FEN ve MÜHENDİSLİK BİLİMLERİ DERGİSİ

Vol: 6 No: 2 Year: 2024 | Araştırma Makalesi/Research Article | e-ISSN: 2667-7989

https://doi.org/10.47112/neufmbd.2024.47

Hava Kalitesi Parametrelerinin (PM_{10} ve SO_2) Değerlendirilmesi: İç Anadolu Bölgesi Örneği

Fatma KUNT[1*] Ahmet ÖZKAN[1]

[1] Necmettin Erbakan University, Faculty of Engineering, Department of Environmental Engineering, Konya, Türkiye

Makale Bilgisi

Geliş Tarihi: 19.03.2024
Kabul Tarihi: 15.06.2024
Yayın Tarihi: 31.08.2024

Anahtar Kelimeler:
Hava kalitesi,
Hava kirliliği,
İç Anadolu Bölgesi,
Kükürt dioksit,
Partiküler maddeler.

ÖZET

Canlı yaşamını, çevresel dengeyi önemli derecede etkileyen ve küresel iklim değişikliğinin ana nedenlerinden biri olan hava kirliliği günümüzde önemli bir çevre sorunudur. Hava kirliliği etkilerinin dünya çapında seviyelere erişmesiyle birlikte hava kirliliğine sebebiyet veren kaynaklar da daha çok araştırmaya konu edilmektedir. Hızla artan dünya nüfusuyla paralel olarak kaynakların enerji için tüketimi de çoğalmıştır. Nüfus artışı ve sanayi alanının ihtiyaçları sebebiyle hava kirliliği günden güne artmakta ve bütün doğa (canlı ve cansız) bundan olumsuz etki görmektedir. Türkiye'nin havasındaki kirlilik, yüksek seviyede ısınma, sanayi ve ulaşım kaynaklıdır. Bununla birlikte yan etkenlerin de etkisiyle kış döneminde kirliliğin daha da arttığı bilinmektedir. Bu çalışmada İç Anadolu bölgesinde bulunan Niğde, Nevşehir, Konya, Kayseri ve Karaman illeri olmak üzere 5 ilin 2017-2021 yılları arasındaki PM_{10} ve SO_2 konsantrasyonları değerlendirilmiştir. Ölçüm periyodu boyunca elde edilen yıllık PM_{10} konsantrasyon değerleri 23-88 µg/m^3, SO_2 konsantrasyon değerleri ise 7-31 µg/m^3 aralıklarında değişiklik göstermektedir. Sonuçlar değerlendirildiğinde, beş ilin SO_2 değerlerinin sınır değerlerin altında olduğu fakat PM_{10} değerlerinin sınır değerleri aştığı görülmektedir. PM_{10} seviyesinin özellikle kış aylarında, hava kirliliğinde ciddi payı olduğu tespit edilmiştir.

Evaluation of Air Quality (PM_{10} and SO_2) Parameters: Example of Central Anatolia Region

Article Info

Received: 19.03.2024
Accepted: 15.06.2024
Published: 31.08.2024

Keywords:
Air quality,
Air pollution,
Central Anatolia Region,
Sulfur dioxide,
Particulate matters.

ABSTRACT

Air pollution, which significantly affects living life and environmental balance and is one of the main causes of global climate change, is an important environmental problem today. As the effects of air pollution reach worldwide levels, the sources that cause air pollution are also subject to more research. In parallel with the rapidly increasing world population, the consumption of resources for energy has also increased. Due to population growth and the needs of the industrial area, air pollution is increasing day by day and all nature (living and inanimate) is negatively affected by this. Pollution in Türkiye's air is caused by high levels of heating, industry and transportation. However, it is known that pollution increases even more during the winter period due to side factors. In this study, PM_{10} and SO_2 concentrations of five provinces in the Central Anatolia region, namely Niğde, Nevşehir, Konya, Kayseri and Karaman, were evaluated between 2017 and 2021. Annual PM_{10} concentration values obtained during the measurement period vary between 23-88 µg/m^3, and SO_2 concentration values vary between 7-31 µg/m^3. When the results are evaluated, it is seen that the SO_2 values of five provinces are below the limit values, but the PM_{10} values exceed the limit values. It has been determined that PM_{10} levels have a serious share in air pollution, especially in the winter months.

To cite this article:
Kunt, F. & Özkan, A. (2024). Evaluation of air quality (PM_{10} and SO_2) parameters: Example of Central Anatolia Region. *Necmettin Erbakan University Journal of Science and Engineering*, 6(2), 255- 271. https://doi.org/10.47112/neufmbd.2024.47

***Sorumlu Yazar:** Fatma KUNT, *drfatmakunt@gmail.com*

INTRODUCTION

Due to the advancement of technology worldwide and the rapid increase in population, humans have become more harmful to nature by consuming more energy resources in their lifetime. Considering the impact of extreme natural events in recent years, it can be said that humans are causing direct damage not only to nature, but also to themselves [1]. It is known that air pollution is the presence of pollutants in the atmosphere to a level that is harmful to humans and animal nature. The main sources of this situation can be classified as industrial and heating-related energy use, disproportionate urbanization, the intrusion of settlements and industry, the use of poor-quality fuels and inappropriate combustion methods.

It is known that pollutants in the atmosphere, especially due to air pollution, cause serious health problems on human health [2]. For example, asthma; It has been understood that it is a disease caused by factors such as cigarette smoke [3,4] and air pollution [5]. It has also been reported that migration, seasons and air pollution during pregnancy have an increased risk of diseases such as autism [6].

It is well known to many in today's world that air pollution loads are increasing every day, reaching global levels, and the impact of emissions, indirectly or directly, is transcontinental. As the world's population grew rapidly, irregular urbanization and land abuse increased, and agricultural land decreased. Industrial settlements have reached the habitats of people. Because of the rapid increase in fossil fuel consumption, the pollution burden on cities is increasing even more.

The Ministry of Environment, Urban Affairs and Climate Change has prepared a “Air Quality Assessment and Management Regulation” [7] to minimize the environmental impact of air pollution, take measures to improve air quality and set targets. To the objectives of the regulation, measurement and monitoring tasks are carried out throughout Türkiye at Clean Air Centers, monitoring and inspection at the District Directorates and Metropolitan Municipalities.

During the first years of the online air quality monitoring process, a total of 81 stations were monitoring the parameters of Sulphur dioxide and particulate matter. The number of air quality monitoring stations currently in place across the country has reached 360. 340 of these stations measure particulate matter (PM_{10}), 305 Sulphur dioxide (SO_2), 302 nitrogen oxides (NO_x), 206 ozone (O_3), 190 carbon monoxides (CO) and 173 particulates ($PM_{2.5}$).

The main sources of particulate matter are factories, power plants, incinerators, construction activities, fires and wind. Particles with an aerodynamic diameter of less than 2.5 μm, $PM_{2.5}$ and less than10 μm are defined as PM_{10}. These particles can be stored in the respiratory system.

The main source of Sulphur dioxide (SO_2) is the combustion of high-Sulphur fats, coal and linate. SO_2 is also produced by the melting of bronze and brass with a high Sulphur ratio [8]SO_2 is a pollutant, especially from heating, industry and traffic. Turkey's Environmental Issues and Priorities Assessment Report is based on data from 2022 by the Turkish Ministry of Environment, Urban Development and Climate Change. The report, prepared in 2023, ranked Turkey's Environmental Problems and Priorities by priority, considering the seven pollution sources identified because of a previous survey. According to priority, the environmental problems of the districts are divided into seven categories: air pollution, noise, water, erosion, soil, waste and environmental damage. In these rankings for all the villages, air pollution took the first place in 22, water contamination in 33, waste in 23, and noise in 3. According to the provincial Directorates, the priority ranking on environmental issues identified 66 districts with air pollution at number 1, 2 and 3 priorities. According to the map of air pollution priorities of the regions in Turkey, as shown in Figure 1, the level of air pollution among all regions is identified as priority problem in 22 districts, secondary priority problem in 19 districts and third priority problem in 25 districts [8].

