Air Pollution Data Analysis Over Van City, Turkey

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Abstract

Air pollution exhibits a very complex and non-linear behavior as a result of positive and negative changes in time and space, depending on the meteorology and topographic structure, in the transportation of the emissions released into the receiving environment as a result of the activity of air pollution sources. The aim of the study is to monitor the behavior of air pollutants over Van in 2019 through statistical analysis of data, to contribute to increasing air quality. PM₁₀ and SO₂ parameters have been observed to have the highest average hourly value of 72.5-25.1 µg/m³, and the lowest value (24.8 µg/m³ at 22:00 hours, 11.4 µg/m³ at 16:00 hours) respectively. It can be seen 64% of the measured PM₁₀ data were observed in the range of 0.1-40.7 µg/m³. 80% of the same data is less than 56.4 µg/m³ and 91% of the data has the highest density observed in the range 1.1-82.1 µg/m³. while 77% of the measured SO₂ data was observed in the range of 1.5-22.7 µg/m³. 80% of the same data is less than 25.1 µg/m³ and 90% of the data has the highest density in the range of -4.7-37.8 µg/m³. The results also showed wind plays an effective role in the horizontal transport of pollutants in the atmosphere. If the wind is calm, the polluted air stays where it is, and the precipitation help collapse pollutants in the atmosphere, because of this feature, precipitation is described as the cleaner of the atmosphere.

Keywords: Urbanization, PM₁₀, SO₂, air pollution, health.

Van Hava Kirliliği Analizi

Özet

Hava kirliliği, emisyonların taşınımı, meteoroloji ve bölgenin topografik yapısına bağlı olarak zaman ve mekandaki olumlu ve olumsuz değişimler sonucunda çok karmaşık ve doğrusal olmayan bir davranış sergilemektedir. Çalışmanın amacı, hava kalitesinin artırılmasına katkıda bulunmak için verilerin istatistiksel analizi yoluyla 2019 yılında Van üzerindeki hava kirlleticilerinin davranışını izlemektir. PM₁₀ ve SO₂ parametrelerinin sırasıyla en yüksek ortalama saatlik değer olan 72.5-25.1 µg/m³ ve en düşük değer ise (22:00'da 24.8 µg/m³, 16:00'da 11.4 µg/m³) olarak gözlemlenmiştir. Ölçülen PM₁₀ verilerinin % 64'ünün 0.1-40.7 µg/m³ aralığında gözlemlendiği görülmektedir. Aynı verilerin % 80'i 56.4 µg/m³'den azdır ve verilerin % 91'i 1.1-82.1 µg/m³ aralığında gözlemlenen en yüksek yoğunluğa sahiptir. Ölçülen SO₂ verilerinin % 77'si ise 1.5-22.7 µg/m³ aralığında gözlemlenmiştir. Aynı verilerin % 80'i 25.1 µg/m³'den azdır ve verilerin % 90'ı -4.7-37.8 µg/m³ aralığında en yüksek yoğunluğa sahiptir. Sonuçlar ayrıca rüzgârın atmosferdeki kirleticiler maddelerin yatay taşınmasında etkili bir rol oynadığını göstermiş olup rüzgâr sakınse kirli hava olduğu yerde kalır ve yağışlar atmosferdeki kirleticileri çöktürmeye yardımcı olur. Bu özelliği nedeniyle yağış atmosferin temizleyicisi olarak tanımlanır.

Anahtar Kelimeler: Şehirleşme, PM₁₀, SO₂, hava kirliliği, sağlık, büyükşehir.

