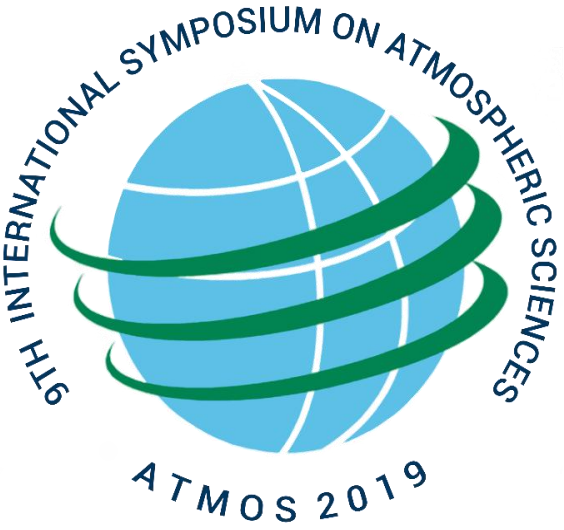

EDITORS

Dr. Kasım KOÇAK
Dr. Levent ŞAYLAN
Dr. Emine Ceren EYİGÜLER
Dr. Zerefşan KAYMAZ
M.Sc. Evren ÖZGÜR

e-ISBN: 978-975-561-482-3

e-Proceedings of the 9th International Symposium on Atmospheric Sciences

International Symposium on Atmospheric Sciences 23.10.2019 – 26.10.2019

All rights reserved. All authors are responsible for the integrity of their research.

ATMOS2019 supports and follows the ethical standards developed at the 2nd World Conference on Research Integrity, Singapore, July 22-24, 2010.

General Assessment of Sulfur Dioxide Gas (SO2) in Turkey and Data Quality Control

Rozerin Koyuncu[1], İlayda Kelkitli[1], Hüseyin Toros[1]

[1] Istanbul Technical University
Faculty of Aeronautics and Astronautics, Department of Meteorological Engineering
koyuncu15@itu.edu.tr; kelkitli15@itu.edu.tr, toros@itu.edu.tr

ABSTRACT

With the Industrial Revolution, the use of coal as the energy source of the rapidly increasing industry and then the fossil fuels used to meet the energy needs caused an increase in the concentration of harmful gases such as dust, smoke, NO, NO2, SO2, CO2 and O3. Air pollution, dust, smoke, gas and impurities in the form of steam, pollutants, negative impact on human health and material damage is defined as. Recent studies on air pollution reveal the seriousness of the situation. At the same time air pollution related studies were done in Turkey. The aim of this study was to evaluate air pollution by addressing SO2 gas in Turkey. In this study, Akdeniz, Doğu Anadolu, Ege, Güneydoğu Anadolu, İç Anadolu, Karadeniz and Marmara regions in Turkey observed and regional assessments are made.

Keywords: *Air pollution, SO2, Data, Quantity, Turkey, Region*

INTRODUCTION

With the Industrial Revolution, the rapidly increasing industry used coal as an energy source. Fossil fuels used to meet the energy demand increased the concentration of harmful gases such as dust, smoke, NO, NO2, SO2, CO2, and O3 in the atmosphere. Air pollution is defined as the pollutants that may be present in the form of dust, smoke, gas and impure water vapor in the atmosphere adversely affect human health and cause material damage. Negative effects of air pollution on living health and ecosystem are known. Recent studies on air pollution reveal the seriousness of the situation. This study aimed to sulfur dioxide (SO2) gas, Turkey general inspection.

According to study by Atmospheric Chemistry and Physics (ACP), although the SO2 content in East America was quite high, a significant reduction in SO2 content was detected from 2005 to 2015. The 1990 Clean Air Law Amendments (CAAA, 1990) and other regulations were effective in this reduction. Likewise, a significant reduction in SO2 emissions occurred in the West of Europe between 1990 and 2011. In contrast, SO2 emissions have increased in India due to the predominance of coal-fired thermal power plants in India. This is due to the very low rate of installation and use of emission control devices in India. In China, the highest concentrations of SO2 are observed in the North China Plain, which has the highest concentrations in the world. However, it has been observed that the values measured from 2007 to 2015 decreased by half. Turkey SO2 concentration was observed to increase with the industry (2016).

Air pollution is a major environmental problem in the developing countries of the world with rapid growth of population, industrial activities, and traffic density. Turkey, as a rapidly developing country, faces similar air pollution problem (Toros, 2015). The air pollution is seen in Turkey, more domestic heating fuel and motor vehicles. In addition, industrial emissions of pollutants have also been added to these resources arising from the industrial centers in Turkey. Air pollution in some cities has been closely linked to urbanization, which began in the 1950s and accelerated in the 1960s and developed in parallel with industrialization. However, it is necessary to determine the concentrations of pollutants within a certain period of time in order to determine the air pollution of cities (Garipağaoğlu, 2006). Exceeding the specified limit values of SO2 concentration is very dangerous for human and environmental health. SO2 concentrations are often seen in cities where coal is common for domestic heating high values in central and industrial areas (Akyürek, 2012).

National Air Quality Monitoring Network established by the Ministry of Environment and Urbanization. From this point of view, the National Air Quality Monitoring Network within the

Ministry of Environment and Urbanization is of primary importance for providing digital data as it is the most easily accessible resource. Within the scope of the data, the concentration of sulfur dioxide (SO2), particulate matter (PM), nitrogen oxides (NOx), ozone (O3), and carbon monoxide (CO) can be examined. In this study, Turkey general sulfur dioxide using the data received from the specified source (SO2) ratings were made. The period of this study was determined as 2010-2018.

