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Effect of Covid-19 Outbreak on Particulate Matter Pollution in Istanbul City Centre

Yağmur Sıla KILIÇ[1], Şükrü DURSUN[2], Hüseyin TOROS[1]

[1] Istanbul Technical University, Faculty of Aeronautics and Astronautics, Meteorology Engineering Department, Istanbul, Turkey
[2] Konya Technical University Faculty of Engineering and Natural Sciences. Selcuklu, Konya, Turkey.

Abstract
Istanbul is a big, crowded, megacity. Air quality decreases as cities get crowded so air pollution is more important issue in a crowded city like Istanbul. Due to Covid-19 all human's habits have changed. For instance, people mostly stayed at home and used less vehicle during the period when many precautions are taken against the disease. Istanbul's air quality is affected more by this habit changes of people because over 15 million people live in Istanbul. This change has led to the reduction of human-made air pollutants. In this study, 2 and a half years of $PM_{2.5}$ and PM_{10} data was examined to understand the change in air pollution. Particulate matter amounts were examined in 3 periods as before, during and after lockdown. Istanbul's air quality has improved thanks to the precautions taken by people against coronavirus.

Keywords: Particulate matter, Coronavirus, air pollution, lockdown, Istanbul

1. *Introduction*

Air pollution is a significant issue in human beings' life since the Industrial Revolution. Air pollution has been recognized for decades. All creatures suffer from pollutants that occurs by people. Air pollution occurs from mostly human activities but there are some natural activities such as volcanic eruptions are unrelated with people. High amount of air pollution has terrible impacts on human health and earth ecosystem. For last 3 decades air pollution's adverse impacts on human health has become a remarkable subject (Schwartz, 2004). Air pollution affects every people and may cause health problems even leads to death. People are more aware of the bad effects of the air pollution that increase every day on human health such as air pollution increases the rate of respiratory and cardiovascular diseases (Mannucci et al., 2015).

Air pollution does not only affect people's health but also affects plants and ecosystems. Particulate matters do not distribute homogeneously, covering plants with this heterogeneous dust may cause erosion and radiation heating, this event may damage plants (Grantz et al., 2003). Especially, particulate matter can damage crops.

Air pollutants can be examined in two types as particulate and gases (Vallero,2014). "The composition of PM varies, as they can absorb and transfer a multitude of pollutants" (Kampa & Castanas, 2008). PM means particulate matter and PM is very small dust or other things and may include tiny liquid particle. PM_{10} is a type of an air pollutant. PM_{10} means that a particle's size is smaller than 10 µg. $PM_{2.5}$ is another type of an air pollutant. $PM_{2.5}$ means that a particle's size is smaller than 2.5 µg. Meteorological parameters and physical features of an area can affect presence of particulate matter, the amount of particulate matter is affected by natural sources and human activities (Unal et al., 2011). Industrial activities, construction activities, transportation, fossil fuel consumption creates particulate matters. Especially in big cities these type of activities as construction and transportation are more than small cities or towns.

A disease because of coronavirus first appeared in Wuhan city in China, then World Health Organization named this disease as Covid-19, the disease spread in a very short time to all China and to whole world (Hou et al., 2020). This disease spreads all the world in a short time then it became a pandemic disease. There are lockdowns because of the Coronavirus disease and this disease has many impacts on people's life and natural life on earth. Covid-19 pandemic has been affected people in many different ways. By examining the change in the air pollution levels during the coronavirus prevention can help to improve air quality (Berman & Ebisu, 2020).

Due to Covid-19 People's behavior had to change. This big change in human behavior has affected air pollution because human behavior is a big part of air pollution. Main purpose of this study is to understand whether the precautions applied to protect people from coronavirus pandemic have an impact on air pollution.

2. *Material and Method*

1.1 Research area

Istanbul is in the Marmara Region and located in Turkey's north-west. Istanbul has a history approximately 300 thousand years. Istanbul is the most crowded city in Turkey and its population increasing every year, today over 15 million people live in Istanbul. As we can see in Figure 1, Istanbul is like a bridge that combines Asia and Europe continents. The latitude of Istanbul is 28 E 58 and the longitude is 41 N 01 and the surface area is 5.343km².

Istanbul locates in between Sea of Marmara and Black Sea. Istanbul's climate type is Csa as known as Hot-summer Mediterranean climate (URL-1). Istanbul's climate affected from both Mediterranean and Black Sea climate. In this province average annual temperature is 14.5°C, average number of rainy days is 106.9, the average amount of precipitation is 677.2mm and the sum of annual sunshine duration is 75.3 hours (URL-2). Istanbul's flora is like Mediterranean Region's flora, evergreen shrubs and small trees. Istanbul is Turkey's economic and tourism center, there are lots of industrial facilities. Until 2020, each year over 10 million tourist visited Istanbul. There are over 4 million traffic vehicles in Istanbul (URL-3).

Figure 1. Map of Istanbul (URL-4)

Fig. 2. shows the average temperature values of Istanbul. According to Fig. 2 Istanbul's air temperatures change periodically. Mean temperature values generally range between 0°C and 30°C.

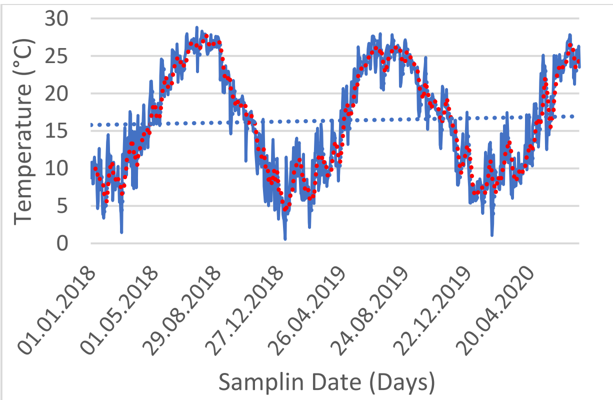

Figure 2. Temperature values of Istanbul

In a study about particulate matter episode in winter in Istanbul made by Im et al., (2010) shows there are more emission measured in European side of Istanbul because there are more vehicle traffic and industrial area are than Anatolian side.

1.2 Data

Daily meteorological parameter as temperature and concentrations of two pollutants as PM_{10} and $PM_{2.5}$ were included in this study.

Daily data of PM_{10} in 2018, 2019 and 6 months of 2020 and daily data of $PM_{2.5}$ in 2019 and 6 months if 2020 were analyzed. Hourly data of PM_{10} and $PM_{2.5}$ in between March 15^{th} and April 15^{th} belong to 2018, 2019 and 2020 were analyzed. Air pollution data taken from the website of Ministry of Environment and Urbanism of Turkey. Temperature data were also analyzed to understand whether the change in air pollution was related with precautions. Temperature data taken from Turkish State Meteorological Service.

1.3 Method

To determine the changes in air pollution levels, data analyzed with Excel calculations, graphed and tabulated with Excel. Data were analyzed daily and hourly. The relationship between temperature change and air pollution was examined.

3. Results and Discussion

Out of transport and industrial activities, those months are winter so people use fuels for heating. In the middle of March 2020 Turkey announced lockdown. During the lockdown period due to coronavirus people used transportation vehicles less because students started studying online and some people started working from home. But at the beginning of the coronavirus period PM_{10} did not decrease suddenly because people continued to use fuel for heating. As can be seen in the Daily PM_{10} values graph, there is a downtrend in PM_{10} levels over the years.

Figure 3 shows that the PM_{10} concentrations averaged daily values of Istanbul province for time range from 01.01.2018 to 30.06.2020. Averaged daily PM_{10} values of Istanbul from first day of the 2018 to middle of June 2020 are generally between 15 $\mu g/m^3$ and 130 $\mu g/m^3$. Blue line means the daily PM_{10} values of Istanbul and the red line means five-day average of the daily PM_{10} values of Istanbul. In Figure 3, as we can see the amount of PM_{10} is high in the last few months of 2019 and in the first 2 months of 2020.

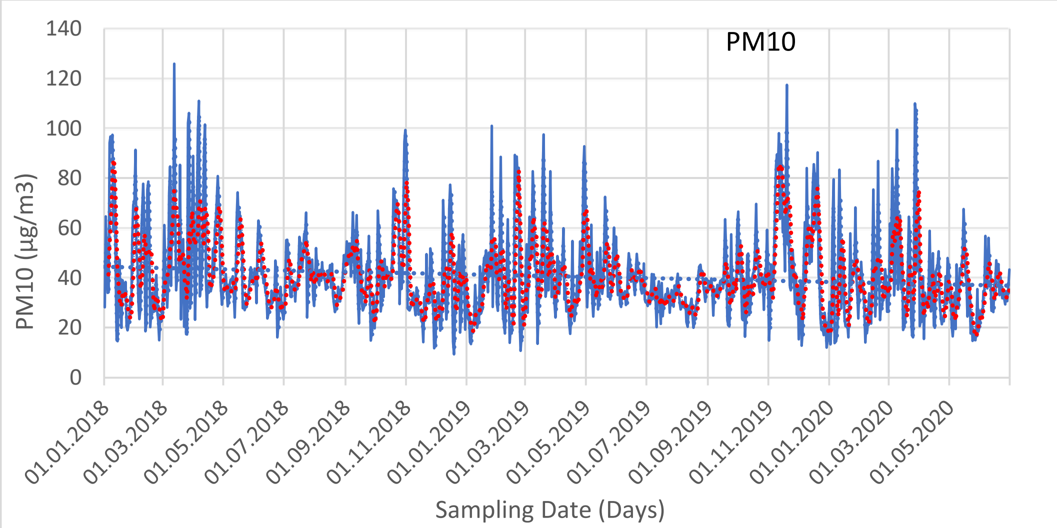

Figure 3. Daily PM_{10} values of Istanbul between 01.01.2018 and 30.06.2020

Fig. 4 shows that the PM_{10} concentrations averaged hourly values of Istanbul province for time range between March 15th and April 15th in 2018, 2019 and 2020. As can be seen in the graph the amount of PM_{10} of the year 2020 is lower than the year of 2018 in the all hours. At 7 a.m. and 5 p.m. amounts of 2020 have higher values than the amount of 2019. From 8 a.m. to 16 a.m. the amounts of 2020 are lower than 2019. In the other hours, values are very close to each other.

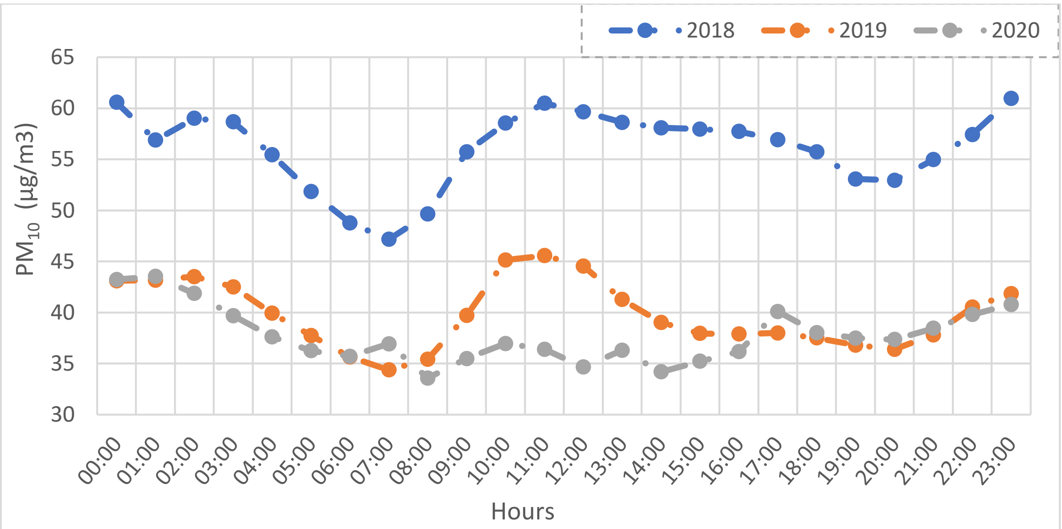

Figure 4. Hourly PM_{10} values of Istanbul between March 15th and April 15th in 2018, 2019 and 2020

Table 1 prepared to understand to see if there is a change in the amount of PM_{10} before, during and after period of lockdown precautions. Lockdown period started in the middle of March so the second period is which people take precautions. When compared with the values of 2018 and 2019, the amount of PM_{10} in 2020 decreased by 28% during the lockdown period.

Table 1. Changing PM_{10} values over the years

PM10 (µg/m3)				
Periods	2018	2019	2020	Change (%) 2020/ (2018;2019)
Jan 1 – Mar 15	43	40	42	0
Mar 16 – May 31	53	42	34	-28
Jun 1 – Jun 30	34	38	36	0

Figure 5 shows that the PM2.5 concentrations averaged daily values of Istanbul province for time range from 02.01.2019 to 30.06.2020. Averaged daily $PM_{2.5}$ values of Istanbul generally between 5 µg/m^3 and 65 µg/m^3. Blue line means the daily $PM_{2.5}$ values of Istanbul and the red line means five-day average of the daily $PM_{2.5}$ values of Istanbul.

Figure 6 shows that the $PM_{2.5}$ concentrations averaged hourly values of Istanbul province for time range between March 15th and April 15th in 2018, 2019 and 2020. As can be seen in the graph the amount of $PM_{2.5}$ of the year 2018 and the year 2019 are very close to each other. The amount of $PM_{2.5}$ of the year 2020 is lower than the values in both 2018 and 2019 in all hours. There is a significant decrease in $PM_{2.5}$ values in Istanbul in a month period compared to previous years.

