID-19, Hava Kirliliği, İstanbul, Ankara

1. Introduction

Air pollution due to industrialization is one of the biggest and most important problems of our day. Air pollution occurs when solid, liquid and gaseous substances in the air we breathe are in a density and time that will harm living health and the earth's environmental balance. Air pollution is caused by natural causes such as forest fires and volcano eruptions, as well as growing human activities today. Today, air pollution is mostly caused by motor vehicles, industrial facilities and heating (Toros, 2000).

In particular, it is important to have a strong immune system to protect against coronavirus and to breathe quality air for a strong immune system. Non-pollution of the air is very important in terms of the sustainability and safety of human health. Increasing worldwide, urbanization, industrial activities and fuel consumption can lead to pollution threatening human health in many parts of the world (Toros & Anbarcı, 2018). Restricting human activities to reduce the spread of the disease against the danger posed by the epidemic has made significant contributions to the reduction of air pollution (Venter et al., 2020; Dursun et al., 2021, Öztürk et al., 2021). Unal et al. (2021; Fu et al. 2020) examined the change between meteorological conditions and air pollution in Istanbul during the epidemic period. As of March 15, 2020, restrictions against COVID-19 have started in Turkey. Relationships between air pollution and meteorological

variables such as wind speed and direction, pressure and humidity were evaluated in their studies. When the effect of meteorological conditions, which are extremely effective in the increase of air pollution, it is seen that the restriction of activities is effective in the decrease of air pollution density. Öztürk et al. (2021) reported that during the COVID-19 process, mostly traffic-related NO_2 values decreased.

The coronavirus, which emerged in Wuhan, China on December 1, 2019, was first announced in Turkey on March 11, 2019. The coronavirus, which has the ability to spread in a short time through contact, caused the spread of cases throughout the country until the beginning of April (Dursun et al., 2021). The impact of COVID-19 control measures on the air quality of the city of Adana was studied between January 1 and June 30, 2020. The year 2020 of PM_{10}, O_3, NO_2 and SO_2 was compared with the same periods of the previous years and no significant impact of restriction of human activities on air quality was detected (Tunç and Taurus 2020). Kılıç et al. (2020) examined the $PM_{2.5}$ and PM_{10} data in 3 periods before, during and after the epidemic disease measures in Istanbul and concluded that the measures increase the air quality. Bilgin and Toros (2020) investigated the effect of control measures taken by the government in Izmir to reduce the spread of COVID-19 disease on daily air pollution levels. The daily data of PM_{10}, $PM_{2.5}$, NO_2, CO, SO_2 and O_3, which have data from 14 different air quality measurement stations in İzmir province between January 1, 2018 and June 30, 2020, were examined. To assess the relationship between air pollution and COVID-19, the data were divided into three periods: the period before the pandemic measures (January 1 - March 15), the period of stringent measures (March 16 - May 31), and the normalization period (June 1 - June 30). The changes in the level of air pollution in 2020 were examined and compared with the values in the same periods of 2018 and 2019. In general, it has been observed that the decrease in air pollution levels is not reflected in PM_{10} and $PM_{2.5}$ values. However, a decrease was observed in other pollutants both during the period when control measures were taken and during the normalization period. In the study conducted by Yiğiter and Toros (2020), PM_{10}, $PM_{2.5}$, NO_2, CO, SO_2 and O_3 between January 1 and June 30 for 2018-2020 in Bursa, which is a dense residential area in terms of both population and industry, the first period before the epidemic was January 1 - March 15, the second period when intensive measures were taken due to the epidemic was March 16 - May 31, and the third period of normalization was June 1 - June 30. During the period of epidemic measures in Bursa, a significant decrease was observed in the density of these pollutants. Depending on the measures taken due to the epidemic disease, changes in air pollution have also been made in Trabzon, Istanbul and Ankara (Leg et al., 2020; Dündar et al., 2020; Kara et al., 2020).

In order to minimize contact due to epidemic disease in Turkey, some restrictions were imposed by the government between March 16 - June 1, 2019. Human activities have been minimized as a result of full closure for disadvantaged age groups (under 18 and over 65), and restrictions on work, education and social life for other age groups, and people have been called to stay at home. Curfews have been imposed on certain days, especially on weekends, to encourage people to stay at home and to minimize contact. Restrictions on human activities were lifted with the normalization process in June, as the negative impact and spread rate of the virus decreased. The number of cases has started to increase due to the increased contacts since September. Thereupon, the government, as of November, increased the coronavirus measures in order to prevent the increase in the number of cases, while imposing a curfew between 21.00 - 05.00 on weekdays; has imposed a curfew except 10.00-17.00 on weekends. These restrictions, which significantly prevent human activities, caused a noticeable decrease in air pollution values compared to previous years. This study includes the comparison of the months when human activities were restricted due to epidemic diseases in the two largest cities of Turkey and the normal process continued.

2. Data and Method

The data of the PM_{10} pollutant for the years 2019 and 2020 used in this study were obtained from the website of Republic of Turkey Ministry of Environment and Urbanization and Istanbul Metropolitan Municipality.

2.1 Research Area

In this study, the air pollution data of Istanbul and Ankara, which have the two largest populations of Turkey, were examined. Istanbul has an important geographical location that connects the European and Asian continents. Istanbul, which has the largest population in Europe, is also a city of history and culture. In addition to industry, Istanbul, where it is concentrated in commercial activities, acts as a center between North, South, East and West due to its location. Istanbul is the most populous city in Turkey with a population of around 16 million. The high number of human activities that come with the excess of the population also directly affect the PM_{10} concentration, which is one of the pollutants that cause air pollution.

In this study, the air pollution (PM_{10}) data of Ankara, another important province, capital city of Turkey, was examined. Ankara is the second most populous city in Turkey with a population of nearly 6 million. As in other crowded cities all over the world, the presence of high amount of human activities in Ankara also affects the concentration of PM_{10}, which is one of the pollutants that cause air pollution (Figure 1).

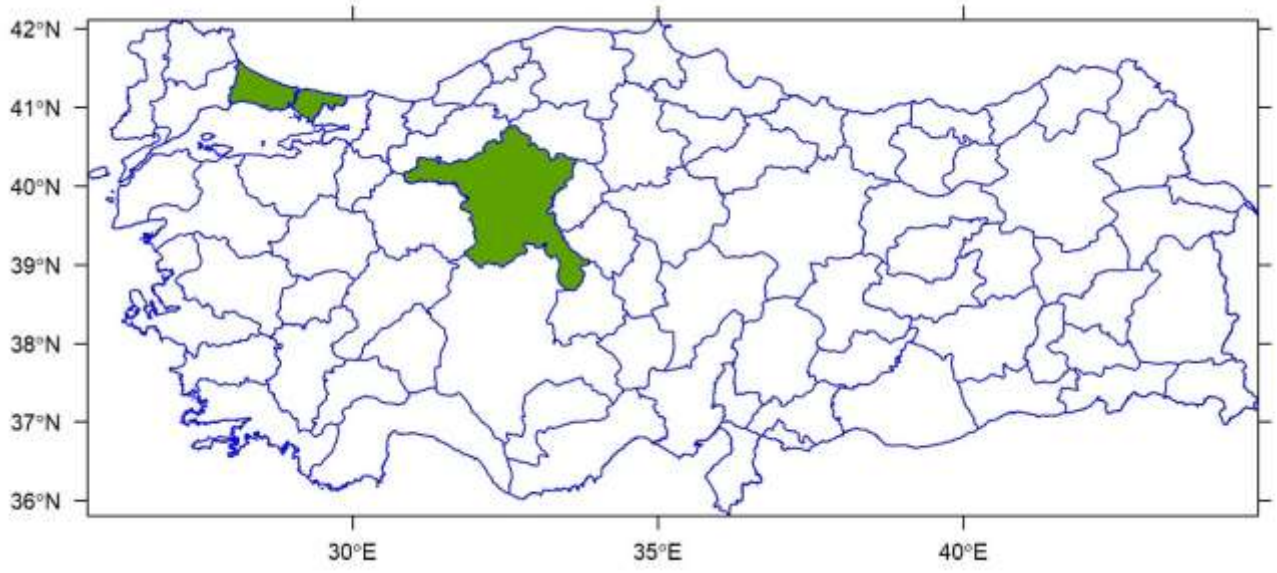

Figure 1. The location of Istanbul and Ankara on the map of Turkey

2.2 Examination Method

Since the construction activities have changed before and during the epidemic and to investigate the effects of this change on air pollution, the data for 2019 and 2020 were examined. Particulate matter (PM_{10}) concentration, which is one of the main pollutants that are formed as a result of human activities other than natural roads and adversely affects human health, has been investigated.

In order to observe the changes that occurred, for the purpose of compare with other years, 2019 and 2020, which includes the epidemic process, were examined in two different periods for Istanbul and Ankara. These are January, February, March, June, July, August, September and October, which do not include restrictions, and the months of April, May, November and December, which are accepted as epidemic disease processes and where restrictions continue to exist. In addition, the time restrictions imposed during the epidemic process were examined on the basis of these two categories and the effect of human activities on air pollution was examined.

3. Results and Discussion

Inhalable particulate matter PM_{10} originates from human activities or occurs naturally. Intrinsically, it is formed as a result of human activities such as motor vehicles, factories, thermal power plants, construction activities, mining and agriculture, as well as natural causes such as volcanic explosions, forest fires, which are naturally mixed into the air from the earth. For this reason, PM_{10} values have low concentrations values in rural areas where there is less human activity to cause industrialization and pollutant formation; It has high values in urban areas (Öztürk et al., 2011; Toros et al., 2013). Istanbul and Ankara are two important cities in the country in terms of human activity. With the curfews imposed during the epidemic process, there was a restriction in human activities, and it was found as a result of the examination that there were differences due to restrictions between the 2019-2020 PM_{10} pollutant amounts.

In Figure 2, the months of January, February, March, June, July, August, September and October (JFMJJASO) covering the pre-epidemic and normalization processes of the province of Istanbul and April, May, November and December covering the restrictions imposed due to the epidemic process (AMND) data for the years 2019 and 2020 are included. Between the hours of 21.00-05.00, when the stay home call is made the PM_{10} values of 2020 are less intense than the PM_{10} values of 2019. In Table 1, it is seen that the PM_{10} value in the months of 2020, when the restrictions continue, decreased by 25.9% compared to the PM_{10} value in 2019. In the months before the epidemic and normalization processes, it is observed that there is an increase of 4.8% in the PM_{10} concentrations of 2020 compared to 2019. With the end of the curfew, the human-induced activities carried out by people to continue their daily activities and to revive the social life they left behind during their stay at home are the main reason for the increase in PM_{10} density of 2020. If a review is made on all months, it is noteworthy that the PM_{10} density of 2020 decreased by 6.5% compared to 2019.

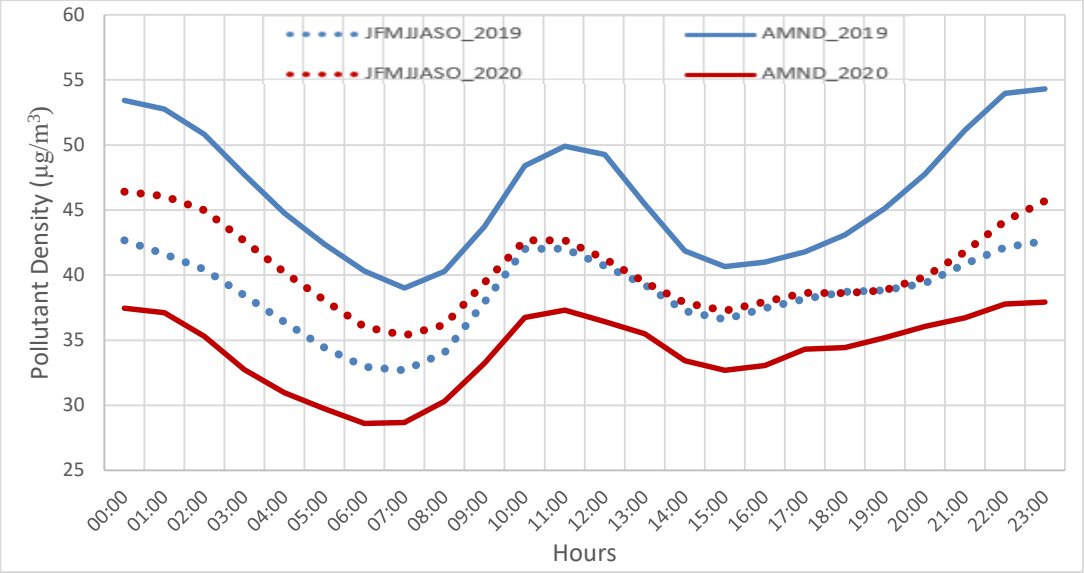

Figure 2. Hourly PM_{10} Values for Istanbul Province in 2019 and 2020

Table 1.PM_{10} Change in Istanbul Province in 2019 and 2020

	All Data	**JFMJJASO**	**AMND**
2019	41.1	38.7	46.2
2020	38.5	40.5	34.2
Percentage changes	-6.5	4.8	-25.9
	All months change of 2020 compared to 2019	The change in the months without action in 2020 compared to 2019	Measures taken months 2020 change compared to 2019

When the PM_{10} data of the weekdays of 2020 in Table 2 are compared for all months compared to 2019, it is seen that there is an average decrease of 10%. When the dust measurement values of the weekdays in January, February, March, June, July, August, September and October are compared, there was no significant change in percentage in 2020 compared to 2019. In addition, when the data of April, May, November and December, when the intensive measures were taken due to COVID-19, it was determined that the dust values in 2020 decreased by 27% compared to 2019.

Table 2.PM_{10} Change on Weekdays in Istanbul Province in 2019 and 2020

	Weekday Data	**JFMJJASO**	**AMND**
2019	42.2	39.8	47.3
2020	38.1	39.9	34.5
Percentage changes	-9.7	0.2	-27.1
	All months change of 2020 compared to 2019	The change in the months without action in 2020 compared to 2019	Measures taken months 2020 change compared to 2019

As can be seen in Table 3, when the PM_{10} data of the weekend days of 2020 are compared for all months compared to 2019, it is seen that there is an average increase of 2%. When the dust measurement values of the weekend days in January, February, March, June, July, August, September and October are compared, it is observed that there is an increase

of 18% in 2020 compared to 2019. In addition, when the data for April, May, November and December, when intensive measures were taken due to COVID-19, it is seen that the dust values in 2020 decreased by 22% compared to 2019.

