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RESEARCH ARTICLE / ARAŞTIRMA MAKALESİ

The Impact of the COVID-19 Pandemic on the Air Quality (PM10) in Şile District of Istanbul, Turkey

COVID-19 pandemisinin İstanbul'un Şile ilçesinde hava kalitesine (PM10) etkisi

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Abstract
The first COVID-19 case in Turkey was approved on March 11, 2020. Based on the rapid spread feature of the COVID-19 pandemic, a partial lockdown was put into practice in the whole of İstanbul for the weekends from March 21st to June 1st, 2020. The application of strict restriction precautions enabled us to decrease the effect of the COVID-19 pandemic on the Turkey National Health System while changing social behaviors. On the other hand, these forced measures provided an opportunity to determine the impact of anthropogenic events on air quality based on controlling pollution levels. The main goal of the present study is to examine the effect of the partial lockdown precautions on the pattern of air quality in the Şile district of İstanbul. The analysis of the air quality was carried out with the aid of air quality data from the monitoring station in Şile that contains PM10 concentration. The results showed an increase of approximately 16.90% in PM10 concentrations in Şile. This was ascribed to the increment of vehicle traffic and human mobility due to the migration from other districts of İstanbul during the COVID-19 outbreak. It is considered that the rural and characteristic properties of the district are among the reasons for taking immigration from the other districts of İstanbul during the COVID-19 outbreak. This study examines the impacts of the psychological behavioral changes and the restrictions related to the pandemic on air pollution.
Keywords: COVID-19, Lockdown, Air quality, PM Concentration, Şile district, Istanbul

Öz
Türkiye'deki ilk COVID-19 vakası 11 Mart 2020'de onaylandı. COVID-19 salgınının hızlı yayılma özelliğine bağlı olarak, 21 Mart - 1 Haziran 2020 tarihleri arasında İstanbul genelinde hafta sonları için kısmi kısıtlama uygulamaya konuldu. Sıkı kısıtlama önlemlerinin uygulanması, sosyal davranışları değiştirirken COVID-19 Türkiye Ulusal Sağlık Sistemi üzerindeki etkisini azaltmayı sağladı. Öte yandan, bu zorunlu önlemler insan kaynaklı olayların havat kalitesi üzerindeki etkisini kirlilik seviyelerini kontrol etmeye bağlı olarak belirleme fırsatı sağladı. Bu çalışmanın temel amacı, kısmi kısıtlama önlemlerinin İstanbul'un Şile ilçesi hava kalitesi üzerine etkisini incelemektir. Hava kalitesi analizi, Şile'deki izleme istasyonunun PM10 konsantrasyonu içeren hava kalitesi verileri yardımıyla gerçekleştirildi. Sonuçlar, Şile'nin PM10 konsantrasyonlarında yaklaşık % 16.90 artış olduğunu gösterdi. Bu, COVID-19 salgını sırasında İstanbul'un diğer ilçelerinden göç nedeniyle araç trafiğinin ve insan hareketliliğinin artmasıyla ilişkilendirildi. İlçenin kırsal karakteristik özelliklerinin COVID-19 salgını sırasında İstanbul'un diğer ilçelerinden göç alma sebepleri arasında olduğu değerlendirilmektedir. Bu çalışma, pandemi ile ilgili psikolojik davranış değişikliklerinin ve kısıtlamaların hava kirliliği üzerindeki etkilerini incelemektedir.
Anahtar Kelimeler: COVID-19, Kısıtlama, Hava kalitesi, PM Konsantrasyonu, Şile ilçesi, İstanbul

I. INTRODUCTION

On March 11, 2020, it was announced that COVID-19 is the worst infectious disease brought by the new coronavirus SARS-CoV-2 at the beginning of the 20th century, both in terms of mobility and mortality(Organization, 2020d). This worldwide outbreak of COVID-19 caused many deaths and cost billions of dollars (Allocati et al., 2016). The World Health Organization (WHO) has reported that COVID-19 has spread rapidly throughout the world, including Asia, Africa, Europe, the Americas, and Oceania, with 1,279,722 confirmed cases and 72,614 deaths as of April 8, 2020 (Medicine, 2020; Organization, 2020b). The COVID-19 disease, which was first detected in China on December 8, 2019 (News, 2020), causes severe respiratory illness in most people and was designated a "pandemic" by the World Health Organization (WHO) on March 12, 2020, due to its rapid spread (Organization, 2020c). To respond to this situation, governments around the world have begun to implement unprecedented public policies such as isolation, social distancing, distance learning, and self-quarantine (Anderson et al., 2020). The comprehensive psychosocial and economic consequences of the COVID-19 pandemic have unprecedented effects worldwide. Millions of people around the world have been asked to stay at home (as-called “lockdowns”).