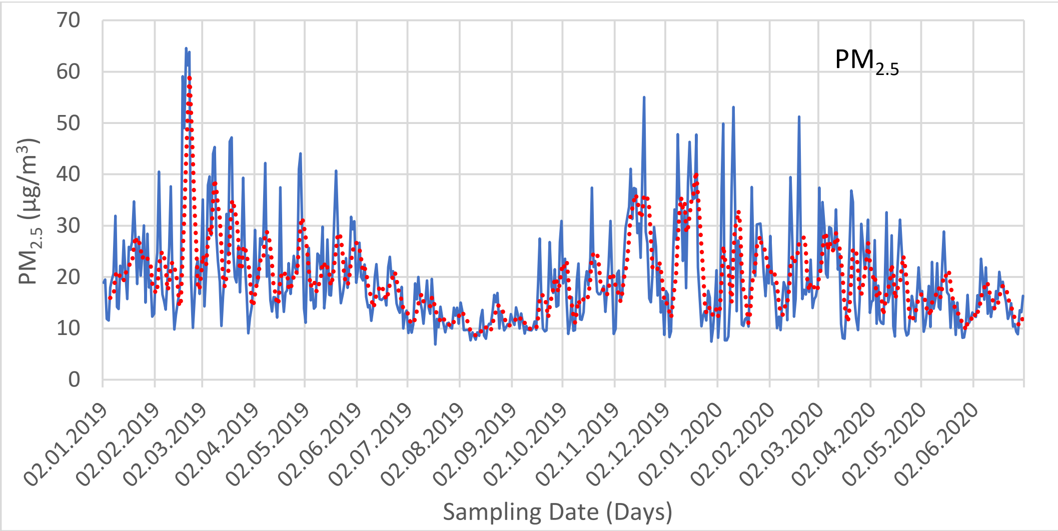

Figure 5. PM2.5 values of Istanbul between 01.01.2018 and 30.06.2020

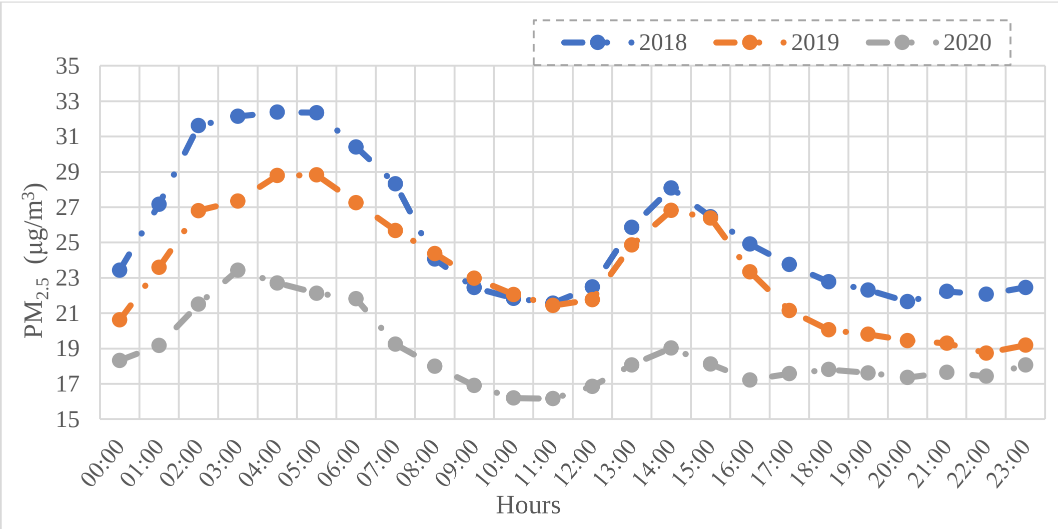

Figure 6. Hourly $PM_{2.5}$values of Istanbul between March 15th and April 15th in 2018, 2019 and 2020

Table 2 prepared to understand to see if there is a change in the amount of $PM_{2.5}$ in the period of lockdown. When compared with the values of 2019, the amount of $PM_{2.5}$ in 2020 decreased by 27% during the lockdown period. All the values of 2020 are lower than the values of 2019, but there has been a greater decrease in lockdown period.

Table 2. Changing $PM_{2.5}$ values over the years

PM2.5 (µg/m3)			
Period	2019	2020	Change (%) 2020/2019
Jan 1 – Mar 15	25	22	-11
Mar 16 – May 31	23	17	-27
Jun 1 – Jun 30	17	15	-15

According to a study conducted in China, the highest concentration of PM_{10} occurred in the cold winter season and PM_{10} concentration was measured lower during periods of higher air temperature (Zhang, et al., 2015). Fig. 2 has mean temperature values of Istanbul. We can divide the time of 2 and a half years into 3 periods as before, during and after lockdown. If we look at the all the periods, we can see increases and decreases from time to time. These increases and decreases might cause by meteorological events such as temperature changes. There is uptrend in temperatures in Istanbul. There is no sudden change in temperature values corresponding to the coronavirus period.

4. Conclusion and Recommendations

The main cause of the amount of particulate matter before the lockdown period is heating. People who live in Istanbul needs heating in winter season because of the weather conditions of Istanbul. Heating types create particulate matter pollution in air. After the winter season so in the spring, the weather gets warmer and the need for warming is reduced. Thus, particulate matter pollution is also reduced. However, in 2020, the amount of particulate matter has decreased more in the spring season than in previous years thanks to the lockdown precautions.

Because of the coronavirus related lockdowns air pollution decreases almost %44 in the whole world (Arora et al., 2020). There are so many cars and they cause traffic and traffic is a huge problem in Istanbul because most vehicles use fossil fuel. While lockdowns in some Turkish people stayed at home mostly, some factories did not work, all students took their lessons online so they stayed at home and do not use transportation. That's why between March 16th and May 31th pollutants created by people are reduced.

All people have tasks to do in order to reduce air pollution. In coronavirus quarantine precautions, we have seen that many people can do their jobs over the internet. Employers should consider this issue in order to reduce air pollution. In lockdown period, the precautions taken by humans have helped reduce air pollution. People should continue these precautions, both as a avoid catching the coronavirus disease and to reduce air pollution.

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References

Arora, S., Bhaukhandi, K., D., Mishra, P., K. (2020). Coronavirus lockdown helped the environment to bounce back. Science of the Total Environment, 742. Doi: https://doi.org/10.1016/j.scitotenv.2020.140573

Berman, J. B., Ebisu, K. (2020). Changes in U.S. air pollution during the COVID-19 pandemic. Science of The Total Environment *739*. Doi: https://doi.org/10.1016/j.scitotenv.2020.139864

Grantz, D.A., Garber, J. H. B, Johnson, D.W. (2003) Ecological effects of particulate matter.Elsevier *29*(2-3), 213-239. Doi: https://doi.org/10.1016/S0160-4120(02)00181-2

Hou, C., Chen, J., Zhou, Y., Hua, L., Yuan, J., He, S., Guo, Y., Zhang, S., Jia, Q., Zhao, C., Zhang, J., Xu, G., Jia, E. (April, 2020). The effectiveness of quarantine of Wuhan city against the Corona Virus Disease 2019 (COVID-19): A well-mixed SEIR model analysis. *Medical Virology*, *92*(7), 841-848. Doi: https://doi.org/10.1002/jmv.25827

Im, U., Markakis, K., Unal, A., Kindap, T., Poupkou, A., Incecik, S., Yenigun, O., Melas, D., Theodosi, C., Mihalopoulos, N., (2010). Study of a winter PM episode in Istanbul using the high resolution WRF/CMAQ modeling system. Atmospheric Environment *44*(26), 3085-3094 Doi: https://doi.org/10.1016/j.atmosenv.2010.05.036

Kampa, M. & Castanas, E. (2008) Human health effects of air pollution. EnvironmentalPollution *151*(2), 362-367. Doi: https://doi.org/10.1016/j.envpol.2007.06.012

Mannucci, P.M., Harari, S., Martinelli, I., Franchini, M., (2015) Effects on health of air pollution: a narrative review. Intern Emerg Med *10*, 657–662. Doi: https://doi.org/10.1007/s11739-015-1276-7

Unal, Y., Toros, H., Deniz, A., Incecik, S., (2011). Influence of meteorological factors and emission sources on spatial and temporal variations of PM10 concentrations in Istanbul metropolitan area. Atmosheric Environment *45*(31), 5504–5513. Doi: 10.1016/j.atmosenv. 2011.06.039

URL-1. https://en.climate-data.org/asia/turkey-67/ , Accessed August, 2020

URL-2. https://www.m.gov.tr/veridegerlendirme/il-ve-ilceler-istatistik.aspx?m=ISTANBUL , Accessed August, 2020

URL-3. http://www.tuik.gov.tr/PreHaberBultenleri.do?id=27643&utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+tuikbulten+%28TÜİK-Haber+Bültenleri+%28Son+1+Ay%29%29 , Accessed August, 2020

URL-4. https://paintmaps.com/tr/harita-grafikleri/40c/Istanbul-harita-grafigi, Accessed February, 2021

Schwartz, J. (2004) Air pollution and children's health. Pediatrics *113*(3), 1037-1043. Retrieved from: https://pediatrics.aappublications.org/content/113/Supplement _3/1037.short

Vallero, D. (2014) *Fundamentals of air pollution* (5th ed.). Oxford: Elseiver. https://books.google.com.tr/books?hl=tr&lr=&id=iFcXAwAAQBAJ&oi=fnd&pg=PP1&dq=air+pollution&ots=rfOft58c3m&sig=ibmeqYWThki_3tIOFRTeC_MEDRQ&redir_esc=y#v=onepage&q&f=false , Accessed September, 2020

Xiao, Q., Ma, Z., Li, S., Liu, Y. (2015) The Impact of Winter Heating on Air Pollution in China. Plos One *10*(1). Doi: https://doi.org/10.1371/journal.pone.0117311

Zhang, H., Wang, Y., Hu, J., Ying, Q., & Hu, X.-M. (2015). Relationships between meteorological parameters and criteria air pollutants in three megacities in China. Environmental Research, 140, 242–254. Doi: 10.1016/j.envres.2015.04.004.

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Relationship between air pollution and COVID-19 in Bursa, Turkey

Kübra Yiğiter[1], Hüseyin Toros[1]

[1] Istanbul Technical University, Faculty of Aeronautics and Astronautics, Meteorology Engineering Department, Istanbul, Turkey

Abstract

Daily observations of PM_{10}, $PM_{2.5}$, NO_2, CO, SO_2 and O_3 data collected in the city of Bursa, Turkey from January 1 through June 30 in 2018, 2019 and 2020 were analyzed to investigate the impact of the COVID-19 control measures taken within the city on the air pollution concentration levels in 2020. The data analysis period was divided into three periods: a) Before pandemic precautions (January 1 - March 15), b) the period of pandemic precautions (March 16 - May 31), and c) normalization period (June 1 - June 30). Time variation of concentrations of these pollutants within these periods of 2020 were compared to the same periods in 2018 and 2019 to identify the changes of the concentrations within each period, from one period to the next and from one year to the next over the same period. A significant decrease in the concentration of these pollutants were seen during the period of pandemic precautions in Bursa.

Keywords: Air pollution, Bursa, COVID-19, particulate matter, pandemic.

1. Introduction

Air pollution in general and especially Particulate Matter (PM) pollution is a major environmental risk to human health as well as to the air-land-water ecosystem. Problems are observed at local, regional and global levels due to air pollution. It seriously threatens our future, especially the negative effects it creates on the climate (Toros and Bagis, 2017). The negative effects of air pollution on the environment and human health are gradually increasing and reaching serious levels. The effects of pollutants such as PM_{10}, SO_2, NO_2 and O_3 can occur as chronic diseases in the long term. In the short term, serious levels of air pollution can result in penetrative respiratory effects (Toros et al, 2014). The air pollution is particularly a serious problem in urban environments due to increased vehicle emissions compared to rural environments where major pollution sources are typically scarce or more controlled. In a world where at least 50% of the population lives in urban environments, air pollution denoting a wide range of pollutants has become one of the most critical issues for human health (Ozdemir, Mertoglu, Demir, Deniz and Toros, 2012). It is estimated that approximately 4.2 million premature deaths worldwide deaths occur due to PM pollution (Cohen et al, 2018).

COVID-19 as a viral disease started negatively impacting our everyday lives in February 2020 and was identified by the World Health Organization (WHO) as a pandemic on March 12, 2020 (WHO, 2020). Like many nations around the world, the local municipalities and state government in Turkey started taking control measures to mitigate the harmful impacts of COVID-19 around this date by limiting human activity. Control measures included the closure of businesses, schools, restaurants and other public places, restricting vehicle travel between cities and lockdown and eliminating domestic and international air travel for a while or substantially reducing it for prolonged periods of time. Many of these stringent control measures were implemented from March 16 to May 31 in Turkey and hence this time period was named as "the period of pandemic precautions" in this study

Working from home and distance education inevitably led to a reduction in traffic during pandemic precaution period. Hence, the air quality around the world was markedly improved as a result of fewer exhaust emissions from vehicles and industry during lockdown period (Bao and Zhang, 2020; Zangari et al, 2020). Flexible work arrangements made in working life, entry-exit bans in cities where cases are frequent, the curfew on weekends, compulsory mask in public areas, appeared to limit the spread of COVID-19. Turkey began taking steps to transition to normalization period at the beginning of June, 2020 (Sirin and Ozkan, 2020). The normalization process implemented in June included returning to the regular public transportation hours, resuming the routine work hours at most workplaces, opening up public areas, normalizing the intercity travel and eliminating lockdown.

In this study; the temporal variations of the concentration air pollutants in the city of Bursa were analyzed to investigate if the control measures created a reduction in pollution concentration during the pandemic precaution period. PM_{10}, $PM_{2.5}$, NO_2, CO, SO_2 and O_3 concentrations recorded at 7 ambient air monitoring station in years 2018,2019 and 2020 in Bursa were analyzed. The six-month study period from January 1 through June 30, 2020 was divided into three periods: Before pandemic precautions (January 1 - March 15), period of pandemic precautions (March 16 - May 31) and normalization period (June 1 - June 30). The daily concentration data measured within each period was compared to the same time periods defined.

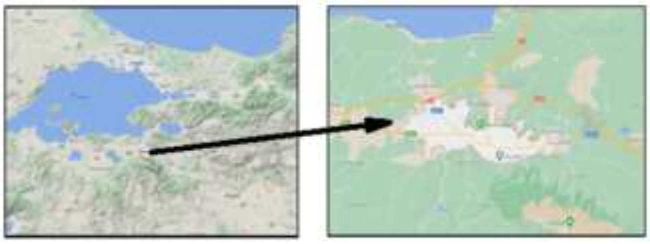


Figure 1: The location of the city of Bursa over terrain map of Marmara region in Turkey (from Google map).

2. Study Area, Data and Methodology

2.1.Study Area

Bursa is the fourth most populous city in Turkey with nearly 3 million after Istanbul, Ankara and Izmir. In addition, Bursa is the second largest city of the Marmara region after Istanbul. Bursa is located between 40.18° N latitude and 29.06° E longitude in Marmara Region. Bursa generally has a mild climate while it varies by region. Despite the soft and warm climate of the Marmara Sea in the north, the harsh climate of Uludağ is encountered in the south. The hottest months of the province are July - August, and the coldest months are December – January (Garipagaoglu & Duman, 2017). The average annual rainfall is 70.6 cm as of the 52-year observation period. The average relative humidity in the province is around 69%. With a population of 3,056,120, the surface area of Bursa is 10,811 km2.

Daily PM_{10}, $PM_{2.5}$, NO_2, CO, SO_2 and O_3 concentrations collected at 7 ambient air quality monitoring stations, Bursa, Beyazit, Inegol (OSB), Inegol (MTHM), Ketsel (MTHM), Kulturpark (MTHM) and Uludag Uni. in Bursa in 2018, 2019 and 2020 were analyzed in this study.

