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## O 21. INVESTIGATION OF BURSA CITY AIR POLLUTION

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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.

***Keywords***: *Air pollution, Bursa city, particle matter, $SO_2$*

## 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 (H2SO3), sulfuric acid (H2SO4) 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.

## MARTIALS AND METHODS

### 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.

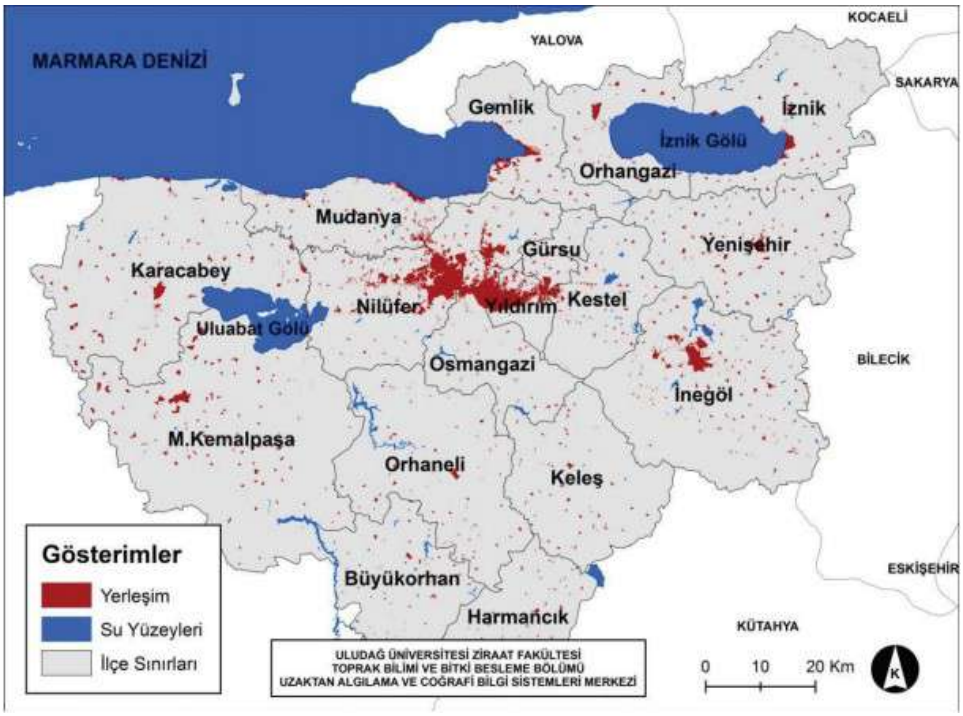


