# Air Quality Status in Konya City Centre, Konya, Turkey during Pandemic Covid-19

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**Abstract.** High developed industry regions, provincial centers with a heavy traffic and dense populations with cold winters, using low-quality fossil fuel consumption have an effect on quality of life especially for people with respiratory diseases. The air quality data gathered from air monitoring stations for the City Center of Konya, Turkey were analysed statistically during the period when curfew due to the Covid-19 pandemic in 2020. The restrictions that cause the reduction of vehicle exhaust emissions, which are important factors in the formation of some air pollutants, are thought to be effective in improving the air quality as well as meteorological conditions are effective on the days when the air quality is analysed. It is thought that the reduction in HC, NOx, CO and PM emissions, which can be evaluated as exhaust emissions, will be an effective factor due to the restrictions of Covid-19 pandemic. Comparing between the 2019 and 2020 MCO data, we identified that most of the gases decreased with $NO_2$ (-24 µg/m$^3$), $SO_2$ (-24 µg/m$^3$), CO (-37 µg/m$^3$) and an increment of $O_3$ of +50 µg/m$^3$ which indicates that the MCO and restricted of movement were give an impact to air quality levels in Konya City. The increase in $O_3$ values were found by the existing of the sun rays in the atmosphere with the formation of $O_3$ during the clean air period.

## 1. Introduction

Rapid population growth in cities causes many environmental problems including air pollution levels. For this reason, the changes in the air quality should be examined in more detail with its sources and related factors. It is thought that the reduction in HC, $PM_{10}$, $SO_2$, $NO_x$, $O_3$ and CO emissions, which can be evaluated as exhaust emissions, will be an effective factor due to the restrictions of vehicle movements. This conditions should not be neglected; as meteorological conditions are an important parameters in air pollution levels. In addition, atmospheric ozone reduces $NO_x$, CO and HC compounds from the air pollutants by oxidizing them with the reactions it creates some different compounds. Investigation of [1] showed that atmospheric PM levels were increased during winter period and increasing traffic were also evaluated. [2] detected higher level of respirable size of PM capital city Tiran, because of because of heavy and clogged traffic in city centre. [3] also show similar explanation for Istanbul city. As expected, and occurred in other cities, the concentrations of $PM_{10}$ was dramatically

increased during rush hours in the morning and evening which link to human activities especially in urban environments. As well as the emission sources, many factors have effect on environmental pollution [4]. Apart from that, rapid increasing population also increases the need for food production and enhances industrial activities to groom. An analysis of the European Environment Agency (EEA) shows that 45.8 percent of the $NO_x$ emissions in Turkey is the result of energy use and production. The second important source of $NO_x$ is road transport, whose contribution is 35.2 percent. Furthermore, it seems that 62 percent of $SO_2$ emissions comes from energy production and 23.2 percent from use of energy. This means that 85.6 percent of $SO_2$ emissions in Turkey can be attributed to the use and production of energy.

The Covid-19 pandemic is thought to originate from China by human contact with non-domestic animals. The origin of the Covid-19 virus is thought to have spread from the wild animal market in Wuhan, China [5]-[6]. Infectious rates of diseases occur faster than in the past, and the rate of spread increases with increasing human contact. Between the beginning of January 2020 to middle of July 2020 Covid-19 infections were detected in more than 13 million people worldwide, and about 600 thousand people died. According to the [7], there have been 5,313,098 confirmed cases of Covid-19 with 48,524 deaths from 3 January 2020, 11 June 2021 in Turkey. Covid-19 infection first detected activity in Turkey was on March 15, 2020 and the measures taken in Turkey to reduce the impact of Covid-19. The causes and possible consequences of the outbreak have not yet been adequately studied. Since contact is the most important factor in infection, methods should be developed to reduce it. It has become important to understand the impact of the Covid-19 episode on the level of pollutants in this region. This link is to prevent a sustainable environment. Table 1 shows air pollutant standards for the European Union and World Health Organizations and Turkish Air Quality that is controlled by the Ministry of Environment and Urbanization of the Turkish Republic for comparisons.