2.2. Data

Daily PM_{10}, $PM_{2.5}$, NO_2, CO, SO_2 and O_3 concentrations collected at Bursa, Beyazit, Inegol (OSB), Inegol (MTHM), Ketsel (MTHM), Kulturpark (MTHM), Uludag Uni. ambient air quality monitoring stations of "Çevre ve Şehircilik Bakanlığı Marmara Temiz Hava Merkezi" in 2018, 2019 and 2020 were analyzed. In order to see the majority distribution in the data, the upper and lower 5% extreme value data were not included in the study. If there is 75 percent of the data in the relevant periods, that period has been examined.

2.3 Methodology

The data was studied on Excel.

- Number of measurements, average maximum, minimum values determined for each station
- If there is 75% or more data in the specified date ranges, the average values were found for these date ranges by including them in the average.
- How the pollutant amount changed during these time intervals was examined
- These averages were calculated for the last three years and the change was examined
- The resulting values are shown on the graphs.
- The role of pandemic in this change was evaluated by taking the precautions in the pandemic process into consideration.

3. Results and Discussion

3.1. PM_{10}

The temporal variations of daily PM_{10} concentrations averaged at all stations in Bursa during the first six months of 2018, 2019 and 2020 at 7 stations is shown in Figure 2. Averaged daily PM_{10} concentrations decrease within each year from January through June while daily PM_{10} concentrations were larger in the first and second period in 2018, compared to the same periods in 2020. In addition, PM_{10} concentrations were already lower in 2020 than the values in 2018 and 2019. This indicates that there was already a decrease of PM_{10} concentrations from 2018 to 2020. As one part of the purpose and anticipated results of this study, daily PM_{10} concentrations were observed to decrease significantly in the second period of 2020 during the pandemic precautions taken compared to the period before control measures taken. On the other hand, a sudden jump in the daily PM_{10} concentrations in the second half of May, from an average of about 40 µg/m3 to about 80 µg/m3 was also seen. A similar increase in $PM_{2.5}$ (Fıg. 3), NO_2 (Fig. 4), CO (Fig. 6) and SO_2 (Fig. 7) concentrations was also seen within the second half of May. Although the exact reason of this jump in concentration is not known, the sudden relaxation of control measures taken by the city in the second half of May after a prolong lockdown created the sudden increase in human activity in terms of vehicle traffic and some industrial activity, resulting in the emissions of primary and formation of secondary pollutants, which ultimately caused this jump seen in PM_{10}, $PM_{2.5}$, NO_2, CO and SO_2 concentrations (Fig. 2).

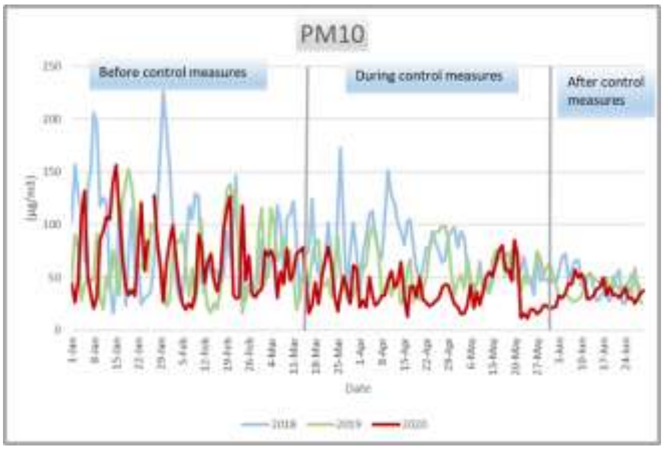


Figure 2. Average daily concentrations of PM_{10} collected at 7 stations in Bursa in 2018, 2019 and 2020.

Table 1: The average PM_{10} concentrations within each study period.

PM10 (µg/m3)			
Time Period	2018	2019	2020
January 1 - March 15	86	67	66
March 16 - May 31	85	57	37
June 1 - June 30	46	37	37

3.2. $PM_{2.5}$

Contrary to the PM_{10} observations (Fig. 2), $PM_{2.5}$ concentrations do not show a decrease from one year to the next while a steady decrease of $PM_{2.5}$ concentration is seen from first period to the next in order from January to the end of June within each year. In addition, $PM_{2.5}$ concentration in all three periods in 2018 were slightly larger than those in other two years while $PM_{2.5}$ concentrations in the first period of 2020 were as large as those in 2018. Furthermore, there was a sudden jump of $PM_{2.5}$ concentrations from a very low values near zero in the first half of May to about 25 µg/m3 and higher in coming days in the second half of May, similar to the jump seen in PM_{10} concentrations (Fig. 2). It is likely that this increase could be attributed to the increased human activity in the city. By comparing the averages in 2019 and 2020, it can be said that there is no change in $PM_{2.5}$ concentration in the first and third periods. (Table 2.) Despite this, there is a decrease in $PM_{2.5}$ concentration in the second period of 2020.

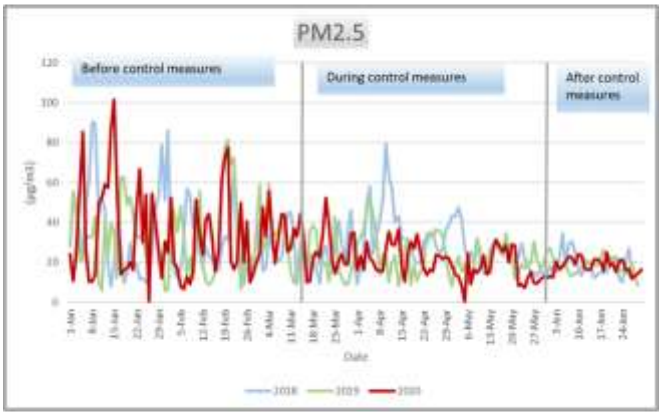


Figure 3. Average daily concentrations of $PM_{2.5}$ collected at 7 stations in Bursa in 2018, 2019 and 2020.

Table 2: The average $PM_{2.5}$ concentrations within each period.

PM2.5 (µg/m3)			
Time Period	2018	2019	2020
January 1 - March 15	32	33	33
March 16 - May 31	31	25	21
June 1 - June 30	18	18	18

3.3. NO_2

Similar to the temporal changes seen in PM_{10} (Fig.2) and $PM_{2.5}$ (Fig. 3), daily averages of NO_2 concentrations also showed a decrease within each year from January through June (Fig. 4 and Table 3). However, the averaged NO_2 concentrations within the first study period of 2019 and 2020 were larger than that of 2018 (Table 3).

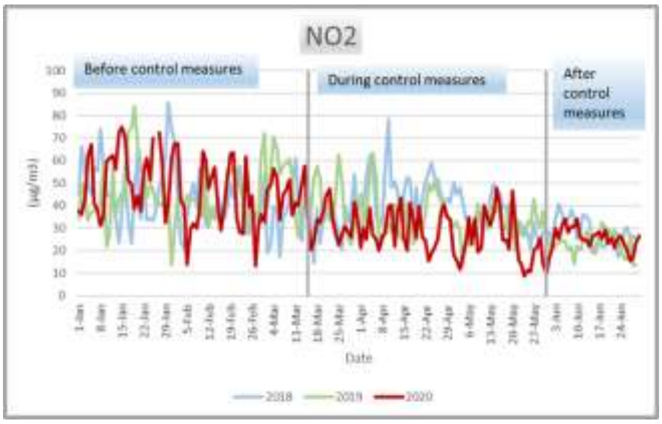


Figure 4. Average daily concentrations of NO_2 collected at 7 stations in Bursa in 2018, 2019 and 2020.

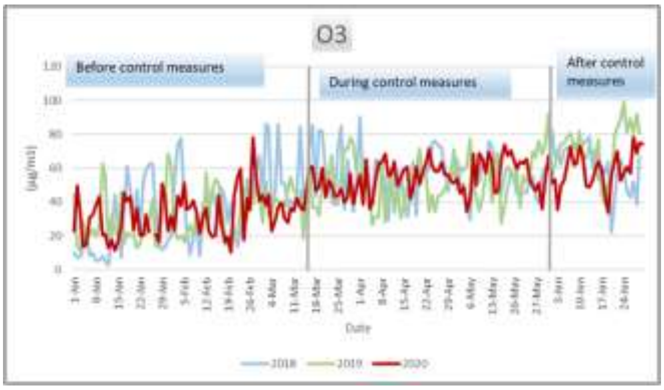
Table 3: The average NO_2 concentrations within each study period.

NO2 (µg/m3)			
Time Period	2018	2019	2020
January 1 - March 15	36	51	50
March 16 - May 31	41	45	27
June 1 - June 30	29	29	26

Similar to the one observed in daily PM_{10} and $PM_{2.5}$ concentrations, a sudden jump in daily NO_2 concentration was also observed within the second half of May in 2020, likely as a result of increased human activity due to the relaxation of control measures mentioned earlier.

3.4. O_3

Since O_3 is typically a summer phenomenon and forms as a result of increased ambient temperature, daily O_3 concentrations increase in time from January through June within each year (Fig. 5) and from one study period to the next (Table 4). Although O_3 concentrations are seen slightly larger from the second half of February to the beginning of April (Fig. 5), there is no systematic or significantly different O_3 concentration changes from one year to the next or from one



study period to the next.

Figure 5. Average daily concentrations of O_3 collected at 7 stations in Bursa in 2018, 2019 and 2020.

Table 4: The average O_3 concentrations within each study period.

O3 (µg/m3)			
Time Period	2018	2019	2020
January 1 - March 15	35	32	36
March 16 - May 31	57	50	56
June 1 - June 30	62	72	59

3.5. CO

Daily CO concentrations steadily decreases from the beginning of a year to the end of June in all three years studied here (Fig. 6). Furthermore, the daily CO concentrations were larger in the first period of each year, compared to the other two periods of the same year. In addition, daily CO concentrations in the second and third study periods of 2020 were larger than the same periods of other two years (Fig. 6 and Table 5).

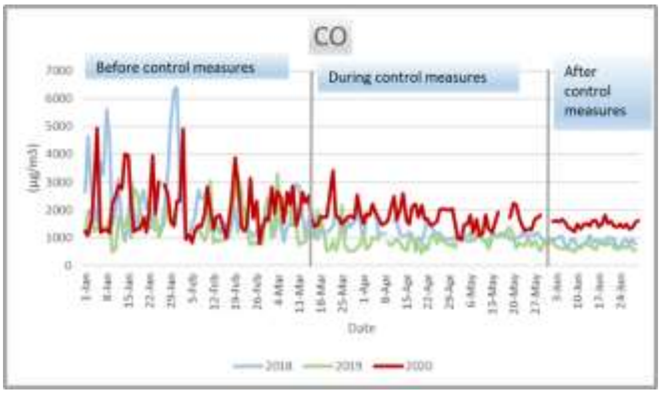


Figure 6. Average daily concentrations of CO collected at 7 stations in Bursa in 2018, 2019 and 2020.

Table 5: The average CO concentrations within each study period.

CO (µg/m3)			
Time Period	2018	2019	2020
January 1 - March 15	2124	1512	2064
March 16 - May 31	1344	883	1742
June 1 - June 30	864	692	1489

3.6. SO_2

Daily SO_2 concentrations of 2020 larger in the first study period compared to the other two periods of 2020 (Fig. 7) while there was no discernible difference in the daily SO_2 concentrations between the second and third study period of 2020. On the other hand, there was a steady decrease of daily SO_2 concentrations from the beginning of the year to the end of June for 2018 and 2019. Finally, similar to the previous cases, there was a noticeable jump in the daily SO_2 concentration in the second half of May (Fig. 7).

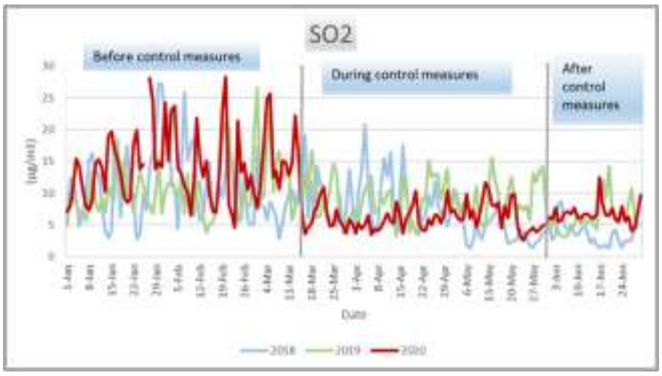


Figure 7. Average daily concentrations of SO_2 collected at 7 stations in Bursa in 2018, 2019 and 2020.

Table 6: The average SO_2 concentrations within each study period.

SO2 (µg/m3)			
Time Period	2018	2019	2020
January 1 - March 15	11	7	13
March 16 - May 31	6	9	6
June 1 - June 30	3	6	7

4. Conclusions and recommendations

The increase and decrease in the concentration of air pollutants in the air depends on many meteorological factors. On and off-road traffic, factories and heating methods are important sources of pollutants. We came across a situation that showed a simulation effect on what would happen when these factors disappear. A highly contagious COVID-19 virus that first reported in Wuhan, China in December 2019, measures by local, state and federal governments throughout the world in the form of lockdown, the restrictions for inter and between city travels, and closure of public places to reduce the spread of the virus. As a result of these restrictions, a decrease in the amount of pollution that is either directly emitted into the atmosphere as a primary pollutant or forms in the atmosphere as a secondary pollutant was expected.

In this study; the daily concentrations of PM_{10}, $PM_{2.5}$, NO_2, CO, SO_2 and O_3 collected at 7 ambient air quality monitoring stations from January 1 through June 30 in 2018, 2019 and 2020 in Bursa were analyzed. The six-month study period of each year was divided into three episodes and the concentrations of the pollutants within the second period of 2020, at which control measures applied, was compared against the other two periods of 2020 as well as to the same period of other two years. Our analyses here indicate that the daily concentrations of PM_{10}, $PM_{2.5}$, NO_2, CO and SO_2 in Bursa decreases from January through the end of June in each year while O_3 concentration increases in time. In addition, a decrease in the daily concentration of these pollutants were generally observed from the first period to the second and third for PM_{10}, $PM_{2.5}$, NO_2, CO, but not SO_2 and O_3. Finally, as one of the assumed outcomes of this study, a decrease in daily concentrations of all these pollutants were typically observed during the second period at which COVID-19 control measures were taken to reduce the spread of the virus. Furthermore, a sudden increase in the daily PM_{10}, $PM_{2.5}$, NO_2, CO and SO_2 concentrations was also seen in the second half of May of the second period of 2020. It is assumed that this increase of daily pollutant concentration occurred when the local and state governments relaxed the control measures within the second half of May after a prolonged lockdown and reduced vehicle and industrial activity.

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References

Bao, R. and A. Zhang, 2020: Does lockdown reduce air pollution? Evidence from 44 cities in northern China. Science of the Total Environment, 731, 139052. Elsevier Publications.