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The first COVID-19 case in Turkey was announced on March 11, 2020 by the Ministry of Health of the Republic of Turkey. In a few weeks, there are 214.993 verified cases in all regions of Turkey, most of the cases approved in İstanbul (108.749)(Ji et al., 2020; "TÜRKİYE GÜNLÜK KORONAVİRÜS TABLOSU, https://covid19.saglik.gov.tr/, 2020," 2020). These data show that the ratio of confirmed cases in İstanbul to total cases in Turkey is about % 50.6. Therefore, partial closures were imposed by the government throughout İstanbul on weekends from March 21 to June 1, 2020, to reduce the rate of spread of the virus. Stringent measures were also taken after March 15 to encourage millions of people to stay at home. These include switching the education system to online classes, restricting vehicles from entering the country, and enforcing curfews for people under 20 and over 65.

It is known that COVID -19 is more painful than other infectious diseases worldwide and causes fear in many people. Fear and curfews have been shown to impact COVID-19 the environment, as well as reduce displacement and emissions from transportation and industry. In a study conducted in Somerville, Massachusetts, it was found that truck and private vehicle transportation will decrease by 46% and 71%, respectively, between March 27 and May 14, 2020, as people are advised to stay home (Hudda et al., 2020). However, it is acknowledged that reducing displacements and industrial activities can aid in observing the impact of anthropogenic activities on air pollutants in Milan, which is regarded as one of the most polluted cities in Italy and Europe (Carugno et al., 2017; Van Donkelaar et al., 2015). Therefore, the changes in air quality during this closure period may also provide an opportunity to evaluate the impact of anthropogenic events on air pollution in İstanbul in order to control air pollution in the future. COVID-19 can cause fever, cough, and dyspnea as an acute respiratory illness (Jiang et al., 2020). In addition, the cause of death of many COVID -19 patients is associated with cytokine storm syndrome (Guo et al., 2020; Mehta et al., 2020). This syndrome leads to many destructions and even death in the body due to an uncontrolled release of proinflammatory cytokines (Tisoncik et al., 2012). On the other hand, there is evidence that these symptoms also occur due to the effect of long-term exposure to air pollutants (Gan et al., 2012; Le Tertre et al., 2002; Wong et al., 2002). Several epidemiological studies show that long-term and short-term exposure, especially to PM10 (particulate matter with a diameter of 10 μm or less), leads to severe diseases due to accumulation in the respiratory tract (Kim et al., 2003; Schwartz, 1995, 1999; Van Donkelaar et al., 2015). The International Energy Agency (IEA) announced that nearly 6.5 million people die prematurely each year due to air pollution (Huang & Kuo, 2018). The concentration of air pollutants may be related to emissions, road traffic, and population density, which all negatively affect urban regions. The USEPA introduced the Pollutant Standards Index (PSI) to analyze the air quality consisting of pollutants in 1976 (Qian et al., 2004).

The aim of this study is to compare PM10 concentrations before and during partial quarantine and to understand how stress due to low social distance in urban centers and partial quarantine may affect air quality in rural areas adjacent to urban centers during the initial phase of the COVID -19 outbreak. Therefore, Şile was selected as a rural area near the city of İstanbul. To our best knowledge, there is no study investigating air pollution from migration to areas outside urban centers due to the psychological effects of COVID.