STUDY AREA, DATA AND METHODOLOGY

Turkey; It is a country covered by seas on three sides on a large area on the territory of Anatolia and Thrace. Turkey; surrounded by the Black Sea to the north, the Mediterranean Sea to the south and the Aegean Sea to the west. Turkey, located between 36 ° -42 ° degrees north latitude and 26° - 45° eastern meridians. Turkey; mathematically located in the middle latitude temperate zone, the diversity of topographic conditions, the three sides covered by the sea, close to the centers of important air mass, the general atmosphere of the winter period in the summer season due to the circulation of a more diverse climate that changes in a wide variety of climate mosaic and environmental conditions (Öztürk, Çetinkaya & Aydın, 2017).

Turkey's coastal areas, the impact of sea features are seen more temperate climates. The North Anatolian Mountains and the Taurus mountain range prevent marine influences from entering the interior. For this reason, continental climate characteristics are seen in the inner parts of our country (Şensoy, Demircan, Ulupınar & Balta, n.d.).

According to the Köppen-Geiger climate classification in Turkey;

1) Arid climate (B) type is dominant in the inner parts. It is seen in 18% of Turkey. It is a climate type that covers a large area in the Central Anatolia Region.

2) The most common type of climate in Turkey (43%) humid temperate mid-latitudes in winter climates (C) includes all coastal areas and most of the Southeast Anatolia.

3) Turkey has the second most common type of climate winters are cold humid medium latitude climate type (D) or continental climate type (39%). This climate type is seen in the mountainous areas of Central Anatolia and Southeastern Anatolia and throughout Eastern Anatolia (Öztürk, Çetinkaya & Aydın, 2017).

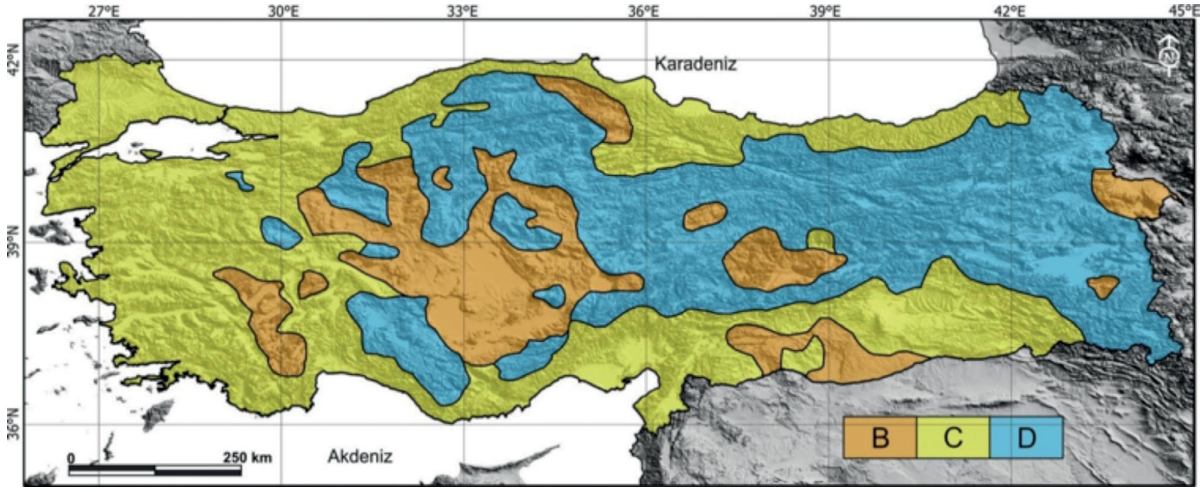

Figure 1. Main climates types (received from Öztürk, Çetinkaya & Aydın, 2017)

The main reasons for the presence of sulfur dioxide (SO2) in the atmosphere are the use of sulfur-containing fuel and volcanic eruptions in domestic heating, transportation, and industrial facilities. High concentrations of SO2 in the air can also lead to the formation of other sulfur oxides (SOx). In addition, the use of coal for heating purposes during the winter months causes various pollutants,

especially SO2, PM and carbon monoxide (CO) to spread to the environment (Kara, Tezel, 2017). Exceeding the specified limit values of SO2 concentration is very dangerous for human and environmental health.

It is also the responsibility of the authorities to provide the public with up-to-date information on air pollution through communication tools, as it is a matter that has a direct impact on public health, as well as responsibilities for the protection and improvement of air quality. However, it is quite difficult for the general public and local authorities to understand the measurements of different pollutants, even if it is possible for a scientist working on this subject. For this reason, when explaining the state of air pollution/air quality to the public, a classification system that is easily understood by the public is used. With this classification system, which is widely used all over the world, called Air Quality Index (AQI), it is possible to determine the air quality according to the concentration of pollutants in the air as good, medium, bad, dangerous and so on. The methods and criteria used to calculate the index in many countries of the world have been established in accordance with the air quality standards applied in their own countries (National Air Monitoring Network, n.d.).

Air Quality İndex (AQI) in Turkey, the EPA Air Quality Index was created by adapting their national legislation and limit values.

Table 1. EPA Air Quantity İndex (AQI) (received from EPA)

Air Quality Index (AQI) Values	Levels of Health Concern	Colors
When the AQI is in this range:	*..air quality conditions are:*	*...as symbolized by this color:*
0 to 50	Good	Green
51 to 100	Moderate	Yellow
101 to 150	Unhealthy for Sensitive Groups	Orange
151 to 200	Unhealthy	Red
201 to 300	Very Unhealthy	Purple
301 to 500	Hazardous	Maroon

SO2 measurements carried out in Turkey were provided daily from the Ministry of Environment and Urbanization UHKİA the website for the years 2010-2018. The UHKİA has a total of 162 stations measuring SO2. For the quality control and evaluation of the data, the commonly used Excel program was used in statistical analysis. Excel was chosen because it gives fast results. In this way, data analysis and presentation was performed. In order to make a general evaluation, it is necessary to remove the wrong measurements and missing data in the data. The data obtained from the UHKİA are raw data. Therefore, UHKİA data were used after quality control in this study. While analyzing the measurements, it was paid attention to have at least 22-day data monthly and 75% data annually. Months and years that do not comply with these conditions are excluded from the data and analyzed. In this study, monthly and annual analysis of sulfur dioxide (SO2) was had.