There are many studies in the literature to identify the impact of PM_{10} and SO_2 on air quality. For example, in 2014, Zortuk and his colleague sought to establish a relationship between the country's per capita national income by using particle density data in the air [9].

In 2022, Çıldır and Murlu [10]'s study at the Balikesir center, the researchers analyzed the PM_{10} and SO_2 densities along with meteorological impacts, depending on time and location, and compared their pollutant densities statistically with the meteorological conditions. İpek & Uyanık [11], in 2022, studied the contribution of industrial power generation plants in the atmospheric pollution in Kayseri, compared emission levels with data from coal-fired plants used in the industry to generate energy, along with natural gas used in industry in 2015-2019. In Uğurlu [12]'s study conducted a field-based study of the air-polluting pollutants PM_{10}, SO_2, CO, NO_2 and O_3 for the years 2019-2020, in Konya, in 2022. In Eren et all [13]'s study for Erzurum, they compared the differentiation in the city's air quality with atmospheric data based on PM_{10} and SO_2 data starting in the winter of 1978-1979 (the first-time pollution was detected) up to winter 2018-2019, in 2022.

Zeydan 2021 [14] compared all air quality monitoring stations' PM_{10} measurements recorded (excluding mobile and test stations) in Türkiye during 2019 according to the regulatory limit values and Koçak, 2018[15], compared these data with the measurements of PM_{10} and SO_2 in Aksaray, which are bordered by Aksaray.

In this study, the PM_{10} and SO_2 compounds have a serious adverse effect on air pollution. Therefore, data from the five provinces selected for the Inner Anatolia Region for the years 2017-2021 from the provinces affiliated with the Southern Anatolia Clean Air Centre were compared, evaluated and recommended that the necessary precautions be taken to reduce air pollution.

MATERIALS AND METHODS

In Türkiye, the Air Quality Index is an index determined by the United States Environmental Protection Agency (EPA) based on polluting parameters, and the main objective of coloring according to this index and index is to ensure that the data is easily understood by the public. The Air Quality Index is used daily and shows how clean or polluted the air in the city we live for that day is. The air quality index is calculated by measuring 5 main pollutant parameters. These parameters are particulate matter (PM_{10}), CO, SO_2, NO_2 and O_3 [16].

According to the air pollution priority map (Figure 1) prepared by the Department of Environment, Urbanization and Climate Change, it was determined that 71 provinces have priority air pollution problems. Among these 71 provinces, 27 provinces were determined as first air pollution priority, 24 provinces were determined as second air pollution priority, and 20 provinces were determined as third air pollution priority region [16]. This is shown in Figure 1 in the Air Pollution Priorities Map prepared for those provinces where air pollution is a priority problem.

For this study, 5 stations from the area of responsibility of Southern Inner Anatolia Clean Air Center were selected, with the most healthy and continuous data flow. The locations of 5 stations including Karaman, Kayseri, Konya, Nevşehir and Niğde are shown in Figure 2 on the map.

The stations are in central cities to reflect the impact of emissions from heating and transport. The station's measurements reflect pollution at a width of 2 kilometers. In this context, it can be said that the healthiest way to detect the level of pollution in cities is to multiply the presence of stations and focus on modeling work. Among the parameters measured at the stations, PM_{10} - $PM_{2.5}$ - SO_2 - NO_x - CO - O_3 values were considered, with measurement data being more regular and covering longer periods, as well as the PM_{10} and SO_2 parameters, which are the most important factors affecting the country's air quality.

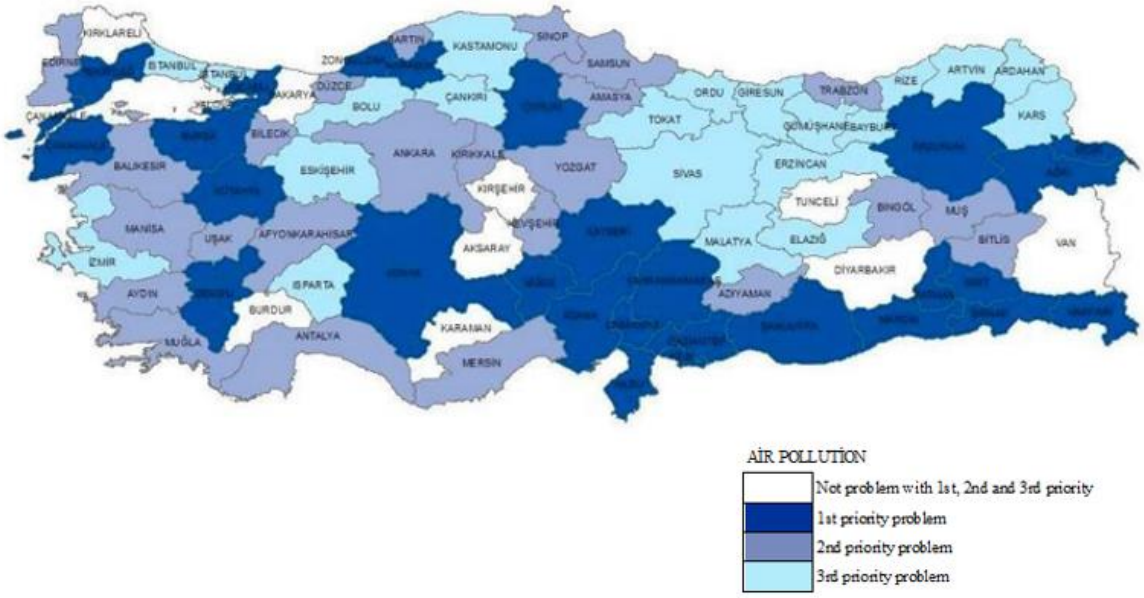

Figure 1
Map of Air Pollution Priorities [16]

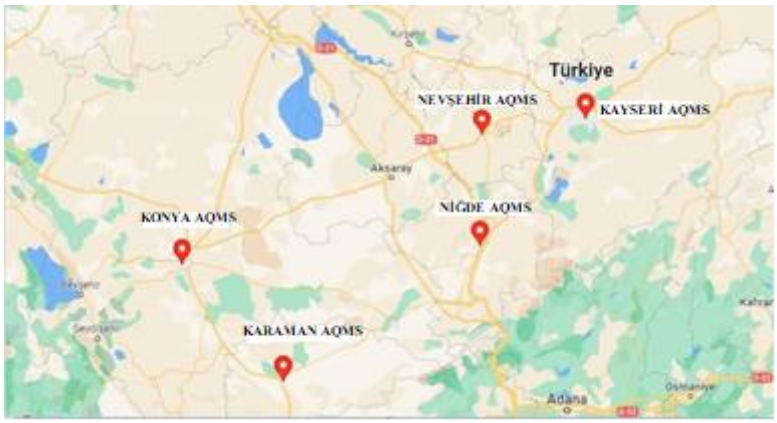

Figure 2
The Combined Display of 5 Air Quality Monitoring Stations on The Map

In the province of Karaman, there are two monitoring stations, including the Central and Ermenek air quality monitoring station, and the Karaman Central Air Quality Monitoring Station [17], which uses data for the work, is on the road. Central Anatolia Small Industry Site is 1.27 km away and Organized Industry District is 6.89 km away. MEY alcohol factory is close to 2.96 km from the station. and it is close to 5.43 km from the stone pits.