**Table 1.** Air quality standards for the European Union and World Health Organisation.

| Air Pollutants | European Union Air Quality Standards[a] | WHO Guidelines[b] | Turkish Air Quality Standards (2019)[c] |
|---|---|---|---|
| $PM_{2.5}$ (24-hr mean) | NA | 25 μg/m$^3$ | NA |
| PM $_{2.5}$(Annual) | Limit Value, 25 μg/m$^3$ | 10 μg/m$^3$ | NA |
| $PM_{10}$ (Hourly) | Limit Value, 50 μg/m$^3$ | 50 μg/m$^3$ | 60 μg/m$^3$ |
| $PM_{10}$ (Annual) | Limit Value, 40 μg/m$^3$ | 20 μg/m$^3$ | NA |
| $O_3$ (8-hr mean) | Target Value, 120 μg/m$^3$ | 100 μg/m$^3$ | NA |
| $NO_2$ (Hourly) | Limit Value, 200 μg/m$^3$ | 200 μg/m$^3$ | 250 μg/m$^3$ |
| $NO_2$ (Annual) | Limit Value, 40 μg/m$^3$ | 40 μg/m$^3$ | NA |
| $SO_2$ (Hourly) | Limit Value, 350 μg/m$^3$ | 500 μg/m$^3$ (10 Minutes mean) | NA |
| $SO_2$ (24-hour) | Limit Value, 125 μg/m$^3$ | 20 μg/m$^3$ | 125 μg/m$^3$ |
| CO (1-hr daily mean) | NA | 26 ppm | NA |
| CO (8-hr daily mean) | Limit Value, 10 mg/m$^3$ | 9 ppm | 10 μg/m$^3$ |

[a]EU Air Quality Directive (2008/50/EC)
[b]WHO, 2006, Air Quality Guidelines: Global update 2005.
[c]Air pollution in Istanbul (rvo.nl) (2017)

Many recent studies have explored impacts of the Covid-19 lockdowns or Movement Control Order (MCO) on air quality. The most common approach that has been used to determine a simple statistical analysis that compares air quality before and after the lockdowns began or during the lockdowns with the same periods in previous years [8]-[9]. Study by [10] in Spain also compared the

air quality before and after lockdown started for periods with similar meteorological conditions. While [11] assesses nitrogen dioxide levels by using satellite observations. Similar techniques were used by [12], [13] and [14] that analysed the level of $NO_2$ have also been used to estimate the reduction in column $NO_2$ due to the lockdowns. [15] studied the air quality status during the 2020 Malaysia Movement Control Order (MCO) due to the 2019 novel coronavirus (2019-nCoV) pandemic by comparing $PM_{2.5}$ level. The study revealed that the changes of fine particulate matter ($PM_{2.5}$) at 68 air quality monitoring stations were found that the $PM_{2.5}$ concentrations showed a high reduction of up to 58.4% during the MCO. Several red zone areas (N41 confirmed Covid-19 cases) had also reduced up to 28.3% in the $PM_{2.5}$ concentration variation. Study by [16] in Klang Valley air quality data in Malaysia indicated that there were significant reductions ($p < 0.05$) of $PM_{10}$, $PM_{2.5}$, $NO_2$ and CO during the MCO compared with the same periods in 2019 and 2018. The highest percentage of reduction during the MCO was recorded by $NO_2$ with high percentage of reduction were recorded.