RESULTS AND DISCUSSION

Annual and monthly SO2 averages between 2010 and 2018 were calculated by analysing the data obtained from the National Air Quality Monitoring Network (UHKİA) stations. When analysing the data, attention was paid to 22 days per month and 75% per year. The months and years that did not

meet these conditions were excluded from the data and long-term averages were obtained. The presence of missing measurements also negatively affected the statistical analysis.

The data analysis is based on the 24-h averages of SO2 concentrations. In Turkey, PM10 concentrations show a seasonal dependence with high concentrations in winter and autumn and lower concentrations in summer and spring. Due to the emissions added by poor quality coal burning in winter season for domestic heating, and winter concentrations especially tend to be higher in some parts of Turkey. Besides, urbanization, industrialization, and the number of motor vehicles have increased rapidly in recent years, causing increased levels of air pollutants (Toros et al., n.d.).

The top ten provinces with the highest level of yearly SO2 levels are Şırnak (93,6416 µg/m3), Hakkari (84,5935 µg/m3), Edirne (76,3663 µg/m3), Tekirdağ (50,7378 µg/m3), Bitlis (41 µg/m3), 9103 µg/m3), Karabük (34,9559 µg/m3), Muğla (34,4086 µg/m3), Afyon (32,9219 µg/m3), Manisa (32,7295 µg/m3) and Canakkale 8830 µg/m3).

SO2 concentrations in Turkey, winter and high in the autumn, summer and shows a seasonal dependence with low concentrations in the spring. This is due to the coal used for heating during the winter and autumn months. Due to the emissions added by poor quality coal burning in winter season for domestic heating, and winter concentrations especially tend to be higher in some parts of Turkey (Toros et al., n.d.). Considering the seasons in which pollution is observed, it is thought that there is pollution caused by domestic heating.

Although high SO2 concentrations were observed between 2010 and 2014 in provinces such as Hakkari, Şırnak, and Tekirdağ a decrease was observed in the following years. Although high SO2 concentrations were observed between 2010 and 2014 in provinces such as Hakkari, Şırnak, and Tekirdağ, a decrease was observed in the following years. This may be due to the reduction of coal used for domestic heating. On the other hand, increases in SO2 concentration have been observed in Edirne and Tekirdağ provinces in recent years.

Table 2. Annual of SO2 values in Turkey with city names

	1. PERİYOT					2. PERİYOT				AVARAGE
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2010-2018
Adana	5,8532	6,0811	6,2607	5,4696	3,7459	5,8959	4,1032	4,4103	9,2142	5,6705
Adiyaman	8,0145	10,7171	8,1364	10,6046	7,7391	12,3364	10,5116	2,9841	9,0942	8,9042
Afyon	32,4280	31,9506	34,8841	64,8914	40,0701	30,4805	20,1205	23,2184	18,2534	32,9219
Agri	19,6944	15,3114	19,1010	9,7977	9,2470	6,7761	20,9850	25,6082	19,9817	16,2781
Aksaray	26,0956	16,7556	6,6477	11,8976	10,0565	9,9157	6,5799	7,4207	7,6506	11,4467
Amasya						32,5907	36,3145	9,6088	6,8047	21,3297
Ankara	14,3563	15,0677	16,1777	10,4950	11,3025	9,3384	9,7087	7,5383	7,6393	11,2915
Antalya	15,7948	7,0625	5,1771	3,1459	4,2466	6,4972	3,8246	3,5302	5,4260	6,0783
Ardahan	26,5014	18,8839	12,8345	20,4044	20,5291	14,3441	14,6366	14,4365	14,9413	17,5013
Artvin	5,0094	5,6989	2,6832	4,1873	6,0723	9,2477	6,7918	8,6253	10,5389	6,5394
Aydin	21,9818	41,2091	19,9260	6,4372	7,1697	20,6656	11,1539	9,5024	8,6853	16,3035
Balikesir	6,2082	7,7701	7,8215	6,8611	7,1501	6,7113	6,1746	9,1248	8,1712	7,3325
Bartin	7,2822	11,2922	4,0127	14,5370	14,0414	12,0084	9,6814	9,8539	12,0491	10,5287
Batman	12,0592	12,7719	16,1377	30,5425	12,3258	7,3182	4,5245	7,6035	6,0855	12,1521
Bayburt	15,5791	9,4303	4,4524	7,5710	5,1084	4,3636	6,7658	5,8061	5,7839	7,2067
Bilecik	11,1424	13,1461	7,3082	9,4901	9,2239	7,6837	8,5448	8,3599	5,7222	8,9579
Bingol	15,3304	12,0600	14,5457	5,4909	6,2736	7,0197	5,1396	7,5710	8,4986	9,1033
Bitlis	91,5472	64,8139	41,0667	38,3493	32,1457	9,5782	17,3645	39,3386	42,9889	41,9103