Table 3.PM_{10} Change at Weekend in Istanbul Province in 2019 and 2020

	Weekend Data	**JFMJJASO**	**AMND**
2019	38.5	35.9	43.6
2020	39.3	42.3	33.9
Percentage changes	2.1	18.0	-22.2
	All months change of 2020 compared to 2019	The change in the months without action in 2020 compared to 2019	Measures taken months 2020 change compared to 2019

In Figure 3, the months of January, February, March, June, July, August, September and October (JFMJJASO) covering the pre-epidemic and normalization processes of the province of Ankara and April, May, November and December covering the restrictions imposed due to the epidemic process (AMND) months, examinations of 2019 and 2020 are included. Between 21.00-05.00, which is the time frame when the stay at home call is made, the PM_{10} values of 2020 have a higher density than the PM_{10} values of 2019. If this result is evaluated specifically for the province of Ankara, the excess amount of pollutants caused by the increase in heating needs with the transition of people to home life in the province with colder weather conditions than Istanbul may be the reason for the increase in the amount of density compared to 2019. At the same time, if Table 3 is examined, it is concluded that the PM_{10} value in the months of 2020, when the restrictions continue, increased by 7.2% compared to the PM_{10} value in 2019. In the months before the epidemic and normalization processes, it is observed that there is an increase of 29% in the PM_{10} density of 2020 compared to 2019. With the end of the curfew, people continue their daily activities and revive the social life they left behind during their stay at home, the fuel they use to meet the need for heating in the winter months are the main reasons for the increase in PM_{10} density of 2020. If a review is made on all months, it is seen that the PM_{10} density for 2020 has increased by 20.4% compared to 2019.

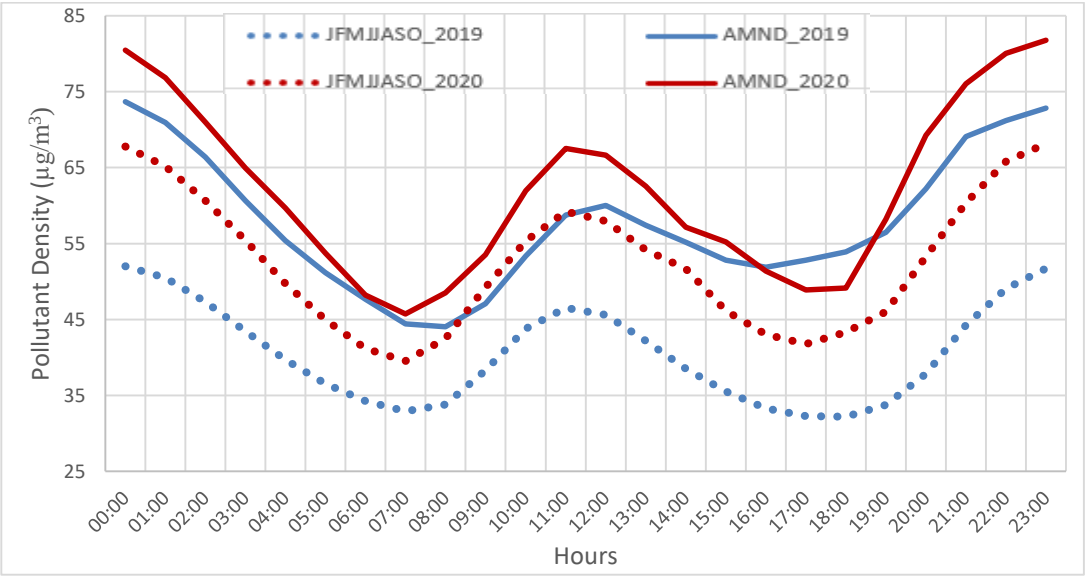

Figure 3. Hourly PM_{10} Values for Ankara Province in 2019 and 2020

Table 4.PM_{10} Change in Ankara Province in 2019 and 2020

	All Data	**JFMJJASO**	**AMND**
2019	46.3	40.6	57.9
2020	55.8	52.6	62.0

Percentage	20.4	29.4	7.2
	All months change of 2020 compared to 2019	The change in the months without action in 2020 compared to 2019	Measures taken months 2020 change compared to 2019

When the PM_{10} data of weekdays for 2020 in Table 5 are compared for all months compared to 2019, it is seen that there is an average of 18% increase. When the dust measurement values of the weekdays in January, February, March, June, July, August, September and October are compared, there is an increase of 28% in 2020 compared to 2019. In addition, when the data of April, May, November and December, when the intensive measures were taken due to COVID-19, it was determined that the dust values in 2020 increased by 4.5% compared to 2019.

Table 5.PM_{10} Change on Weekdays in Ankara Province in 2019 and 2020

	Weekdays Data	**JFMJJASO**	**AMND**
2019	48.2	41.7	61.3
2020	57.1	53.7	64.1
Percentage Changes	18.5	28.6	4.5
	All months change of 2020 compared to 2019	The change in the months without action in 2020 compared to 2019	Measures taken months 2020 change compared to 2019

If Table 6 is examined, it is seen that the PM_{10} data of the weekend days of 2020 are compared for all months compared to 2019, showing an average increase of 26%. When the dust measurement values of the weekends in January, February, March, June, July, August, September and October are compared, it is observed that there is an increase of approximately 32% in 2020 compared to 2019. In addition, when the data for April, May, November and December, when intensive measures were taken due to COVID-19, it is seen that the dust values in 2020 increased by 16% compared to 2019.

Table 6.PM_{10} Change at Weekend in Ankara Province in 2019 and 2020

	Weekend Data	**JFMJJASO**	**AMND**
2019	41.6	38.2	49.0
2020	52.4	50.3	56.9
Percentage Changes	25.9	31.9	16.1
	All months change of 2020 compared to 2019	The change in the months without action in 2020 compared to 2019	Measures taken months 2020 change compared to 2019

4. Conclusion and Recommendations

Due to the coronavirus epidemic affecting the whole world, curfew restrictions started to be applied in Turkey as of March 16, 2020. In order to prevent the spread of the virus, which can be easily transmitted through contact and crowded environments, the government has imposed various restrictions by calling the public to stay at home. As a result of the restrictions imposed, the activities of people are restricted, so activities that cause pollution are generally minimized. As a result, a significant decrease in PM_{10} was observed in Istanbul in 2020 compared to 2019. In the conditions of epidemic disease process, the increase in human activities with the initiation of the normalization process by stretching the restrictions has also emphasized the importance of human activities on air pollution by causing an increase in pollutant values. In short, as a result of the examinations and comparisons, the decrease in vehicle use during the epidemic process, where human activities are minimized, studies in the

industry sector, and the reduction of fumes caused by fossil fuels used for other purposes have shown that human activities have an important role in the concentrations of air pollution by causing a decrease in air pollution values.

Acknowledgment: We are grateful to the Ministry of Environment and Urbanism of Turkey, Istanbul Metropolitan Municipality for air pollution and meteorological data. This study was presented to the 6th international Marmara sciences congress IMASCON 2021.

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Journal of research in Atmospheric science

Research Article

Journal of Research in Atmospheric Science
Vol. 3, No. 1, pp. 8-12, June 2021

ISSN:2687-6418
http://resatmsci.com/

Air Pollution Data Analysis Over Van City, Turkey

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Abstract

Air pollution exhibits a very complex and non-linear behavior as a result of positive and negative changes in time and space, depending on the meteorology and topographic structure, in the transportation of the emissions released into the receiving environment as a result of the activity of air pollution sources. The aim of the study is to monitor the behavior of air pollutants over Van in 2019 through statistical analysis of data, to contribute to increasing air quality. PM_{10} and SO_2 parameters have been observed to have the highest average hourly value of 72.5-25.1 µg/m³, and the lowest value (24.8 µg/m³ at 22:00 hours,11.4 µg/m³ at 16:00 hours) respectively. It can be seen 64% of the measured PM_{10} data were observed in the range of 0.1-40.7 µg/m³. 80% of the same data is less than 56.4 µg/m³ and 91% of the data has the highest density observed in the range 1.1-82.1 µg/m³. while 77% of the measured SO_2 data was observed in the range of 1.5-22.7 µg/m³. 80% of the same data is less than 25.1 µg/m³ and 90% of the data has the highest density in the range of -4.7-37.8 µg/m³. The results also showed wind plays an effective role in the horizontal transport of pollutants in the atmosphere. If the wind is calm, the polluted air stays where it is, and the precipitation help collapse pollutants in the atmosphere, because of this feature, precipitation is described as the cleaner of the atmosphere.

Keywords: Urbanization, PM_{10}, SO_2, air pollution, health.

Van Hava Kirliliği Analizi

Özet

Hava kirliliği, emisyonların taşınımı, meteoroloji ve bölgenin topografik yapısına bağlı olarak zaman ve mekandaki olumlu ve olumsuz değişimler sonucunda çok karmaşık ve doğrusal olmayan bir davranış sergilemektedir. Çalışmanın amacı, hava kalitesinin artırılmasına katkıda bulunmak için verilerin istatistiksel analizi yoluyla 2019 yılında Van üzerindeki hava kirleticilerinin davranışını izlemektir. PM_{10} ve SO_2 parametrelerinin sırasıyla en yüksek ortalama saatlik değer olan 72.5-25.1 µg/m³ ve en düşük değer ise (22:00'da 24.8 µg/m³, 16:00'da 11.4 µg/m³) olarak gözlemlenmiştir. Ölçülen PM_{10} verilerinin % 64'ünün 0.1-40.7 µg/m³ aralığında gözlendiği görülmektedir. Aynı verilerin % 80'i 56.4 µg/m³'den azdır ve verilerin % 91'i 1.1-82.1 µg/m³ aralığında gözlemlenen en yüksek yoğunluğa sahiptir. Ölçülen SO_2 verilerinin% 77'si ise 1.5-22.7 µg/m³ aralığında gözlenmiştir. Aynı verilerin % 80'i 25.1 µg/m³'den azdır ve verilerin % 90'ı -4.7-37.8 µg/m³ aralığında en yüksek yoğunluğa sahiptir. Sonuçlar ayrıca rüzgârın atmosferdeki kirletici maddelerin yatay taşınmasında etkili bir rol oynadığını göstermiş olup rüzgâr sakinse kirli hava olduğu yerde kalır ve yağışlar atmosferdeki kirleticileri çökertmeye yardımcı olur. Bu özelliği nedeniyle yağış atmosferin temizleyicisi olarak tanımlanır.

Anahtar Kelimeler: Şehirleşme, PM_{10}, SO_2, hava kirliliği, sağlık, büyükşehir.

1. Introduction

Air pollution happens when gases, solid and liquid particles substances in the air we breathe are in a density and time that will harm living health and the earth's environmental. Air pollution is one of the biggest and most important problems of humanity. Air pollution exhibits a very complex and non-linear behavior as a result of positive and negative changes in time and space, depending on the meteorology and topographic structure, in the transportation of the emissions released into the receiving environment as a result of the activity of air pollution sources. Air pollution is caused by natural causes such as forest fires and volcano eruptions, as well as growing human activities today. Today, air pollution is mostly caused by motor vehicles, industrial facilities and heating. Air quality is very important in terms of the security and sustainability of human health. Increasing worldwide industrial activities and inefficient use and waste can lead to pollution threatening human health in many parts of the world (Toros, 2000; Toros & Anbarcı, 2018; Ouyang et al., 2019; Venter et al., 2020; Dursun et al., 2021, Öztürk et al., 2021). Unal et al. (2021; Fu et al. 2020). Following the COVID-19 outbreak that started in 2019, changes in human activities and behavior necessarily led to significant reductions in air pollution within the framework of efforts to limit their exposure to the infectious virus (Dursun et al., 2021; Öztürk et al. 2021; Tunç and Taurus 2020; Kılıç et al. 2020; Bilgin

and Toros 2020; Yiğiter and Toros 2020; Leg et al., 2020; Dündar et al., 2020; Kara et al., 2020).

There is no more study about air pollution of the Van city so there are more study about it to understand level, behavior and changes of air pollution city of Van. Öztürk and Bayram (2019) studied temporal and seasonal distribution of air pollutant parameters, concentrations, and the relationship of pollutant parameters with temperature in the city center of Van were discussed according to the allowed limit values and solutions for the city were given. They concluded that the topographic and geographical location of the city, the winter season is harsh, and the average temperature of the city is lower than the country average. Tekin (2021) evaluated the air pollutants (PM_{10} and SO_2) in the first year of the COVID-19 in the province of Van compared to the previous year.

In this study, the 2019 air pollution analysis was made for the Van province of Turkey. In this article, the behavior, source, etc. of the pollutants are analyzed by analyzing the data that has passed the quality control process with statistical techniques. It is aimed to create a systematic structure in these matters and thus contribute to the increase of air quality, which is extremely important for human health, to create socio-economically sustainable and safe of tomorrows.

2. Study Area, Data and Methodology

Hourly PM_{10} and SO_2 parameters data for 2019 were obtained from the Ministry of Environment and Urbanization air quality monitoring stations (Figure 1). Air pollution and meteorological data are obtained from the Ministry of Environment and Urbanism of Turkey and the Turkish State Meteorological Service.

The study area is located in the eastern sites of the Lake Van region, Eastern Turkey with a population of approximately 1 million 150 thousand. The city center of Van is located at latitude 38.497 N and longitude 43.3816 E. The continental climate is dominant in the province located in the east of Turkey. Therefore, it is dry and hot in summer and cold and snowy in winter. However, Lake Van, Turkey's largest lake, makes the continental climate of the city slightly more humid (Öztürk and Bayram 2019).

Figure 1. Map of Turkey and location of the Van areas.

The temporal variation of each pollutant (according to density and index values), the largest, smallest, average values over time, temporal variation of meteorological data, and the relationship between meteorological data and pollutants were examined.

3. Results and Discussion

It is very important in analysis to see how pollutants have changed over time. The situations where the pollution intensity increases, decreases or reaches the highest level can be observed with the help of graphs. In addition, the simultaneous increase and decrease of two different pollutant parameters is also very important in terms of determining the pollutant source.