**Figure 4.** Bursa Province Settlement Map by Districts

## 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.

## RESULTS

### 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 1.** 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 | |

**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.

**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.

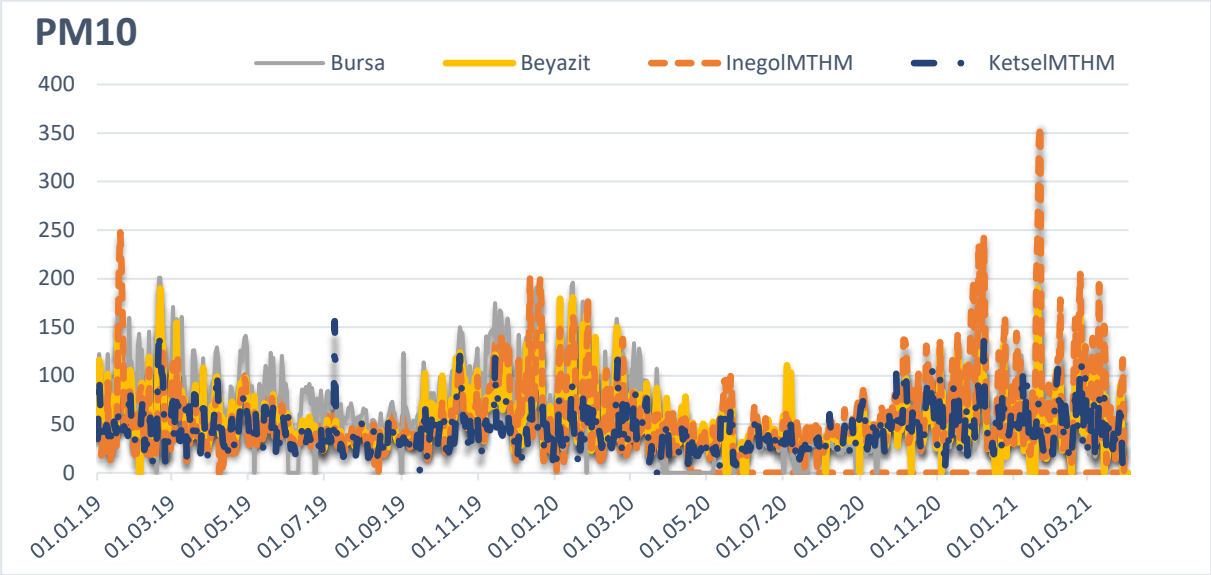


**Figure 2.** Particle Matter (PM10) levels 4 air quality station of Bursa Province last 2 years (2019-2020)

**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.

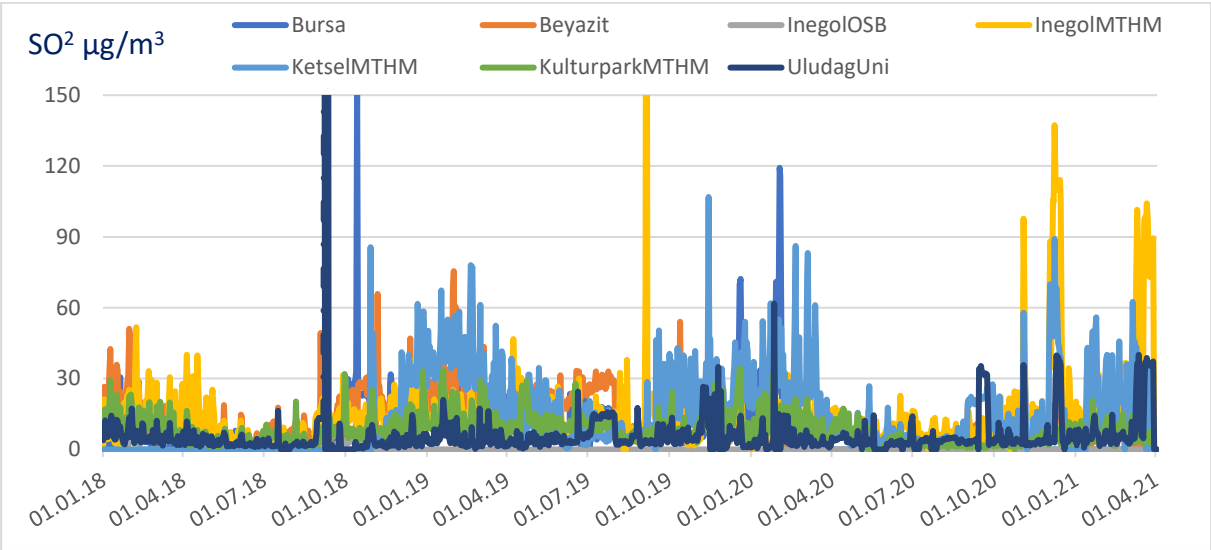