Bolu	62,3130	39,6358	33,0623	12,3631	29,1741	22,8371	12,6772	11,9509	10,3855	26,0443
Burdur	25,1222	19,6787	10,8357	11,8802	12,6707	15,0357	7,0082	8,5165	14,4807	13,9143
Bursa	5,7349	12,2434	7,8621	17,8726	16,1271	13,1416	11,2763	10,4900	6,5245	11,2525
Canakkale	20,9855	45,6375	31,5084	45,5406	55,1660	33,8809	22,8606	14,1495	8,2176	30,8830
Cankiri	9,4923	7,7023	4,9955	16,8425	17,0286	19,4686	6,0393	7,6908	12,3361	11,2884
Corum						26,1043	28,0197	39,6222	21,1630	28,7273
Denizli	15,9133	5,6769	6,1627	18,0946	20,9727	23,7431	16,7954	14,8050	16,6976	15,4290
Diyarbakir	17,6603	9,7161	7,3576	18,2724	9,8612	9,2448	6,6316	8,3457	6,5389	10,4032
Duzce	8,7326	5,5806	3,9556	8,4063	6,1225	7,1620	9,7147	7,4048	8,0258	7,2339
Edirne	45,0327	57,2530	48,9478	88,2543	113,9491	115,1967	101,7036	66,0480	50,9117	76,3663
Elazig	11,1098	6,1933	7,1717	14,6604	12,3450	12,8167	5,1059	5,6085	7,2870	9,1443
Erzincan	12,7155	9,8833	4,4208	9,2507	10,3220	12,8946	10,4072	9,8333	8,6872	9,8238
Erzurum	12,7380	13,7542	12,5282	9,3609	12,9659	12,9902	12,4388	12,3532	10,0317	12,1290
Eskisehir									10,9340	10,9340
Gaziantep	16,7326	17,6989	12,6331	12,1738	6,6309	10,9433	8,3287	9,6113	7,0335	11,3096
Giresun	5,8729	11,8023	5,3077	5,3206	7,7866	7,5276	5,1111	7,3397	7,6780	7,0829
Gumushane						11,4326	16,8437	12,7640	12,7111	13,4378
Hakkari	116,7663	169,3349	164,8272	83,5556	52,0670	55,9781	39,1324	38,1952	41,4847	84,5935
Hatay	6,2948	18,1948	10,0096	10,9835	20,2000	14,3605	12,7767	11,4753	14,5460	13,2046
İgdir	12,4327	24,1622	10,3268	11,3228	8,7463	7,7860	9,0878	10,4083	12,9375	11,9122
İsparta	19,1723	33,7054	27,0167	28,8077	21,6792	14,5697	12,7827	14,6787	12,5211	20,5482
İstanbul				6,5046	7,0941	5,9194	7,2090	8,0040	4,9310	6,6104
İzmir	12,2750	13,2952	8,1715	7,7465	7,3295	9,3925	9,8532	10,5709		9,8293
Kahramanmaras	7,3041	7,2409	10,5166	27,0907	24,4037	23,1580	13,7787	18,4658	21,5414	17,0555
Karabuk			52,7356	56,7452	32,0901	37,3101	21,3192	20,8481	23,6431	34,9559
Karaman	22,5673	23,5643	13,4758	24,5492	22,8988	19,2845	12,5962	12,9254	8,5665	17,8253
Kars	25,5363	28,2034	16,6942	20,8466	14,5417	20,6868	31,7341	22,1392	15,9320	21,8127
Kastamonu	12,5480	14,1511	14,0982	9,4911	8,9785	6,7606	10,2962	11,5132	9,8754	10,8569
Kayseri	12,5480	14,1511	14,0982	9,4911	8,9785	6,7606	10,2962	11,5132	9,8754	10,8569
Kilis	4,7619	8,2543	5,8328	3,8467	5,0280	8,3248	8,7151	12,2770	7,9190	7,2177
Kirikkale	37,5219	15,2047	8,8795	15,4613	11,4430	15,6190	16,5093	15,9430	17,9368	17,1687
Kirklareli	21,7177	34,9697	9,9434	13,7640	17,9919	12,1073	10,7267	10,2540	7,8618	15,4818
Kirsehir	7,1294	8,0260	7,1011	8,5266	12,2714	10,2074	10,8882	5,3721	9,4551	8,7753
Kocaeli	16,6814	10,7809	12,7659	12,1710	10,8167	10,7757	16,4036	14,3366	7,2726	12,4449
Konya	12,4039	20,2525	19,4157	10,0383	9,9459	7,9670	11,9142	17,1706	9,7364	13,2049
Malatya	11,5925	29,7427	3,2640	9,9860	9,3739	11,2910	7,3384	6,2645	8,6537	10,8341
Manisa	6,8054	16,2339	13,2291	22,4970	35,4844	56,6142	51,6564	41,6052	50,4401	32,7295
Mardin	27,8179	39,5357	24,9042	16,6149	16,4673	10,5343	13,9775	9,5910	12,1954	19,0709
Mersin	2,9055	3,1596	2,8202	3,9629	3,7251	5,6389	3,0500	4,6901	7,5965	4,1721
Mugla	34,5711	48,2676	45,5540	53,0219	44,5968	24,0410	17,0838	14,0970	28,4445	34,4086
Mus	19,9215	14,3569	21,5583	30,2234	20,8689	22,4756	21,7639	20,8625	11,2126	20,3604
Nevsehir	16,5524	16,6194	10,0646	10,6058	16,6472	13,1892	12,6710	11,7285	11,1785	13,2507
Nigde	25,4944	21,4205	8,0141	7,5737	6,1336	6,7198	8,8261	5,5866	5,9055	10,6305
Ordu	7,8227	12,0443	7,0813	12,9322	17,2788	18,2913	25,5773	17,7420	8,1579	14,1031
Osmaniye	4,5801	4,9362	10,5444	9,8333	11,6300	23,0508	12,1756	15,9969	18,8327	12,3978
Rize	15,5568	12,8850	3,4466	6,9680	5,8780	4,5251	2,8862	3,9745	4,4487	6,7299