The change parameters PM_{10} and SO_2 at weekdays the highest hourly average value of (78.7 µg/m³ - 27.5 µg/m³) at 21:00 hours respectively, and the lowest value of (24.5 µg/m³ - 10.9 µg/m³) at 06:00 hours respectively, as seen in Figure 2 while see in Figure 3 at the weekend the highest average hourly value of PM_{10} and SO_2 parameter (72.5 µg/m³, 25.1 µg/m³), and observed the lowest value of (24.8 µg/m³, 11.4 µg/m³) at (22:00,16:00 hours) respectively.

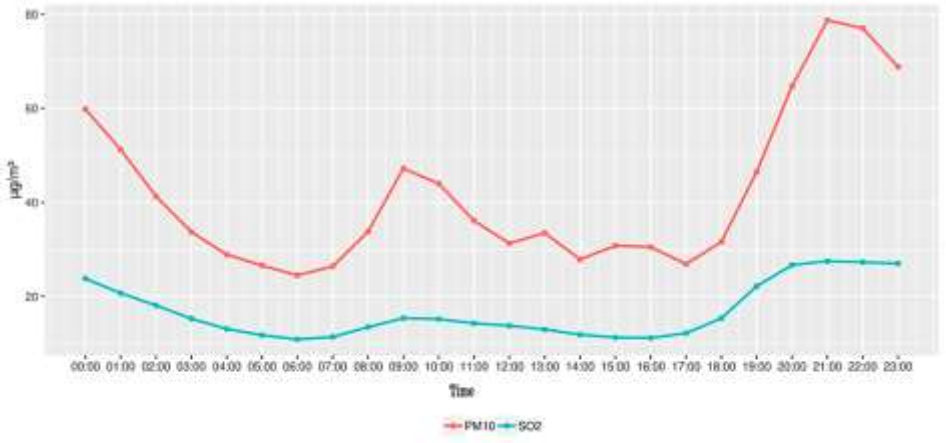

Figure 2.Time change graph of pollutants during the week.

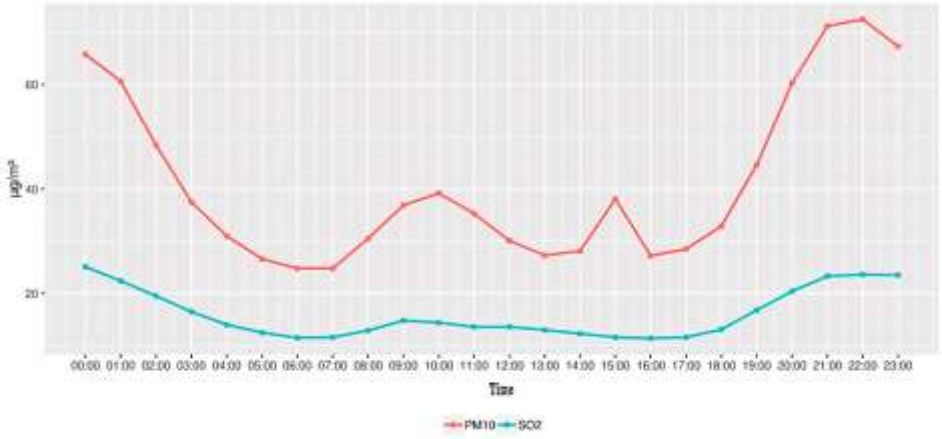

Figure 3.Time-change graph of pollutants over the weekend.

The high daily average change of pollutants PM_{10} and SO_2 of (146.1 µg/m - 82 µg/m³) was observed (on Tuesday, July 09 - on Thursday, February 07) respectively, but the lowest daily average of (9.4 µg/m³ -1.8 µg/m³) value was observed (on Thursday, April 18- on Tuesday, July 02) respectively as seen in Figure 4.

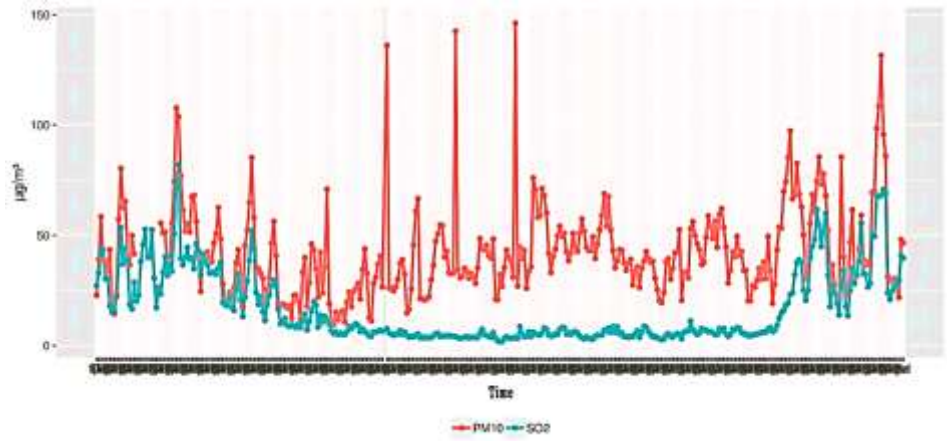

Figure 4.Daily average change graph of pollutants.

Figure 5 show 64% of the measured PM_{10} data were observed in the range of 0.1-40.7 µg/m³. 80% of the same data is less than 56.4 µg/m³ and 91% of the data has the highest density observed in the range 1.1-82.1 µg/m³, and also 77% of the measured SO_2 data was observed in the range of 1.5-22.7 µg/m³. 80% of the same data is less than 25.1 µg/m³ and 90% of the data has the highest density in the range of -4.7-37.8 µg/m³.

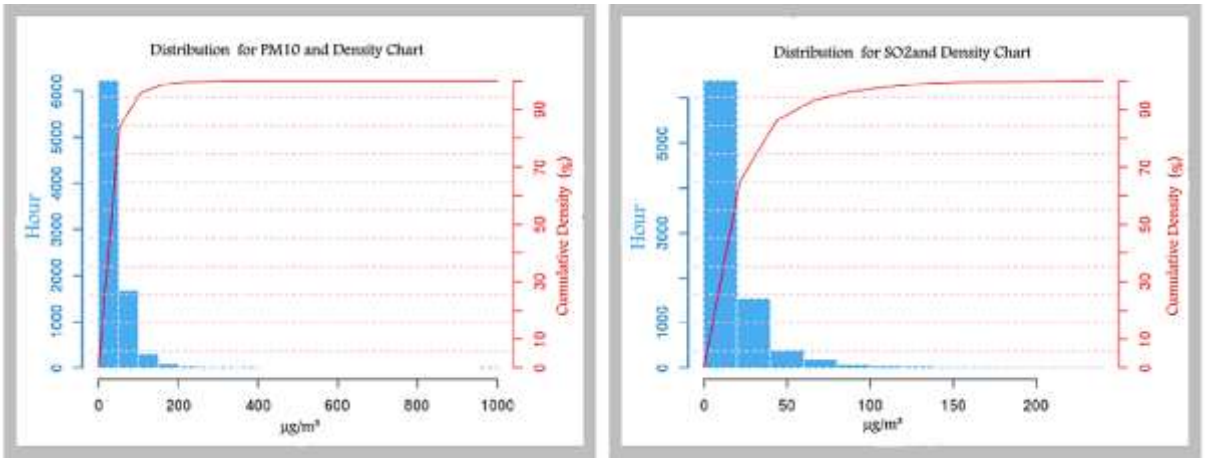

Figure 5. Histogram and density graphs of pollutants.

The average values of PM_{10}, SO_2 parameters were measured as 41.6, 16.5 µg/m³, respectively. The extreme values corresponding to 75 percent were measured as 50.3 and 21 µg/m³, respectively show in Table 1.

Table 1. Measurement data summary information. (NM: Number of Measurement, Min: Minimum, %25: the value of 25th value of data, Avg: Average, %75: the value of 75th value of data, Max: Maximum, SD: Standard deviation)

Type	NM	Daily%	Min.	%25	Avg.	Median	%75	Max.	SD.
PM_{10}	8697	96	0.1	20.7	41.6	32.9	50.3	1000	40.5
SO_2	8697	100	1.5	4.6	16.5	7.7	21	232.1	21.2

Table 2, shows the ranges for the air quality index applied in our country. When the PM_{10} measurement values were examined as a percentage, it was observed that 73% was in the GOOD class, 25% in the MIDDLE class, and 2% in the SENSITIVE class. also, SO_2 measurement values are examined as a percentage, it is observed that 99% is in the GOOD class and 1% is in the MIDDLE class.

Table2. *National Air Quality Index*

Index	Air Quality Index	SO_2 [µg/m³]	PM_{10} [µg/m³]
		1 Hour Cover.	24 Hours Cover.
Good	0 – 50	0-100	0-50
Middle	51 – 100	101-250	51-100
Sensitive	101 – 150	251-500	101-260
Unhealthy	151 – 200	501-850	261-400
Bad	201 – 300	851-1100	401-520
Dangerous	301 – 500	>1101	>521

Wind plays an effective role in the horizontal transport of pollutants in the atmosphere. In the presence of wind, the pollution is moved from one place to another. If the wind is calm or slightly intense, the polluted air stays where it is. Therefore, air pollution is most intense in areas that are closed to the wind. In this case, dilution of the pollutants in the air occurs in direct proportion to the increase in wind speed. Figure 6 as show, the pollution rose graph is examined, depending on the wind direction for PM_{10} and SO_2 pollutant parameters, the direction with the highest pollution frequency was observed as East.

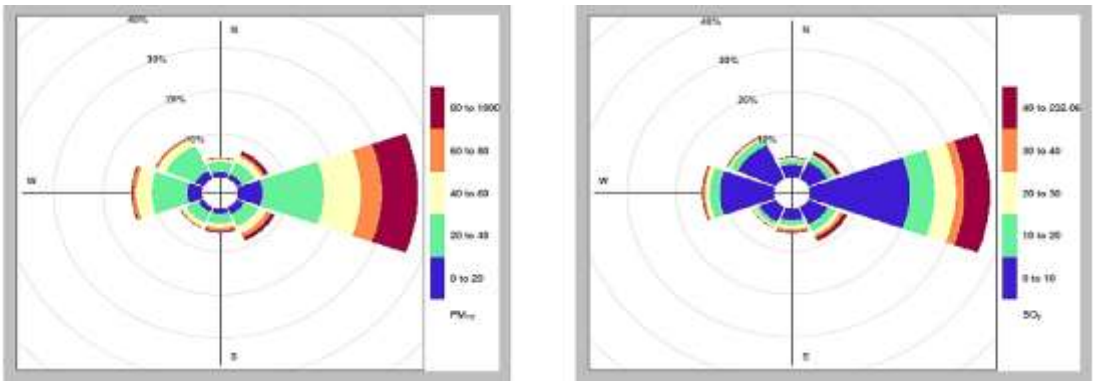

Figure 6. Pollution rose graph

4. Conclusion

The main concluding remarks obtained from this study are summarized as follows:

- The parameters PM_{10} and SO_2 are highest on a weekday and decrease on weekend.
- The high daily average parameters PM_{10} and SO_2 of (146.1 µg/m³ - 82 µg/m³) was (on Tuesday, July 09 - on Thursday, February 07) respectively.

- PM_{10} and SO_2 pollutant parameters, the direction with the highest pollution frequency was observed as East.

Acknowledgment

The authors are grateful to the Ministry of Environment and Urbanism of Turkey, the Turkish State Meteorological Service for air pollution and meteorological data. This study was presented to the International Symposium for Environmental Science and Engineering Research ISESER2021. This study benefited from Bijyan Bulut undergraduate thesis.

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Journal of research in Atmospheric science

Research Article

Journal of Research in Atmospheric Science
Vol. 3, No. 1, pp.13-20, June 2021

ISSN:2687-6418
http://resatmsci.com/

Investigation of Air Pollution in Bursa City Centre

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Abstract

The part of the atmosphere in which people and other living things live, which is close to the earth; As clean air, nitrogen, oxygen and a small amount of it are made up of other gases. The distribution of these gases is a mixture of 21% oxygen, 78% nitrogen and 1% other gas by volume. Other gases other than oxygen and nitrogen are gases such as argon, carbon dioxide, water vapor, helium, neon, hydrogen, nitrogen monoxide, nitrogen dioxide, ozone and ammonia. Chemical substances that can be in gas, liquid or solid form that change this natural composition of air are called air pollutants. The increase in the number of pollutants in the atmosphere adversely affects the air quality and creates air pollution. Air pollution is defined as the presence of solid, liquid and gaseous foreign materials in the atmosphere that may harm human health and the life of living things or prevent the use of material objects necessary for their survival. Air pollution adversely affects the health of humans, animals and plants and destroys the metal, stone and wood parts of the buildings. Its effects span not only present but future generations as well. The aim of the research is to evaluate the reasons causing the rapidly increasing air pollution problem in cities and the physical geography factors affecting air pollution; Bursa City is to examine the change of air quality over time. First of all, by scanning the literature in the field of study, studies examining the air quality of the city were examined, and the air quality data of the City of Bursa were obtained through the National Air Quality Monitoring Network of the Ministry of Environment and Urbanization system between 2019 and 2021. The data obtained were converted into tables and graphics using Microsoft Excel and distribution of pollution level were presented. While air pollutant values are generally close to the limits, it has been observed that nitrogen oxides exceed the limits, especially in the Beyazit region.