II. EXPERIMENTAL

2.1. Air Quality Data Collection and Processing

Şile was one of the most heavily populated areas of the city during the COVID epidemic. The reason for this is that in this area, away from the city center and surrounded by nature, the inhabitants felt safe from the COVID epidemic. Therefore, the sampling site was decided as the Şile district of İstanbul (41° 10' 13"–29° 33' 48"), located in the north-east of the Marmara Region, on the shore of the Black Sea, and has an area of 735 km^2. It is bordered with Kandıra in the east, Derince and Körfez in the southeast, Pendik and Gebze in the south, Çekmeköy in the southwest and Beykoz in the west. According to the census, the population of the district was 37,692, of which 24.26% was the elderly population ("ENDEKSA, https://www.endeksa.com/tr/analiz/istanbul/bahcelievler/sirinevler/demografi," 2020; " T.C. Şehir ve Çevre Bakanlığı, Ulusal Hava Kalitesi İzleme Ağı, Air Quality Monitoring Station," 2018). Its population increases in the summer period, as it is located on the Black Sea coast and is chosen for summer holidays. In addition, the forests that cover approximately 90% of the district are among the reasons for travel during the summer season (Tuzlacı & Tolon, 2000). In this study, the obtained dataset contains concentrations of particulate matter with a diameter of less than 10 μm (PM10) for Şile (Figure 1) were collected from the Republic of Turkey Ministry of Environment and Urbanization, "Air Quality Monitoring Stations" website (" T.C. Şehir ve Çevre Bakanlığı, Ulusal Hava Kalitesi İzleme Ağı, Air Quality Monitoring Station," 2018). The daily mean pollutant concentration ($\mu g \cdot m^{-3}$) was used to determine the relative change (%) for comparing the partial closure period (from March 21, 2020, to June 1, 2020) with the year prior to the partial closure (from March 21, 2019, to June 1, 2019). Prior to performing the data analysis, missing observations were deleted on a daily basis. To exclude seasonal changes in air pollution, the same data as a year ago was selected for the period before the partial closure.

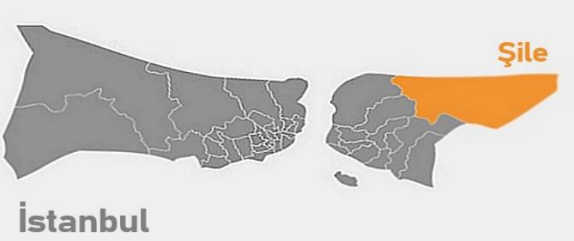

Figure 1. Localization of the Şile district in İstanbul

III. RESULTS

3.1. COVID-19 Outbreak

In addition to the fact that the COVID-19 pandemic causes physical health problems, the environmental effects of the coronavirus should also be taken into account, depending on the psychological health of people and the change in their social lives. For this reason, the number of patients and mortality rates were studied first, as the COVID-19 epidemic increased the anxiety of people in the city center, and they moved to rural areas. This relationship also shows the impact of the COVID-19 pandemic on the environment due to increased road traffic and population density in rural areas.

The first COVID-19 case in Turkey was reported by the Ministry of Health of the Republic of Turkey on March 11, 2020. Within a few weeks, 214,993 cases were confirmed in all regions of Turkey, most of them in Istanbul (108,749) (Ji et al., 2020; "TÜRKİYE GÜNLÜK KORONAVİRÜS TABLOSU, https://covid19.saglik.gov.tr/, 2020," 2020). By July 20, 2020, there were 220,572 confirmed cases and 5508 deaths in Turkey due to COVID-19 (BAKANLIĞI & MÜDÜRLÜĞÜ, 2020). From these results, the ratio of reported cases in İstanbul to total cases in Turkey is about 50.6%. Therefore, the partial lockdown of the whole of İstanbul for the weekends from March 21 to June 1, 2020, was introduced by the government to reduce the rate of spread of the virus. Stringent measures have been taken to keep millions of people at home, such as switching the education system to online classes, restricting the entry of vehicles and enforcing curfews for people under 20 and over 65. To examine the current distribution of the disease throughout the country, the total numbers of cases and deaths were given in Fig.2.