1. Introduction

Air pollution happens when gases, solid and liquid particles substances in the air we breathe are in a density and time that will harm living health and the earth's environmental. Air pollution is one of the biggest and most important problems of humanity. Air pollution exhibits a very complex and non-linear behavior as a result of positive and negative changes in time and space, depending on the meteorology and topographic structure, in the transportation of the emissions released into the receiving environment as a result of the activity of air pollution sources. Air pollution is caused by natural causes such as forest fires and volcano eruptions, as well as growing human activities today. Today, air pollution is

mostly caused by motor vehicles, industrial facilities and heating. Air quality is very important in terms of the security and sustainability of human health. Increasing worldwide industrial activities and inefficient use and waste can lead to pollution threatening human health in many parts of the world (Toros, 2000; Toros & Anbarcı, 2018; Ouyang et al., 2019; Venter et al., 2020; Dursun et al., 2021, Öztürk et al., 2021). Unal et al. (2021; Fu et al. 2020). Following the COVID-19 outbreak that started in 2019, changes in human activities and behavior necessarily led to significant reductions in air pollution within the framework of efforts to limit their exposure to the infectious virus (Dursun et al., 2021; Öztürk et al. 2021; Tunç and Taurus 2020; Kılıç et al. 2020; Bilgin

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

There is no more study about air pollution of the Van city so there are more study about it to understand level, behavior and changes of air pollution city of Van. Öztürk and Bayram (2019) studied temporal and seasonal distribution of air pollutant parameters, concentrations, and the relationship of pollutant parameters with temperature in the city center of Van were discussed according to the allowed limit values and solutions for the city were given. They concluded that the topographic and geographical location of the city, the winter season is harsh, and the average temperature of the city is lower than the country average. Tekin (2021) evaluated the air pollutants (PM₁₀ and SO₂) in the first year of the COVID-19 in the province of Van compared to the previous year.

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

is extremely important for human health, to create socio-economically sustainable and safe of tomorrows.

2. Study Area, Data and Methodology

Hourly PM₁₀ and SO₂ parameters data for 2019 were obtained from the Ministry of Environment and Urbanization air quality monitoring stations (Figure 1). Air pollution and meteorological data are obtained from the Ministry of Environment and Urbanism of Turkey and the Turkish State Meteorological Service.

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

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

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

3. Results and Discussion

It is very important in analysis to see how pollutants have changed over time. The situations where the pollution intensity increases, decreases or reaches the highest level can be observed with the help of graphs. In addition, the

simultaneous increase and decrease of two different pollutant parameters is also very important in terms of determining the pollutant source.

The change parameters PM₁₀ and SO₂ at weekdays the highest hourly average value of (78.7 µg/m³ - 27.5 µg/m³) at 21:00 hours respectively, and the lowest value of (24.5 µg/m³ - 10.9 µg/m³) at 06:00 hours respectively, as seen in Figure 2 while see in Figure 3 at the weekend the highest average hourly value of PM₁₀ and SO₂ parameter (72.5 µg/m³, 25.1 µg/m³), and observed the lowest value of (24.8 µg/m³, 11.4 µg/m³) at (22:00,16:00 hours) respectively.

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

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

The high daily average change of pollutants PM₁₀ and SO₂ of (146.1 µg/m - 82 µg/m³) was observed (on Tuesday, July 09

- on Thursday, February 07) respectively, but the lowest daily average of (9.4 µg/m³ -1.8 µg/m³) value was observed (on Thursday, April 18- on Tuesday, July 02) respectively as seen in Figure 4.

Figure 4. Daily average change graph of pollutants.

Figure 5 show 64% of the measured PM₁₀ data were observed in the range of 0.1-40.7 µg/m³. 80% of the same data is less than 56.4 µg/m³ and 91% of the data has the highest density observed in the range 1.1-82.1 µg/m³, and also 77% of

the measured SO₂ data was observed in the range of 1.5-22.7 µg/m³. 80% of the same data is less than 25.1 µg/m³ and 90% of the data has the highest density in the range of -4.7-37.8 µg/m³.

Figure 5. Histogram and density graphs of pollutants.

The average values of PM₁₀, SO₂ parameters were measured as 41.6, 16.5 µg/m³, respectively. The extreme values corresponding to 75 percent were measured as 50.3 and 21 µg/m³, respectively show in Table 1.