Cohen, A. J., Brauer, M., Burnett, R., Anderson, H. R., Frostad, J., Estep, K., Balakrishnan, K., Brunekreef, B., Dandona, L., Dandona, R., Feigin, V., Freedman, G., Hubbell, B., Jobling, A., Kan, H., Knibbs, L., Liu, Y., Martin, R., Morawska, L., … Forouzanfar, M. H. (2017). Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: an analysis of data from the Global Burden of Diseases Study 2015. The Lancet, 389(10082), 1907–1918. https://0-doi-org.divit.library.itu.edu.tr/10.1016/S0140-6736(17)30505-6

Garipağaoğlu, N., & Duman, C. (2017). Bursa Kenti Hava Kalitesinin Zaman İçerisindeki Değişimi. Marmara Cografya Dergisi, 36, 57–70

Ozdemir, H., Mertoglu, B., Demir, G., Deniz, A., & Toros, H. (2012). Case study of PM pollution in playgrounds in Istanbul. https://0-doi-org.divit.library.itu.edu.tr/10.1007/s00704-011-0543-4

Sirin, H. & Ozkan, S. (2020). COVID-19 Epidemiology: In the World and Turkey. http://dergi.kbb-bbc.org.tr/ . Retrieved May 21, 2020. from http://dergi.kbb-bbc.org.tr/issue/2020/28/83

Toros, H., & Bağış, S. (2017). Hava Kirlilik Modellerinde Kullanılacak Emisyon Envanteri Oluşturulması için Yaklaşımlar ve İstanbul Hava Kirliliği Dağılımı Örneği. Çukurova Üniversitesi.

Toros, H., Erdun, H., Çapraz, Ö., Özer, B., Daylan, E., & Öztürk, A. (2014). Air Pollution and Quality Levels in Metropolitans of Turkey for Sustainable life. Osman SAĞDIÇ.

Zengari, S.. D. T. Hill, A. T. Charette, and J. E. Mirowsky, 2020: Air quality changes in New York City during the COVID-19 pandemic. Science of the Total Environment, 742, 140496. Elsevier Publications.

World Health Organization (WHO). WHO announces COVID-19 outbreak a pandemic. Update: Mar 12, 2020. Access: Aug 12, 2020.

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Relationship Between Air Pollution and COVID-19 measures in İzmir, Turkey

Melike Bilgin[1], Hüseyin Toros[1]

[1]Istanbul Technical University, Faculty of Aeronautics and Astronautics, Meteorological Engineering Department, Istanbul, Turkey

Abstract

To investigate any impact of control measures taken by the government to reduce the spread of COVID-19 *disease* on daily air pollution levels were investigated. Daily data of PM_{10}, $PM_{2.5}$, NO_2, CO, SO_2 and O_3 measured at 14 ambient air quality measurement stations in İzmir province between 1 January 2018 and 30 June 2020 were analyzed. In order to evaluate the relationship between air pollution and COVID-19, each year was divided into three periods: the period before the pandemic measures (January 1 - March 15), the period when strict measures were implemented (March 16 - May 31) and the normalization period (June 1 - June 30). Changes in the air pollution level in 2020 was studied and compared to the values within the same period in 2018 and 2019. It was observed that the decrease in air pollution levels in general was not reflected in PM_{10} and $PM_{2.5}$ values. However, a decline in other pollutants both in the period when control measures are taken and during the normalization period.

Keywords: *COVID-19, air pollution, İzmir*

1. Introduction

COVID-19 is a virus that was first identified on January 13, 2020 as a result of research conducted in a group of patients with respiratory symptoms in Wuhan Province, China, in late December, 2019 (www.covid19bilgi.saglik.gov.tr, 2020). In the face of this highly contagious and rapidly spreading virus, the lack of equipment required for the prevention of the disease and the lack of any medicines or vaccines ready for use has caused a worldwide health crisis. Within five months the disease affected more than 210 countries and all parts of the world with 2,700 deaths by 25 February 2020 (Wang et al., 2020; He, Pan & Tanaka, 2020; Mukherjee et al., 2020). Governments around the world have applied strict quarantine and imposed restrictions on private and public transport, such as home-stay aimed at reducing the rate of interaction with social / physical distance to contain the virus and reduce the transmission of disease. Control measures also included mass testing to identify people who are infected, banning public gatherings, closing schools, and even imposing an entry and exit ban from countries or cities (Mukherjee et al., 2020; He, Pan & Tanaka, 2020; Son et al., 2020). However, prevalence, morbidity, violence and mortality rates vary between countries or in different regions of the same country (Gupta & Misra, 2020).

It is anticipated that the implementation of these preventive measures will not only reduce the level of traffic-related air pollution but also increase the environmental air quality significantly. Accordingly, when satellite images were examined in many countries that took measures to slow the spread of the virus, it was seen that there was a sharp decrease in air pollution (Son et al., 2020; He, Pan & Tanaka, 2020). Air pollution can be defined as the presence of foreign substances in the air in the form of solid, liquid and gaseous substances in the atmosphere at a concentration and time that can harm human health, living life and ecological balance (Sonsuz et al., 2011). Pollution is mainly caused by industrial facilities, fuel consumption for heating purposes and motor vehicle exhausts. It is known that pollutants, and especially Particulate Matter (PM), increase respiratory symptoms, cause impairment in respiratory functions and cause inflammatory changes in the airways (Bayram et al., 2006). However, when evaluating the relationship of environmental air pollution with public health, it is necessary to consider the indirect effects of drinking and irrigation water resources, damage to vegetation and macro climate changes, as well as direct health effects. In short, it is an undeniable fact that the wastes generated during the production and consumption activities that occur as a result of various activities of people pollute the air layer (Sonsuz et al., 2011). Therefore, it is not possible to talk about a decrease in air pollution due to traffic only in this process.

In this study, PM_{10}, $PM_{2.5}$, SO_2, NO_2, CO and O_3 data collected from January 1 through June 30 of years 2018, 2019 and 2020 at 14 air monitoring stations located in Izmir province were analyzed. January 1 – June 30 period was divided into three periods: a) the period before the pandemic measures (January 1 - March 15), b) the period when strict measures were implemented (March 16 - May 31) and c) the normalization period (June 1 - June 30). Temporal variation of the pollutants within the second period was compared to the changes in other periods in order to reveal the relationship between air pollution and the control measures implemented to mitigate COVID-19 impacts. In addition, the same periods from 2018 and 2019 were also compared to the periods in 2020 to evaluate the temporal changes of the pollutants over a three year period.

2. Data and methods

2.1. Study site

The study region is the city of İzmir located at 38.4189 N and 27.1287 E with an area of 11.891 km^2. The study area is located in the Mediterranean climate zone with hot and dry summers and warm and rainy weather conditions. Drought-resistant trees and shrubs with large, hard and coniferous leaves that remain green continuously form the common natural vegetation. Red pine, pistachio pine, larch, cypress scrub and olive trees are common and orchards occupy a very large area. Kozak Mountain, is one of Turkey's largest pine nut production areas. The depression plains in this region and the deposit plains in the mouths of the streams are located between the mountain ranges extending in the east-west direction and form the main lines of the landforms. In addition, as the mountains extend perpendicular to the sea, the penetration of the plains to the inner parts causes the marine effects to be carried to the inner parts (www.izmir.csb.gov.tr, 2020). In the study, 14 air quality measurement stations were used, which are Seferihisar, Aliağa, Alsancak IBB, Bayraklı IBB, Bornova IBB, Ciğli IBB, Gaziemir, Güzelyalı IBB, Karşıyaka, Karşıyaka IBB, Kemalpaşa, Konak, Ödemiş and Şirinyer IBB.

Figure 1. Map of studied area (www.izmir.csb.gov.tr, 2020)

2.2. Data used

Daily measurement of PM_{10}, $PM_{2.5}$, SO_2, NO_2, O_3 and CO concentration from January 1 through June 30 for years 2018, 2019 and 2020 were obtained from the ambient air quality measurement stations of the Ministry of Environment and Urbanization.

2.3. Methods

The concentration data was analyzed using Excel spreadsheet. The temporal variation of each pollutant was studied according to its concentration values, and the largest, smallest and average values were calculatedwithin each period for the three years examined here. In order to see the majority distribution in the data, the extreme value data of 5% from the top and bottom were not included in the study. If 75 percent of the data was available in the relevant periods, it was examined at that time. In addition, daily data measured from January 1, 2018 to June 30, 2020 for each pollutant have been plotted.

3. Results and discussion

a) PM_{10}

The daily mean PM_{10} values measured from January 1, 2018 to June 30, 2020 are shown in the Figure 2. The comparison of the temporal evolution of PM_{10} concentration in 2018 through 2020 over the first six months period shows a steady decrease of PM_{10} concentrations from the beginning of each year to the end each year. Furthermore, PM_{10} values in 2020 were generally lower than the concentrations in 2018 and 2019 within during the six months period. In addition, the daily PM_{10} concentrations show large fluctuations over several consecutive days in 2018 and 2020, for example from 160 to 35 μg/m^3 within the last week of January in 2018 (Fig. 2) while the daily PM_{10} concentration does not change abruptly over several consecutive days during the entire time period examined in 2020. However, there was a sudden increase in the second half of May in 2020. The exact reason of this jump is not known but it is expected that this jump may be due to the sudden relaxation of control measures after a lengthy lockdown within the city that resulted in short lived increased human activity. Similar but smaller increases in $PM_{2.5}$ (Fig. 3) and NO_2 (Fig. 4) concentrations are also seen within the second half of May. Table 1 shows the PM_{10} values that were averaged within each period, which shows a decrease in PM_{10} values from the first period to the last within each of these three years. During the period of 16 March - 31 May when the measures were taken, there was a decrease every year. When we evaluate the 2020 pandemic process, it is seen that the PM_{10} concentration is constantly decreasing. On a yearly basis, the biggest decrease occurred in 2018. However, when we compare 2019 and 2020, it is clear that the values are close to each other and there is no big difference between them. In addition, PM_{10} values have decreased in every period and every year compared to the previous year. This result indicates a decrease in PM_{10} values regardless of COVID-19 measures.

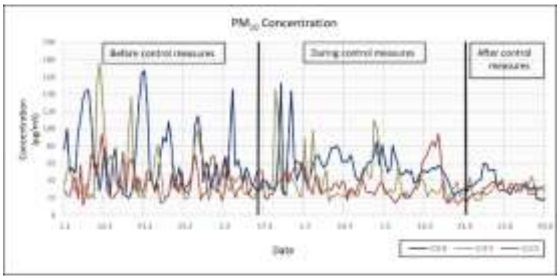

Figure 2. Daily mean PM_{10} by years

Table 1. Annual mean PM_{10} concentrations by periods

PM_{10} (μg/m3)			
Periods	**2018**	**2019**	**2020**
First	66	48	39
Second	55	36	35
Third	35	31	30

b) $PM_{2.5}$

The daily mean $PM_{2.5}$ values measured from January 1, 2018 to June 30, 2020 are shown in the Figure 3. In the graph, it is seen that there has been a serious decrease in $PM_{2.5}$ concentrations in 2018 while it can be said that the values generally progress regularly in 2019 and 2020. Moreover, the daily $PM_{2.5}$ concentrations show large fluctuations from 120 to 20 μg/m^3 in first period of 2018 while the daily $PM_{2.5}$ concentrations does not change abruptly the entire six-month period in 2019 and 2020. The average values of the daily

$PM_{2.5}$ data for the years 2018, 2019 and 2020 within the three periods examined are given in the table. There is a serious decrease in $PM_{2.5}$values from 2018 to 2019. In 2020, the values increased again, but could not reach their old value. When the 2020 pandemic year is examined, there is an increase in the period between 16 March and 31 May when strict measures are taken. In other words, it seems that COVID-19 measures are not reflected in $PM_{2.5}$ values.

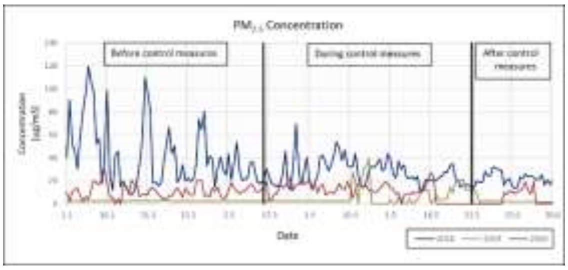

Figure 3. Daily mean $PM_{2.5}$ by years

Table 2. Annual mean $PM_{2.5}$ concentrations by periods

$PM_{2.5}$ (µg/m3)			
Periods	**2018**	**2019**	**2020**
First	38	2	12
Second	27	8	14
Third	22	3	12

c) NO_2

The daily mean NO_2 values measured from January 1, 2018 to June 30, 2020 are shown in the Figure 4, which shows a general increase. On the other hand, the six-month period in 2019 and 2020 shows a decline in NO_2 values until May. In addition, NO_2 values in 2018 were higher during the entire six months analysed than the concentrations in 2019 and 2020 within the same six months period. The average values of the daily data for the years 2018, 2019 and 2020 received from the stations for the three periods examined are given in the table. Although there was a serious decrease in 2019 and 2020 during the period of 16 March - 31 May, when intensive measures were taken during the pandemic process. The biggest decrease occurred in the period of 16 March - 31 May when the measures were taken. When we examine the 2020 pandemic year within itself, it is seen that there is a decrease after the measures taken, but after this period, that is, in the normalization process, an increase has occurred. The reason for this can be explained roughly as the activities restricted in the period of 16 March - 31 May were started to be implemented suddenly.

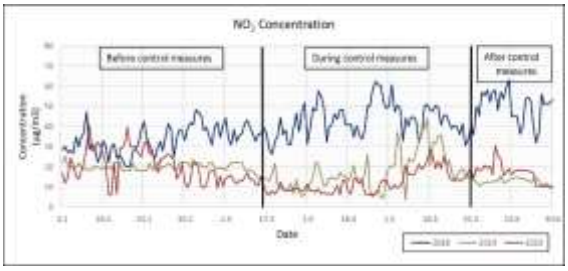

Figure 4. Daily mean NO_2 by years

Table 3. Annual mean NO_2 concentrations by periods

NO_2 (µg/m3)			
Periods	**2018**	**2019**	**2020**
First	34	22	21
Second	48	14	13
Third	57	13	19

d) O_3

The daily mean O_3 values within the first six months of 2018-2020 are shown in Figure 5. The maximum O_3 value within the three half-year period was measured with 123 µg/m^3 on April, 30 in 2018. A tendency of increase in daily mean O_3 concentrations from January to the end of June is observed in all three years. However, this increase is more noticeable in 2018 and 2019 compared to that in 2020. Although a net decrease in O_3 concentration in the control measure period is not clearly seen, the daily mean O_3 concentrations in 2020 are lower than the values measured in other two years during the first six months period. Furthermore, a subtle but sudden increase in O_3 concentration is observed towards the end of control measure period probably due to the increase of human activity as a result of sudden relaxation of home stay requirement that was periodically implemented. The average values of the daily data for the years 2018, 2019 and 2020 received from the stations for the three periods examined are given in the table. Looking at the 2020 pandemic year, a decrease in O_3 values is observed in the period of March 16 - May 31, when measures were taken. The decline continued in the same way in the normalization process that followed the measures. When evaluated on a yearly basis, it is observed that the concentration of O_3 decreased for these periods of 2018 and 2020, while the concentration increased gradually in 2019.