Sakarya	8,2004	9,6663	7,0283	13,6153	11,9941	12,9513	14,3433	14,0428	9,3498	11,2435
Samsun	8,8976	11,2694	20,4003	14,5225	12,4079	15,1820	16,6385	14,6820	10,2730	13,8081
Sanliurfa	8,3209	7,0441	6,9011	11,0772	10,9747	8,4620	13,4153	17,3886	34,8239	13,1564
Siirt	29,4393	24,3296	21,0145	22,2203	20,4043	17,7784	17,5994	18,1264	14,9594	20,6524
Sinop	5,3426	12,3057	7,1604	7,5954	7,3702	12,9205	17,1772	19,9164	16,9790	11,8630
Sirnak	114,2792	123,8762	149,4984	151,7902	148,2473	118,8586	22,0750	3,1538	10,9959	93,6416
Sivas	27,3378	21,7242	8,9835	18,1362	22,2239	19,0854	19,2938	17,3975	13,2875	18,6078
Tekirdag	133,3740	97,8220	58,5762	40,9338	30,4899	27,5545	29,1762	21,4019	17,3121	50,7378
Tokat	13,8818	14,8029	6,1275	6,2940	7,9088	14,4000	19,8647	13,9878	8,2552	11,7247
Trabzon	11,1373	8,3667	10,7327	21,4257	25,9052	16,3055	11,4675	7,8039	6,6992	13,3160
Tunceli	5,2029	5,0379	7,0691	6,4164	8,1951	4,4448	5,0000	8,8405	9,5233	6,6367
Usak	12,0568	17,5417	10,2144	16,0434	16,6679	15,2566	6,8321	6,2041		12,6021
Van	46,7067	17,8796	24,5419	45,0924	17,7686	11,6118	14,4246	14,8643	15,2074	23,1219
Yalova	3,4459	14,2493	6,4518	5,7278	6,0941	6,7243	7,1062	6,4127	4,7608	6,7748
Yozgat	19,8043	28,7082	16,5553	24,5325	32,7361	45,2986	34,8596	18,8044	23,1009	27,1555
Zonguldak	30,6128	42,3759	31,5094	25,0677	13,2702	16,9609	16,0877	18,4988	12,9527	23,0373
Average	21,6805	22,7321	18,3077	20,0542	18,6160	17,9029	15,0921	13,8080	13,3174	

The top ten provinces with the lowest level of yearly SO2 levels are Mersin (4,17209 µg/m3), Adana (5,67045 µg/m3), Antalya (6,0783 µg/m3), Artvin (6,5394 µg/m3), Istanbul (6,6103 µg/m3), Tunceli (6,6366 µg/m3), Kilis (6,72986 µg/m3), Rize (6,77476 µg/m3), Yalova (7,0829 µg/m3), and Giresun (7,2067 µg/m3).

The provinces with the highest SO2 concentration in winter are Şırnak (326,0400 µg/m3), Muş (179,9849 µg/m3), Edirne (161,7808 µg/m3) and Tekirdağ (107,2421 µg/m3). The provinces with the lowest concentrations are Mersin (6,2132 µg/m3), Antalya (7,2355 µg/m3), Adana (7,6033 µg/m3), Rize (7,9484 µg/m3), and Yalova (8,5182 µg/m3).

The provinces with the highest SO2 concentration in spring are Şırnak (94,4127 µg/m3), Muş (72,8565 µg/m3) and Edirne (73,5529 µg/m3). The provinces with the lowest SO2 concentration in spring are Mersin (3,6709 µg/m3), Antalya (3,7223 µg/m3), Adana (4,8753 µg/m3), Artvin (5,1002 µg/m3), Rize (5,0633 µg/m3), and Tunceli (5,1172 µg/m3).

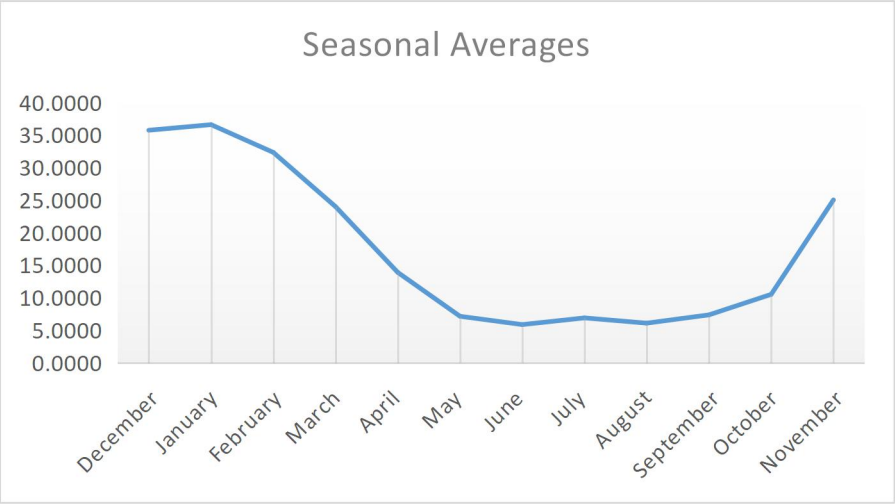

Figure 1. Seasonal Averages

The provinces with the highest SO2 concentration in the summer months are Manisa (30,4821 µg/m3), Kahramanmaraş (19,4171 µg/m3), and Şırnak (12,7215 µg/m3). The provinces with the lowest SO2 concentration in the summer months were Aksaray (2,7696 µg/m3), Kırıkkale (3,6653 µg/m3), Gümüşhane (2,7645 µg/m3) and Kırklareli (2,7136 µg/m3), Bartın (2,8505 µg/m3), Bayburt (2,5864 µg/m3) and Balıkesir (2,8865 µg/m3).