## 2. Materials and Methods

Konya is located in central Anatolia and it has the largest surface area in all the provinces of Turkey (41 thousand $km^2$). Konya is geographically located between 36º 41' and 39º16' north latitudes and 31º41' and 34 º 26' east longitudes (Figure 1). The average height from the sea level is 1016 m and the height, the city center is 1028 m from the level of the sea. As of the 2020 census, Konya population is at 2.25 million people, which constitutes 2.7% of Turkey's population of 84 million. When the comparisons are made in other provinces of Konya, Turkey's 7$^{th}$ largest city. In terms of area it is the largest city of Turkey. The number of people per $km^2$ for Konya metropolitan is 55 people. Due to the fact that the annual average rainfall in Konya city is 320 mm, it made it necessary to carry out dry farming. Because summers are hot and dry in the research area. The steppe climate, which has harsh and snowy winters, is observed. When Konya's long years of data are analysed, the seasonal condition of temperature and precipitation shows a continuous fluctuation according to the years. In the region, these fluctuations have reached extreme values, leading to the development of steppe vegetation. In terms of its land structure, vegetation has the appearance of a plain steppe. Low mountain and high mountain steppe surrounded the plain steppe [17]-[18].

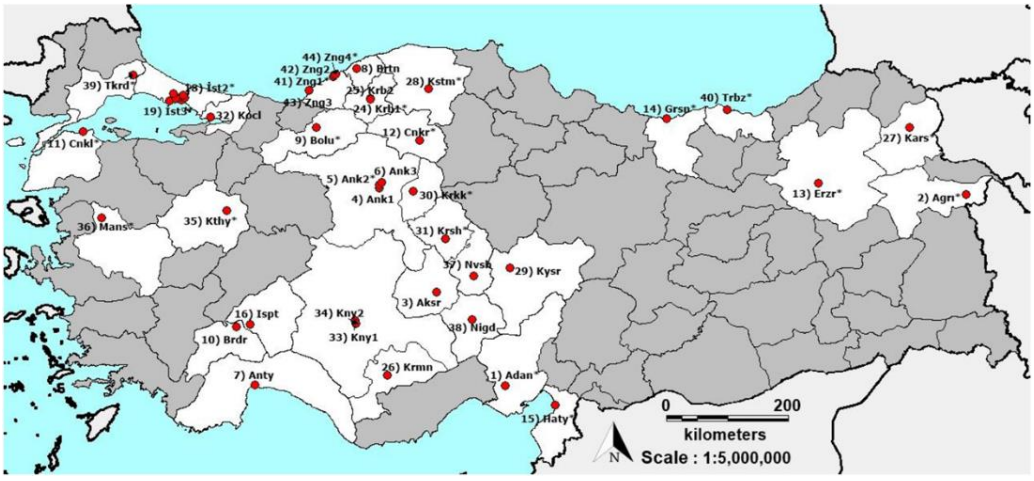


**Figure 1.** Location of the investigation area

Konya province has a closed basin structure and the basin consists of wide plain areas and plateaus. The Taurus Mountains cover the south of the basin and there are high mountains to the west, preventing the moist air of the Mediterranean from coming to the region. Therefore, it has a very arid climate and has an arid feature. With this feature, summer is hot and dry, and winter is cold and snowy.

Konya has less rainfall compared to most provinces in Turkey. Although it is known in Turkey as a grain warehouse development, the change of climate and water resources vary this feature. Industrial areas have developed and are developing in the city centre.

Air quality data of $PM_{10}$, $NO_2$, CO, $SO_2$ and $O_3$ were gathered from four sampling stations of Konya city, via the Ministry of Environment and Urbanization of the Turkish Republic. Data of the research area were divided in two parts that; First Period 1: before the Covid-19 measures were taken to reduce effect of pandemic problem which is between January 1 and March 15 of 2020; and Period 2: after the Covid-19 struggle started in Turkey and Covid-19 measures applied which is between March 16 and April 15 of 2020 and in June for summer time. In addition to hourly data, daily air pollutant data of 01.01.2020-15.06.2020 were compared to see the effect of Covid-19 measures and seasonal effect on pollution parameters. Same season of 2018 and 2019 were also collected and compared between 2020 and earlier data. There are various sampling methods to be used in research. According to the purpose of the research, restrictive conditions such as cost, duration and the characteristics of the audience, the most appropriate among them should be selected. Data analysis covers all the statistical methods required to summarize and evaluate the data collected within the scope of the research. In this study, R-program, an open code statistics program, was used to create the distribution maps of the data.