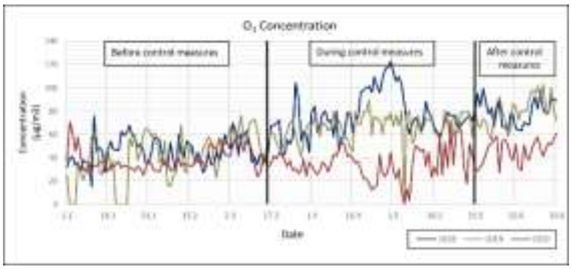

Figure 5. Daily mean O_3 by years

Table 4. Annual mean O_3 concentrations by periods

O_3 (µg/m3)			
Periods	**2018**	**2019**	**2020**
First	46	46	45
Second	72	67	34
Third	89	80	27

e) CO

The daily mean CO values measured from January 1, 2018 to June 30, 2020 are shown in the Figure 6. CO values in 2018 were higher during the entire six months analysed than the concentrations in 2019 and 2020 within the same six months' period. Furthermore, in first period of 2018, there is a significant decrease in CO values, which are more regular in 2019 and 2020. The average values of the daily data for the years 2018, 2019 and 2020 received from the stations for the three periods examined are given in the table. When analyzed on a yearly basis, the biggest decrease in CO values occurred in 2019. It is seen that there is a continuous decrease in the 2020 pandemic year.

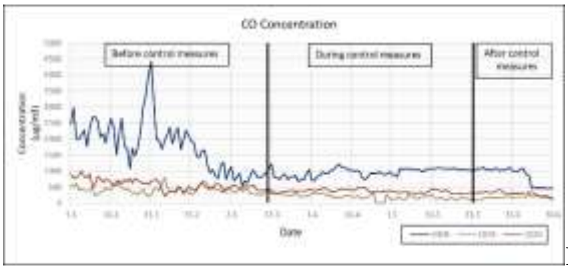

Figure 6. Daily mean CO by years

Table 5. Annual mean CO concentrations by periods

CO (µg/m3)			
Periods	**2018**	**2019**	**2020**
First	1690	413	575
Second	1027	211	371
Third	1105	177	325

f) SO_2

The daily mean SO_2 values measured from January 1, 2018 to June 30, 2020 are shown in Figure 7. It is seen that SO_2 concentrations show fluctuations in first period of 2018. In addition, it can be said that the values generally progress regularly after the first period. Compared to the daily evolution of SO_2 concentration from 2018 to 2020 over the first six months, 2019 is more regular. The average values of the daily data for the years 2018, 2019 and 2020 received from the stations for the three periods examined are given in the table. On a yearly basis, it is seen that the biggest decrease is in 2020. As a result of the measures taken within the scope of the pandemic in 2020, a serious decrease in SO_2 value occurred between March 16 - May 31. In the following normalization process (June 1 - June 30), there was a decrease again. When the three periods are analysed separately, it is seen that the biggest decrease is between 1 June and 30 June.

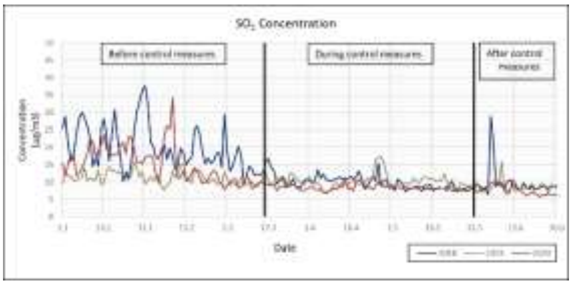

Figure 7. Daily mean SO_2 by years

Table 6. Annual mean SO_2 concentrations by periods

SO_2 (µg/m3)			
Periods	**2018**	**2019**	**2020**
First	20	11	14
Second	10	10	8
Third	9	9	4

4. Conclusion

The COVID-19 outbreak in Turkey resulted in local and state-wide control measures, which resulted in a period of substantially reduced human activity, which in turn resulted in improved air quality. The concentration changes of PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO and O_3 collected at 14 stations in Izmir province from January 1 through June 30 in year 2018, 2019 and 2020 was analyzed. 6-month time period from January 1-June 30 within each year was divided into three period based on COVID-19 occurrence: a) pre-pandemic period (January 1 to March 15) b) strict pandemic measures period (March 16 - May 31) and c) the normalization period (June 1 - June 30). According to the results, the decrease in air pollution levels in general was not reflected in PM_{10} and $PM_{2.5}$ values. In addition, a decrease was observed in the concentrations of all pollutants, except for $PM_{2.5}$, during the period of 16 March - 31 May, when strict measures were implemented. It is seen that this decrease continues in the normalization process, except for NO_2. According to this result, it is clear that human activities greatly affect air pollution. The increase or decrease in the concentration of air pollutants depends not only on anthropogenic sources but also on many meteorological variables. Therefore, meteorological parameters should also be taken into consideration while evaluating this process. In fact, the biggest gain we can achieve in this research is that it is in our hands to reduce air pollution levels and improve environmental quality. It is possible to achieve positive results in air quality with changes such as reducing fuel consumption, using thermal insulation in buildings and houses, using clean energy sources and quality fuels, building chimneys with sufficient height and using filters in the chimneys, and making facilities outside of residential areas as much as possible for our health.

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References

Wang, P., Chen, K., Zhu, S., Wang, P., & Zhang, H., (2020). Severe air pollution events not avoided by reduced anthropogenic activities during COVID-19 outbreak. Resources, Conservation and Recycling, 158, 104814

He, G., Pan, Y., & Tanaka T., (2020, July). The short-term impacts of COVID-19 lockdown on urban air pollution in China. Nature Sustainability. doi: 10.1038/s41893-020-0581-y

Mukherjee, M., Chatterjee, R., Khanna, B. K., Dhillon, P. P. S., Kumar, A., Bajwa, S., et al., (2020). Ecosystem-centric business continuity planning (eco-centric BCP): A post COVID19 new normal. Progress in Disaster Science, 7, 100117

Son, J., Fong, K. C., Heo, S., Kim, H., L,m, C. C., & Bell, M. L., (2020). Reductions in mortality resulting from reduced air pollution levels due to COVID-19 mitigation measures. Science of The Total Environment, 744, 141012

Gupta, R., & Misra, A., (2020). COVID19 in South Asians/Asian Indians: Heterogeneity of data and implications for pathophysiology and research. Diabetes Research and Clinical Practice, 165, 108267

Sonsuz, B., Kargıoğlu, A. F., Şıpka, M., Oruç, M. M., Hepşen, Ö., Selvi, E., et al., 2011. Adapazarı İlçesindeki Endüstriyel Kaynaklı Emisyonların Envanterlemesi. Bitirme tezi. Sakarya Üniversitesi Mühendislik Fakültesi, Sakarya.

Bayram, H., Dörtbudak, Z., Fişekçi, F., Kargın, M., Bülbül, B., Hava Kirliliğinin İnsan Sağlığına Etkileri, Dünyada, Ülkemizde ve Bölgemizde Hava Kirliliği Sorunu. Dicle Medical Journal, 33 (2006)

Çevre ve Şehircilik Bakanlığı internet sitesi (https://izmir.csb.gov.tr, 2020)

Çevre ve Şehircilik Bakanlığı internet sitesi (https://www.havaizleme.gov.tr, 2020)

Sağlık Bakanlığı internet sitesi (https://covid19bilgi.saglik.gov.tr, 2020)

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The Impact of COVID-19 on Air Quality in the city of Adana, Turkey

Dilan Ç. Tunç[1], Hűseyin Toros[1]

[1]Department of Meteorological Engineering, Faculty of Aeronautics and Astronautics, Istanbul Technical University, İstanbul, Turkey, tuncd17@itu.edu.tr; toros@itu.edu.tr

Abstract

The impact of COVID-19 control measures on the air quality of the city of Adana was studied during period between January 1 and June 30, 2020. The temporal variation of the observed concentration of PM_{10}, O_3, NO_2 and SO_2 collected by the urban development ministry of Adana at four ambient air quality stations was analyzed. The data collected during this study period was also compared to the data collected at the same period in 2018 and 2019 to evaluate the degree of any change in the air quality of the city of Adana. While some decrease in the concentration of the ambient pollution was noted both during the pandemic and compared to the previous years, not a significant impact of the control measures on the general air quality of the city of Adana was identified during the pandemic.

Keywords: *Covid-19, Lockdown, Air Pollution, Adana*

1. Introduction

The Corona Virus was first identified by the World Health Organization (WHO) in the city of Wuhan, China at the end of 2019 (hereon COVID-19) as an infectious disease. The spread of the disease showed some characteristics of the Influenza Virus, or Flu, such as high fever, cough and fatigue (Covid-19, 2020). However, its spread and fatality rate greatly surpassed the impact of any Flu epidemic seen during the last century, other than the H1N1 Flu Pandemic Influenza seen in 1918 that caused a great fatality rate in the order of millions in a short time period (Flu, 1918). As a precaution for the transmission of the disease, social life has been restricted worldwide and social distance policy has been followed. In accordance with this policy, many daily life activities have been canceled or substantially reduced. The education and work opportunities are restricted to continue from home. Travel restrictions caused a sharp decrease on the use of vehicles and the general traffic activity. Air pollution that was defined as "a problem that can be inhaled, smelled, visible or invisible, growing physically, biologically and chemically" because of industrialization and urbanization appear to decrease especially during the time when peak control measures taken" (Toros and Bağış, 2017).

China is one of the countries with the highest air pollution in the world, especially due to its large number of factories and high population (Liu et al, 2018; Kan et al, 2009). The air pollution problem in China is so severe that He et al (2020) states using the predicted results that each-year 25 million healthy human could lose their lives due to air pollution. As the COVID-19 disease spread across China and to the neighboring countries, the "Quarantine" lifestyle was adapted at an earlier time than the other countries implemented. The process of staying at home required by this lifestyle has restricted people from going to work. The quarantine measures that were implemented in China and later by all nations throughout the world reduced the air pollution significantly (e.g. Berman and Ebisu, 2020; He et al, 2020). Griffith et al (2020) showed using the satellite observations in China that NO_2 concentrations decreased substantially in the third and fourth weeks of the quarantine period (Figure 1). Similar to what the radar images pointed out in China, The European Environment Agency has also showed observed decrease in pollution concentration widely across Europe (Berman and Ebisu, 2020).

He et al (2020) observed through their air quality research that the airborne $PM_{2.5}$ level decreased by 24% during January 1 and March 1 period and concluded that overall air quality increased by 22%. Correspondingly, in many other metropolitan cities, such as Delhi, London, Los Angeles, Milan, Mumbai, New York, Rome, São Paulo, Seoul and Wuhan, there was a decrease in air pollution levels between 9% to 60% in 2020 compared to the air pollution levels recorded in 2019. Even the visual observations of aerosols suspended in the air showed a large decrease in visible air quality after only one week of reduced human activities in many countries (Baldasano, 2020). For instance, in the United States during the COVID-19, NO2 concentration decreased by 25.5% and PM2.5 decreased by 11.3% (Berman and Ebisu,2020).

Similar to other nations in the world, Turkey has also adopted the control measures to reduce the spread of COVID-19 and similar impacts on visible air pollution was observed in many cities. This work studies the airborne concentration of several pollutants collected in the city of Adana to quantify the impact of control measures on the air pollution problem on the city.

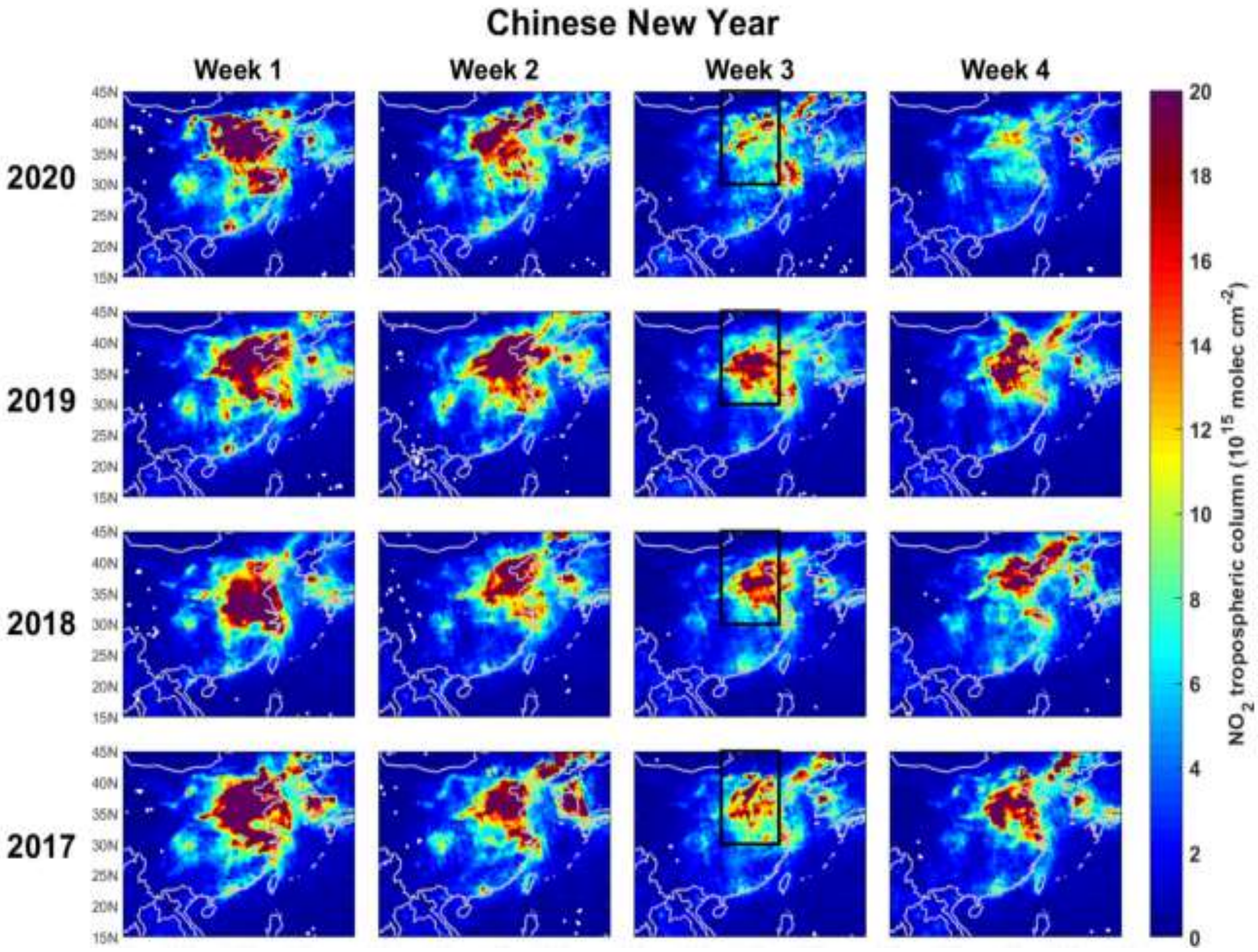

Figure 1. The result of the measurement of NO2 concentration over China (Long-range air pollution transport in East Asia during the first week of the COVID-19 lockdown in China ,2020, p.3)

2. Data and Analysis Methods

2.1. Study Site

The city of Adana is the 6th largest city in Turkey and located along the Mediterranean coast with a surface area of 17.253 km^2. Summers are dry and hot while winters are rainy and warm.