Keywords: Air pollution, Health, Bursa, PM, Ozone

Bursa İl merkezinde Hava Kirliliğinin İncelenmesi

Özet

Atmosferin insanların ve diğer canlıların yaşadığı yeryüzüne yakın kısmı; Temiz hava olarak azot, oksijen ve bunun az bir miktarı da diğer gazlardan oluşur. Bu gazların dağılımı hacimce %21 oksijen, %78 azot ve %1 diğer gazın karışımıdır. Oksijen ve azot dışındaki diğer gazlar ise argon, karbondioksit, su buharı, helyum, neon, hidrojen, azot monoksit, azot dioksit, ozon ve amonyak gibi gazlardır. Havanın bu doğal bileşimini değiştiren gaz, sıvı veya katı halde olabilen kimyasal maddelere hava kirleticileri denilmektedir. Atmosferdeki kirletici sayısındaki artış hava kalitesini olumsuz etkilemekte ve hava kirliliği oluşturmaktadır. Hava kirliliği, atmosferde insan sağlığına ve canlıların yaşamına zarar verebilecek veya hayatta kalabilmeleri için gerekli maddi nesnelerin kullanılmasını engelleyebilecek katı, sıvı ve gaz halindeki yabancı maddelerin varlığı olarak tanımlanmaktadır. Hava kirliliği insan, hayvan ve bitki sağlığını olumsuz etkilemekte ve binaların metal, taş ve ahşap kısımlarını tahrip etmektedir. Etkileri sadece şimdiki nesillere değil, gelecek nesillere de yayılıyor. Araştırmanın amacı, şehirlerde hızla artan hava kirliliği sorununa neden olan nedenleri ve hava kirliliğini etkileyen fiziki coğrafya faktörlerini değerlendirmek; Bursa Şehir merkezi, hava kalitesinin zaman içindeki değişimini incelemektedir. Öncelikle çalışma alanındaki literatür taranarak şehrin hava kalitesini inceleyen çalışmalar incelenmiş ve Bursa İlinin hava kalitesi verileri Çevre ve Şehircilik Bakanlığı Ulusal Hava Kalitesi İzleme Ağı aracılığıyla elde edilmiştir. 2019-2021 yılları arasındaki kentleşme sistemi. Elde edilen veriler Microsoft Excel programı kullanılarak tablo ve grafiklere dönüştürülerek kirlilik düzeyi dağılımları sunulmuştur. Hava kirletici değerleri genelde limitlere yakın bulunurken özellikle Beyazit bölgesinde azot oksitlerinin sınırları aştığı gözlenmiştir.
Anahtar kelimeler: Hava kirliliği, Sağlık, Bursa, PM, Ozon

Keywords: Air pollution, Bursa

1. Introduction

In order to protect the health of all living things in the world, threshold values have been determined for the air quality of the countries. These threshold values are determined by taking into account the varying negative effects of pollutants in the atmosphere in order to prevent short and long-term negative situations in the environment. In the 6th article of the Air Quality Protection Regulation published in the Official Gazette No. 19269 on 2.11.1986 in Turkey, the limit values of air pollutants are specified. According to this, the limit values of air quality are defined as "the levels expressed in concentration units determined by taking into account the changing harmful effects of air pollutants in the atmosphere when they coexist, in order to protect human health and prevent short and long-term negative effects on the environment".

Generally, long-term threshold values are used for air quality threshold values, upper threshold values for chronic effects that appear with long-term inhalation of low amounts of pollutants. The short-term threshold value definition is used to indicate the acute effects that occur when high amounts of pollutants enter the body through inhalation in the short term.

Air pollution from energy facilities, motor vehicles, fossil-based materials used for heating and industrial facilities that use fossil-based substances as fuel has more than one negative effect on the health of living things. Although air pollutants are in small amounts, they contain compounds with carcinogenic effects. Negative effects of air pollutants; diseases that negatively affect health such as lung cancer, bronchitis, rheumatism, osteoporosis and various heart diseases can be given as examples. Apart from these visible effects, effects such as burning in the eyes, blurred vision, difficulty in breathing, and blood poisoning can also be seen on people. As a result of the increase in the dangerous emission pollutants in the air we breathe in the human body, loss of appetite is observed and as a result of this loss of appetite, the immunity of the body weakens and increases the effect of diseases. Various negativities are observed with the difficulty of breathing as a result of various dusts combining with body moisture and clogging the pores on the skin tissue. A high degree of fatigue is observed on people after difficult breathing. In addition, as a result of the toxic substances contained in the emissions entering the body through the upper respiratory tract, they mix with the blood and cause an event called blood poisoning. Sulphur-dioxide and nitrogen-oxides in the atmosphere provide the formation of acid particles. These nitric and sulfuric acids adhere to the other emission material and cause the acids to reach the lungs with the inhalation of these emission substances. These acidic dusts and gases that go down to the lungs affect the alveoli in the lungs and mix with the blood.

As a result of the developing technology, the means of transportation have changed greatly. Motor vehicles, which have changed in the process from the steam machines that emerged with the industrial revolution to the present, have started to use fossil-based materials as fuel. Increasing population and increasing urbanization in direct proportion to this brought together public transportation. Gases emitted from the exhausts of individual and collective transportation vehicles, fossil fuels burned for heating purposes in residences, and pollutants such as sulphur dioxide, nitrogen oxide, particulate matter and hydrocarbon released into the atmosphere from industrial establishments have a negative effect on the air. These pollutants are substances that can remain suspended in the atmosphere for more than one day. During its suspension, it enters into various chemical reactions in the atmosphere and can be transported to as far as possible. These pollutant emissions complete the chain reactions by entering into a chemical reaction with the humidity and other components in the atmosphere and form sulfuric acid ($H2SO_3$), sulfuric acid (H_2SO_4) and nitric acid (HNO3). The chemical formations that occur are precipitated by rain and cause acid rain to occur. Harmful formations in places where people and other living things live can reach levels that can directly affect human health, and they affect the health of living things negatively by mixing with the soil as a result of acid rain.

Acid rain negatively affects the structure of the soil. It carries elements such as calcium and magnesium already in the soil to deep points, as a result of which it deteriorates its structure and decreases the yield in agriculture. It prevents the activity by destroying the beneficial microorganisms that make the soil rich in organic matter by breaking up the living residues. Since it affects all living things living in the ecosystem, it also causes the deterioration of the ecological balance between species. The first source of substances that cause the soil to become acidic is sulphur compounds and acid moisture, which pass into the soil as a result of accumulation in the atmosphere. When nitrogen compounds are more than the amount needed by the plants, they mix with the soil and negatively affect its structure and cause acidification.

Bursa province is one of the provinces with air pollution potential as it is in the center of a city in Turkey. With the industrial development of the province, the use of fuel for heating and the exhaust emissions of vehicles in traffic, depending on the population, are the most important sources of air pollutants. The aim of this study is to investigate the air quality in the city center as Spatial and temporal variations by using the data of the air quality measurement station in the city center.

2. Martials and Methods

1.1 Research Area

Bursa air pollution values T.C. Accessed via the Bursa Governorship website, T.C. It was obtained through the National air quality monitoring network established by the Ministry of Environment and Urbanization. The measurement stations in the city of Bursa (Bursa, Beyazıt, İnegöl-OSB, İnegöl-MTHM, Kestel-MTHM, Kültür Park-MTHM, Uludağ University) in the system provide daily pollution values to the above-mentioned system. These values were tabulated on the Excel program, compared with the limit values and interpreted, taking into account the increase and decrease of pollution values over the years.

The study area layout is shown in Figure 1. Bursa province, located in the South-Marmara region of Turkey, has the distinction of being the fourth largest city in Turkey in terms of population. The city is geographically located between 40º West Longitude and 29o North latitude circles. It has a total area of 10,819 km² with its 17 districts. It is among the most developed cities in Turkey in terms of economy and industry. It preserves its importance in terms of history, industry and tourism features, as it was in the past.

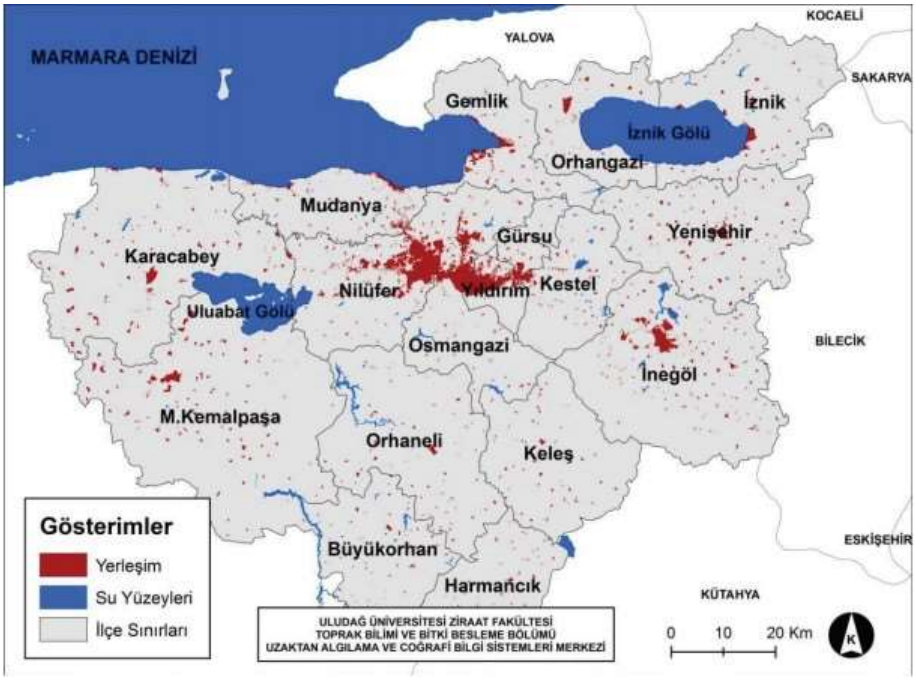

Figure 1. Bursa Province Settlement Map by Districts (URL-01)

2.2 Measuring Stations

Our country has taken important initiatives in 2008 in order to reduce or prevent the negative effects of air pollutants on animal health and the environment. This initiative is the Marmara Clean Air Center Directorate within the scope of the "Institutional Structuring Project in the Field of Air Quality in the Marmara Region" financed together with the European Union. It was established in the city of Istanbul with the decision of the Council of Ministers dated 10.05.2008 and numbered 26872. With this Clean Air Center directorate, information about air quality and the information obtained are provided to the public through warning thresholds. The Directorate continues its activities within the scope of the Decree Law No. 644 on the Organization and Duties of the Ministry of Environment and Urbanization published in the Official Gazette dated 04.07.2011 and numbered 27984 (Marmara Clean Air Center Directorate, 2018). Marmara Regional Clean Air Center Directorate operates a total of 54 pollution measurement stations in 11 provinces in the Marmara Region (Istanbul, Edirne, Kırklareli, Tekirdağ, Kocaeli, Sakarya, Bilecik, Yalova, Bursa, Balıkesir and Çanakkale) (Marmara Clean Air Center Directorate, 2018). Marmara Regional Clean Air Center Directorate air quality measurement stations; It was established in four different categories as urban, traffic, industrial and rural. There are differences in the parameters measured according to the categories.

Three stations (Kültürpark, Uludağ University and Bursa-Osmangazi) have been established in Bursa to monitor air pollution caused by fossil fuels used for heating purposes. Two stations (Kestel and İnegöl) were established to monitor industrial air pollution. A station (Beyazıt Caddesi) was established to monitor the pollution caused by traffic, which is one of the important problems that developed as a result of the increasing population of Bursa. In total, six stations were established, previously established. It is operated by the Marmara Regional Clean Air Center Directorate (Figure 1). The raw data obtained from the stations are presented to the public on the www.havaizleme.gov.tr website.

3. Results

3.1 Air Pollutants Measured at Stations

The city of Bursa is a city established in the lower parts of Uludağ mountain and is surrounded by mountain ranges that can reach 1000 m in height. For this reason, polluted air accumulates in the city. In addition, cold air masses moving down from the high mountain ranges surrounding the city reach the plains and tend to precipitate there. The polluted air continues to exist in the city due to the resulting temperature inversion. A total of six pollutants are measured at six air quality measurement stations in Bursa. Air pollutants that can be measured at a total of six air quality measurement stations in Bursa are presented in Table 1.

Table 2. Pollutants measured at air quality measurement stations in Bursa

SAMPLING STATION	PM_{10}	PM_{25}	NO_2	SO_2	O_3	CO
Bursa-Osmangazi	X			X	X	
Beyazıt			X	X		X
Kültürpark			X	X	X	
Kestel	X		X	X		
İnegöl OSB			X	X		
Uludağ University		X	X	X	X	

3.2 Air Pollution in Bursa

As a result of the researches conducted in Turkey in 2014, Bursa is among the top five cities with the highest annual PM_{10} averages. Measured classical air pollutants; SO_2, PM_{10}, NO_X, $PM_{2.5}$ and O_3 are pollutants whose measurements are frequent and whose effects can be observed in the atmosphere to a great extent. As can be seen as a result of the evaluation of the measurement results specified by the Marmara Clean Air Directorate, three pollutant source groups have been identified in the city of Bursa.

3.3 Particle Matter 10µm (PM_{10})

These are the main sectors that cause air pollution in the city and are considered classics such as heating, industry and transportation. Considering the reasons for the emergence of this situation; The fact that the income distribution varies greatly according to the regions, the traffic congestion caused by the lack of alternative roads on the main roads and the fact that it has a large industrial network explain the reasons for the formation of pollutants. In the air where PM10 pollutant was observed, it was observed that the biggest sources of particles were burning coal for heating purposes at a rate of 67%. Considering the reasons for its formation, it was observed that the emissions of motor vehicles were 19% and coal used in industry was 9%.

Throughout Turkey, PM10, together with SO2, has been measured in all provincial centers since the 1980s. However, since it is more important in recent years, 2.5 micron-sized particles have also been measured. PM2.5 is also measured along with PM10 at some stations in every province. Although most of the PM10 pollutant is estimated to be natural and inert substances, it is thought to originate from the consumption of fossil fuels for heating purposes, industrial activities and vehicle exhausts. Since some of it reaches the lungs, it should be measured and its values should be reduced, and the limit values should be lowered for the following periods. As seen in Figure 2, PM10 values, which go above the limit values in winter months, decrease to or below the limit values in summer months.