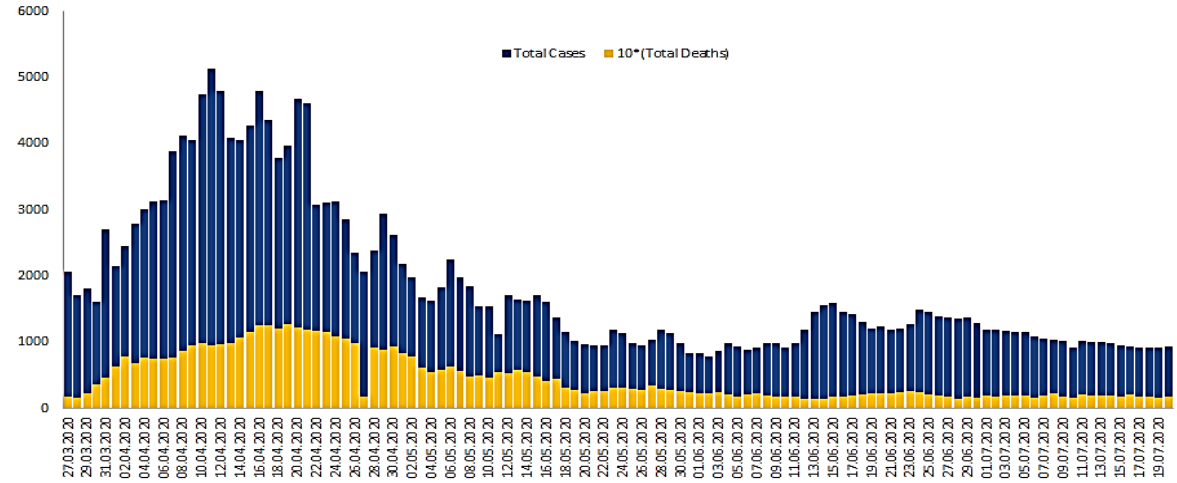

Figure 2. The distribution of COVID-19 cases in Turkey

These figures also show the impact of measures on the outbreak of COVID-19. As shown in Fig.2, the decreasing trend of the number of cases and deaths has been observed since March 15, when the restrictions started. Moreover, Figure 3, showing the relationship between deaths and the number of cases, shows that there is a linear relationship and that the death rate increases as a function of the spread of the disease. Thus, we can conclude that the death rate is lower in rural areas, where there are fewer cases, than in urban centers, where the disease spreads more rapidly.

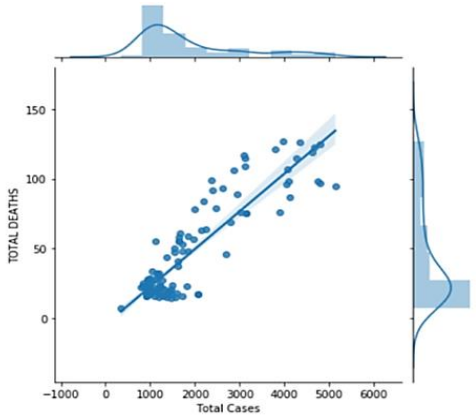

Figure 3. The relationship between total case and death numbers

3.2. Behavioral and Environmental Effects of the COVID-19 Outbreak

Since the beginning of civilization, man has manipulated nature for his own benefit. It is an unavoidable fact that the rapid growth of industrialization and urbanization is affecting air quality. In addition, environmental problems such as climate change, ozone layer depletion and global warming are the result of air pollutants entering urban areas from power plants, road traffic and natural disasters. In recent years, air pollution has been considered an important problem to be addressed.

On the other hand, the suddenness and global scale of the COVID-19 pandemic has raised important issues that require collaborative research to contain the devastation caused by the disease. A global ban on social gatherings has been imposed for a period of several weeks to months as a precautionary measure against SARS-CoV-2. Furthermore, public health authorities, including the World Health Organization (WHO), have made some recommendations to prevent the transmission of COVID-19 outbreaks during social gatherings (Organization, 2020a). In addition to government restrictions, the media and other stakeholders such as doctors and researchers have also urged people to avoid public gatherings such as sporting events or religious ceremonies to prevent the spread of coronavirus infection. Meanwhile, efforts to restrict movement have had critical environmental impacts that are seen as critical to positively impacting people's health status. Although people spend more time indoors during the pandemic period due to personal precautions and/or partial curfews, there are no emissions of toxic particulates and greenhouse gasses, and air quality has improved significantly. Therefore, it is considered that the COVID-19 pandemic has had an unprecedented impact on human civilization worldwide, but also a very positive impact on the environment.