In Kayseri province, there are 6 stations including Traffic, Hürriyet, Melikgazi, Kocasinan, Talas and OSB air quality monitoring stations, and the work is done at the Hürriyet Station [18], which is closed to 110 meters from the main road.

There are nine monitoring stations in Konya province, including Traffic, Meram, Karatay-Sunaypark, Karatay-Karkent, Selçuklu-Bosna, Selçuklu-Laboratuvar, Akşehir, Ereğli and Sarayönü air quality surveillance stations. The Konya Meram air quality monitoring station [19] has been selected

for the study because it is in the city center.

There are two Air Quality Monitoring Stations in the district of Nevşehir, including Central and Avanos, which use the data for the work of the Central Air Quality monitoring station [20] in the Municipal Park, 30 m off the road, 10 km from the Islah Organized Industrial Area. It is 7.18 km from the machined stone pits. Nearest BIMS Facility is approximately 12.52 km away.

The Niğde Central Air Quality Monitoring Station [21] is in Kılıçarslan Park, 3 km from the district's stone mines and 6 km to the industrial district.

Devices used for PM_{10} and SO_2 measurements at air quality monitoring stations

Continuous Particle Monitor BAM 1020

PM_{10} and $PM_{2.5}$ can be measured with the BAM 1020 model device from Met One Instruments. BAM 1020 automatically measures and records particle concentration levels in the air (in milligrams or micrograms per cubic meter) using the industry-tested principle of beta-ray depletion [22]. The particulates in the air drawn from the external environment are placed on the filter and are measured by the device on a filtering strip wrapped on the inside of the device. The interior and exterior appearance of the device are shown in Figure 3.

Figure 3

The Combined Display of 5 Air Quality Monitoring Stations on The Map

Continuous Particle Monitor MP101M

The MP101M model device of Envea, shown in Figure 4, can be used to measure the concentration of PM_{10}, $PM_{2.5}$ and PM_1 fine dust in the range 0-10,000 $\mu g/m^3$ in accordance with ISO 10473 Standard. The MP101M uses the standard ISO 10473 beta indicator measurement method for continuous measurements of the concentration of fine dust in ambient air [23].

Figure 4

Continuous Particle Monitor MP101M Device View

Sulphur Dioxide Analyzer AF22e

The E Series Sulphur Dioxide Analyzer AF22e, shown in Figure 5 by Envea, is capable of measuring in the range of 0-10 ppm or 0-1 ppm. For monitoring SO_2 in the device, the UV Flüoresan uses the EN 14212 standard method for measuring SO_2 with a gas monitor [24].

Figure 5

E Series Sulphur Dioxide Analyzer AF22e Device View

RESULTS

Clean air is one of the most important criteria for making human life healthy and sustainable. The increased load of air pollution causes respiratory problems, but also adversely affects the growth of plants. In this context, the reduction in air pollution in our neighborhoods will be beneficial to all beings. In this study, monthly data for PM_{10} and SO_2 parameters were evaluated on the basis of measurement data from the Air Quality Monitoring Stations from 2017 to 2021. According to the results obtained, the national threshold values for SO_2 have not been exceeded in five provinces, while for PM_{10} there has been noticeable excesses.

The following are graphs of the five-year PM_{10} and SO_2 monthly averages of the selected Air Quality Monitoring Stations for the study, as well as for five provinces separately, and the measurement by months of the number of PM_{10} limits exceeded for five years.

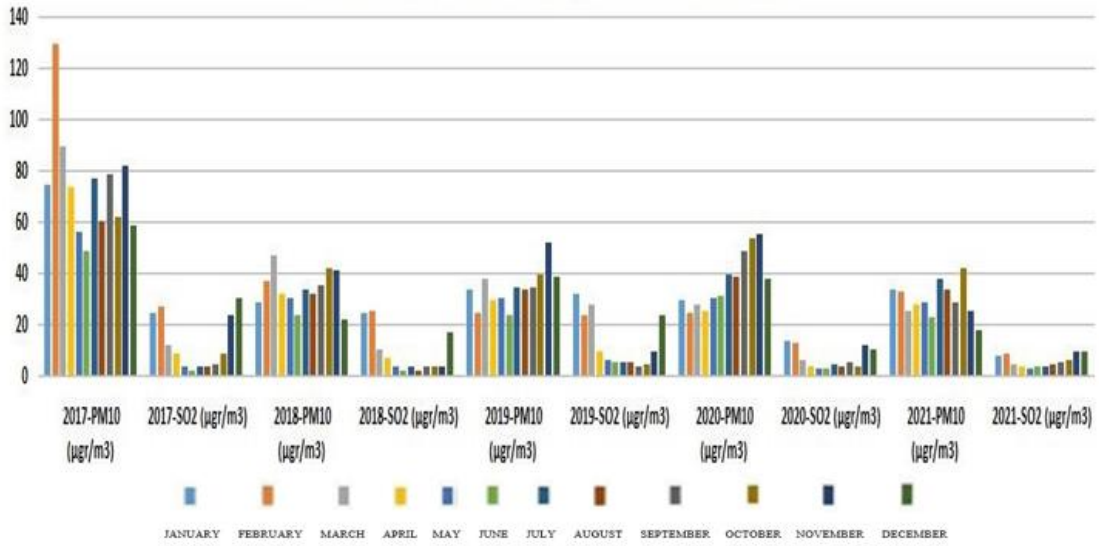

Figure 6
5-Year PM_{10}-SO_2 Monthly Averages at Karaman-Central Air Quality Monitoring Station

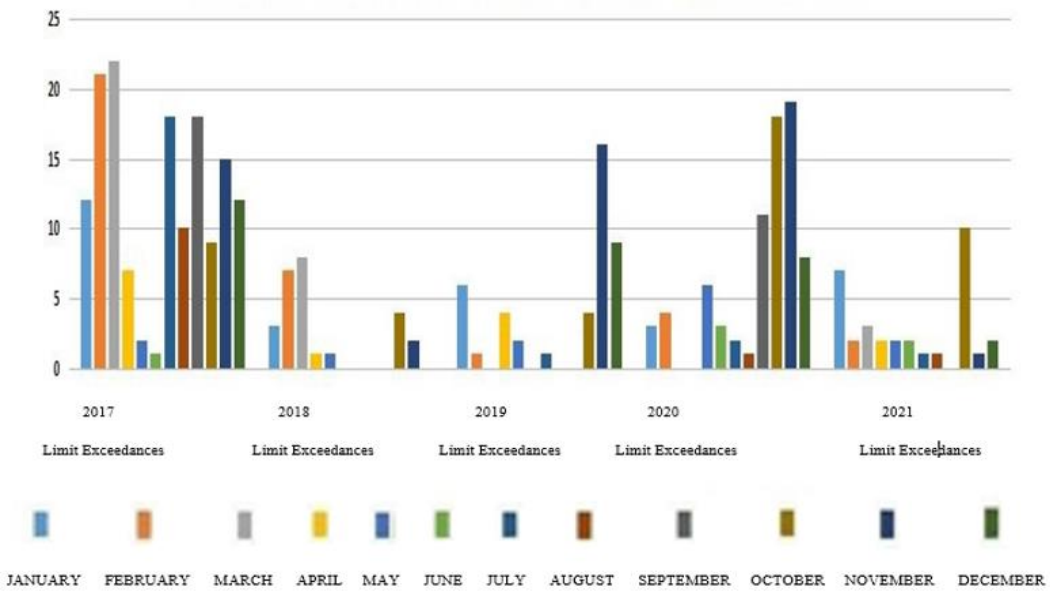

Figure 7
Assessment of 5-Year PM_{10} ($\mu g/M^3$) Limits by Months by The Karaman-Central Air Quality Monitoring Station

When Figure 6 and Figure 7 are examined, it is apparent that the PM_{10} averages in Karaman province in 2017 and the limits are too high compared to other years.