After the occurrence of the first infection case in Turkey, it was very quickly becoming a measure as a part of the fight against infection with various precautions. In this context, after 16th March 2020, all schools were closed, then online study started in Konya city. Furthermore, mass worship was interrupted in mosques, and quarantine measures were implemented in all metropolitan cities in Turkey. Therefore, the mobility of people has been reduced between the metropolitan cities. Furthermore, the age of 65 and under the age of 20 are forbidden to go out in all the cities of Turkey, and curfew measures were introduced for all age groups of all metropolitan areas during the weekends. And finally, commercial/touristic flights were canceled in many countries where the pandemic infection was widespread. All the restrictions have an impact on mobility and reduced pollutants that are emitted from transportation sectors.

## 3. Results

Investigation region where Konya metropolitan is one of the highly developed industry provinces in Turkey. Provincial living centres also have heavy traffic around settlement roads, and the settlements region has a very cold winter season. When low-quality fossil fuels consumption affects quality of life especially in people with respiratory diseases because of emission of incineration. Air pollution is increasing some days due to specific climatic conditions occurring via the topographic structure of the region. Climatic features of a region are as effective as increasing emission locally in the formation of air pollution. Especially in the winter months, there is an increase in the emission levels as the temperature decreases with increasing fuel usage for heating systems. However, some days of winter period, the negativity caused by meteorological conditions causes lower than expected levels of air quality.

## 4. Descriptive Statistics

Hourly particles, gases, and meteorological data were gathered from the four sampling stations of Konya city, via the Ministry of Environment and Urbanization of the Turkish Republic. All the data measurements were averaged by using a similar averaging time of 1 hour for comparison purposes. Data were gathered and separated by two datasets from 01 January 2020 to 31 December 2020 and were analysed by using a comprehensive packages R Software version 4.1.0 [19] and an Openair packages [20]-[21] and its packages statistically and graphically are summarized in Table 2. Data were also screening processes that involved the deletion of several spur data. Every outlier and extreme value were

analysed by time series plot and the spur value was detected and deleted before further analyses were conducted.

## 5. Temporal Variation of Pollutants

Konya metropolitan is one of the highly developed industry provinces in Turkey. Provincial living centres also have heavy traffic around settlement roads. The settlements region has a very cold winter season that has some effects on concentrations of air pollution here. Other factors such as the topographic structure of the region also influenced the specific climatic condition and surface terrain. Climatic features of a region are as effective as increasing emission locally in the formation of air pollution. Especially in the winter months, there is an increase in the emission levels as the temperature decreases with increasing fuel usage for heating systems. However, some days of winter period, the negativity caused by meteorological conditions causes lower than expected levels of air quality. Four air quality parameters of Konya Erenkoy sampling station are $SO_2$, CO, $NO_2$ and $O_3$ given following figures. They show that $SO_2$, $NO_2$ and CO values significantly decreased and the opposite trend for $O_3$ values which were increased, during the period of Covid-19 outbreak, after March 15, 2020 (Figures 3-6). Figure 3 shows the $SO_2$ concentrations were higher in January and lowered down to10 μg/m³ and after covid-19 outbreak decreased about 5 μg/m³ then turned to normal levels as shown in Table 2. Four air quality parameters of Konya Selcuklu Municipality (Selcuklu Belediye) sampling station are PM10, SO2, CO and $NO_2$, there is no $O_3$ measurement in this station. Results of measurements for 4 pollutant parameters show that $PM_{10}$ and $NO_2$ were initially lowered, but other two parameters, $SO_2$, and CO values were not significantly decreased.