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

Type	NM	Daily%	Min.	%25	Avg.	Median	%75	Max.	SD.
PM ₁₀	8697	96	0.1	20.7	41.6	32.9	50.3	1000	40.5
SO ₂	8697	100	1.5	4.6	16.5	7.7	21	232.1	21.2

Table 2, shows the ranges for the air quality index applied in our country. When the PM₁₀ measurement values were examined as a percentage, it was observed that 73% was in the GOOD class, 25% in the MIDDLE class, and 2% in the SENSITIVE class. also, SO₂ measurement values are

examined as a percentage, it is observed that 99% is in the GOOD class and 1% is in the MIDDLE class.

Table2. National Air Quality Index

Index	Air Quality Index	SO ₂ [µg/m ³]	PM ₁₀ [µg/m ³]
		1 Hour Cover.	24 Hours Cover.
Good	0 – 50	0-100	0-50
Middle	51 – 100	101-250	51-100
Sensitive	101 – 150	251-500	101-260
Unhealthy	151 – 200	501-850	261-400
Bad	201 – 300	851-1100	401-520
Dangerous	301 – 500	>1101	>521

Wind plays an effective role in the horizontal transport of pollutants in the atmosphere. In the presence of wind, the pollution is moved from one place to another. If the wind is calm or slightly intense, the polluted air stays where it is. Therefore, air pollution is most intense in areas that are closed to the wind. In this case, dilution of the pollutants in the air

occurs in direct proportion to the increase in wind speed. Figure 6 as show, the pollution rose graph is examined, depending on the wind direction for PM₁₀ and SO₂ pollutant parameters, the direction with the highest pollution frequency was observed as East.

Figure 6. Pollution rose graph

4. Conclusion

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

- The parameters PM₁₀ and SO₂ are highest on a weekday and decrease on weekend.
- The high daily average parameters PM₁₀ and SO₂ of (146.1 µg/m³ - 82 µg/m³) was (on Tuesday, July 09 - on Thursday, February 07) respectively.

- PM₁₀ and SO₂ pollutant parameters, the direction with the highest pollution frequency was observed as East.