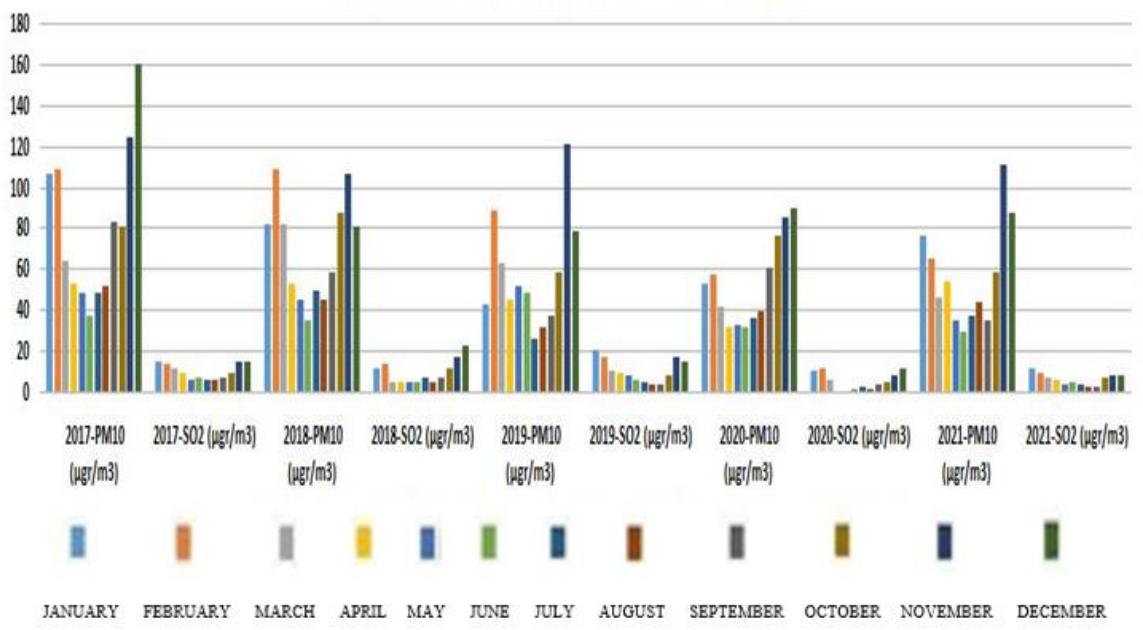

Figure 8
5-Year PM_{10}-SO_2 Monthly Averages at The Kayseri-Hürriyet Air Quality Monitoring Station

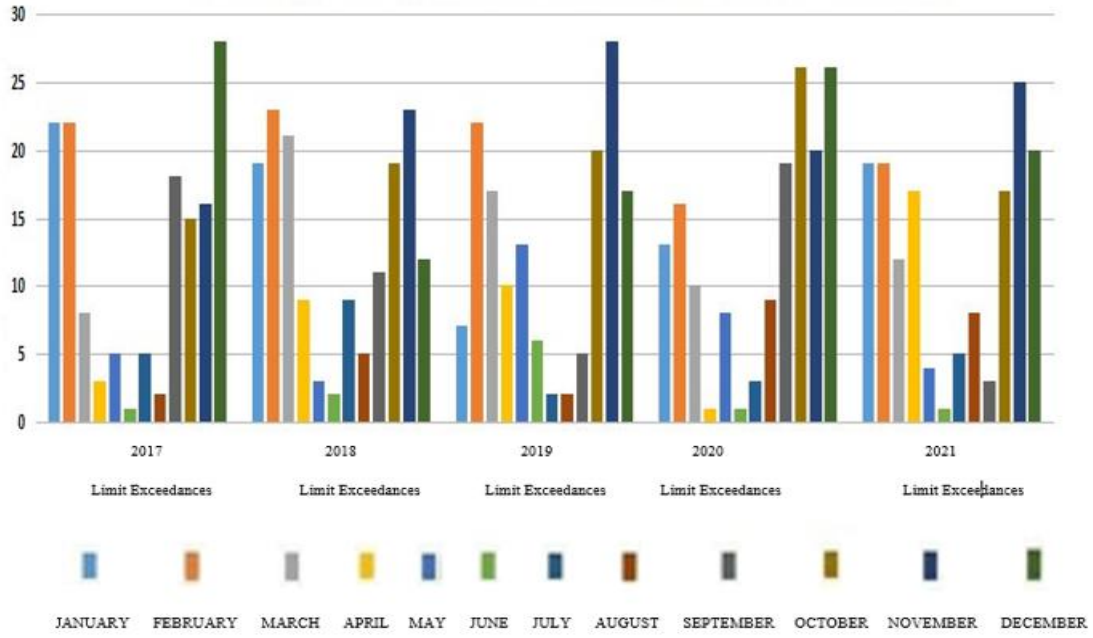

Figure 9
The Kayseri-Hürriyet Air Quality Monitoring Station Assesses 5-Year PM10 (µg/m^3) Limits by Month

When Figure 8 and Figure 9 are examined, the PM_{10} averages in Kayseri province and the limits of excesses are almost identical in the years 2017-2021.

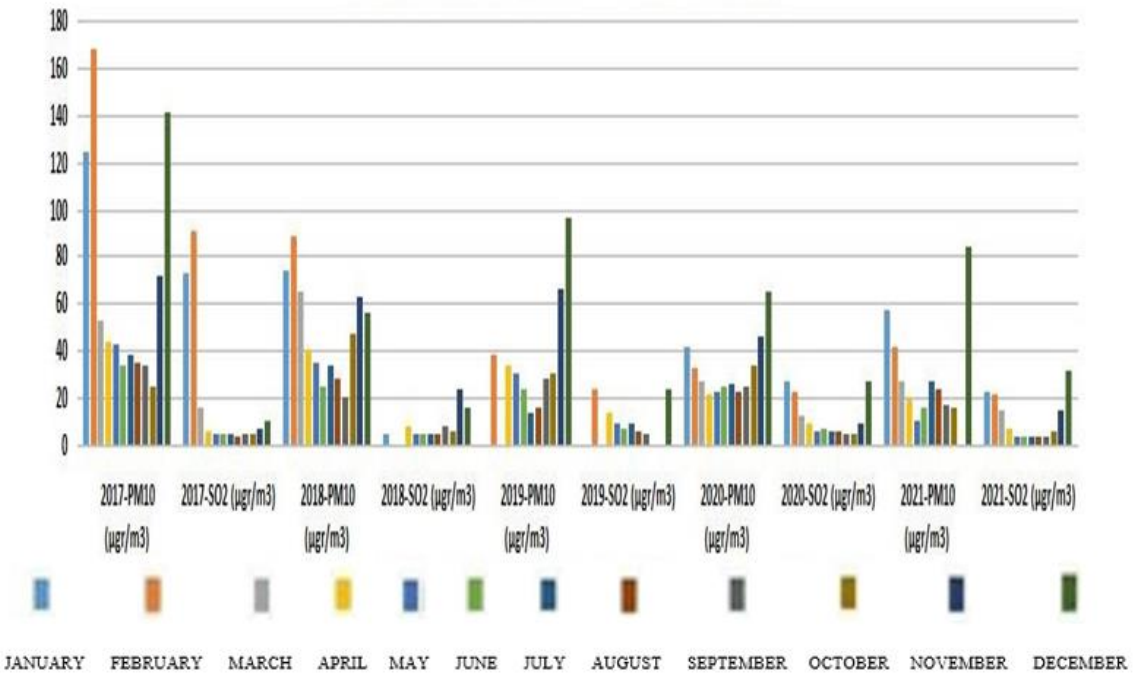

Figure 10
5-Year PM_{10}-SO_2 Monthly Averages at Konya-Meram Air Quality Monitoring Station