**Table 2**. The summary of descriptive of pollutants during the year 2020.

| Stations | EU Standard (μg/m³) | Selcuklu (mean,max/sd) | Karatay (mean,max/sd) | Meram (mean,max/sd) | Beledye (mean,max/sd) |
|---|---|---|---|---|---|
| $PM_{10}$ (1-hr mean) | 50 | 37.94/678.56/ | 37.41/523.6/39.2 | 31.94/297.5/30.3 | 35.49/387.5/37 |
| $O_3$ 8-hr mean | 120 | NA | 11.9/38.7/14.9 | NA | NA |
| $NO_2$ (1-hr mean) | 200 | 50.00/232/31.3 | 25.0/92.2/15.8 | NA | 37.29/165.1/22 |
| $SO_2$ (1-hr mean) | 350 | 17.1/257.6/21.6 | 11.3/89.6/9 | 11.55/317.4/16 | 10.6/127.80/9 |
| CO (24-hr mean) | 10000 | 780.9/9315/792 | 691.8/15614/1134 | na | 704/8876/849 |

Figure 2-6 shows that $PM_{10}$ and other pollutant levels of four air quality sampling stations were significantly lowered by Covid-19 outbreak period and were increased with Sahara dust affecting periods which is common conditions in this region. Results of atmospheric $PM_{10}$ measurement not only affected the emissions source, but also affected meteorological factors and special situations. Figure 2 shows the $PM_{10}$ values of four different air quality sampling stations in Konya city centre during the first half of 2020 including the period of Covid-19 outbreak. Figure 2 shows that $PM_{10}$ levels of four air quality sampling stations were significantly lowered by Covid-19 outbreak period and were increased with Sahara dust affecting periods then lowered to normal levels again. Results of atmospheric $PM_{10}$ measurement are not only affected by the emissions source, but also affected meteorological factors and special situations. Figure 2- 4 (a and b) illustrates the time series plots for the 1-hour averaged data for $PM_{10}$ for all two stations.

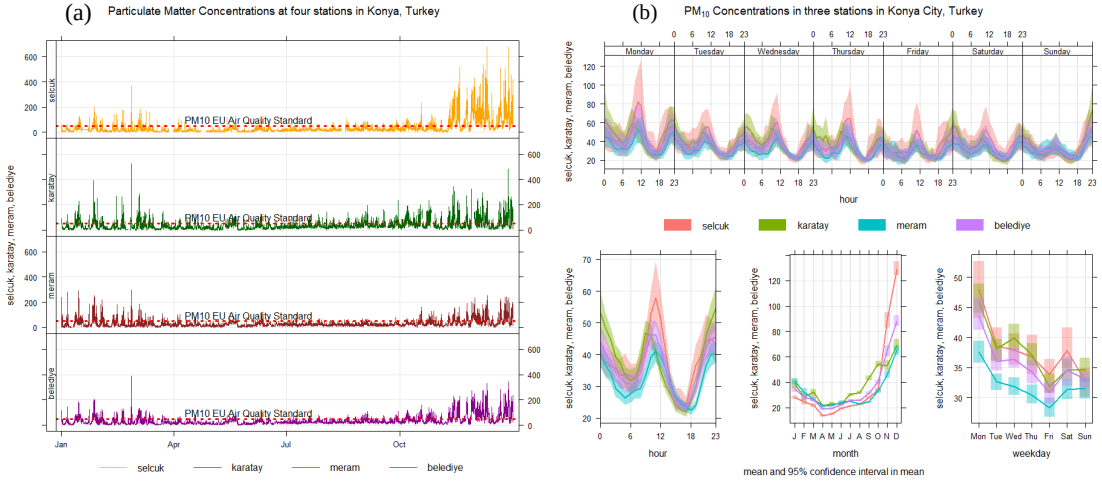


**Figure 2.** (a) TimePlot and (b) Time variation plots for $PM_{10}$ concentrations at four stations in Konya City, Turkey.