The provinces with the highest SO2 concentration in autumn are Edirne (61,6163 µg/m3), Muş (59,0537 µg/m3) and Şırnak (41,8272 g/m3). The cities with the lowest SO2 concentration in autumn were Kastamonu (5,2217 µg/m3), Adana (5,3791 µg/m3), Istanbul (5,5069 µg/m3), Kars (5,8222 µg/m3), and Yalova (5,5226 µg/m3).

Table 3:Seasonal of SO2 values in Turkey with city names

	WİNTER			SPRİNG			SUMMER			AUTUMN		
	December	January	February	March	April	May	June	July	August	September	October	November
Adana	7,9836	7,1822	7,6440	5,5296	4,8247	4,2718	4,3466	6,1060	4,1241	5,0846	4,8769	6,1759
Adiyaman	21,9429	10,1183	9,8700	7,4791	4,6652	3,7718	4,2322	5,4091	4,9909	4,9352	5,5063	19,5508
Afyon	65,6058	55,0650	55,2486	45,6677	31,7184	11,8648	11,9503	12,7765	11,1115	8,1528	27,9204	55,7376
Agri	30,8909	39,2299	33,3989	18,9037	12,1214	6,5300	6,1735	7,7621	8,3051	7,0175	10,0712	18,9132
Aksaray	22,5196	25,8211	23,4659	17,0255	2,6749	2,7696	2,7696	2,9567	2,9936	3,2399	5,8001	18,3273
Amasya	72,9919	68,9783	75,2479	47,8417	21,2126	7,5282	5,2000	6,5335	6,2593	9,8019	27,2590	63,4566
Ankara	15,5576	15,3933	15,7856	12,5579	9,3782	9,7791	7,6789	7,5733	8,1195	9,2629	9,9729	14,7210
Antalya	9,1763	6,9676	5,5628	4,2556	3,4962	3,4152	3,2896	4,0886	5,5000	14,5319	5,5379	7,0216
Ardahan	37,3910	47,1600	34,5480	22,6279	12,4979	6,9373	4,2941	4,0447	4,0515	4,2069	10,1760	21,9843
Artvin	16,1092	10,8396	10,0833	8,4245	4,1352	2,7410	3,0642	3,4491	3,9349	3,1157	4,7566	9,9294
Aydin	41,4574	34,1413	26,6056	20,1140	11,2654	5,3243	4,8533	5,4402	4,7054	6,0179	7,1157	28,9963
Balikesir	14,5521	12,8004	11,8719	10,1907	7,4452	4,3575	3,3617	2,6403	2,6574	4,4898	4,8164	9,6113
Bartin	21,6592	23,2877	19,3694	16,6627	9,5273	4,2296	3,1500	2,5175	2,8841	3,1073	6,1314	14,5463
Batman	25,5072	32,6694	23,6667	10,9177	7,1391	4,5481	4,3252	5,6986	6,8030	8,7185	6,1450	11,7629
Bayburt	11,1606	14,1115	13,1526	9,7426	6,7626	3,3730	2,4070	2,6023	2,7500	3,1468	5,5894	11,6466
Bilecik	16,1955	14,7490	14,0932	12,2718	8,5242	5,5330	4,4589	4,2231	3,6272	4,7331	6,4038	12,3105
Bingol	16,7521	14,9474	19,7644	17,1190	7,8745	3,7846	4,2681	3,9012	3,0113	3,6388	5,0036	12,1240

Bitlis	74,5304	81,5740	81,2377	60,8947	33,0939	33,0939	8,7207	10,3390	10,2487	8,0153	17,7950	57,7545
Bolu	55,5556	59,9091	41,3600	32,3251	22,2632	9,7151	6,5049	5,1864	4,9843	6,4132	15,7040	36,7582
Burdur	31,2867	23,5090	20,3673	19,7576	11,9888	5,9339	3,5763	5,6738	4,4982	3,8030	8,3777	27,8185
Bursa	17,2754	16,7998	15,2614	15,7845	12,6929	9,1805	8,0927	6,5616	6,0709	9,1469	9,2253	14,7058
Canakkale	55,8402	65,7385	57,4173	56,1773	29,4664	12,9999	8,9962	8,1523	7,0597	10,5310	15,2616	36,6945
Cankiri	22,0995	14,3085	17,8571	16,8433	11,8021	5,6546	4,5883	4,0483	4,9345	4,6135	9,7773	21,2744
Corum	38,8564	34,1436	38,2463	25,9829	20,5075	14,9085	10,0498	13,0236	9,7020	19,2509	18,8801	38,9371
Denizli	35,6201	28,7630	25,0648	16,6510	10,5538	7,4395	6,2380	8,5128	7,9311	9,3547	10,1023	18,4049
Diyarbakir	18,2868	21,0571	15,8189	9,7198	8,4500	5,3532	4,6231	5,4831	6,8644	7,1042	6,7860	12,3376
Duzce	7,6082	10,2351	11,8831	10,9963	7,8321	5,8043	4,2383	4,3676	4,9269	4,4564	6,0267	7,5543
Edirne	160,6722	160,5603	164,1098	144,6608	63,8383	12,1596	5,4452	6,2243	5,9176	6,8037	56,2859	121,7594
Elazig	15,3484	17,5097	15,3817	10,2979	6,8038	4,2552	3,7860	4,1116	5,0545	5,0829	5,1538	8,7327
Erzincan	21,1107	18,6630	14,1066	12,5581	7,8233	4,5290	3,1493	3,0147	2,7249	3,3511	7,1906	19,6679
Erzurum	9,3659	10,8730	15,5733	6,8161	5,3766	7,3614	6,6515	8,1667	8,3625	7,1111	8,1778	6,9872
Eskisehir	11,5450										8,7633	11,4083
Gaziantep	24,0414	20,8577	21,9960	13,7355	5,4008	4,8745	5,1822	5,1870	5,0037	5,4679	7,2045	17,1188
Giresun	10,1945	5,8729	11,8023	5,3077	5,3206	7,7866	9,4801	10,9774	10,0519	10,1945	10,2604	10,0519
Gumushane	17,1492	15,7283	12,0810	9,0438	6,2932	2,9361	2,8117	2,5857	2,8959	2,5714	6,5255	12,8359
Hakkari	24,6022	25,6880	24,6818	11,0288	7,3625	4,5755	4,9519	7,0513	5,4916	6,7833	6,9650	14,6180
Hatay	26,0932	20,6344	18,0689	11,5498	8,9795	6,8114	5,2454	7,0858	7,6964	8,0019	10,0886	25,1364
İgdir	33,9310	34,3951	37,4375	15,1519	11,8889	8,0824	6,9138	4,5873	4,1324	34,3951	13,2674	28,8851
İsparta	41,3203	33,6797	31,1749	22,9814	13,9956	8,5714	7,8010	9,7250	10,7054	10,2521	14,6782	35,9421
İstanbul	8,9454	10,2036	9,2850	8,7192	8,5160	6,0835	4,7476	3,8219	3,6850	4,6315	5,1807	6,7085
İzmir	13,4942	14,4665	12,2281	10,5345	8,8444	7,9253	8,4849	8,3012	8,1623	8,5724	7,8685	10,2708