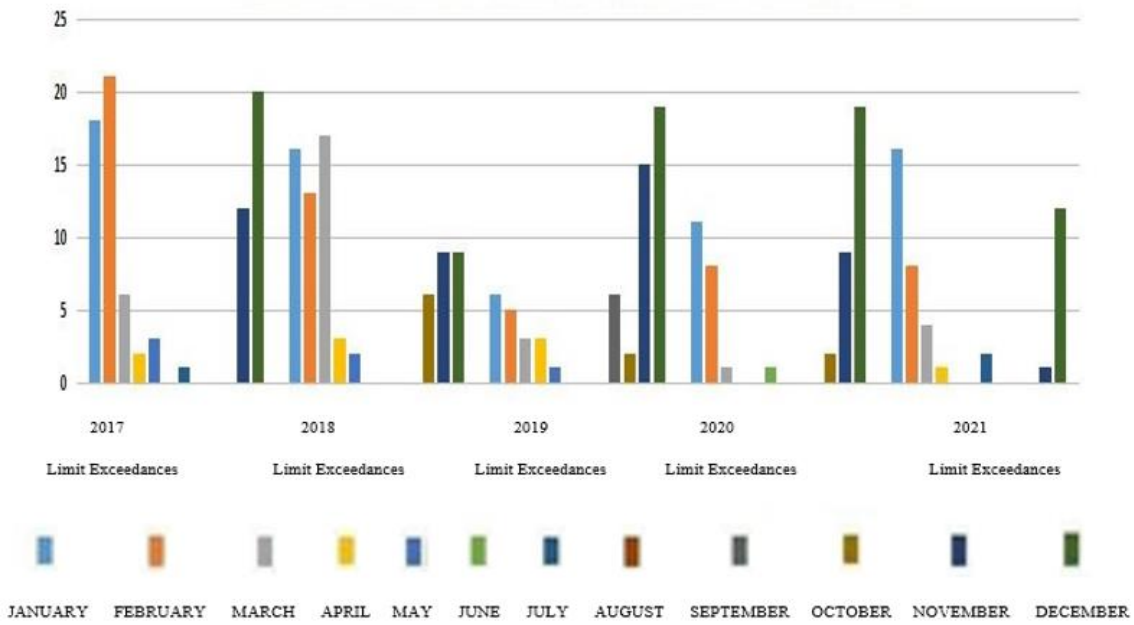

Figure 11
Konya-Meram Air Quality Monitoring Station Estimates 5-Year PM_{10} ($\mu g/m^3$) Limits by Months

When Figure 10 and Figure 11 were examined, it was found that after the years 2017 and 2018, the province of Konya has a tendency to decrease PM_{10} averages and the number of exceeding limits towards 2021. The data for January, November and December appear to be well above the other months.

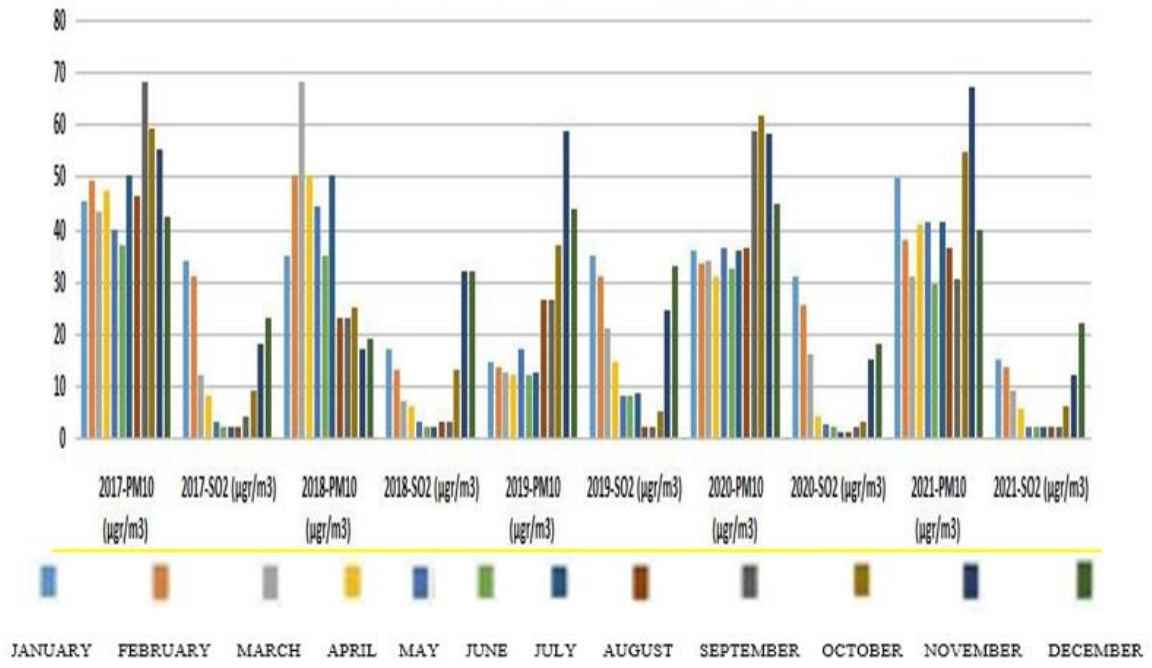

Figure 12
5-Year PM_{10}-SO_2 Monthly Averages at Nevşehir-Central Air Quality Monitoring Station

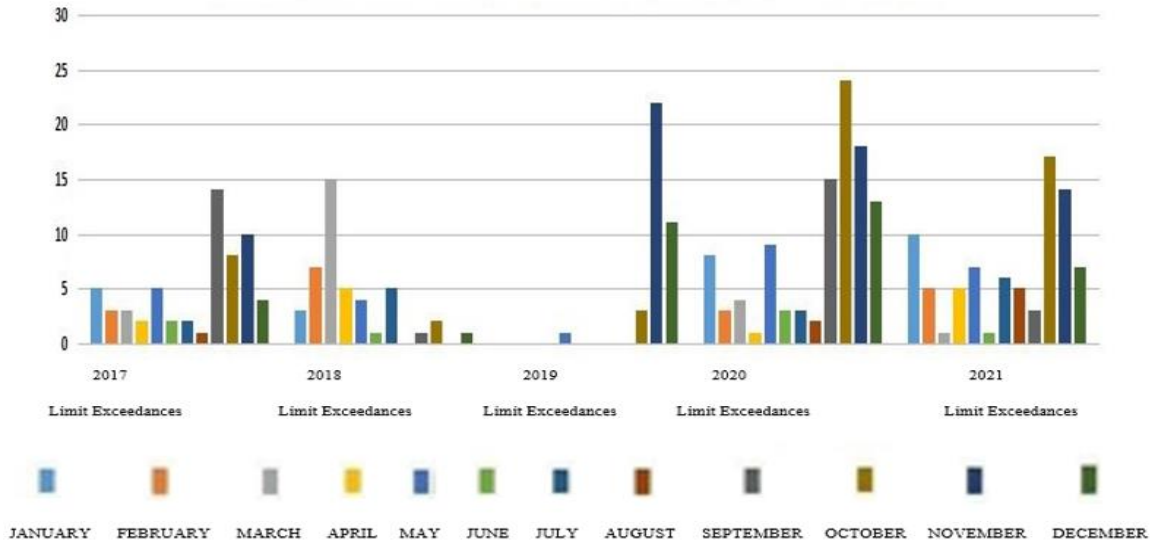

Figure 13
Nevşehir-Central Air Quality Monitoring Station 5-Year PM_{10} ($\mu g/m^3$) Exceeding Limits in Months

When Figure 12 and Figure 13 were examined, it was found that the PM_{10} averages in Nevşehir province and the limits of excesses were almost identical in the years 2017-2021. The months of January, November and December coincide with the fact that the data are much higher than the other months.