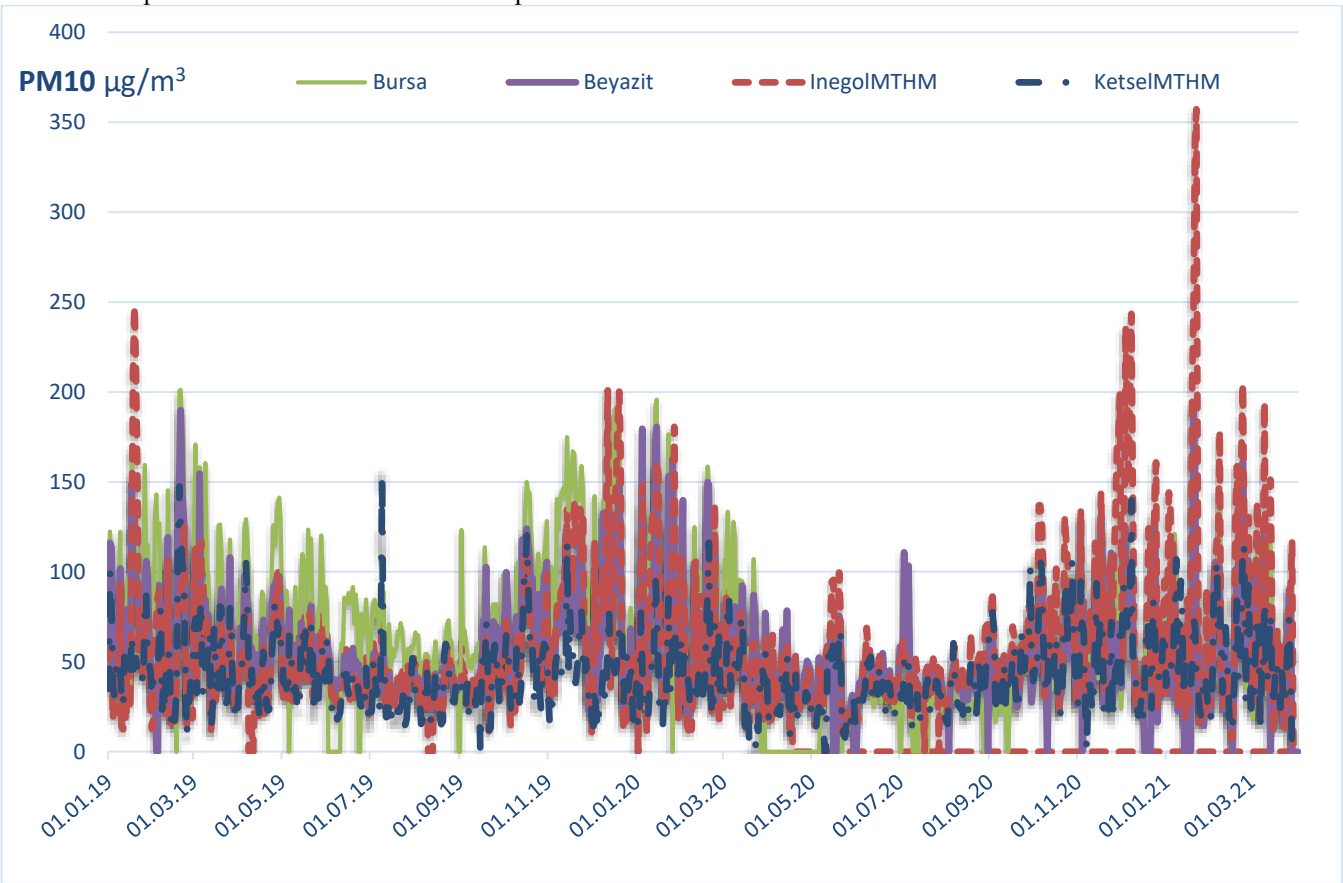

Figure 2. Particle Matter (PM10) levels 4 air quality station of Bursa Province last 2 years (2019-2020)

3.4 Sulphur Dioxide (SO_2)

Sulphur Dioxide is a non-flammable and colourless gas. About 60% of the measured sulphur oxides are formed as a result of the combustion of fossil fuels used for heating purposes. Thermal power plants are among the biggest sources of SO2 emissions due to the coal they use. There are sulphur oxides mixed into the atmosphere as a result of natural events, forest fires and volcanic activities can be given as examples. It has negative effects on living things as a result of its presence in the atmosphere in large quantities. To give an example of its negative effects, it can cause blockages in the respiratory tract. It creates sulphate particles in the atmosphere. These particles can be transported to very distant places by the winds. In the presence of suitable environment such as sunlight and chemicals, sulfuric acids are formed.

The temporal variation of sulphur dioxide values taken from 7 air quality stations in Bursa city is shown in Figure 3. It is observed that the concentrations below the long-term limit values in summer seasons exceed the national and international limit values determined for winter season. It is thought that the very high values that appear on some days are

due to the special conditions of meteorological factors. Since these values can sometimes affect human health, special measures are needed on similar days.

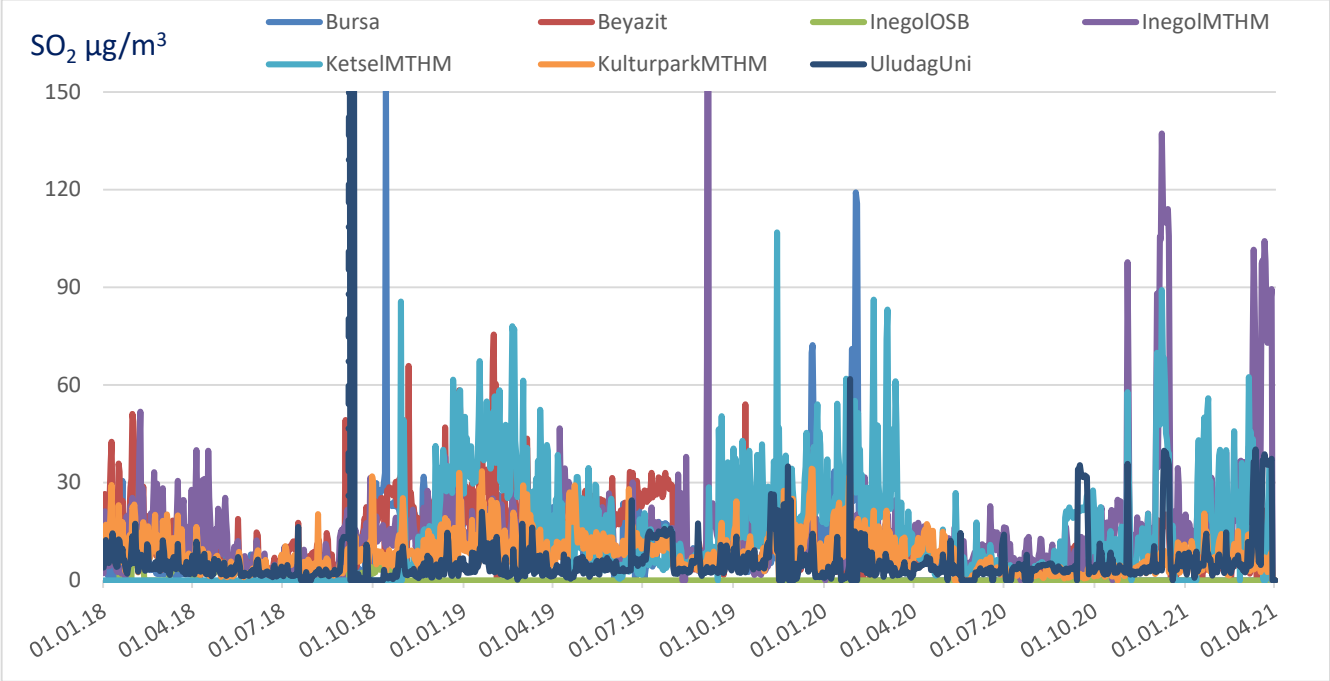

Figure 3. Sulphur Dioxide levels 7 air quality station of Bursa Province last 2 years (2019-2020)

3.5 Nitrogen Dioxide (NO_2)

Gases defined as nitrous oxide (NOx) are reactive gases that occur at high temperatures such as 1200 ºC. Many types of NOx are odourless and colourless. Nitrogen oxides are insoluble in water. Therefore, they reach the deepest points of the respiratory tract without being filtered in the upper respiratory tract and show harmful effects at these points. Upon combustion at high temperatures, nitrogen monoxide (NO) forms nitrogen dioxide (NO_2), albeit in a small amount. NO mixed into the atmosphere transforms into NO_2 as a result of oxidation. NO_2, which is present in the atmosphere in large proportions, is a strong oxidant substance. When they are together with the particles, they can be seen as a red-brown layer in cities. It has two major sources. These sources are the combustion of fuels used in transportation vehicles and fossil fuels used in thermal power plants. The remaining industrial facilities and the use of fuel for domestic heating are among the other sources of nitrogen oxides. The use of motor vehicles, which has increased especially with urbanization, has an important share in the increase of nitrogen oxides. When we look at the developing countries, nitrogen oxide emissions show an increase even though sulphur dioxide and particulate matter are seen in small amounts in the general framework.

When Figure 4 is examined, it will be seen that; Nitrogen dioxide values of 7 air quality stations in Bursa province are quite high between December and May. Although the values of the university station are low in others, it is also seen that the values of this station are high on some days. It is thought that nitrogen oxides mostly originate from industrial facilities and vehicle exhausts, and the topographic structure of the region and meteorological factors are also effective in the increase in concentration. It is seen that the values are low at all stations on the days when the measures started and continued due to the pandemic. The decrease in human activities has also led to an increase in air quality.

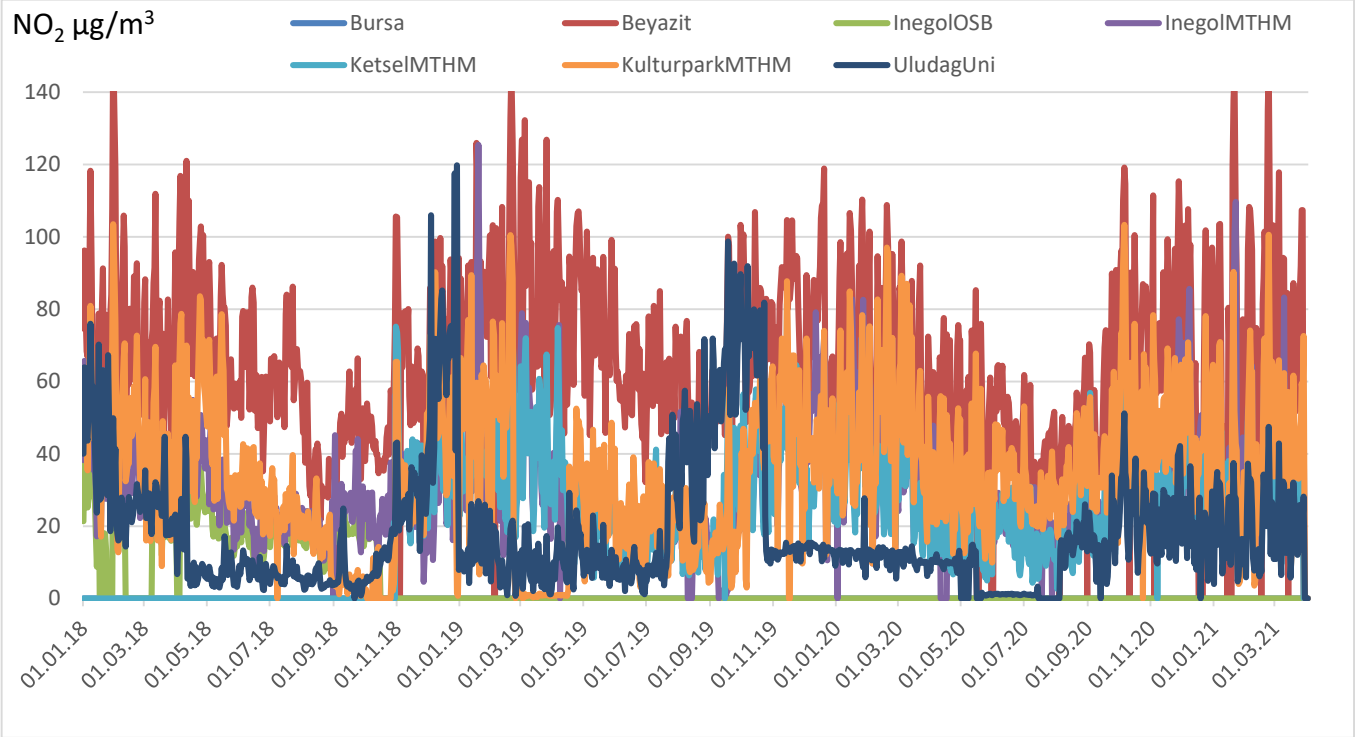

Figure 4. Nitrogen Dioxide levels 7 air quality station of Bursa Province last 2 years (2019-2020)

3.6 Ozone (O_3)

Although ozone is not one of the basic building blocks of the air we breathe, it is a product of oxygen. It has the property of reaching its maximum concentrations in the stratosphere layer and being reactive. Since ozone is not a water-soluble gas, the amount in the air can reach the lungs and have harmful effects. It occurs as a result of photochemical reactions that occur in the atmosphere of cities and rural areas, in the presence of nitrogen dioxide and sunlight, that is, in suitable conditions. It was first detected photochemically in the Los Angeles atmosphere in the 1950s and is a special air pollutant. The occurrence of ozone in clean and sunny weather can be considered as not a pollutant gas. Ozone concentration, which exceeds certain values, affects the health of living things as well as on goods, including vehicle tires. Ozone can interact with other air pollutants in the atmospheric environment and cause secondary pollutants to occur.

Since there is no local ozone data at all stations in Bursa, the daily average ozone concentrations of only 4 stations are shown in Figure 5. As can be seen from the figure, the change in temporal ozone values shows the opposite of other air quality parameters. It is observed that the values that are relatively low in the winter months are around 100 µg/m3 values in the hot and sunny summer months. The fact that high values are encountered, albeit rarely, in winter is due to the effect of clear and sunny weather on some days.

Figure 5. Ozone levels 4 air quality station of Bursa Province last 2 years (2019-2020)

3.7 Carbon monoxide (CO)

Carbon monoxide is a colourless and odourless gas. It occurs when the carbon in the structure of the fuels is not completely burned. To give an example of the causes of carbon monoxide emissions, Industry, burning of fossil fuels and forest fires can be said. Carbon monoxide diffuses and binds to haemoglobin, leading to the formation of COHb in the blood. Carbon monoxide binds to haemoglobin 200 times more strongly than oxygen. For this reason, it prevents the transport of oxygen to the tissues and eventually leads to suffocation.

Sufficient CO data could be obtained from only one station (Beyazit) in Bursa city center. Like ozone, CO has recently begun to be measured at stations. Although CO values are measured between 1000-5000 µg/m3 values, it goes up to 10000 µg/m3 values (Figure 6). However, the CO values are below the limit values. In summer, the values are low and the use of fossil fuels is considered as a resource.