Kahramanmaras	38,3732	30,2455	25,0354	16,9227	9,8426	8,4839	7,1097	8,4982	7,4438	8,5037	12,4945	31,1970
Karabuk	63,2489	52,2754	45,0726	28,2699	30,8248	22,4276	22,1902	17,4746	18,5865	19,8988	27,2345	43,2303
Karaman	39,7123	32,3688	30,2959	27,2303	11,1129	4,9578	3,9921	4,3811	4,4660	4,7037	11,7503	31,3402
Kars	7,9167	11,2000	8,2877	7,7848	10,6047	9,9851	9,2941	10,1667	9,0429	6,1412	5,6404	5,6849
Kastamonu	9,7675	14,6972	11,1379	11,1290	9,0485	5,1771	4,0928	3,3151	4,2407	3,4370	4,4890	7,7391
Kayseri	16,9300	15,0200	14,0464	9,5099	8,5304	5,6800	5,6188	6,7800	6,1200	8,3900	12,9935	
Kilis	11,6751	10,7862	13,7273	10,3160	4,8333	3,4819	5,3407	5,6667	5,5701	4,1767	4,8556	10,1039
Kirikkale	27,9245	40,9896	32,7326	23,6614	15,5192	6,2451	4,3267	3,8151	2,8540	4,6891	9,4736	28,2658
Kirklareli	27,2533	34,6413	31,5154	29,5141	14,4284	4,1355	2,7863	2,7059	2,6486	3,6983	9,2207	23,8705
Kirsehir	16,5044	15,1010	17,7341	13,1422	7,0828	3,5856	3,0107	3,0971	2,9567	3,8901	5,2523	13,0679
Kocaeli	2,0000	19,7883	15,5052	15,6713	15,5260	10,4137	11,9602	5,6804	5,3749	9,7507	9,5304	13,0134
Konya	28,3188	21,5113	23,3292	16,0354	11,3272	6,6920	6,0338	5,6462	5,9084	6,7836	8,3826	
Malatya	23,1085	24,4106	22,7843	10,9471	7,0331	5,3580	5,8505	7,5757	6,2438	7,1145	7,1759	14,8081
Manisa	83,4084	73,0173	53,0922	39,6962	19,8857	9,5159	9,0488	73,0173	9,3801	11,1832	17,9692	59,7173
Mardin	36,6781	34,8536	34,1727	25,1301	9,0133	5,6300	6,7689	9,4830	10,3929	10,3422	12,9855	24,3810
Mersin	6,1477	6,8252	5,6667	3,7757	3,5560	3,6809	2,6748	2,9905	3,8010	3,9064	2,8951	4,0153
Mugla	80,7825	70,2077	64,2798	50,7631	29,0025	12,6445	10,0403	11,1925	11,0268	12,9062	14,3792	40,9954
Mus	173,3289	184,2314	182,3942	130,8010	67,8703	19,8983	9,6066	10,8689	16,6575	18,9073	28,6183	129,6356
Nevsehir	30,5302	27,5938	24,4388	15,0034	8,1612	3,5929	2,5261	3,1041	2,8839	3,5783	8,7485	24,2661
Nigde	18,4730	21,1003	15,5656	12,7833	10,6041	5,5513	3,7545	5,1943	4,9912	5,8073	9,4083	14,2883
Ordu	43,2969	47,5441	39,5638	25,8978	13,6114	5,4108	3,4960	4,3835	5,1863	7,0555	10,3027	20,8419
Osmaniye	28,7842	22,9424	20,6279	9,2108	7,9571	3,6774	3,6477	4,9000	4,4607	6,2452	6,4661	14,6792
Rize	6,3602	8,2582	9,2268	6,4660	5,2066	3,5172	3,1728	3,8873	3,4016	3,6176	4,1708	5,5648
Sakarya	22,7531	23,7131	20,6652	17,2365	10,4431	4,7377	2,9793	3,0045	3,6272	4,7304	6,9690	15,0511