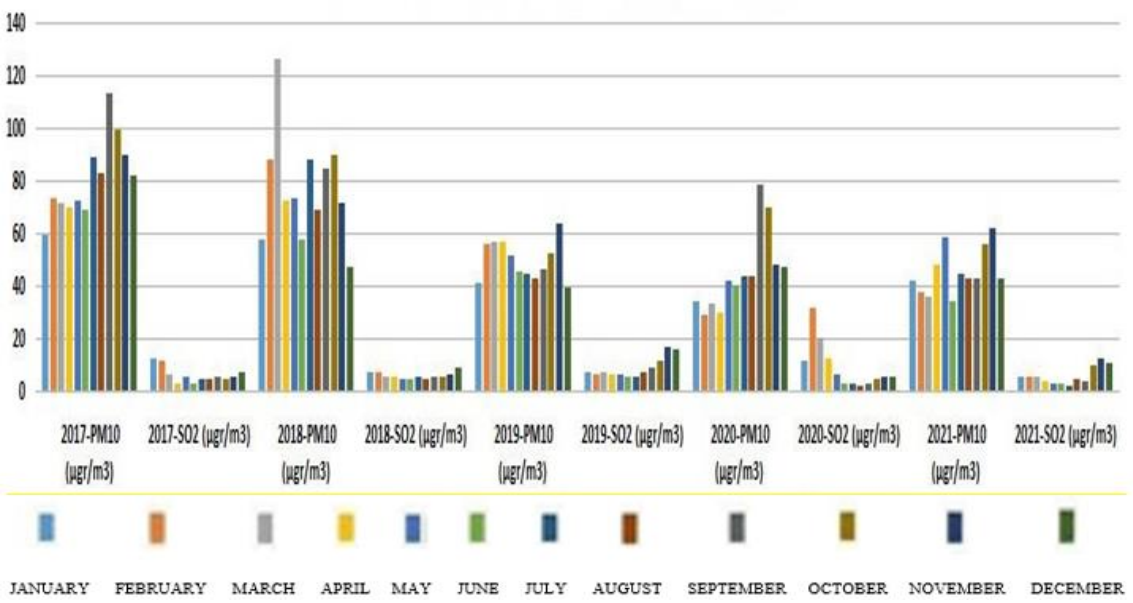

Figure 14
Niğde-Central Air Quality Monitoring Station 5-Year PM_{10}-SO_2 Monthly Averages

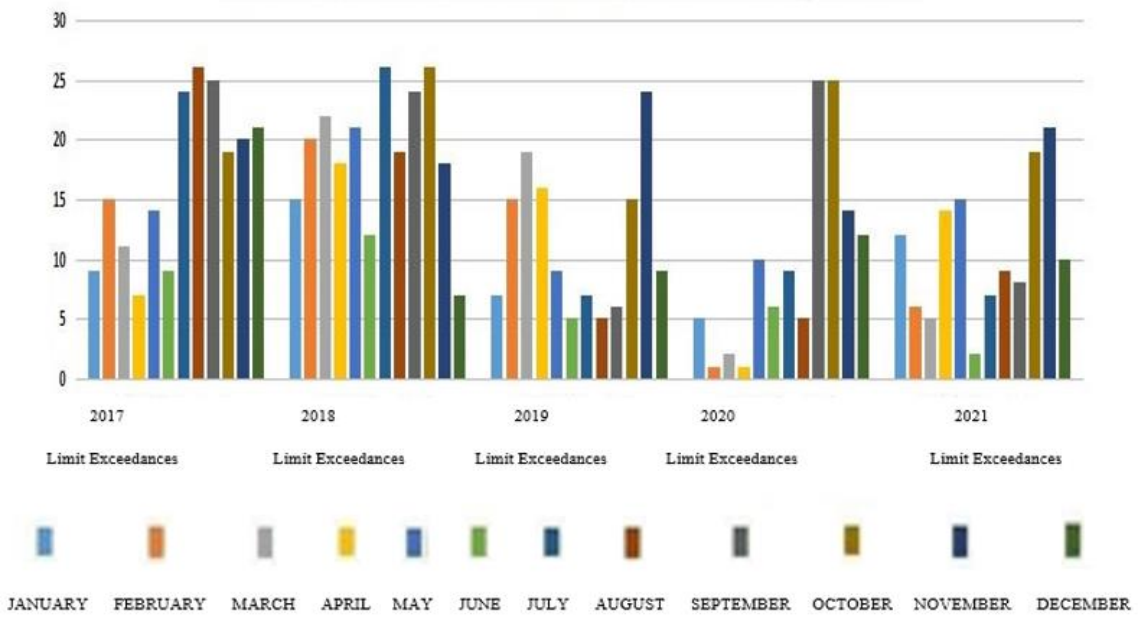

Figure 15
The Niğde- Central Air Quality Monitoring Station Assesses the Five-Year PM_{10} ($\mu g/m^3$) Limits by month

When Figure 14 and Figure 15 are examined, it is estimated that the PM_{10} averages and the limit exceeding numbers in Niğde province are much higher than in other provinces, which may be directly related to the level of advancement of the provinces.

According to the Ministry of Environment, Urban Affairs and Climate Change Directorate-General for Environmental Management No. 2013/37 "General Air Quality Assessment and Management", the limit values for PM_{10} are given in the table of gradual reduction in limits (Table 1) [25].

Table 1
Gradual Reduction Limit Values for PM10 (µg/m3) by Years

POLLUTANT	AVERAGE DURATION	LIMIT VALUE (µg/m^3)						
		2013	2014	2015	2016	2017	2018	2019
PM_{10}	24 Hours -For the protection of human health	100	100	90	80	70	60	50
	Yearly-For the protection of human health	60	60	56	52	48	44	40

PM_{10} measurement data of 5 provinces between 2017 and 2021 were compared with the limit values in Table 1 based on seasonal, annual and 5-year averages. Comparisons made separately for each province are given and the limit excess values are given as bold in Table (2-6).

Table 2
Seasonal, Annual And 5-Year Averages of PM_{10} (µg/m^3) for Karaman Province

	YEAR	SEASONAL AVERAGE PM_{10} (µg/m^3)					ANNUAL AVERAGE PM_{10} (µg/m^3)
		WINTER	SPRING	SUMMER	AUTUMN		
KARAMAN	**2021**	29.55	26.66	31.06	33.29		30.14
	2020	30.58	27.41	36.12	**52.57**		36.67
	2019	31.91	27.34	30.73	**41.70**		32.92
	2018	29.56	36.02	29.25	39.39		33.56
	2017	**86.89**	**73.02**	**61.70**	**74.01**		**73.91**
	5-YEAR SEASONAL AVERAGE PM_{10} (µg/m^3)	**41.70**	38.09	37.77	**48.19**	**5 YEAR AVERAGE PM_{10} (µg/m^3)**	**41.44**

Table 3
Seasonal, Annual and 5-Year Averages of PM_{10} (µg/m^3) for Kayseri Province