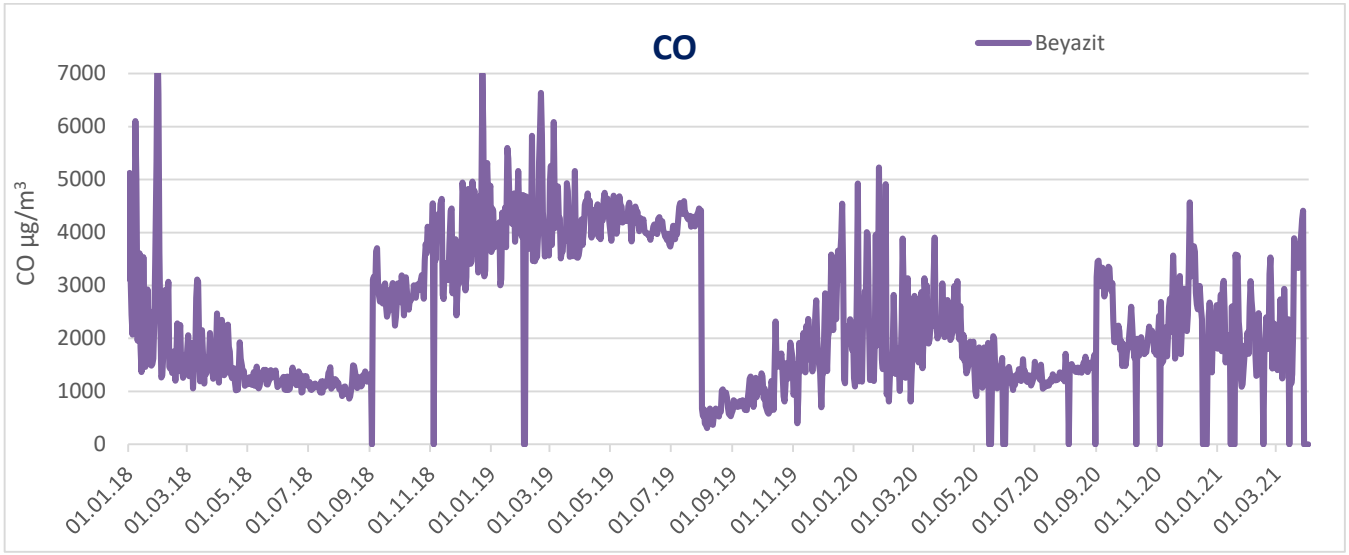

Figure 6. Carbon monoxide levels 1 air quality station of Bursa Province last 2 years (2019-2020)

PM2.5, which has been started to be measured in Turkey in recent years, has started to be measured at a station in Bursa city center and it is planned to be measured at other stations. Although its sources are mostly exhaust gases, it is thought to be formed by the condensation of other combustion products and gaseous/liquid air pollutants. In terms of origin, it is more toxic than larger particles. Considering Figure 7, although the values are high enough to be important, the legal limit values related to this are limited. Although high values are observed in the winter season, very high values are observed in the summer months, and it is seen that the pollutants originating from traffic and industry are important for the region.

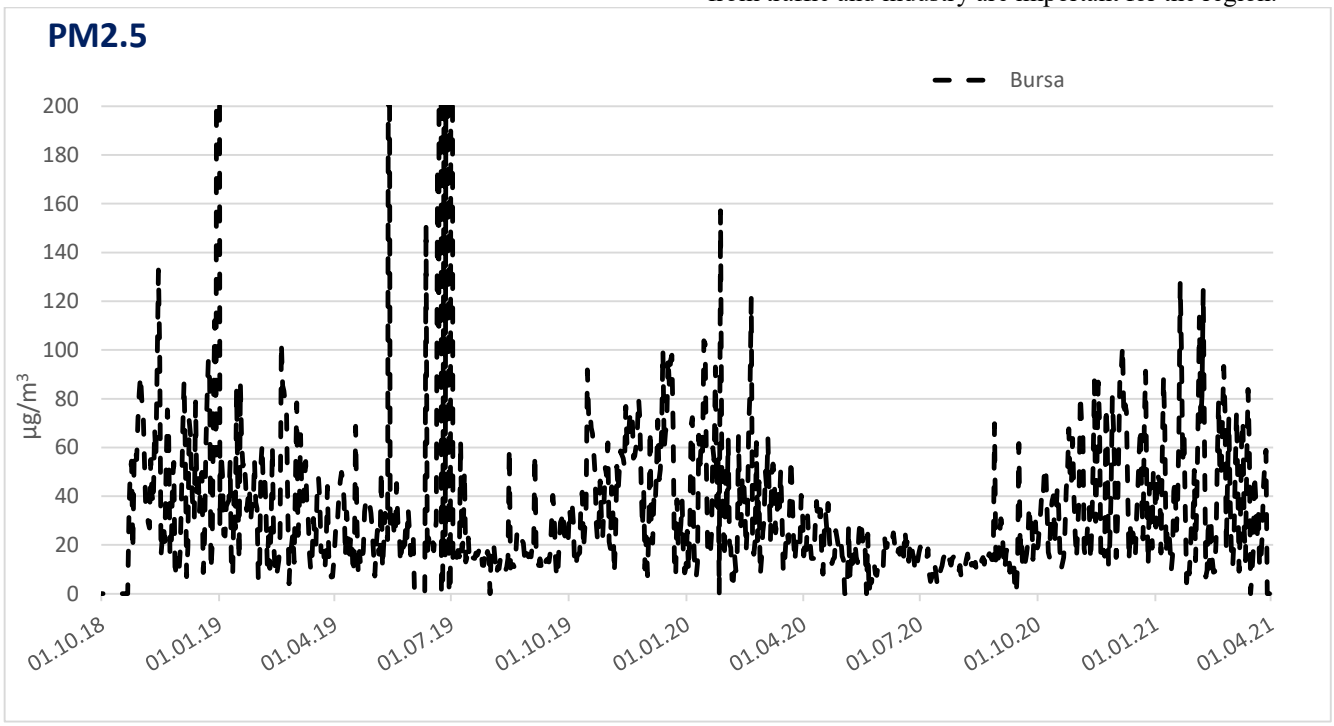

Figure 7. Particle Matter ($PM_{2.5}$) levels 1 air quality station of Bursa Province last 2 years (2019-2020)

4. Result and Discussion

It has been observed that 32% of the fuels in Turkey are used for heating purposes. It has been observed that most of the extracted fuels have low flammability, substances such as sulphur, nitrogen, ash and moisture content is quite high. The expensiveness of quality fuels has led the people who have no economic power to use cheap and more polluting fuels for a long time. This trend, together with the lack of thermal insulation in the buildings and the continuation of the so-called slums, increased the fuel use and the concentrations of pollutants needed for energy production. It has been observed that the air pollution, which increases in the winter months in Bursa, is generally caused by industrialization and urbanization. It has been seen that Bursa is a city that receives rapid immigration, together with unplanned urbanization without taking into account its topographic and geographical structure, the rapid disappearance of green areas that greatly reduce air pollution, creating unhealthy environmental conditions. Apart from these unfavorable conditions, it was seen that the rapidly increasing transportation vehicles had a significant share in air pollution in Bursa. Apart from public transportation vehicles, the increase in traffic observed as a result of the citizens getting on their personal vehicles also brings air pollution. The average of the data recorded on Excel was taken in the change part and the tables were prepared. The tables created by averaging from the first data to the last data were compared with the air pollution limit values determined by the Ministry of Environment and Urbanization. As a result, it was observed that SO_2 values were below the limit values. When comparing NO_2, it was seen that the average of the measurements made in Beyazıt exceeded the annual limit value (annual) 40 $\mu g/m^3$ for NO_2. The reason for this situation was observed as the traffic jam on the front step boulevard in November and the use of coal rather than natural gas for heating by the locals. It was observed that the annual averages of PM10 data exceeded the (annual) air pollution limit of 40 µg/m3 for PM10. The limit value (annual) determined for $PM_{2.5}$ is 25 $\mu g/m^3$, and it is the Bursa station that is observed to exceed this limit.

Acknowledgment

The authors are grateful to the Ministry of Environment and Urbanism of Turkey, the Turkish State Meteorological Service for air pollution and meteorological data. This study was presented to the International Symposium for Environmental Science and Engineering Research ISESER2021.

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Journal of research in Atmospheric science

Research Article

Journal of Research in Atmospheric Science
Vol. 3, No. 1, pp.21-28, June 2021

ISSN:2687-6418
http://resatmsci.com/

Evaluation of Air Quality in 2020 in Ankara

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Abstract

In particular, annual amounts of pollutants released from artificial sources reach to millions of tons. These produce effects in varying degrees, depending on the area and quantities in which they are formed. The adverse health effects of air pollution occur as a result of the inhalation of pollutants by humans as a direct exposure or the mixing of the pollutants accumulated from the air, soil, water, plants, animals and other environmental environments as an indirect exposure. Especially air pollution in cities caused an increase in health problems. The change in the physical, chemical and biological properties of the air affects natural and artificial non-living beings as well as living things. The change in the physical, chemical and biological properties of the air affects natural and artificial non-living beings as well as living things. Air pollution data are collected from 8 air quality station in Ankara. Air pollution stations are located in Bahçelievler, Demetevler, Dikmen, Keçiören, Sıhhiye and Sincan districts throughout Ankara.
Keywords: *Air pollution, Health, Ankara*

Ankara Hava Kirliliğinin 2020 Yılı Değerlendirmesi

Özet

Özellikle yapay kaynaklardan salınan kirleticilerin yıllık miktarları milyonlarca tona ulaşmaktadır. Bunlar, oluştukları alana ve miktarlara bağlı olarak değişen derecelerde etkiler üretirler. Hava kirliliğinin sağlığa olumsuz etkileri, kirleticilerin doğrudan maruz kalma yoluyla insanlar tarafından solunması veya dolaylı bir maruz kalma olarak hava, toprak, su, bitki, hayvan ve diğer çevresel ortamlardan biriken kirleticilerin karıştırılması sonucu ortaya çıkar. Özellikle şehirlerdeki hava kirliliği sağlık sorunlarının artmasına neden olmuştur. Havanın fiziksel, kimyasal ve biyolojik özelliklerindeki değişim, canlıların yanı sıra doğal ve yapay cansız varlıkları da etkiler. Havanın fiziksel, kimyasal ve biyolojik özelliklerindeki değişim, canlıların yanı sıra doğal ve yapay cansız varlıkları da etkiler. Hava kirliliği verileri Ankara'daki 8 hava kalitesi istasyonundan toplanmıştır. Hava kirliliği istasyonları Ankara genelinde Bahçelievler, Demetevler, Dikmen, Keçiören, Sıhhiye ve Sincan ilçelerinde bulunmaktadır.
Anahtar kelimeler: Hava kirliliği, Sağlık, Ankara

1. Introduction

Our world has changed in the last 50 years for many reasons, both industrial and technological advances. These differences have led to an increase in the world population, and with the migration in developed cities, the population has increased and the use of energy has also increased. With this situation, in the industrialized world; As a result of energy and heat generation, Sulphur dioxide and particulate matter pollution have increased. (Fenger 2009). Due to the increase, the classical way has been followed for environmental protection. In this classic way; first of all, an increase in pollution levels with increased financial comfort, and then to take measures towards reducing pollutants in order to protect public health. Along with the studies, there are important breaks. Environmental pollution problems today are greater than they were in the 1950s. It is especially seen in developing countries with main cities and their environs (Shafik 1994, Fenger 2009). Environmental pollution problems still persist in the industrialized world and are mainly caused by nitrogen oxides, volatile organic compounds and photochemical oxidants associated with increased traffic. Especially, new hazardous compounds from industry have been identified by advanced analytical techniques. As a result; Recently, air pollution has been affecting ecology considerably (Shafik 1994, Fenger 2009). Air quality management in Turkey is carried out by the Ministry of Environment and Urbanization of the Republic of Turkey. EIA, Environmental Permit and License, Industrial Air Pollution Control, Air Quality Assessment Management, Air Pollution Control Due to Heating etc. regulations and measures for air pollution and implementation of mitigation studies are ensured.

Air pollution is “the presence of one or more types of pollutants in the open air outside the building in an amount that harms human, plant and animal life, commercial or personal belongings, and an environmental quality that can be enjoyed over a certain period of time” (Muezzinoğlu, 2000). Air pollutants can be examined in two groups. The first group consists of CO_2, CO, SO_X, NO_X, hydrocarbons (HC), hydrogen fluoride (HF), hydrogen sulfur (H2S), methane (CH4), chlorofluorocarbon (CFC) and powdered particulate matter. O_3, SO_3 (sulphur trioxide), H_2SO_4 (sulfuric acid), acids and photochemical oxidants formed later in the air are added to the second group. (Saracoglu, 2010; 6-7). The aim of this study is to determine the air pollution in Ankara and to monitor the air quality in the cities, to prepare the data and action plans by increasing the capabilities of the responsible institutions

and organizations at the local scale, and to inform the public about the health effects of air pollution.

2.1 Air Quality Measurement Methods

Analysis activities in determining air quality are carried out in two ways. These can be done manually and automatically. The manual is usually done for particulate matter and SO_2 determination. A data can be obtained after 24 hours from the manual measurement. The reliability of the measurement information obtained with these systems is low. These systems were used in Turkey until 2005, but now automatic measurement mechanisms are used. Since 2005, the Ministry of Environment and Forestry has carried out activities to establish an Air Quality Monitoring Network throughout in Turkey, and the National Air Quality Monitoring Network was established by building air quality measurement stations in 36 provinces in 2005, taking into account the cities with high air pollution. At present, air quality measurements are carried out at 116 points by the Ministry of Environment and Urbanization. At the same time, 3 mobile air pollution measurement tools within the structure of the Ministry are dispatched to provinces and districts to measure at a certain time according to the demands. The purpose of establishing measurement stations is to detect air pollution arising from heating.

2.2 Limit Values of Pollutants

The air quality levels in Turkey is known well and determine or reduce order to stop the threat of air pollution to ecology and living health, to observe the air quality based on these methods and data to keep in this study. This is well-being under control in the regions where the air quality is good and otherwise improve to do enough about the pollution control. Air Quality Assessment and Management Regulation was published and entered into force in order to obtain data and raise awareness of the society with warning limits. Limit values for pollutants have been introduced within the scope of Annex-1 of the Regulation. (Air Quality Assessment and Management Regulation (HKDYY) 2008.)