Samsun	20,2633	21,6931	23,2224	18,1839	13,0398	8,5921	8,6897	8,6961	6,1938	8,5968	11,0951	18,8441
Sanliurfa	38,7100	21,6603	20,3194	8,4231	4,8162	5,1139	6,2066	5,7384	7,0615	8,8950	9,6125	23,7716
Siirt	58,7444	40,4472	32,9600	30,8333	11,5732	5,4364	4,9882	4,5756	7,4152	6,5702	5,6444	33,1345
Sinop	26,8850	26,4466	27,8245	23,0596	15,4632	8,8548	7,0320	7,5457	7,4143	8,5922	9,9829	29,1356
Sirnak	312,8721	399,9814	265,2667	193,6384	76,7308	12,8690	10,9938	12,2432	14,9274	13,3430	19,4444	92,6940
Sivas	26,5265	29,2779	29,8674	22,5511	13,6222	6,0223	5,9162	3,4545	3,5279	4,0214	11,7677	25,1449
Tekirdag	98,6726	128,0928	94,9610	71,7756	39,6019	10,3009	5,9082	4,6679	3,5864	5,6710	20,1946	58,0245
Tokat	29,1331	32,5498	30,6656	16,2361	9,1682	5,2054	5,0827	5,6639	5,8922	7,4867	8,4426	25,1976
Trabzon	19,1811	19,0617	17,4668	10,8433	7,1172	4,6339	6,8380	5,2240	4,1864	3,6406	4,7088	10,6268
Tunceli	12,1111	11,2302	9,7004	6,9167	4,4457	3,9892	4,3593	4,7398	4,5719	4,9729	4,6434	7,8636
Usak	21,8891	20,0766	20,3742	16,9759	12,8527	6,8242	7,4282	5,8264	5,9238	7,9185	9,7011	19,6555
Van	23,1215	22,6587	17,0352	16,2882	8,7548	6,6122	5,1542	5,4956	5,9342	6,8512	7,0433	17,1037
Yalova	7,4641	9,1673	8,9232	8,4976	7,3888	4,9448	4,4128	3,7949	3,8378	4,5497	5,3315	6,6864
Yozgat	74,2243	56,6399	52,4184	34,4876	16,8643	6,0102	2,8949	2,8068	3,6627	4,5841	15,3572	52,0823
Zonguldak	26,3887	32,9164	33,4140	28,0852	23,0466	10,3300	10,9159	10,3000	9,2245	9,8670	10,9126	19,9851
Average	35,7711	36,6311	32,3688	24,0322	13,9224	7,1774	5,9018	6,9305	6,1210	7,3940	10,5490	25,0626

CONCLUSION

When winter SO2 concentrations were calculated, it was observed that many stations reached high concentrations during the observation period. In this case, although the decrease over time shows that continuing of SO2 pollution in Turkey.

The level of air quality is a key parameter in ensuring sustainable conditions for the future of cities. European and Asian centers of economic growth, industrialization, urbanization, social dynamics, historical, touristic and cultural areas such as Turkey, has a growing population in a sustainable way. Knowing the air quality is important for well-planned, densely populated areas. Air quality is also important for better health conditions.

Measures, campaigns and coal removal of home heating systems in all cities have helped to reduce air pollution. As a solution, it is recommended to use natural gas for domestic heating instead of low-quality coal and to apply SO2 treatment in coal-fired thermal power plants. Knowing that cities' air quality is sufficient to examine variations, as well as physical and chemical type air pollution needs further work. The result is that all this will help improve the emergency situation of air pollution.

REFERENCES

Toros H., Öztürk A., Çapraz Ö., Deniz A., Erdun H., & Dursun Ş. n.d. " *Spatial Variation of Particle matter in Turkey".*

Kara M.B., & Tezel B. K. 2017. "*Türkiye'de SO2 Ölçümlerinin Değerlendirilmesi ve SO2 Kirliliğinin Zamansal ve Mekansal İncelenmesi".* retrieved from *http://hkk2017.akdeniz.edu.tr/wp-content/uploads/2017/10/041.pdf*

Öztürk M.Z., Çetinkaya G., & Aydın S. 2017. *"Köppen-Geiger İklim Sınıflandırmasına Göre Türkiye'nin İklim Tipleri".* Coğrafya Dergisi. **DOI:** 10.26650/JGEOG295515 . Retrieved from https://dergipark.org.tr/download/article-file/370152

T.C. Orman ve Su İşleri Bakanlığı Meteoroloji Genel Müdürlüğü. 2016. "*Köppen İklim Sınıflandırmasına Göre Türkiye İklimi".* Retrieved from https://www.mgm.gov.tr/FILES/iklim/iklim_siniflandirmalari/koppen.pdf

Garipoğlu N. Marmara University. 2006. *"Türkiye'de Hava Kirliliği Sorununun Coğrafi Bölgelere Göre Dağılımı".* Retrieved from https://www.researchgate.net/publication/319904936_TURKIYE'DE_HAVA_KIRLILIGI_SORUNUNUN_COGRAFI_BOLGELERE_GORE_DAGILIMI

Krotkov, N. A., McLinden, C. A., Li, C., Lamsal, L. N., Celarier, E. A., Marchenko, S. V., Swartz, W. H., Bucsela, E. J., Joiner, J., Duncan, B. N., Boersma, K. F., Veefkind, J. P., Levelt, P. F., Fioletov, V. E., Dickerson, R. R., He, H., Lu, Z., and Streets, D. G.: "*Aura OMI observations of regional SO_2 and NO_2 pollution changes from 2005 to 2015".* Atmos. Chem. Phys., 16, 4605-4629, https://doi.org/10.5194/acp-16-4605-2016, 2016.