Figure 2. Ambient air quality monitoring stations located in Adana (Weather monitoring, 2020)

2.2. Data used

In this study, daily concentration of PM_{10}, SO_2, O_3, and NO_2 collected by the ministry of the environment and urbanism of

Turkey by the ambient air quality monitoring stations located at Adana Governorship, Adana meteorological office, Adana Çatalan and Adana Doğankent districts were used to investigate the air quality during the chosen time periods in 2018-2020

2.3. Analysis Methods

The daily concentration of pollutants were analyzed and plotted using Excel spreadsheet. The study period was divided into three episodes: a) Before control measures period between January 1 and March 15; b) during the control measures period between March 16 and May 31; and c) after the control measures period between June 1 and June 30. The evolution of the daily concentration of pollutants within a each period was compared to the changes in other periods to study if an impact of the control measures was seen on air pollution levels. The January 1 thru June 30 period was also compared to the same period in 2018 and 2019 to see if any year-to-year variation of air pollution was observed.

2. Results and discussion

a) PM_{10} analysis

Table 1: Averaged PM_{10} concentrations within each period chosen in 2018 - 2020.

PM_{10}			
Patterns	2018	2019	2020
Jan 1 - March 15 (a)	84	50	42
March 16 - May 31 (b)	65	44	25
June1 - June 30 (c)	54	49	24

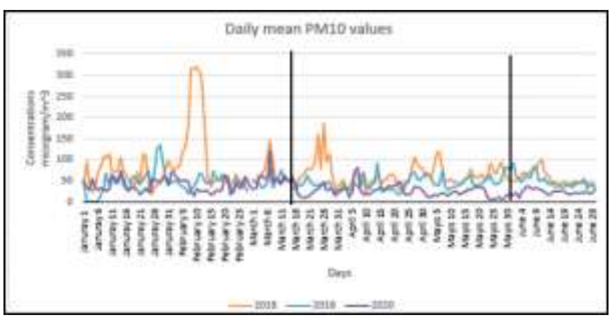

Figure**. 3.** The temporal evolution of the daily mean PM_{10} concentrations between January 1 and June 30 in 2018 - 2020.

The daily PM_{10} concentrations collected at all ambient air quality monitoring stations and averaged over the stations are given in Figure 3. The figure shows that the changes in PM_{10} concentration levels from one year to the next didn't show large variations although a small but steady decrease in PM_{10} concentration from January 1st through June 30th is seen within each year. In addition, apart from some large values of PM_{10} concentrations seen in the first period in 2018, overall PM_{10} levels were slightly higher in 2018 compared to the other years. Moreover, the averaged values PM_{10} concentrations within each period compiled in 2018 – 2020 by the same air quality monitoring stations are given in Table 1. The table points out that the changes in the pollutant concentration averaged within each period of the pandemic are less than the other years' averaged values. Overall, PM_{10} concentrations are lower in 2020 compared to the values recorded in other years. Finally, some PM_{10} values larger than 100 µg/m^3 are recorded within the first and second periods of 2018. Those data points were not removed with the assumption that they were left in the data pool as valid data points by the data provider. If those large values are removed, all PM_{10} concentrations do not exceed 100 µg/m^3.

b) O_3 analysis

Table 2: Averaged O3 oncentrations within each period chosen in 2018 - 2020.

O_3			
Episodes	2018	2019	2020
Jan 1 - March 15 (a)	25	42	37
March 16 - May 31 (b)	34	32	48
June1 - June 30 (c)	32	28	49

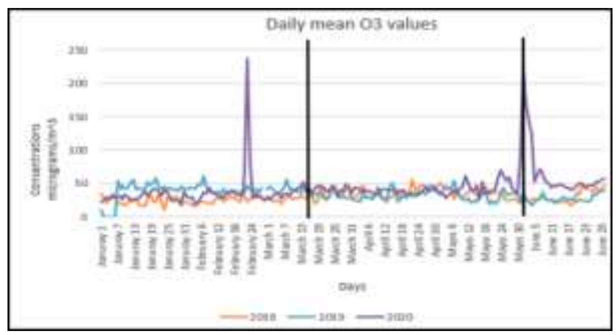

Figure 4. The temporal evolution of the daily mean O_3 concentrations between January 1 and June 30 in 2018, 2019 and 2020.

The daily O_3 concentrations collected by all ambient air quality monitoring stations and averaged over the stations are given in Figure 4. The figure shows that the changes in O_3 concentration levels from one year to the next showed large variations. The values within the second period are not too different from one year to the next. Table 2 also shows that the averaged O_3 concentrations within each period chosen in 2018 – 2020 are not too different from the values at the same period in all years. However, there are some large O_3 values within the first and third periods of 2020. Those data points were not removed from the data with the assumption that they were left in the data pool as valid data points by the data provider.

c) NO_2 analysis

Table 3: Averaged NO2 oncentrations within each period chosen in 2018 - 2020.

NO_2			
Episodes	2018	2019	2020
January 1 - March 15 (a)	17	25	41
March 16 - May 31 (b)	13	28	26
June 1 - June 30 (c)	4	18	18

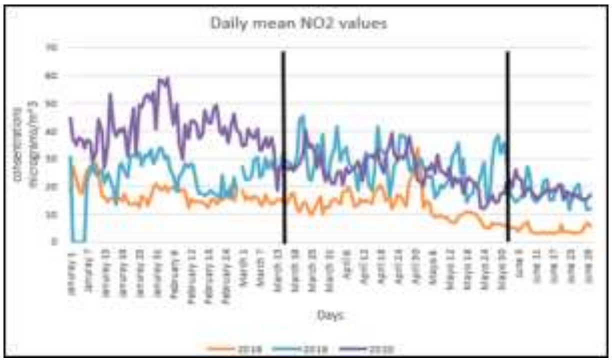

Figure 5. The temporal evolution of the daily mean NO2 concentrations between January 1 and June 30 in 2018, 2019 and 2020.

Figure 5 shows that the NO_2 concentrations gradually decreased in 2018 and 2020 but not in 2019 from January 1 through June 30. The concentrations recorded in the first period of 2020 was higher than the values observed in 2018 and 2019. On the other hand, the concentrations in the second period of 2019 were slightly higher than the first period of the same year. Since NO_2 is typically releases into the atmosphere from burning of fossil fuels from heat sources including home heating as well as from on and off-road vehicles (EPA-1), it is assumed that the people still needed to continue heating their homes in the second period due to cooler temperatures in addition to a increased on and off-road vehicle activity. A further investigation may be needed to learn the cause of this slightly elevated NO_2 levels recorded in 2019.

d) SO_2 analysis

Table 5: Averaged SO2 oncentrations within each period chosen in 2018 - 2020.

SO_2			
Episodes	2018	2019	2020
January 1 - March 15 (a)	8	10	8
March 16 - May 31 (b)	8	14	12
June 1 - June 30 (c)	19	17	16

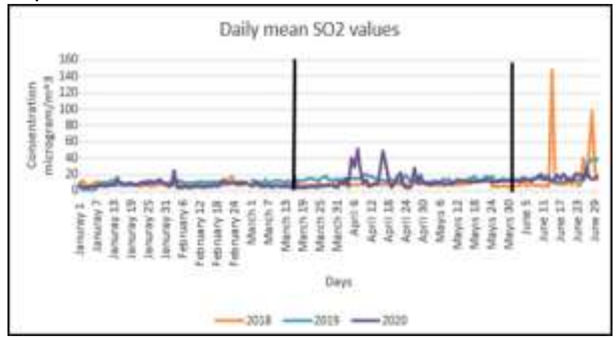

Figure 6. The temporal evolution of the daily mean SO_2 concentration between January 1 and June 30 in 2018, 2019 and 2020.

The daily SO_2 concentrations collected from four stations and averaged at all stations given in Figure 6 show that the SO_2 concentration was lower in 2020 than those in 2019, but more than those in 2018. In addition, there was an increased SO_2 release to the atmosphere during the control measure period in 2020. Since SO_2 is typically released from major industrial activity (EPA-2), it would be interesting to find out the reason of this increase during the control measures where there was a shutdown or substantially decreased human activity due to lock-down implemented. Table 5 also shows the averaged values of SO_2 concentrations within each period. Although the changes from one period to the next is not large, it shows how much of a change was seen in SO_2 levels in each year. There are some large SO_2 values within the third period of 2018. Those data points were not removed with the assumption that they were left in the data pool as they are deemed valid data points.

3. Conclusion

This study analyzes the daily PM_{10}, NO_2, O_3 and SO_2 concentrations collected in the city of Adana by the Ministry of Environment and Urbanization during January 1 – June 30 period in 2020 to investigate the impact of COVID-19 control measures on the air quality levels observed in the city. The concentration levels in 2020 were also compared to the levels observed in 2018 and 2019 to see if there was any change in air pollution levels from one year to the next. While large reduction in air pollution levels were recorded in some parts of the world, the COVID-19 control measures didn't seem to have a major impact on the reduction of air pollution in Adana. Although some decrease in concentration levels in all pollutants other than O_3 was observed from first period to the second and somewhat on the third period, these decreases in concentration levels were not substantial enough to conclude that COVID-19 control measures played a major role in general air pollution levels in Adana. The increase in O_3 concentration from the first period to the second could be partially attributed to the increase in air temperature in the spring and especially due to Mediterranean climate at this time of the year. On the other hand, a steady decrease in concentration levels on all these five pollutants examined is seen from one year to the next. Some large spikes in all concentration data other than NO_2 is also seen. While some of these outliers such as those seen in in PM10 data within the first period of 2018 may have some real reasons for their occurrences, others may be due to some instrument errors or due to environmental factors. However, the entire data were used in the analysis carried here without removing any data points with the assumption that the data passed the quality control by the data provider.

Acknowledgements

I would like to thank the Ministry of Environment and Urbanization for providing the ambient air quality data collected within the city of Adana to conduct this study.

References:

Adana'nın Coğrafi Konumu, n.d. : http://adana.cu.edu.tr/cografya.asp.

Baldasano, J. M. (n.d.). COVID-19 lockdown effects on air quality by NO2 in the cities of Barcelona and Madrid (Spain). Science of the Total Environment, 741. https://0-doi-org.divit.library.itu.edu.tr/10.1016/j.scitotenv.2020.140353

Berman, J. D. And K. Ebisu, 2020: Changes in U.S. air pollution during the COVID-19 pandemic. Science of the Total Environment. 739, 139864.

Covid-19,2020: https://www.who.int/emergencies/diseases/novel-coronavirus-2019.

,000000000000000000000Çevre ve Şehircilik Bakanlığı internet sitesi (https://www.havaizleme.gov.tr, 2020).

EPA-1: https://www.epa.gov/no2-pollution/basic-information-about-no2.

EPA-2: https://www.epa.gov/so2-pollution/sulfur-dioxide-basics.

Flu,1918: https://www.cdc.gov/flu/pandemic-resources/1918-pandemic-h1n1.html

Weather monitoring, 2020: https://www.adana.csb.gov.tr/

Griffith, S. M., W.-S. Huang, W.-S. Huang, C.-C. Lin, Y.-C. Chen, K.-E. Chang, T.-H. Lin, S.-H. Wang and N.-H. Lin, 2020: Long-range air pollution transport in East Asia during the first week of the COVID-19 lockdown in China. Science of the Total Environment, 741, 140214. 10 pages.

He, G., Y. Pan and T. Tanaka, 2020: The short-term impacts of COVID-19 lockdown on urban air pollution in China. Nature Sustainaility. https://doi.org/10.1038/s41893-020-0581-y.

Kan, H., B. Chen and C. Hong, 2009: Health Impact of Outdoor Air Pollution in China: Current Knowledge and Future Research Needs. Env. Health Perspect. 117(5). A187.

Liu, W., Z. Xu and T. Yang, 2018: Health Effects of Air Pollution in China. Int. J. Of Env. Res. and Public Health, 15, 1471.

Toros, H., S. Bagis, 2017: Hava Kirlilik Modellerinde Kullanılacak Emisyon Envanteri Oluşturulması için Yaklaşımlar ve İstanbul Hava Kirliliği Dağılımı Őrneği. Çukurova Üniversitesi Mühendislik-Mimarlık Fakültesi Dergisi, 32, 2, 1 - 12

He,G., Y. Pan and T. Tonaka, 2020: The short-term impacts of COVID-19 lockdown on urban air pollution in China. Nat Sustain, https://doi.org/10.1038/s41893-020-0581-y

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İstanbul Baraj Doluluk Oranlarının Zamansal İncelenmesi ve Çözüm Önerileri

Ferhat Yılmaz[1*], İsmail Ulusoy [2], Hüseyin Toros [3]

[1] Sorumlu yazar: Department of Earth Sciences, University College London, Gower Street, London, UK, ferhat.yilmaz@ucl.ac.uk
[2] Ennotes Hava Kalitesi Yönetim Hizmetleri, Ankara, Türkiye, ismail@ennotes.com.tr
[3]Meteoroloji Mühendisliği Bölümü, Uçak ve Uzay Bilimleri Fakültesi, İstanbul Teknik Üniversitesi, İstanbul, Türkiye, toros@itu.edu.tr

Özet

Bu çalışmada, İstanbul iline temiz su sağlayan barajların doluluk oranlarının 2005 yılından itibaren günlük verileri zamansal olarak analiz edilmiş ve su tasarrufu sağlayacak yöntemler önerilmiştir. Baraj doluluk oranlarının değişimine aylık, mevsimsel ve yıllık olarak bakıldığında 2007, 2008, 2014 ve 2020 yıllarının kurak geçtiği, aylık ortalamaların 2011, 2013, 2019 ve 2020 yıllarının ilkbahar aylarında başlayan düşüşün bahsi geçen yıllar içerisinde tekrar artışa geçmediği tespit edilmiştir. Ayrıca baraj doluluk oranlarının tekrar kazanımının iki ay sonrasına kadar ötelendiği de görülmektedir. Çalışma kapsamında genel hatları verilen su tasarrufu yöntemlerinin etkin uygulanması durumunda su kaynaklarının sürdürülebilir kullanımı ve kuraklık dönemlerinde suyun verimli kullanımı sağlanabilecektir. Özellikle yaşanan Covid-19 salgın hastalığı sürecinde temizlik için artan el yıkama davranışı ve çalışma kısıtlaması sebebiyle su tüketiminin artışı ve azalışı net ilişkilendirilememiştir. Sadece elleri sabunlarken musluğun kapalı olması ile İstanbul ilinde günlük yaklaşık 150 milyon litre su tasarrufu sağlanabileceği hesaplanmıştır. Ayrıca ileride yapılacak olan yağmur sularının aktif kullanımı ve evsel-endüstriyel su kullanım analizleri ile su kaynaklarının etkin ve sürdürülebilir kullanımı sağlanabilir.