The rapid transmission of the COVID-19 infection also had an impact on social life, and people spent more time at home. Air pollution decreased significantly in urban centers, while it increased in rural districts of cities due to population migration to rural areas. In this study, we observed how air quality changed in Şile during the period beginning with the diagnosis of COVID-19 (March 11–June 28, 2020) and compared it with 2019 air quality data (March 11–June 28, 2019). This provided insight into the impact of fear and panic on people's lifestyles during the pandemic COVID-19. In addition, the impact of the partial curfew on air pollution was analyzed by comparing air pollution concentrations before and during the curfew in Şile. The partial curfew and pre-curfew periods were set to March 21 to June 1, 2020, and March 21 to June 1, 2019, respectively. The experimental results of the Şile (PM10) monitoring stations between March 11, 2020 - June 28, 2020, and March 11, 2019 - June 28, 2019, are shown in Figure 4.

Şile is one of the most sparsely populated districts in Istanbul, with a population of about 40,000, and has very low pollutant emissions compared to other districts due to lower anthropogenic activity. On the other hand, a significant increase in analyzed PM10 pollutant concentrations compared to the pre-pandemic period was observed in the rural Şile district of Istanbul (Table 1). As given in Figure 6, the remarkable increase in PM10 concentration was observed after the first COVID case was confirmed. Particulate matter smaller than 10 m in size is known as PM10, and it can come from a variety of sources, including carbonaceous particles from exhaust emissions or natural or anthropogenic effects.The increment of PM10 concentration in Şile can be due to the migration from other districts of İstanbul with the beginning of the COVID-19 outbreak, and this situation is thought to lead to increased road human mobility within the Şile. This can be observed from the Regional Directorate State Roads Volume Map data as given in Fig. 5 and Fig. 6. According to 2019 data, while the total number of vehicles per day for Şile was 11974, it is seen that this number reached 12800 in 2020. However, lower PM10 concentrations observed in certain periods of 2020 (27 April–7 May and 17 May–1 June) compared to 2019 can be attributed to the impact of civil unrest on economic activities and energy use. These results observed for Şile show us that stress and panic, which started with the diagnosis of COVID-19, have an impact on the lifestyle of the people here. The high rate of the elderly population (24.26%) may have been effective in this case.

If we take a closer look at the daily average data, higher PM10 concentrations are observed in 2020 on April 27-May 2, May 05-May 08, and May 17-June 1, compared to the same dates in 2019. The increasing trend in PM10 concentration observed for both 2019 and 2020 from April to June can be associated with changes in seasonality. Because the existing temperature difference may result in an extra accumulation of pollutant particles in the ground layer of the troposphere (Nidzgorska-Lencewicz & Czarnecka, 2015). Besides this, local transport emission properties such as low wind speed and lack of precipitation are commonly considered to be influential parameters for high PM10 concentration levels (Nidzgorska-Lencewicz & Czarnecka, 2015). As shown in Fig. 7, the average hourly wind speed in Şile demonstrates considerable seasonal alteration throughout the year. Therefore, the changes in PM10 concentration observed for May and June of 2019 can be attributed to the flow of air masses due to changes in macroscale atmospheric circulation properties (Demuzere et al., 2008; Wai & Tanner, 2005). On the other hand, it is understood from previous studies that

an increase in the amount of airborne water vapor leads to an increase in PM10 concentration (Canepari et al., 2013). As a result, the exceedances of the limit PM10 concentration values that occurred in 2019 through April, May, and June can be attributed to the Şile atmosphere's humidity comfort levels. As shown in Fig. 8, Şile district shows significant seasonal variation in the perceived humidity. The period of high humidity in the air throughout the year starts in the spring months and continues until September. The increasing trend in PM10 concentration observed during the last days of April may be related to the comfort levels of Şile.