**Figure 3.** Sulphur Dioxide levels 7 air quality station of Bursa Province last 2 years (2019-2020)

### 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.

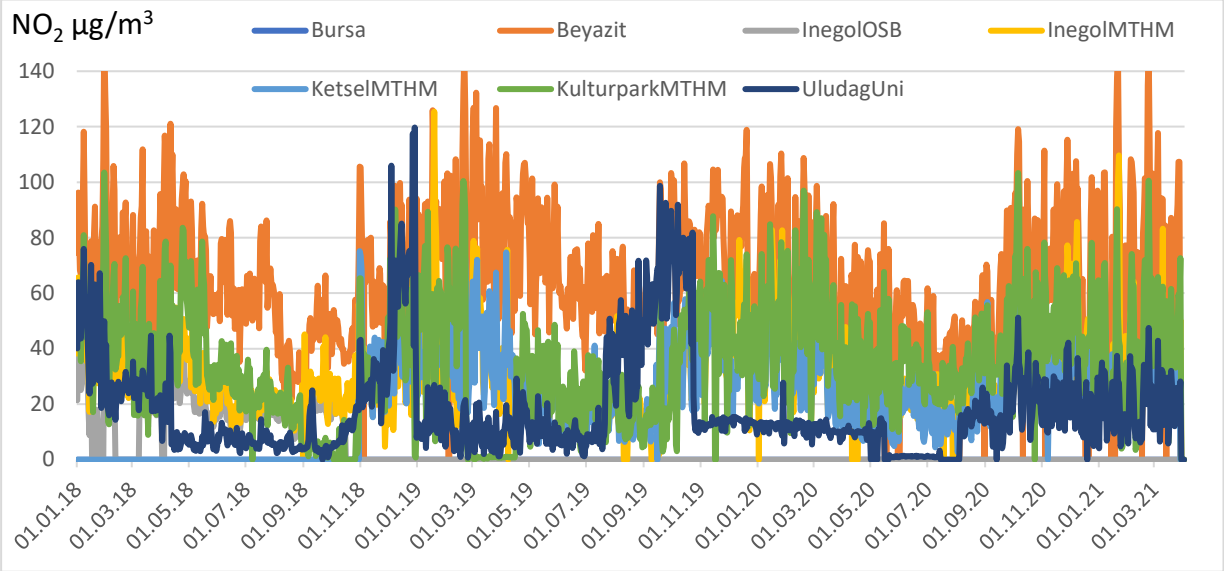


**Figure 4.** Nitrogen Dioxide levels 7 air quality station of Bursa Province last 2 years (2019-2020)

### 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.

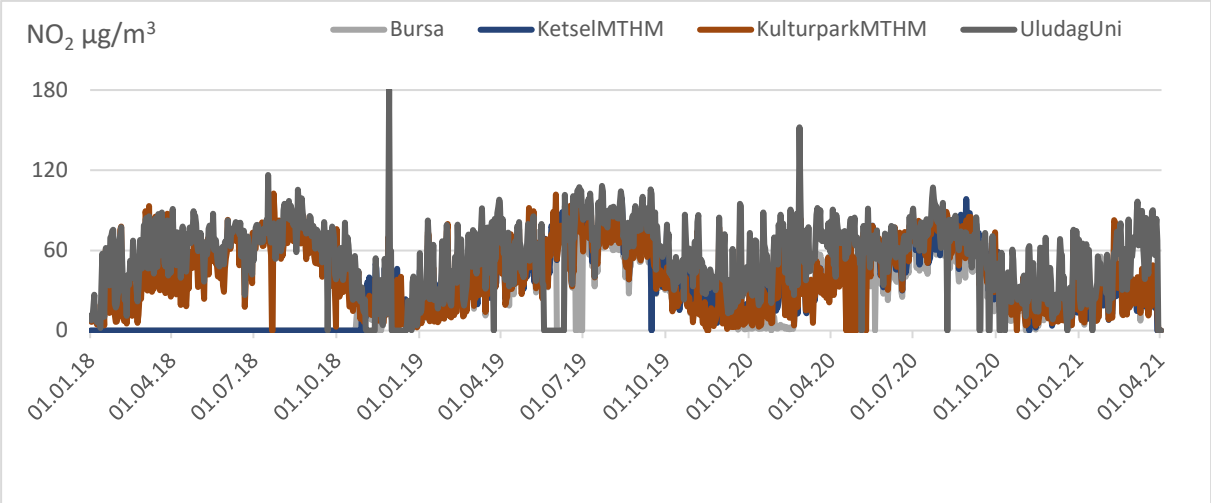


**Figure 5**. Ozone levels 4 air quality station of Bursa Province last 2 years (2019-2020)

**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.

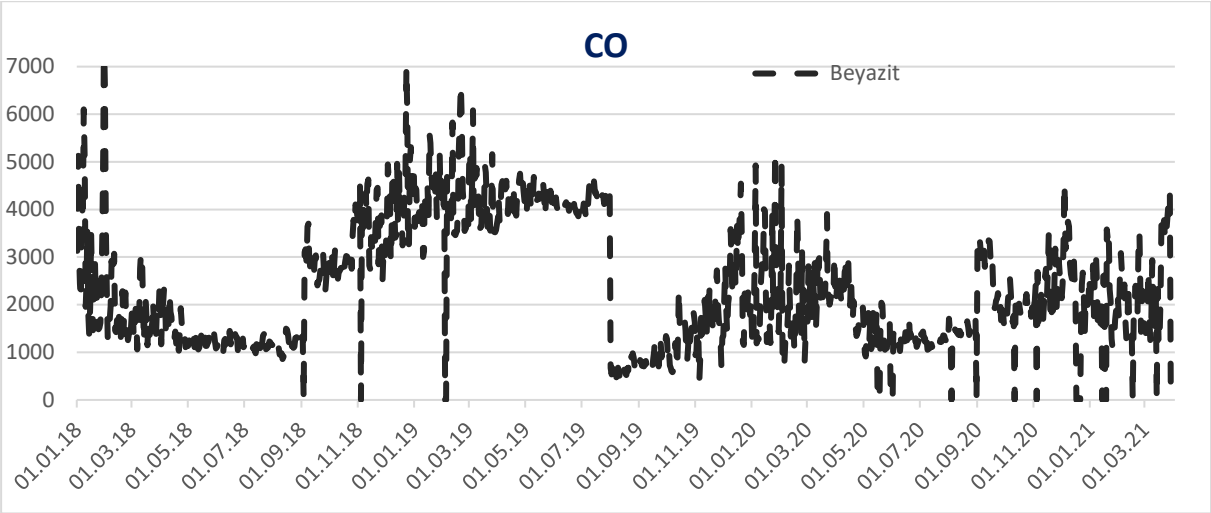


**Figure 6**. Carbon monoxide levels 1 air quality station of Bursa Province last 2 years (2019-2020)

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.