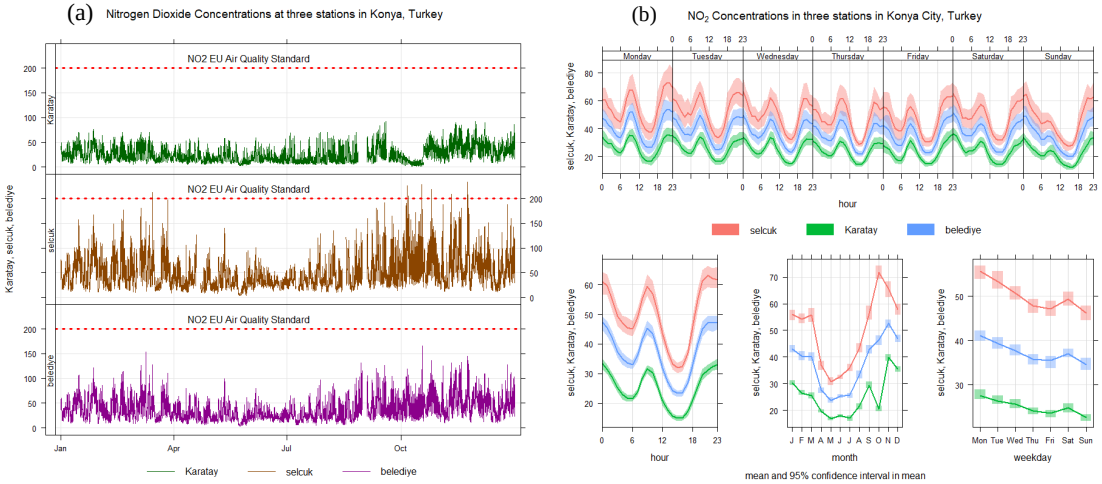


**Figure 3.** (a) TimePlot and (b) Time variation plots for nitrogen dioxides ($NO_2$) concentrations at three stations in Konya City, Turkey.

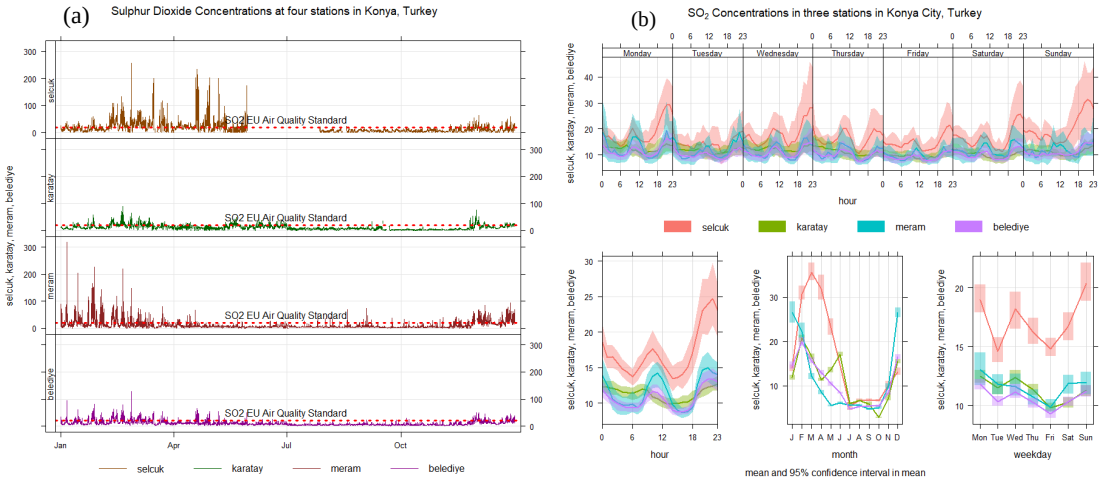


**Figure 4.** (a) TimePlot and (b)Time variation plots for sulphur dioxides ($SO_2$) concentrations at four stations in Konya City, Turkey.