	YEAR	SEASONAL AVERAGE PM_{10} (µg/m^3)					ANNUAL AVERAGE PM^{10} (µg/m^3)
		WINTER	SPRING	SUMMER	AUTUMN		
KAYSERİ	**2021**	**76.45**	**44.58**	36.49	**67.86**		**56.34**
	2020	**66.56**	35.38	35.53	**73.67**		**52.79**
	2019	**68.67**	**53.61**	34.84	**71.59**		**57.18**
	2018	**90.37**	**59.98**	43.09	**83.95**		**69.35**
	2017	**124.93**	**54.33**	45.33	**95.60**		**80.05**
	5-YEAR SEASONAL AVERAGE PM_{10} (µg/m^3)	**85.40**	**49.58**	39.06	**78.54**	**5 YEAR AVERAGE PM_{10} (µg/m^3)**	**63.14**

Table 4
Seasonal, Annual and 5-Year Averages of PM_{10} ($\mu g/m^3$) for Konya Province

	YEAR	SEASONAL AVERAGE PM_{10} ($\mu g/m^3$)					ANNUAL AVERAGE PM_{10} ($\mu g/m^3$)
		WINTER	SPRING	SUMMER	AUTUMN		
KONYA	**2021**	**60.98**	18.48	22.09	19.90		30.37
	2020	**46.08**	23.24	24.13	34.37		31.95
	2019	**71.20**	34.37	17.35	**41.18**		**41.03**
	2018	**72.92**	**46.65**	28.64	43.11		**47.83**
	2017	**144.56**	46.39	35.71	43.82		**67.62**
	5-YEAR SEASONAL AVERAGE PM_{10} ($\mu g/m^3$)	**79.15**	33.83	25.58	36.47	**5 YEAR AVERAGE PM_{10} ($\mu g/m^3$)**	**43.76**

Table 5
Seasonal, Annual and 5-Year Averages of PM_{10} ($\mu g/m^3$) for Nevşehir Province

	YEAR	SEASONAL AVERAGE PM_{10} ($\mu g/m^3$)					ANNUAL AVERAGE PM_{10} ($\mu g/m^3$)
		WINTER	**SPRING**	**SUMMER**	**AUTUMN**		
NEVŞEHİR	**2021**	**40.41**	38.45	35.33	**50.88**		**41.27**
	2020	37.88	33.84	34.83	**58.54**		**41.27**
	2019	23.84	14.06	17.17	**40.81**		23.97
	2018	34.44	**54.09**	35.93	21.90		36.59
	2017	45.23	43.67	44.07	**60.49**		**48.36**
	5-YEAR SEASONAL AVERAGE PM_{10} ($\mu g/m^3$)	36.36	36.82	33.47	**46.53**	**5 YEAR AVERAGE PM_{10} ($\mu g/m^3$)**	38.29

Table 6
Seasonal, Annual and 5-Year Averages of PM_{10} ($\mu g/m^3$) for Niğde Province

	YEAR	SEASONAL AVERAGE PM_{10} ($\mu g/m^3$)					ANNUAL AVERAGE PM10 ($\mu g/m^3$)
		WINTER	**SPRING**	**SUMMER**	**AUTUMN**		
NİĞDE	**2021**	**40.73**	**48.17**	**40.47**	**52.81**		**45.55**
	2020	37.11	34.36	**42.18**	**63.34**		**44.25**
	2019	**45.81**	**55.14**	**43.98**	**53.59**		**49.63**
	2018	**63.55**	**90.54**	**70.48**	**82.05**		**76.65**
	2017	**70.97**	**71.49**	**80.71**	**100.04**		**80.80**
	5-YEAR SEASONAL AVERAGE PM_{10} ($\mu g/m^3$)	**51.63**	**59.94**	**55.56**	**70.37**	**5 YEAR AVERAGE PM_{10} ($\mu g/m^3$)**	**59.38**

DISCUSSION AND CONCLUSIONS

The main reason why PM_{10} and SO_2 parameters are preferred for the study is that long-term and complete data for these parameters can be obtained from air quality monitoring stations. According to the measurements of the air quality monitoring stations involved in the study, especially in winter, the air has been exposed to intense pollution due to high PM_{10} values, which is due to domestic heating fuel consumption. Air pollution has increased significantly due to meteorological factors such as wind, inversion, and criteria arising from the land structure of the areas.

Annual and seasonal changes in SO_2 and PM_{10} average concentrations should be reported for each province and these values evaluated by comparing them with limit values. When the results are evaluated, it is seen that the SO_2 values of five provinces are below the limit values, but the PM_{10} values exceed the limit values.

Topographic structure features and meteorological conditions have a significant impact on the distribution of air pollutants. Air movements in the atmosphere, temperature, temperature reversal, humidity, wind speed and direction are some of these factors.

In terms of topographic structure features, settlement locations are located on areas such as plains, valleys, and in areas where surrounding elevations such as high plateaus, mountains and hills are increasingly surrounded, where air pollution is high. The landforms influence the retention of polluted air in the residential area. On the other hand, although it is not a direct impact, it is significant in terms of affecting the duration of the current pollution.

Air pollution caused by a lot of different factors is a problem in many cities today. Air pollution from urban and industrial activities can be prevented by appropriate location selection. In settlements that are geographically situated at the bottom of the valley, and which have evolved to the advancing land structure, it can be said that urban air pollution activity has concentrated on the settlement and has resulted in a health-threatening atmosphere. In addition, the presence of industrialized areas in the region, regardless of the predominant wind direction, adds to the current pollution.

To the extent that exposure to air pollution can be reduced, climate characteristics, together with the geographical characteristics of the region, should be decisive in the choice of location. Factors such as temperature, humidity, pressure and wind should be considered by the natural structure of the land, and urban and industrial areas should be planned accordingly. Otherwise, our cities, both under the influence of intense polluting activities and the natural phenomena caused by the geographical and climatic characteristics of the natural structure, will create high air pollution and, at the same time, unhealthy habitats.

In this context, it can be said that the PM_{10} value has a significant negative impact on the air quality. It is clear from the air quality monitoring station's data that domestic heating fuel consumption has exceeded the high concentrations especially during the winter season. The highest number of overruns among 5 provinces occurred in 2018 in Niğde.

The way to prevent existing and potential pollution in nature is through the raising of conscious and educated generations. The Provincial Directorates, the Directorates of the Clean Air Centre, and the Ministry of National Education, together, set targets and coordinated awareness-raising training, starting at the primary level, could be an important step towards this goal. To prevent pollution, it is important that local authorities (State and local governments) develop and implement action plans that involve all stakeholders.

Delivering natural gas to every household and every workplace, thus minimizing the use of fossil fuels, widespread central heating in buildings, simultaneous monitoring of high-heat-power

facility gas emissions, increased use of natural-friendly energy sources, and making public transportation easy and economical will contribute to reducing pollution.

The increase in the number of air quality monitoring stations has been determined to be beneficial to more accurately detect and model existing pollution in the provinces.

It is essential for people to have clean air to breathe to live healthy and comfortable lives. Increased pollution causes respiratory disorders, especially in humans, and prevents plants from growing. In addition, air pollution has a devastating effect on architectural structures. In this context, improved air quality in our cities will have a positive impact on living creatures and human beings.

According to the data from our research team, pollution is intense due to the PM_{10} parameter, especially in winter, and national limit values have been exceeded because of the use of fuel for heating purposes. Meteorological (wind, inversion, etc.) and topographic conditions contribute to a significant increase in the air pollution load Air pollution caused by industry and transport also increases the burden of urban contamination. According to the data, SO_2 is not a problem.