Table 1. Limit Values of Air Pollutants in Turkey (Turkish Air Quality Assessment and Management Regulation (HKDYY, 2008.))

Pollutants	Average Duration	Limit Value
SO_2	for the 24 hours	125 µg/m³
NO_x)	for the hour	200 µg/m³
PM	for the 24 hours	50 µg/m³
CO	Daily maximum	10 µg/m³
O_3	8 hourly averages	120 µg/m³
Benzene	Annual average	1.5 µg/m³

2.3 Research Area

There is a lot of air pollution problem during winter period in Ankara. The reason for this is the topography of the city, the use of poor-quality fuel in the heating area, and the misuse of these fuels, the use of poor-quality fuels without improvement, the very low wind speed of the city, exhaust gases, etc. effects accumulate in the city and cause pollution.

There are 8 air quality measurement stations in Cebeci, Demetevler, Dikmen, Bahçelievler, Sıhhiye, Keçiören, Kayaş and Sincan districts affiliated to the National Air Quality Monitoring Network of our Ministry of Environment and Urbanization in order to determine the general situation of air quality in Ankara and to determine measures accordingly. $PM_{2.5}$, PM_{10}, SO_2, NO_X, Ozone, CO etc. in stations. Meteorological measurements with pollutants are made for 24 hours.

Figure 1. Representative Locations of Air Quality Stations (THEP, 2019)

Figure 2. Bahçelievler Air Quality Measurement Station (https://ankara.csb.gov.tr/)

Table 2. Coordinates of Air Quality Measurement Stations and Measured Parameters

Sampling Station	COORDINATES		MEASURED AIR CONTAMINANTS							
	Latitude	Longitude	PM_{10}	$PM_{2.5}$	SO_2	NO	NO_2	NO_X	CO	O_3
Bahçeli	39.918546°	32.822268°	+	+	+	+	+	+	-	-
Demetevler	39.896459°	32.840752°	+	+	+	+	+	+	-	-
Dikmen	39.967753°	32.795703°	+	+	+	+	+	+	-	-
Keçiören	39.967254°	32.862833°	+	+	+	+	+	+	-	+
Sıhhiye	39.927317°	32.859416°	+	+	+	+	+	+	+	-
Sincan	39.972019°	32.585109°	+	+	+	+	+	+	-	-

2. Results

3.1 Sulphur dioxide (SO_2)

Sulphur oxides are among the most well-known air pollutants. Sulphur oxide, which is a non-flammable, colourless, suffocating, acidic gas, persists in the atmosphere for 40 days (Incecik, 1994). Sulphur compounds in the structure of coal and fuel-oil combine and burn to form SO_2. Sulphur dioxide producing activities are industrial works, domestic fuels used for heating purposes, thermal power plants and the use of diesel fuelled vehicles. SO_2 concentrations are generally high in central areas of cities and industrial areas where coal is used for domestic heating (Akyürek, 2012). While the sulphur dioxide values do not exceed the 24-hour limit values specified in the regulation, they are above the long-term limit values and international limit values. While the values reach very high values in winter months, they are relatively low in summer months. However, high values can be observed in industrial areas such as Ankara sites. It is attributed to the use of fossil fuels as a source.

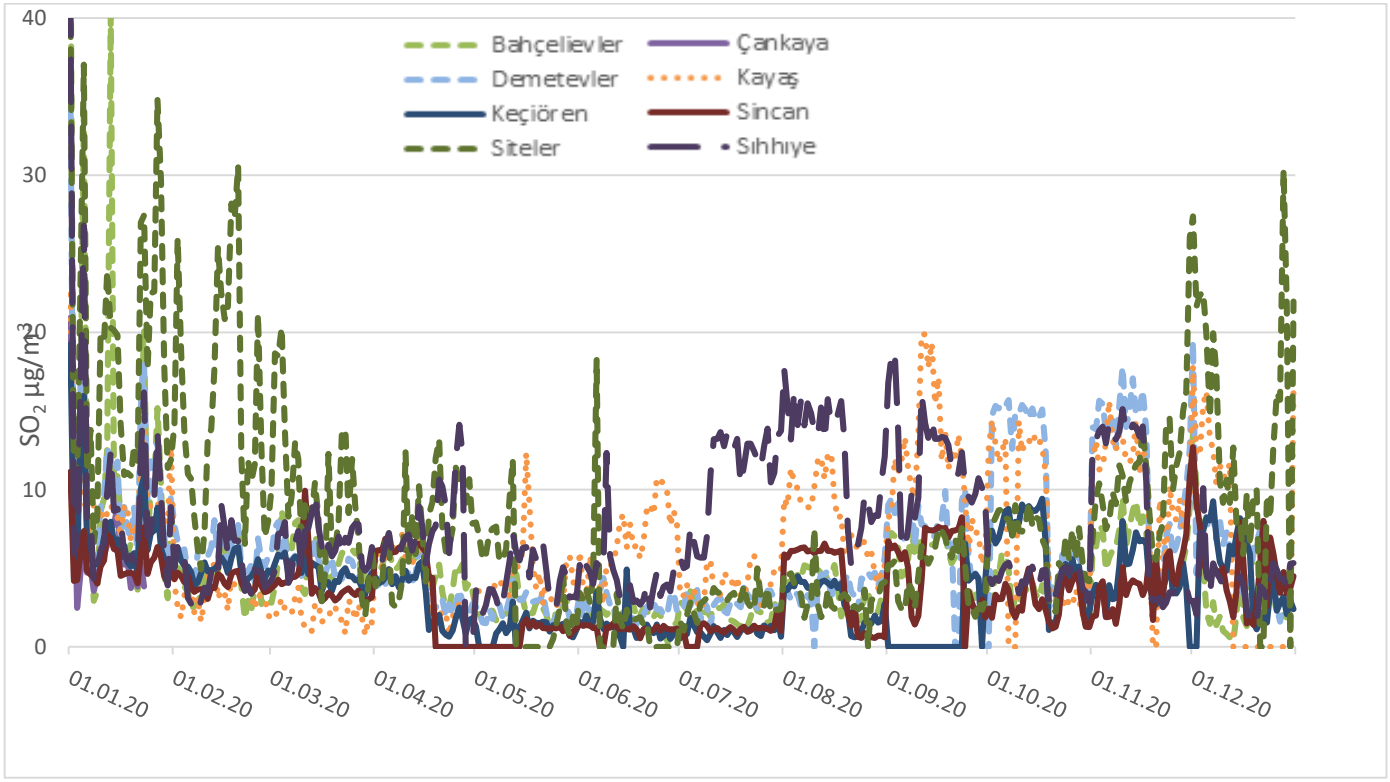

Figure 2. Sulphur dioxide (SO_2) levels 8 air quality station of Ankara Province in 2020

3.2 Particulate Matter (PM)

Because particulate matter is so heavy and large, they can precipitate quickly in the atmosphere. They are also very small granular solid or liquid particles dispersed in the atmosphere. In terms of particulate matter, quality and quantity; particle sizes, concentration, chemical composition and health effects vary. (Öztürk, 2007). Particulate matter sources consist of anthropogenic and natural sources. While SO_2 and PM_{10} (particles smaller than ten micrometres) are measured in all air quality stations in Turkey, as in many other countries in the world, the measurement of the $PM_{2.5}$ parameter, due to its chemical properties, has begun to become widespread. Since the particles smaller than ten microns have a high rate of reaching the lower respiratory tract and are important due to their physical/chemical effects, limit values have been set and values have been reduced over time. PM_{10} values measured at Siteler station after October are thought to be due to industrial activities and the use of fuel for heating purposes in this period. High values in the middle of summer at Demeteveler station can only be explained by a special situation for the region. In general, it is seen that PM10 values are above the limit values.

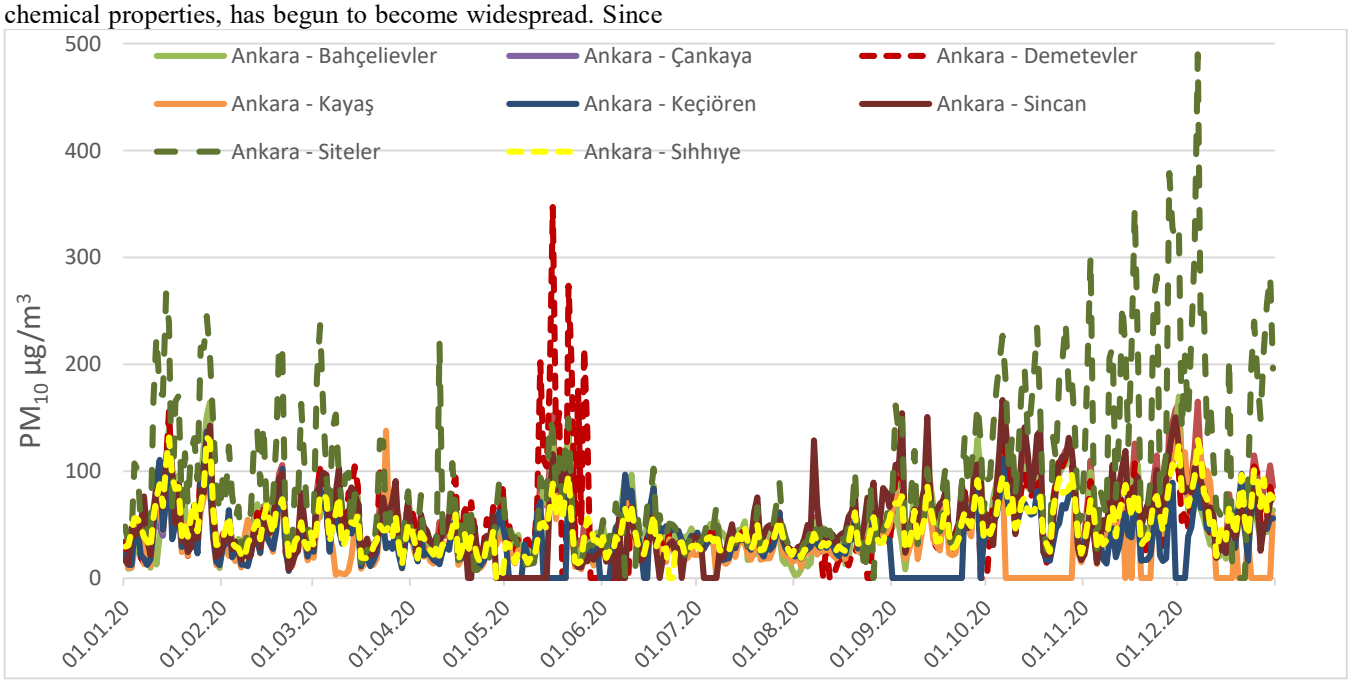

Figure 3. Particle Matter (PM_{10}) levels 8 air quality station of Ankara province in 2020

Particulate matter Contaminants smaller than 2.5 microns are usually caused by combustion products. Combustion events will be fuel consumption for heating purposes, as well as exhaust gases of transportation vehicles. Meteorological events in the winter months can be a factor in the rise of pollutants. At all stations in Ankara, $PM_{2.5}$ values are observed to be above the limit values in winter months, while the values decrease in summer months. The increase in air temperatures may be a factor in the formation of the pollutant as well as in its distribution (Figure 4).

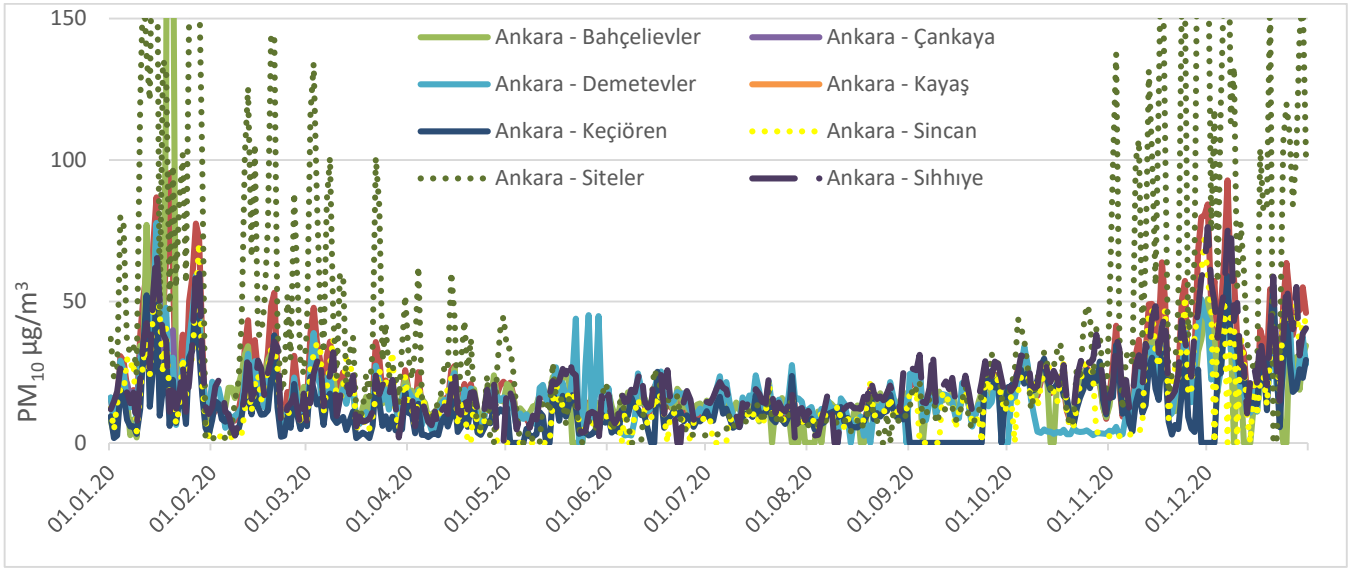

Figure 4. Particle Matter ($PM_{2.5}$) levels 8 air quality station of Ankara Province in 2020

3.3 Nitrogen Oxides (NO_x)

Nitrogen oxides (NO_x) are highly disintegrating gases and most of them are colourless and odourless. In addition, they are insoluble in water and are formed at high temperatures (1,200 °C). NO_x is formed when solid or liquid fuels are burned at high temperatures. Two important sources are motor vehicles and thermal power plants. Fuel consumption for other industrial plants, commercial and domestic heating are among other sources of NOx. Especially in urban areas, NOx concentrations increase due to the increase in the number of vehicles. Therefore, it causes health problems in the upper respiratory tract (Incecik, 1994). Even though SO_2 and particulate matter generally decrease in developing countries, NO_x emissions increase due to the increasing number of vehicles and industrialization.