Anahtar Kelimeler: *Baraj doluluk oranları, İstanbul barajları, kuraklık, su kıtlığı*

Temporal Analysis of Istanbul Water Reservoir Levels and Suggestions for Solution

Abstract

In this study, daily data sets of water reservoir levels in İstanbul since 2005 have been analysed and some suggestions for saving water have been given. When looking at the monthly, seasonally, and yearly reservoirs levels, it is seen that the years of 2007, 2008, 2014, and 2020 were the driest years, and that monthly averages in 2011, 2013, 2019, and 2020 did not increase again throughout the year after the decrease starting from the spring months. It is also seen that the recovery of reservoir levels at the beginning of the year has been delayed up to two months. With the suggestions for saving water, it could be possible to achieve sustainable use of water resources and efficient water usage in drought periods. Especially, during the Covid-19 pandemic, water consumption with the increased hand washing for hygiene could not be associated with the increase and decrease of water consumption with restrictions on workplaces. In addition, it is calculated that daily 150 million litres of water could be saved per day in İstanbul by turning off the taps while soaping hands. With the help of active rainwater usage, and domestic-industrial water usage analyses in the future, efficient and sustainable usage of water resources could be achieved.

Keywords: *Water reservoir levels, İstanbul reservoirs, drought, water scarcity*

1. Giriş

Yağış üzerindeki iklim değişikliğinin etkileri ve artan su talebi dünya genelinde su risklerini arttırmıştır. Su kıtlığı insanlık için 21.yüzyıldaki en önemli sorunlardan birisi haline gelmiştir (Locosselli et al., 2020). Tatlı suyun mevcudiyeti, insanların hayatta kalması ve ulusların ekonomik kalkınması için temel bir ön koşuldur (Gao et al., 2019). Artan nüfus, sanayileşme, sulamaya olan bağımlılık, altyapı eksiklikleri, yüksek yağış ve deşarj değişkenliği nedeniyle; su kaynaklarının kıtlığı dünyanın pek çok bölgesinde yaygındır ve daha şiddetli olması beklenmektedir (Shu et al., 2020). Barajların, göllerin, nehirlerin su seviyeleri ve depolama kapasitelerinin devamlı izlenmesi, su kaynaklarının etkili bir şekilde kullanılmasında çok önemlidir (Thakur et al., 2020). Baraj ve göllerdeki su seviyesindeki değişimin, insan aktiviteleri ve iklim değişikliğinin bölgesel su kaynakları üzerindeki etkisini doğru bir şekilde yansıttığı görülmektedir (Ye et al., 2017). Bu izlenim ise su kaynaklarının etkin yönetimi ve sektörel tahsis ile iklim değişikliğinin etkilerinin daha iyi anlaşılması açısından önemlidir (Shu et al., 2020).

Beş farklı küresel sıcaklık veri setine dayalı olarak, 2020 yılının kayıtlardaki en sıcak üç yıldan birisi olacağı ve ortalama sıcaklığın 1850-1900 dönemine göre 1,2 °C artacağı tahmin edilmiştir (WMO, 2020). Türkiye'de bu beklenti, 2020 yılı ortalama sıcaklığı 14,9 °C olarak, 1981-2010 yılı ortalamasının (13,5 °C) 1,4 °C üzerinde gerçekleşmiş, 1971'den itibaren gerçekleşen en sıcak üçüncü yıl olmuştur. Yağış konusunda 2020 yılı aylık yağışları Şubat, Mart, Nisan, Mayıs ve Haziran aylarında normallerin üzerinde diğer aylarda normallerin altında gerçekleşmiştir (MGM, 2021).

Bu çalışmada İstanbul ilinde bulunan barajların 2005 yılından itibaren su seviyeleri incelenerek, zamansal analizi yapılmış ve gelecekte beklenen olası kuraklıklara karşı çözüm önerileri sunulmuştur.

2. Metodoloji

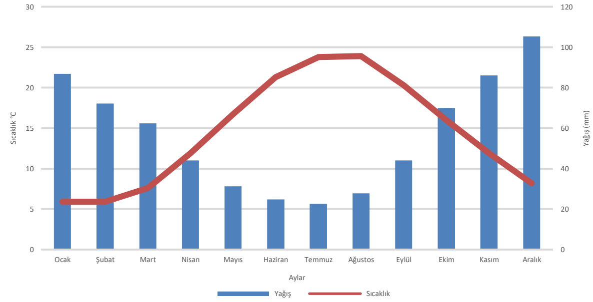
Çalışmada kullanılan barajların doluluk oranları İstanbul Su ve Kanalizasyon İdaresi (İSKİ)'den alınmıştır. Elde edilen veriler aylık, yıllık ve mevsimsel olarak uzun yıllar yağış ve sıcaklık değerleri ile analiz edilmiştir. Aylık ortalama baraj doluluk oranları Python ile yıllara göre görselleştirilmiştir. İstanbul ilinde bulunan ve baraj doluluk oranları hesabına katılan barajlar ve su kaynakları Tablo 1'de verilmiştir.

Tablo 1. İstanbul ili su kaynaklarının yıllık verimleri, azami biriktirme hacimleri ve hizmete giriş yılları

Su Kaynağı	Yıllık Verim (Milyon m^3)	Azami Biriktirme Hacmi (Milyon m^3)	Hizmete Giriş Yılı
Ömerli Barajı	220	235.371	1972
Darlık Barajı	97	107.5	1989
Elmalı 1 ve 2 Barajları	15	9.6	1893-1950
Terkos Barajı	142	162.241	1883
Alibeyköy Barajı	36	34.143	1972
Büyükçekmece Barajı	100	148.943	1989
Sazlıdere Barajı	55	88.73	1998
Istrancalar (Düzdere Barajı, Kuzuludere Barajı, Büyükdere Barajı, Sultanbahçedere Barajı, Elmalıdere Barajı)	75	6.231	1995-1997
Kazandere Barajı	100	17.424	1997
Pabuçdere Barajı	60	58.5	2000
Yeşilçay Regülatörü	145		2004
Melen 1 ve 2 Regülatörleri	575		2007-2014
Yeşilvadi Regülatörü	10		1992
Şile Keson Kuyuları	30		1996
Toplam	**1 Milyar 660 Milyon m^3/Yıl**	**868.683**	

3. Sonuçlar ve Tartışma

İstanbul için Meteoroloji Genel Müdürlüğü verilerine göre uzun yıllar yıllık toplam yağış değeri 677 mm'dir (MGM, 2020). İl genelinde ise yağışların önemli ölçüde Ekim ve Mart ayları arasında yoğun olduğu görülmektedir (Şekil 1). Bu durum, baraj doluluk oranlarının barajlara gelecek fazla yağışla birlikte artacağı dönemleri göstermektedir. Ayrıca ortalama sıcaklığın yaz aylarında yaklaşık 24 °C, kış aylarında ise 5-10 °C arasında değiştiği görülmektedir.



Şekil 1.İstanbul ili uzun yıllar (1929 – 2019) aylık sıcaklık ve yağış ortalamaları.

3.1 Baraj doluluk oranları

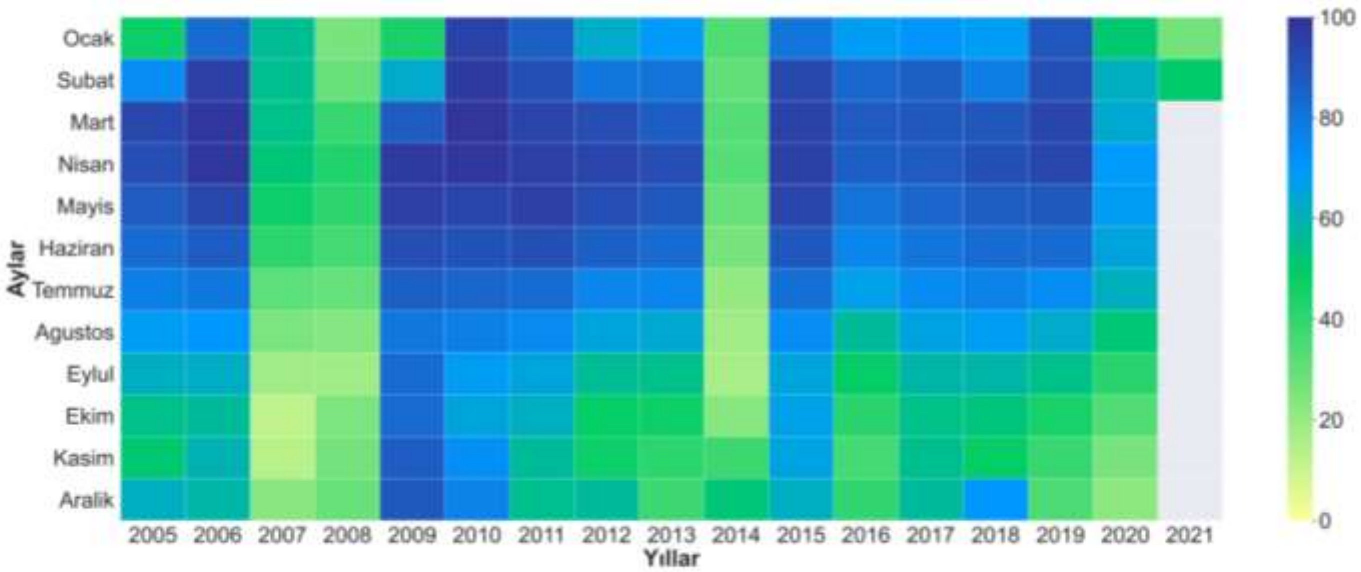
2005 yılından itibaren İstanbul ili aylık baraj doluluk oranlarının yıllara göre değişimi Şekil 2 (a)'da gösterilmiştir. Görüleceği üzere baraj doluluk oranları kış ve ilkbahar aylarında en yüksek seviyeye ulaşırken, yaz aylarında su tüketimi barajlara gelen yağış miktarını geçerek düşük seviyelere gerilemektedir.

Aynı zamanda 2007, 2008 ve 2014 yıllarında İstanbul ilinde meydana gelen kuraklık sebebiyle baraj doluluk oranlarında önemli ölçüde azalma olduğu tespit edilmiştir. Bu durum Şekil 2 (b)'de net bir şekilde görünmektedir. Uzun yıllar verilerine göre 2020 yılı nispeten kurak geçmiş ve en yüksek doluluk oranı (yüzde 69) Nisan ayında görülmüştür.

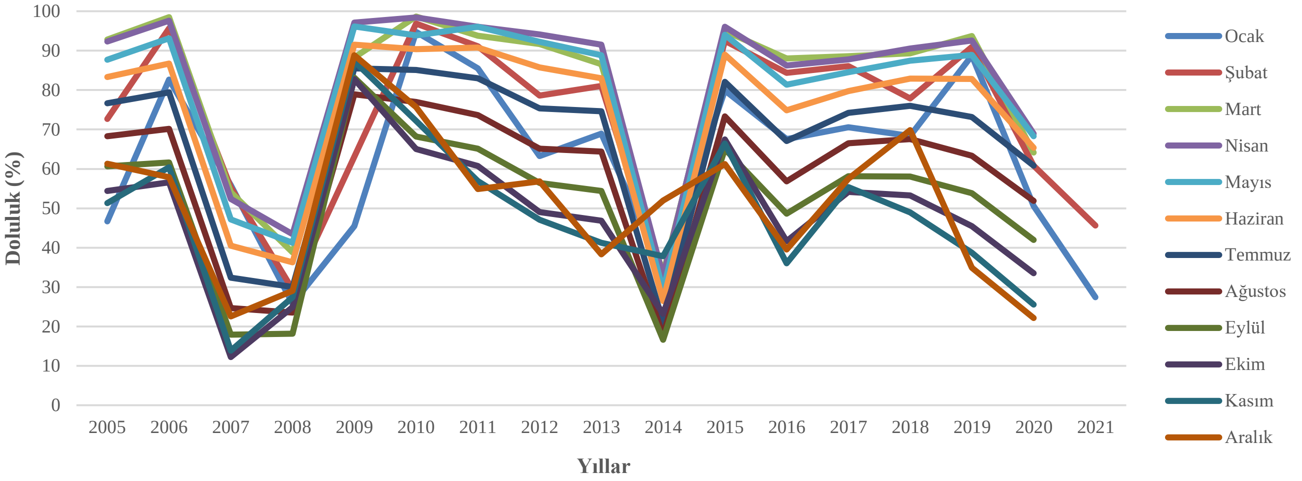
20 Şubat 2021 tarihi itibari ile barajlardaki doluluk oranı yüzde 50,03'tür. Bu oran 2008 yılında 30,4 ve 2014 yılında ise yüzde 30,34'dür. Bu oran son 16 yıldaki en düşük üçüncü seviyesinde olup, 2021 yılı Ocak ayı ortalaması ise son 16 yılın en düşük ikinci seviyesidir. (Tablo 2)

Tablo 2. Karşılaştırmalı Ocak ayı ortalama baraj doluluk yüzde oranı

Kasım 2020	Aralık 2020	Ocak 2021	En Düşük Ocak 2008	Ocak 2020	2021-2020 Ocak Farkı
26	22	27	26	51	24



Şekil 2 (a). Aylık baraj doluluk oranların yıllara göre değişiminin Seaborn grafiği.