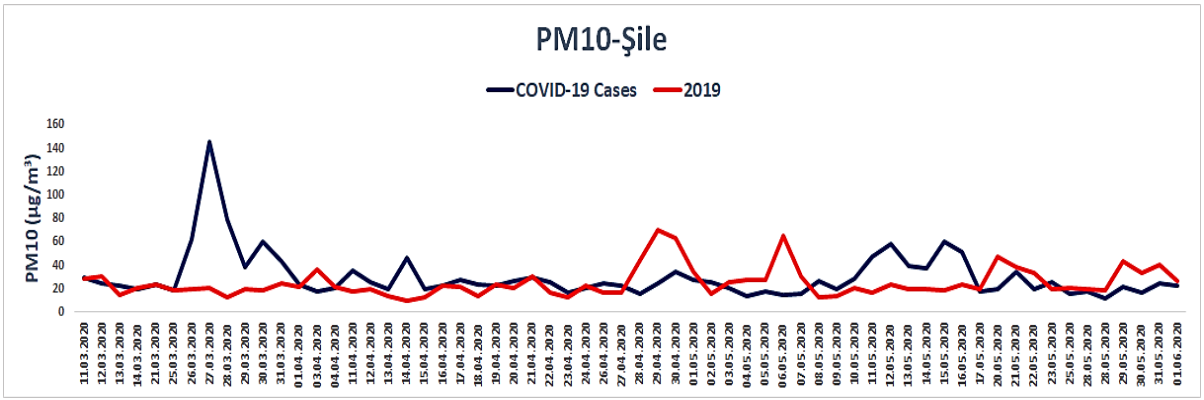

Figure 4. Daily mean concentrations of PM10 (µg·m^3) in in before and duration of COVID-19 pandemic period in Şile

Table 1. Mean concentration and relative change of PM10 in Şile district of İstanbul. Hourly mean for the pandemic period (11 March-1 June 2020) and before COVID-19 (11 March-1 June 2019)

		Mean Concentration (µg/m³) During COVID-19 Pandemic	Mean Concentration (µg/m³) Before COVID-19 Pandemic	Relative Change (%)
Şile	**PM10**	29.94	24.87	16.90

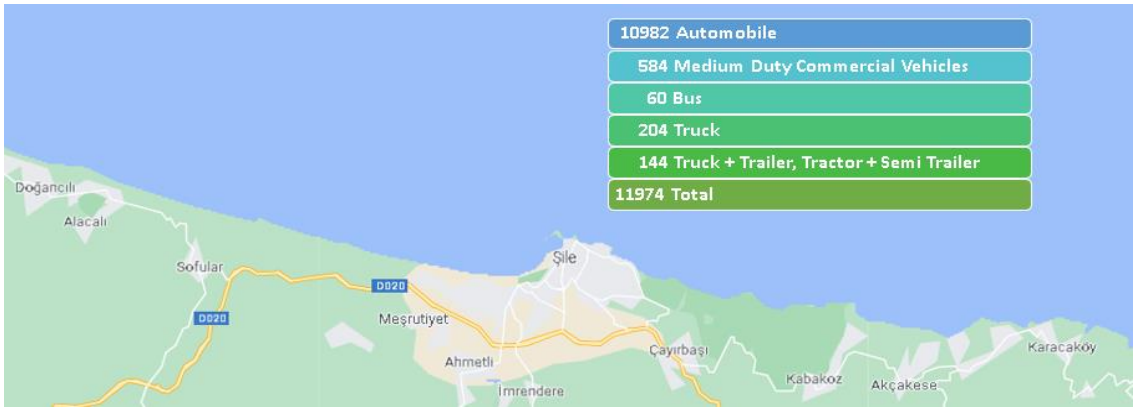

Figure 5. Vehicle density on the D020 highway in 2019 (Müdürlüğü)

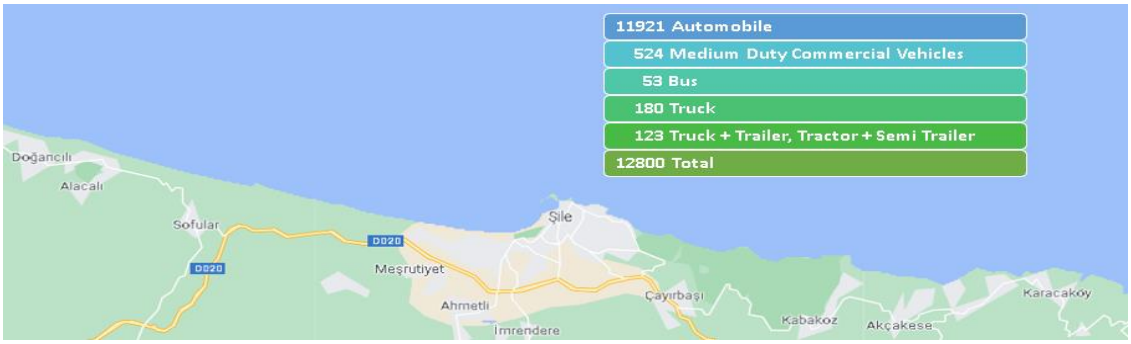

Figure 6. Vehicle density on the D020 highway in 2020 (Müdürlüğü)