Figure 5 shows the NO_2 daily grazing values of 8 air quality stations in Ankara for the years 2019-2020. While the general average values are below 100 µg/m^3, it is seen that the normal values are 3-4 times higher in the last three months of 2019. The explanation of this increase value seems quite complex. If it is not due to measurement errors, this situation needs to be investigated carefully.

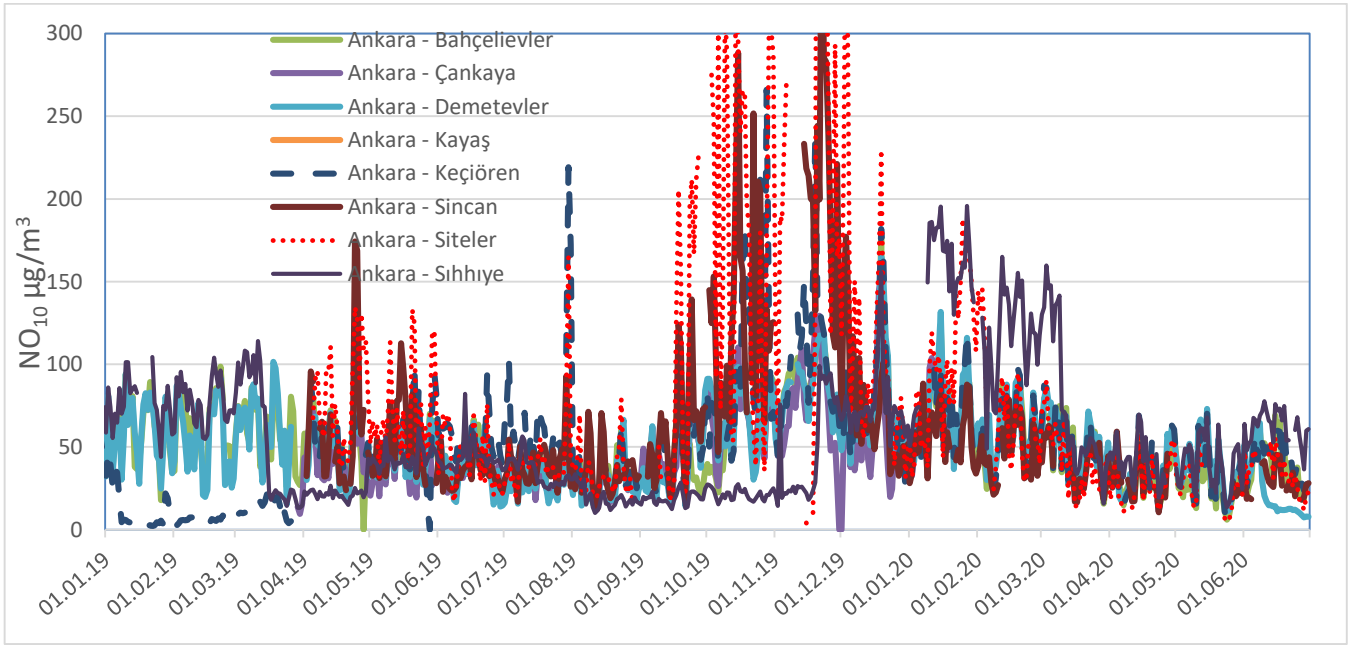

Figure 5. Nitrogen Oxides (NOx) levels 8 air quality station of Ankara Province in 2019-2020

3.4 Carbon Monoxide (CO)

Carbon is generally formed in fuels when it is not fully combusted. The carbon monoxide (CO) formed is an odourless and colourless gas. CO2 in the urban atmosphere is generated from both vehicles and industry, wood burning and forest fires. CO, together with diffusion in the alveolar-capillary membrane, binds to haemoglobin in the blood and causes carboxy-haemoglobin (COHb). CO is an important indoor air pollutant. And because its affinity for haemoglobin is much higher than that of oxygen, it stops oxygen from binding to haemoglobin. In this way, it prevents the flow of oxygen to the tissues, causing health problems such as headaches and suffocation. Figure 6 shows the average daily CO values measured at 6 stations in Ankara. Although the values are below the annual average values, it is seen that the values reach 5000 µg/m^3 in winter and below 1000 µg/m^3 in June-August. It is thought that this pollutant does not pose a risk for the measured time period and areas.

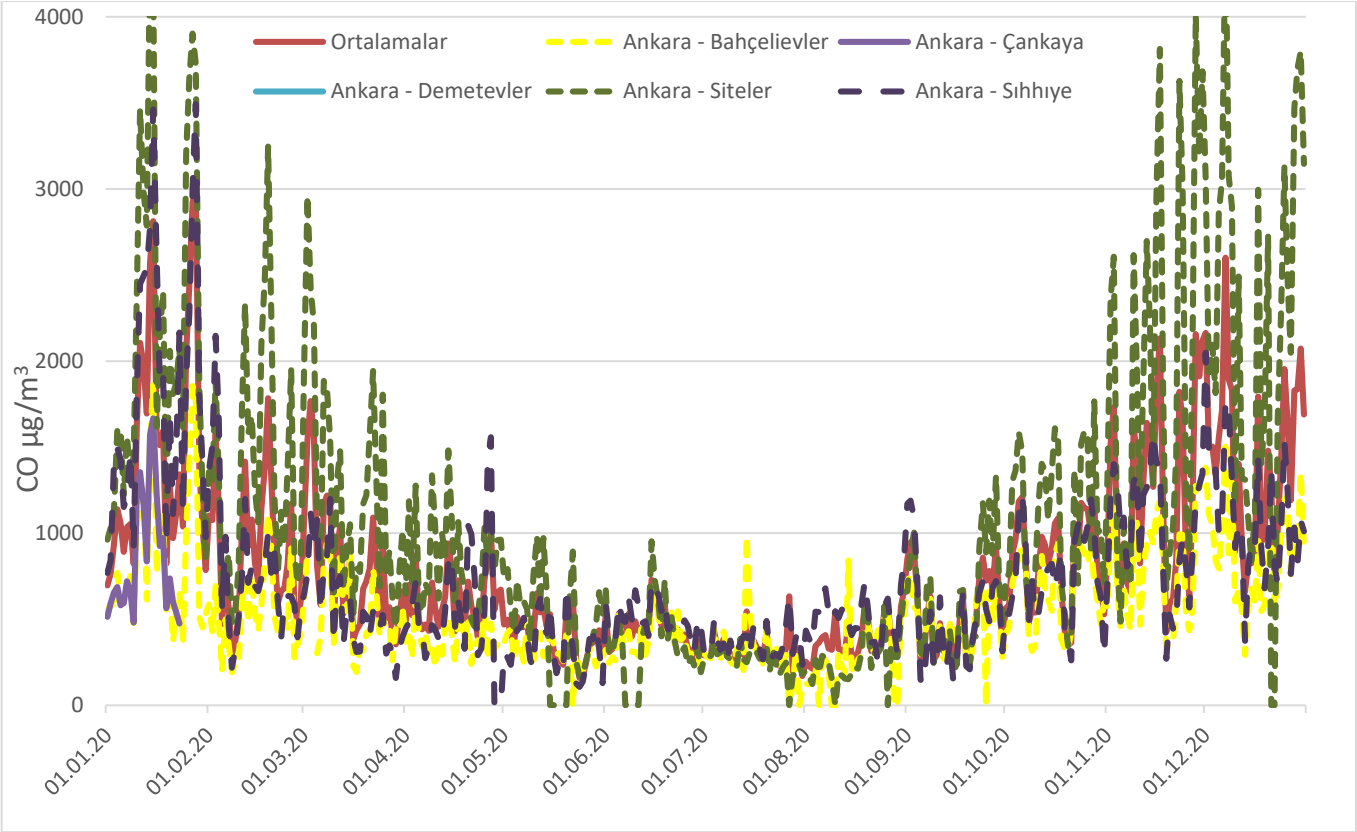

Figure 6. Carbon Monoxide (CO) levels 6 air quality station of Ankara Province in 2020

3.5 Ozone (O_3)

Ozone reaches high concentrations in the stratosphere and is a naturally occurring reactive gas in the atmosphere. In the troposphere, it can be formed as a result of photochemical events from pollutants in anthropogenic sources such as power plants, refineries, chemical factories. (Güler & Akın, 2015). It consists of photochemical processes that take place in the urban and rural atmosphere in the presence of NO_2 and sunlight. It began to be noticed in the atmosphere of Los Angeles in the 1950s. Although transport from the stratosphere also contributes to the increase of O_3 in the atmosphere we live in, it can occur from anthropogenic sources to a large extent.

Figure 6 shows the values with the O_3 daily environment for the year 2020, measured at 6 stations in the province of Ankara. While it is observed that the values are below 40 µg/m^3 in the winter season, it is observed that the values increase from the summer months and exceed 80 µg/m^3 especially in three stations. The number of days when the values exceed the long-term limit values is rare. It is estimated that air pollution is relatively high in regions where ozone value is low in summer months.

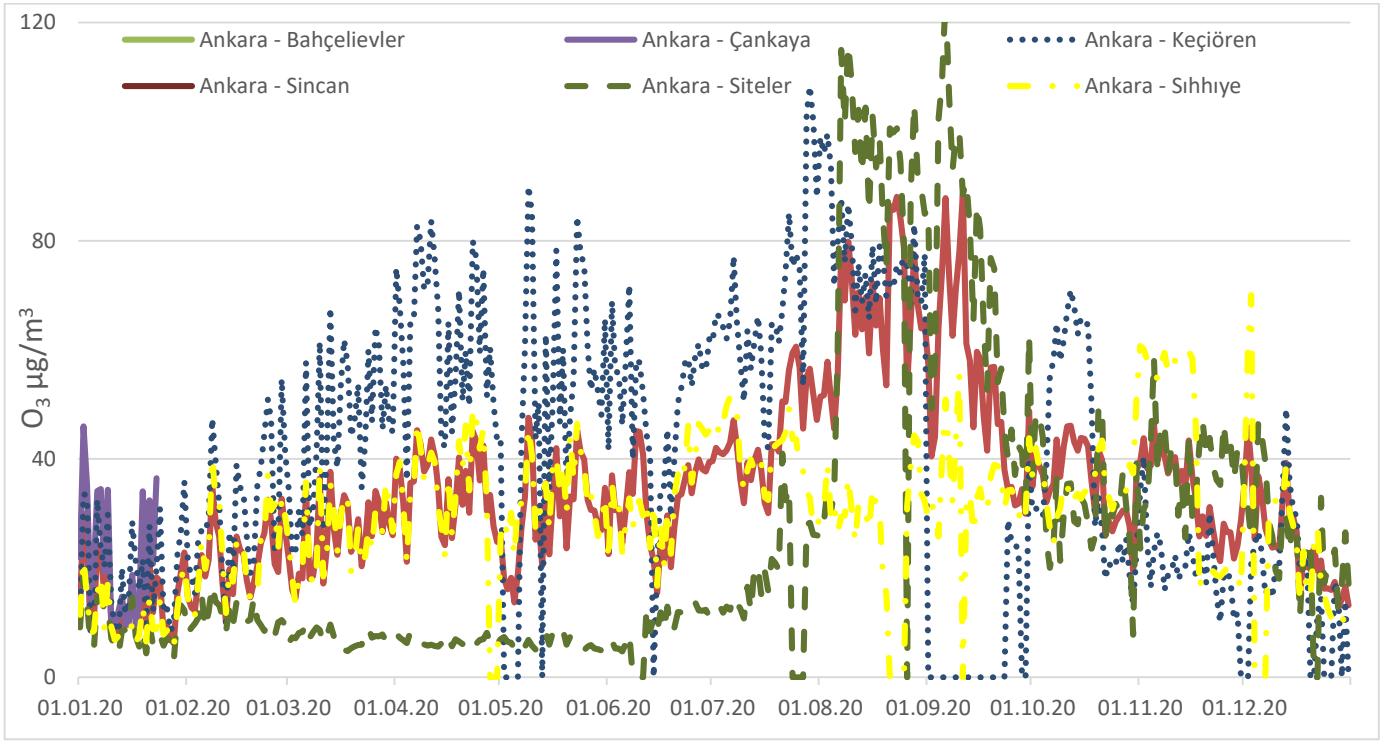

Figure 6. Ozon (O_3) levels 6 air quality station of Ankara Province in 2020

3.6 Suggestions

Diseases arising from air pollution should be declared for public health. Individuals who experience discomfort due to pollution should go to the hospital. Diseases caused by the disease should be investigated in the hospital. At the same time, necessary measures should be taken to reduce the diseases and deaths caused by air pollution. And that is how city plans should go. The absence of unnecessary freedom in thermal power plants will be an important decision in terms of keeping air quality in good condition and reducing it. In order to reduce emissions arising from traffic, which has become the problem of big cities; green wave and smart signalling systems should be used more widely. For patients, children, pregnant women and the elderly, the days and times of temperature reversal should be reported in advance and they should be warned about what to do. Means such as social media and some informing method should be chosen for information. Special precautions should be taken together with the warnings of the measuring stations.

3. Evaluation and Conclusion

It was seen that there is a lot of air pollution in Ankara during the winter months. In general, it has been observed that this pollution is caused by traffic, industrialization and rapid population growth. At the same time, the ignorance of the public about air quality accompanies this pollution. Graphs were prepared as a result of the data entered on Excel. By comparing the threshold values determined by the Ministry of Environment and Urbanization, the state of the pollution was determined. In general, it was observed that the pollution increased at Siteler, Demetevler and Bahçelievler stations. This increase will have a great impact on the public health of the society.

Acknowledgment

The authors are grateful to the Ministry of Environment and Urbanization of Turkey, the Turkish State Meteorological Service for air pollution and meteorological data. This study was presented to the International Symposium for Environmental Science and Engineering Research ISESER2021.

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