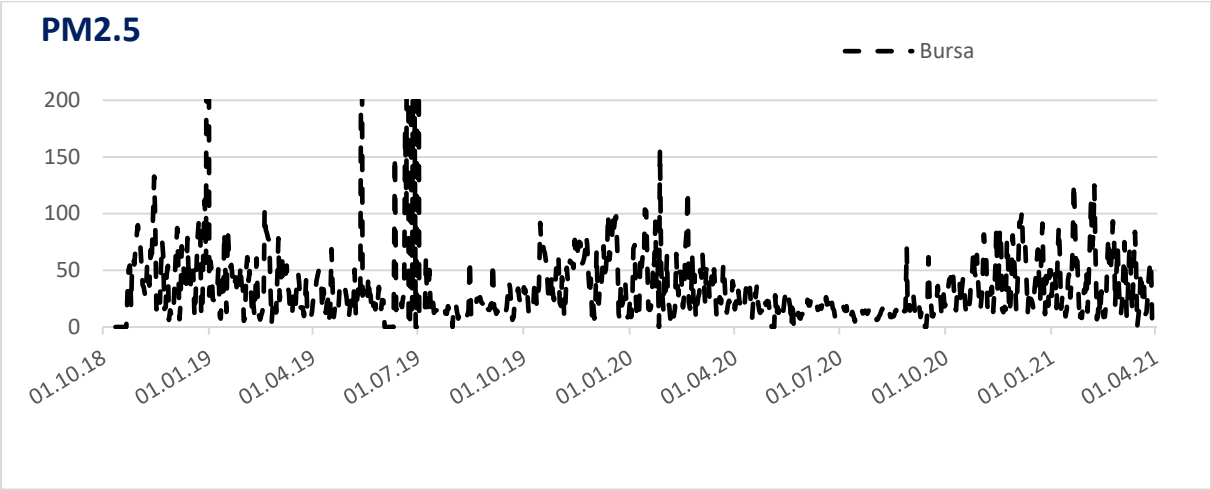


**Figure 7.** Particle Matter ($PM_{2.5}$) levels 1 air quality station of Bursa Province last 2 years (2019-2020)

## 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 SO2 values were below the limit values. When comparing NO2, it was seen that the average of the measurements made in Beyazıt exceeded the annual limit value (annual) 40 µg/m3 for NO2. 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 PM2.5 is 25 µg/m3, and it is the Bursa station that is observed to exceed this limit.

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