Acknowledgment

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

References

- Nadali, A., Arfaeina, H., Asadgol, Z. & Fahiminia, M. (2020). Indoor and outdoor concentration of PM₁₀, PM_{2.5} and PM₁ in residential building and evaluation of negative air ions (NAIs) in indoor PM removal, *Environmental Pollutants and Bioavailability*, 32:1, 47-55, DOI: 10.1080/26395940.2020.1728198.
- Bilgin, M. & Toros, H. (2020). Relationship Between Air Pollution and COVID-19 measures in İzmir, Turkey. *Journal of Research in Atmospheric Science*, 2, 2, 41-45.
- Bacak, T. N., Dursun, Ş. & Toros H. (2020). The Effect of COVID-19 outbreak on Air Quality of Istanbul city centre. *Journal of Research in Atmospheric Science*, 2, 1, 7-11.
- Dilan, Ç. T. & Toros, H. (2020). The Impact of COVID-19 on Air Quality in the city of Adana, Turkey, *Journal of Research in Atmospheric Science*, 2, 46-50.
- Dursun, S., Sagdic, M. & Toros, H. (2021). The impact of COVID-19 measures on air quality in Turkey, *Environmental Forensics*, DOI: 10.1080/15275922.2021.1892876
- Dündar, E., Dursun, Ş. & Toros, H. (2020). Air Pollution in Ankara During COVID-19. *Journal of Research in Atmospheric Science*, 2, 1, 24-30.
- Fu, F., Purvis-Roberts, K. L., & Williams, B. (2020). Impact of the COVID-19 Pandemic Lockdown on Air Pollution in 20 Major Cities around the World. *Atmosphere*, 11(11), 1189. MDPI AG. Retrieved from <http://dx.doi.org/10.3390/atmos11111189>
- Güçük, C., Şahin, E., Bektaş, M., Aras, E., Çinicioğlu, R., Domaç, Z., Nazaroğlu, M. (2019). Evaluation of PM₁₀ Behaviour in Iğdır. *Journal of Research in Atmospheric Science*, vol.1, no.1, 1-9.
- Kara, Y., Dursun, Ş. & Toros, H. (2020). Assessment of Air Pollution in Trabzon During COVID-19 Measures. *Journal of Research in Atmospheric Science*, 2, 1, 1-6.
- Kılıç, Y.S., Dursun, Ş. & Toros, H. (2020). Effect of COVID-19 Outbreak on Particulate Matter Pollution in Istanbul City Centre, *Journal of Research in Atmospheric Science*, 2, 2, 31-35.
- Ouyang X., Shao Q., Zhu X., He Q., Xiang C., Wei G., (2019) Environmental regulation, economic growth and air pollution: Panel threshold analysis for OECD countries, *Science of The Total Environment*, 657, 234-241. <https://doi.org/10.1016/j.scitotenv.2018.12.056>.
- Öztürk, A., Toros, H., Deniz, A., İncecik, S., Sezen, İ., Kahraman, A., Çelebi, H.M. (2011). PM₁₀ air quality variations in urbanized areas and industrialized creek valley in Istanbul. *European Geosciences Union (EGU) (pp.12)*. Viyana, Austria
- Öztürk, B., Çöl, İ., Öztürk, R., Dinç, U., Kara, Y., Ünal, Z.F., Toros, H., Ulubey, A. (2021). Evaluation of Istanbul Air Pollution in Combating COVID-19. *Alternative Energy and Ecology (ISJAEE)*. (01-03):91-101. <https://doi.org/10.15518/isjaee.2021.01.006>
- Öztürk, D., Bayram, T. (2019). Van İli Kent Merkezinde Hava Kirliliği. *Bitlis Eren Üniversitesi Fen Bilimleri Dergisi*, 8 (3), 1142-1153. DOI: 10.17798/bitlisfen.529099
- Tekin Ö.F. (2021) Evaluation of air pollutants (PM₁₀ and SO₂) in the first year of the COVID-19: A city sample from Turkey, *World Journal of Advanced Research and Reviews*, 10(01), 041-047. DOI: 10.30574/wjarr.2021.10.1.0130.
- Toros, H. & Anbarcı K. (2018). Hava Kirliliğine Dirençli Kentler, Şehir & Toplum, 10, 17-30.
- Toros, H. (2000). İstanbul'da Asit Yağışları, Kaynakları ve Etkileri, Doktora Tezi, 110s., İTÜ.
- Toros, H., Hakan, E., Özkan, Ç., Özer, B., Esra, D., & Öztürk, A. İ., (2013). Air Pollution and Quality Level in Metropolitan Turkey for Sustainable life. *Avrupa Bilim ve Teknoloji Dergisi*, 1, 1, 12-18.
- Ünal, Z.F., Kara, Y., Dinç, U., Öztürk, R., Çöl, İ., Öztürk, B., Toros, H. & Aydın U. (2021). Lockdown effects on air pollution with meteorological conditions in Istanbul. *Alternative Energy and Ecology (ISJAEE)*. (01-03):77-90. <https://doi.org/10.15518/isjaee.2021.01.005>
- Ünal, Y., Toros, H., Deniz, A. & İncecik, S. (2011). Influence of meteorological factors and emission sources on spatial and temporal variations of PM₁₀ concentrations in Istanbul metropolitan area. *Atmospheric Environment*, vol.45, no.31, 5504-5513.
- Venter, Z.S., Aunan, K., Chowdhury, S., Lelieveld, J. (2020). COVID-19 lockdowns cause global air pollution declines. *Proc Natl Acad Sci U S A*. 117(32):18984-18990. doi: 10.1073/pnas.2006853117.
- Yığiter, K. and Toros, H. (2020). Relationship between air pollution and COVID-19 in Bursa, Turkey. *Journal of Research in Atmospheric Science*, 2, 2, 36-40.