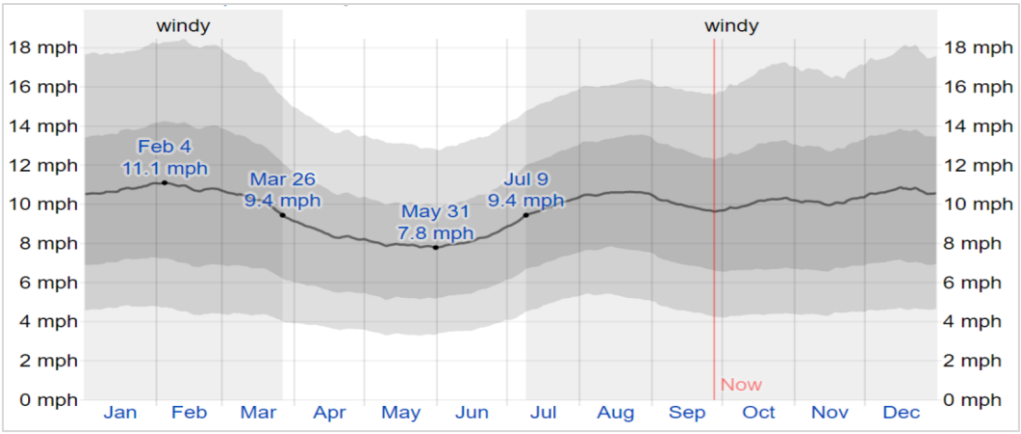

Figure 7. The average of mean hourly wind speeds (dark gray line) in Şile ("Climate and Average Weather Year Round in Şile,")

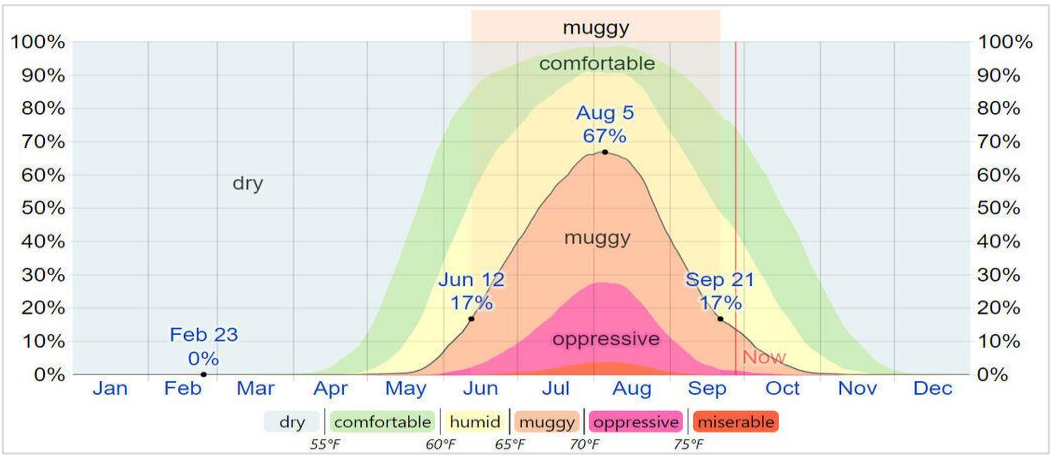

Figure 8. The various humidity comfort levels in Şile, categorized by dew point ("Climate and Average Weather Year Round in Şile,")

IV. CONCLUSION

Şile is one of the districts with the highest population migration before and after the closure during the pandemic, COVID-19. The reason is that in this region, far from the city center and intertwined with nature, people feel safe from the COVID-19 pandemic. Therefore, we studied the relationship between the daily changes of air pollutants in Şile district and the confirmed cases of COVID-19 in Turkey. For this purpose, a time series analysis of average daily air quality levels, COVID-19 case and death rates during the pandemic and partial curfew was studied. The air quality of a district is usually influenced by various factors such as urbanization, vehicle exhaust, traffic, weather conditions, and others. We found a significant association between air quality and the outbreak of COVID-19 in Şile County. The impact of this pandemic was shown in the increasing air pollution (PM10) in Şile district, which is significant because it is known that exposure to PM10 can lead to lung cancer and chronic obstructive pulmonary disease (COPD).

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