In collaboration with the Directorates of Environment, Urbanism and Climate Change, the Directions of the Clean Air Centre and the Provincial National Education Directorates, awareness-raising training from the early age of primary education would be a good starting point. In order to prevent pollution, the decision-makers of the provinces (State and local governments) attach importance to the preparation and implementation of Clean Air Action Plans in a sustainable format with stakeholders. Reducing the use of fossil fuels, increasing central heating and natural gas use, providing natural gas support to needy families, online monitoring of heat-powered industrial facilities, using clean energy such as solar and geothermal, self-sufficiency of bicycle use and public transportation will contribute to reducing pollution. It would be useful to increase the number of stations, to carry out field sampling, and to pay attention to modeling work to fully understand the level of pollution in the provinces.

Ethical Declaration

This study was prepared from the master's thesis titled "Evaluation of PM_{10} and SO_2 Parameters in Five Provinces in the Central Anatolia Region", presented on 28.12.2022, under the supervision of Associate Professor Fatma KUNT.

Author Credits

Research Design, Conceptualization (CRediT 1) Fatma Kunt (%60) – Ahmet Özkan (%40)

Data Collecting (CRediT 2) Fatma Kunt (%50) – Ahmet Özkan (%50)

Research - Data Analysis - Validation (CRediT 3-4-6-11) Fatma Kunt (%40) – Ahmet Özkan (%60)

Writing (CRediT 12-13) Fatma Kunt (%60) – Ahmet Özkan (%40)

Review & Editing (CRediT 14) Fatma Kunt (%60) – Ahmet Özkan (%40)

Conflict of Interest

The authors have no conflicts of interest to disclose for this study.

REFERENCES

[1] T. Singh, A. Biswal, S. Mor, K. Ravindra, V. Singh, S. Mor, A high-resolution emission inventory of air pollutants from primary crop residue burning over Northern India based on VIIRS thermal anomalies, *Environmental Pollution*. 266 (2020), 115132.

[2] T.Y. Oral, F.B. Bekman, İnsan sağlığı hizmetleri çalışanlarının maruz kaldığı meslek hastalığı etkenlerinin iş sağlığı ve güvenliği kapsamında incelenmesi, *Genel Sağlık Bilimleri Dergisi*. 3 (2021), 160-178.

[3] Göğüs hastalıkları polikliniğine başvuran olguların sigara içme özellikleri | GCRIS Database | Pamukkale University, (t.y.). https://gcris.pau.edu.tr/handle/11499/41336 (erişim 24 Mayıs 2024).

[4] G. Göney, C. Gazeloğlu, M. Nal, Association between smoking exposure and obesity in turkey, *Genel Sağlık Bilimleri Dergisi*. 2 (2020), 19-27.

[5] I. Reisli, Y. Köksal, Astım patogenezi, *Selçuk Tıp Dergisi*. 18(4) (2002), 267-273.

[6] K. Nalbant, S. Erden, Autism Spectrum Disorder and Prenatal Risk Factors, *Selçuk Tıp Dergisi*. 4 (2019), 282-290. doi:10.30733/std.2019.00942.

[7] Başbakanlık Mevzuatı Geliştirme ve Yayın Genel Müdürlüğü, Hava Kalitesi Değerlendirme ve Yönetimi Yönetmeliği (t.y.). https://www.resmigazete.gov.tr/eskiler/2008/06/20080606-6.htm (access 22 March 2024).

[8] G. Reis Manap, S. Aydın, Çevresel Etki Değerlendirilmesi, İzin ve Denetim Genel Müdürlüğü, Türkiye Çevre Sorunları ve Öncelikleri Değerlendirme Raporu (t.y.) https://webdosya.csb.gov.tr/db/ced/icerikler/turk-ye-cevre-sorunlari-ve-oncel-kler-_2022_3_ver3.logoduzenlendi-20230901135641.pdf (access 22 March 2024).

[9] M. Zortuk, Y. Bozkurt, Kentlerin çevre kirliliği ve gelişmişlik düzeylerine göre sınıflandırılması: amprik bir yaklaşım, *Journal of Management and Economics Research*. 12 (2014), 72-81.

[10] İ. Çildir, A. Mutlu, Balıkesir şehir merkezinde hava kirliliği seviyelerinin zamansal ve mekansal analizleri, *Journal of Advanced Research in Natural and Applied Sciences*. 8 (2022), 246-266. doi:10.28979/jarnas.950206.

[11] İ. Zeynep, İ. Uyanık, Sanayi kaynaklı noktasal emisyonların hava kalitesine katkısı: Kayseri ili örneği, *Doğal Afetler ve Çevre Dergisi*. 8 (2022), 341-350.

[12] O. Uğurlu, Konya İlinde Hava Kirliliğine Etki Eden Faktörlerin Mekânsal Analizi, Master's Thesis, Necmettin Erbakan Üniversitesi Fen Bilimleri Enstitüsü, 2021.

[13] Z. Eren, F. Yerdelen Tatoğlu, T. Akarsu, A statistical evaluation of the effect of natural gas usage for urban heating on the air quality of Erzurum City via SO_2 ve PM_{10}, *Pamukkale University Journal of Engineering Sciences*. 28 (2022), 869-880.

[14] Ö. Zeydan, 2019 Yılında Türkiye'deki Partikül Madde (PM10) Kirliliğinin değerlendirilmesi, *Journal of the Institute of Science and Technology*. 11 (2021), 106-118.

[15] E. Koçak, Aksaray Kentinin PM10 ve SO2 Konsantrasyonlarının Zamansal Değişimi: Koşullu İki Değişkenli Olasılık Fonksiyonu ve K-means Kümeleme, *Mühendislik Bilimleri ve Tasarım Dergisi*. 6 (2018), 471-478. doi:10.21923/jesd.426741.

[16] A. Nuray, G. Reis Manap, K. Sarıoğlu, A.T. Sanalan, S. Aydın, Çevresel Etki Değerlendirilmesi, İzin ve Denetim Genel Müdürlüğü, Türkiye Çevre Sorunları ve Öncelikleri Değerlendirme Raporu (t.y.) https://webdosya.csb.gov.tr/db/ced/icerikler/tu-rk-yecevresorunlariveoncel-kler-_2020-20210401124420.pdf (access 22 March 2024).

[17] Güney İç Anadolu Temiz Hava Merkezi Müdürlüğü (t.y.) https://webdosya.csb.gov.tr/db/giathm/menu/karaman-brosur_20200313044240.pdf (access 22 March 2024).

[18] Güney İç Anadolu Temiz Hava Merkezi Müdürlüğü (t.y.) https://webdosya.csb.gov.tr/db/giathm/menu/kayseri-brosur_20200313044225.pdf (access 22 March 2024).

[19] Güney İç Anadolu Temiz Hava Merkezi Müdürlüğü (t.y.) https://webdosya.csb.gov.tr/db/giathm/menu/konya-brosur_20200313044114.pdf (access 22 March 2024).

[20] Güney İç Anadolu Temiz Hava Merkezi Müdürlüğü (t.y.) https://webdosya.csb.gov.tr/db/giathm/menu/nevsehir-brosur_20200313044032.pdf (access 22 March 2024).

[21] Güney İç Anadolu Temiz Hava Merkezi Müdürlüğü (t.y.) https://webdosya.csb.gov.tr/db/giathm/menu/nigde-brosur_20200313043816.pdf (access 22 March 2024).

[22] https://metone.com/products/bam-1020/ (access 22 March 2024).

[23] https://www.envea.global/s/ambient/particulate-monitors/mp101m-pm10-pm2-5/ (access 22 March 2024).

[24] https://www.envea.global/s/ambient/gas-monitors-ambient/af22e/ (access 22 March 2024).

[25] Çevre Yönetimi Genel Müdürlüğü (t.y.) https://webdosya.csb.gov.tr/db/cygm/editordosya/GNG2013-37HavaKalitesiDegerl.pdf (Access 14 June 2024).