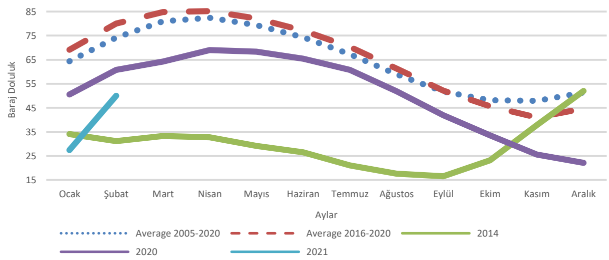


Şekil 2 (b). Aylık baraj doluluk oranların yıllara göre değişiminin Çizgi grafiği.

Ek olarak, barajlardaki doluluk oranlarının düştüğü tarihten yılsonuna doğru artan yağışlarla birlikte oranların artması beklenmektedir. Ancak 2011, 2013, 2019 ve 2020 yıllarının ilkbahar aylarında başlayan düşüşler, yıl boyunca tekrar yükselişe geçememiştir. Özellikle son iki yılın bu şekilde yıl sonu itibari ile düşen oranlarının artışa geçmemesi, İstanbulluların su tasarrufu gibi sıkı önlem ve tedbirler alması gerekliliğinin göstergesidir.

2007, 2008, 2014 ve 2020 yıllarında meydana gelen kuraklık ile kısıtlı dönem verileri, kuraklıkların 6-7 yıllık dönemlerde İstanbul'da etkili olduğu görülmektedir.

Son 5 ve 15 yıllık ortalama doluluk oranlarını karşılaştırdığımızda, son 5 yılın Ocak ve Eylül ayları arasındaki ortalamanın, son 15 yıla göre daha yüksek olduğu ancak Ekim, Kasım ve Aralık aylarında düşük olduğu görülmektedir (Şekil 3). Bu durum, baraj tekrar kazanım durumlarının geçmiş yıllara göre yakın dönemde iki aya kadar ötelendiğini göstermektedir. 2021 yılı Ocak ve Şubat ayına bakıldığında, uzun yıllar ortalamasının 2020 yılına göre daha düşük seviyede kaldığı görülmektedir.



Şekil 3. Yıllık ve ortalama baraj doluluk oranlarının aylara göre değişimi.

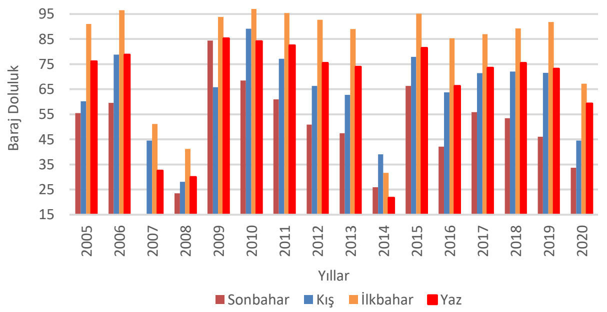
Tablo 2. Aylık baraj doluluk oran farklarının yıllara göre değişimi

Zaman	Ocak	Şıbat	Mart	Nisan	Mayıs	Haziran	Temmuz	Ağustos	Eylül	Ekim	Kasım	Aralık
2005	11.66	24.95	11.96	-4.18	-3.70	-6.19	-7.03	-8.24	-5.46	-6.56	2.93	17.93
2006	15.43	9.08	0.33	-2.66	-5.84	-6.02	-8.34	-9.07	-5.31	-5.57	3.63	-2.68
2007	-1.49	-0.34	-0.79	-4.31	-5.27	-7.55	-7.69	-6.88	-6.11	-4.73	7.92	8.25
2008	-0.53	9.92	7.77	-0.50	-3.75	-5.44	-5.96	-7.15	5.75	3.02	-0.49	6.18
2009	15.99	27.35	17.66	0.09	-2.76	-5.32	-6.18	-6.81	9.70	-4.12	0.23	6.01
2010	5.13	0.02	1.28	-1.82	-5.96	-2.86	-6.06	-9.50	-7.30	10.21	-3.28	12.74
2011	5.94	2.46	1.47	3.09	-3.49	-6.18	-9.02	-8.63	-7.92	-1.07	-5.16	6.14
2012	6.36	21.36	3.31	2.53	-4.29	-9.04	-10.34	-9.09	-8.14	-2.95	-3.84	17.95
2013	12.98	7.16	6.25	0.43	-5.48	-5.69	-9.91	-10.41	-8.55	-5.84	-3.80	-3.44
2014	-2.96	-3.61	5.51	-4.60	-3.35	-2.89	-4.77	-3.10	7.08	9.79	10.11	15.52
2015	19.53	9.81	-1.50	0.79	-3.12	-6.09	-7.60	-8.86	-2.16	2.76	-5.30	-5.30
2016	17.02	11.27	0.60	-3.34	-5.74	-6.39	-9.35	-8.94	-7.06	-7.05	-1.67	14.07
2017	32.44	3.12	1.05	-2.02	-4.73	-3.83	-6.46	-8.01	-8.03	0.91	-1.98	9.05
2018	9.81	8.91	5.13	-1.68	-2.52	-5.65	-7.26	-10.45	-6.78	-5.01	4.80	25.19
2019	8.59	2.29	0.85	-2.47	-4.40	-7.83	-9.67	-9.06	-9.54	-7.21	-5.98	1.39
2020	19.00	6.40	0.78	3.97	-1.69	-1.83	ND	ND	ND	ND	ND	-4.21
2021	20.26	ND										

Tablo 2'de görüldüğü üzere ay sonu ve başındaki doluluk oranlarının farkı Nisan ve Mayıs aylarında eksi seviyelere inmeye başlarken, Kasım ayında yağışların artmaya başlaması ile birlikte gözle görülür bir artış meydana gelmiştir. Tabloda görülen ND (No Data) değerleri günlük verilerdeki eksikliklerden dolayı kaynaklanmış ve o aylar için ay farkları hesaplanamamıştır.

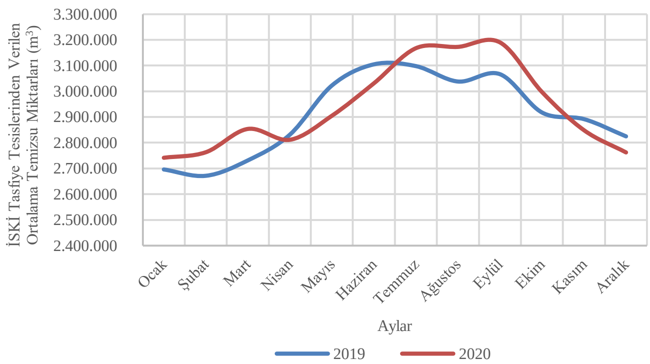
Şekil 4, baraj doluluk oranlarının mevsimsel dağılımının yıllara göre değişimini göstermektedir. Doluluk geri kazanım aylarının ötelendiği, ilkbahar ve kış ayları arasındaki farkın son yıllarda açıldığı ve ilkbahar aylarında daha çok yağış alarak oranların arttığı görülmektedir.

2014 yılında meydana gelen kuraklıkta 2005 yılından itibaren ilk defa kış aylarındaki oranların ilkbahar değerlerinden daha yüksek olduğu görülmüştür. Bu durumda yaz aylarında azalan yağış ile barajlarda düşüşün başlaması İstanbul için su sıkıntısına sebep olmuştur.



Şekil 4. Mevsimsel baraj doluluk oranlarının yıllara göre değişimi.

İSKİ tasfiye tesislerinden verilen günlük ortalama temiz su miktarları (m^3) olarak 2019 ve 2020 aylık değişimleri verilmiştir (Şekil 5). Salgın hastalık çerçevesinde yoğun tedbirlerin alındığı 2020 yılının Nisan, Mayıs, Kasım ve Aralık aylarında su tüketiminin, aynı ayların 2019 yılına göre daha az olduğu görülmektedir.



Şekil 5. İSKİ tasfiye tesislerinden verilen günlük ortalama temiz su miktarları (m^3)

3.2 Su tasarrufu

İstanbul ilinde görülen belirli dönemlerdeki kuraklıkların ve iklim değişikliğinin etkisi ile azalması beklenen yağış miktarı göz önüne alındığında, su tasarrufunun ne kadar önemli olduğu daha iyi anlaşılmaktadır. Bu durum göz önüne alındığında etkin su tasarrufu yöntemlerinin uygulanması önem arz etmektedir. Bu yöntemler genel hatları ile aşağıda değerlendirildiği gibidir;

- Şebeke veya bina içerisinde su kaçaklarını azaltılması,
- Kademeli ücretlendirme sisteminin yaygınlaştırılması,
- Ekonomik musluk başlığı kullanılması,
- Yağmur hasadının yapılması,
- Etrafı açık olan ağaç yalakları ile cadde ve sokak sularının yalakta biriktirilmesi ve bitkilerin daha fazla su alması sağlanarak, yer altı suyunun daha fazla beslenmesi,
- Salgın döneminde ellerin en az 20 saniye yıkanması gerektiği tavsiye edildiğinden, ellerin sabunlanması sırasında muslukların kapalı olması,
- Diş fırçalanırken ve tıraş olurken musluğun kapalı olması,
- Duş kullanımlarında musluk açıldığında gelen soğuk suyu depolayarak temizlik veya bahçe sulama gibi farklı alanlarda kullanılması,
- Çamaşır ve bulaşık makinelerini dolu veya doluya yakın iken çalıştırılması,
- Sebze ve meyve yıkarken akan musluk altında yıkamak yerine bir kap içerisinde bekletilerek durulama yapılıp, kalan suyun bitkileri sulamada kullanılması,
- Banyo ve tuvalet tadilatlarında yeni tip kademeli sifon tercih edilmesi veya mevcut sifon içerisine 1 litrelik su dolu pet şişe konularak tasarruf edilmesi,
- Bahçe sulamada havanın az rüzgârlı, soğuk ve nemin yüksek olduğu dönemlerin seçilmesi,
- Bahçe sulamada damlama ve sızma gibi sistemlerin kullanılması,
- Apartman veya daire girişlerinde sabit basınç ayarlayıcı vanalar ile su akış dengesinin sağlanması.

4. Tartışma ve Öneriler

Son iki yılda yıl içerisinde doluluk oranlarındaki düşüşün yıl boyunca devam etmesi ve yıl sonuna doğru artışın olmaması, ilerisi için daha sıkı tedbir alınması gerektiğini göstermektedir.

Şekil 2'de görüleceği gibi barajlardaki durumun yöneticiler ve çeşitli kurumlar tarafından daha dikkat çekici bir şekilde görselleştirilmesi ile halk arasında farkındalık oluşturulabilir, gerekli önlem ve tedbirlerin daha kolay alınması sağlanabilir.

Su tasarrufu konusunda alınacak tedbirler, gelecekte su kaynakların daha yeterli seviyelerde kalmasını sağlayacaktır. El yıkama sırasında muslukların 20 saniye boyunca açık kullanılması durumunda 2-3 litre su harcanırken, bu süre boyunca kapalı kalması halinde 100-200 mililitre su kullanımı olacaktır. Yaklaşık 15 milyonluk nüfusun bu şekilde günde 10 defa el yıkama sırasında musluklarını kapalı tutması halinde ise günlük 150 milyon litre su tasarrufu sağlanabilecektir.

Ek olarak, yıllık toplam yağışın 677 milimetre olduğu İstanbul ilinde bulunan işyerleri için yağmur hasadı işyeri kurulu alanların büyüklüğü dolayısıyla önem arz etmektedir. Örneğin, bir işyeri 1000 m^2'lik alanda kurulu ise, yağmur su bütçesi yıllık ortalama 677 ton olacaktır. Yüzde 50 kayıp kaçak oranı ile hesaplandığında bu işyeri kendi imkanları ile yılda 338 ton suyunu elde edebilir. Bu durumda ise, İSKİ içme suyu olarak 338 ton suyu arıtmayacak ve su taşıma maliyetine girmemiş olacaktır.

Su kaynaklarının azaldığı ve yağışların öneminin arttığı bu dönemde, yağmur suyu depolama (yağmur hasadı) ve aktif kullanımı konusunda yapılacak çalışmalar, su ihtiyacındaki sorunları ortadan kaldırmaya yönelik daha sürdürülebilir bir yaklaşım sağlayacaktır. Evsel ve endüstriyel su kullanımı analizi ile su kaynakları üzerindeki baskı belirlenerek su kaynaklarının etkin ve sürdürülebilir kullanımı sağlanmalıdır. Son olarak baraj doluluk oranlarının yüzde yüz olduğu durumda dahi suyun verimli ve idareli kullanılması konusundaki duyarlılık devam etmelidir.

Teşekkür

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Kaynakça

Gao, Q., Makhoul, E., Escorihuela, M. J., Zribi, M., Seguí, P. Q., García, P., & Roca, M. (2019). Analysis of retrackers' performances and water level retrieval over the Ebro River basin using sentinel-3. *Remote Sensing*, *11*(6), 1–25. https://doi.org/10.3390/RS11060718

Locosselli, G. M., Brienen, R. J. W., de Souza Martins, V. T., Gloor, E., Boom, A., de Camargo, E. P., Saldiva, P. H. N., & Buckeridge, M. S. (2020). Intra-annual oxygen isotopes in the tree rings record precipitation extremes and water reservoir levels in the Metropolitan Area of São Paulo, Brazil. *Science of the Total Environment*, *743*. https://doi.org/10.1016/j.scitotenv.2020.140798

Meteoroloji Genel Müdürlüğü (MGM). (2020). *İllere Ait Uzun Yıllar Mevsim normalleri*. https://www.mgm.gov.tr/veridegerlendirme/il-ve-ilceler-istatistik.aspx?k=A

Meteoroloji Genel Müdürlüğü (MGM). (2021). *Türkiye 2020 Yılı İklim Değerlendirmesi*.

Shu, S., Liu, H., Beck, R. A., Frappart, F., Korhonen, J., Xu, M., Yang, B., Hinkel, K. M., Huang, Y., & Yu, B. (2020). Analysis of Sentinel-3 SAR altimetry waveform retracking algorithms for deriving temporally consistent water levels over ice-covered lakes. *Remote Sensing of Environment*, *239*(January), 111643. https://doi.org/10.1016/j.rse.2020.111643

Thakur, P. K., Garg, V., Kalura, P., Agrawal, B., Sharma, V., Mohapatra, M., Kalia, M., Aggarwal, S. P., Calmant, S., Ghosh, S., Dhote, P. R., Sharma, R., & Chauhan, P. (2020). Water level status of Indian reservoirs: A synoptic view from altimeter observations. *Advances in Space Research*. https://doi.org/10.1016/j.asr.2020.06.015

World Meteorological Organisation (WMO). (2020). *State of the Global Climate 2020: provisional report*.

Ye, Z., Liu, H., Chen, Y., Shu, S., Wu, Q., & Wang, S. (2017). Analysis of water level variation of lakes and reservoirs in Xinjiang, China using ICESat laser altimetry data (2003–2009). *PLoS ONE*, *12*(9), 1–21. https://doi.org/10.1371/journal.pone.0183800