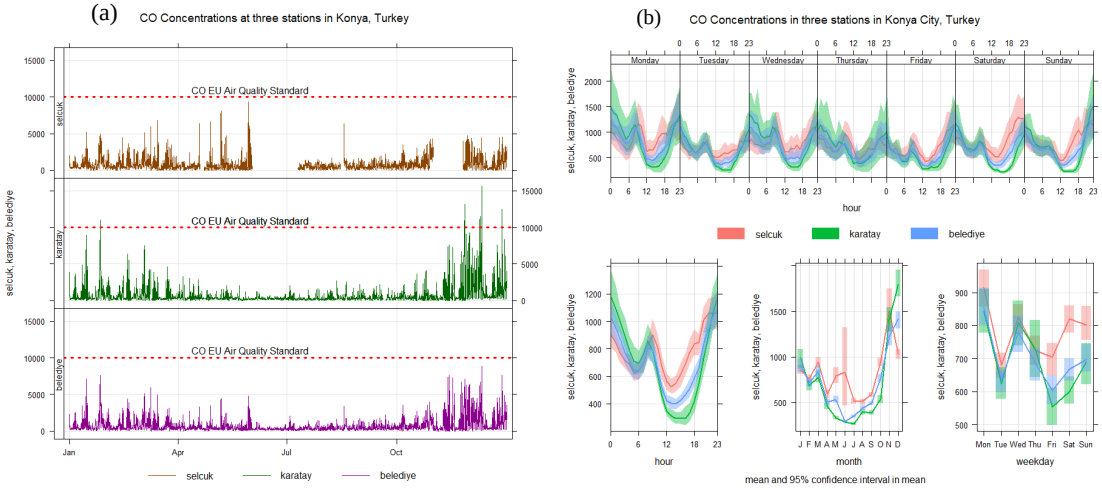


**Figure 5**. (a) TimePlot and (b) Time variation plots for carbon monoxide (CO) concentrations at three stations in Konya City, Turkey.

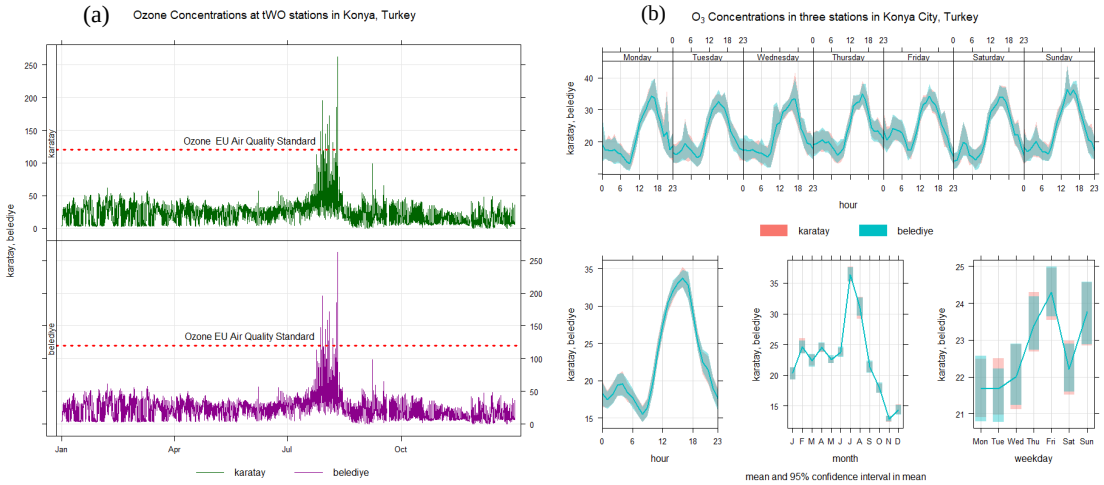


**Figure 6.** (a) TimePlot and (b)Time Variation plots for ozone($O_3$) concentrations at two stations in Konya City, Turkey.

Figure 7 shows the $PM_{10}$ values of three air quality sampling stations Selcuklu, Karatay and Selcuklu Belediye in Konya city centre during first half period of 2020 year. It can be seen slightly lowering from 2018 to 2019, but lowering rate is more in 2020. It is clear that reduction of $PM_{10}$ concentrations was lower during Covid-19 outbreak period (01 January 2018, 15 June 2020) than before the outbreak and 2018 and 2019 years at same period.

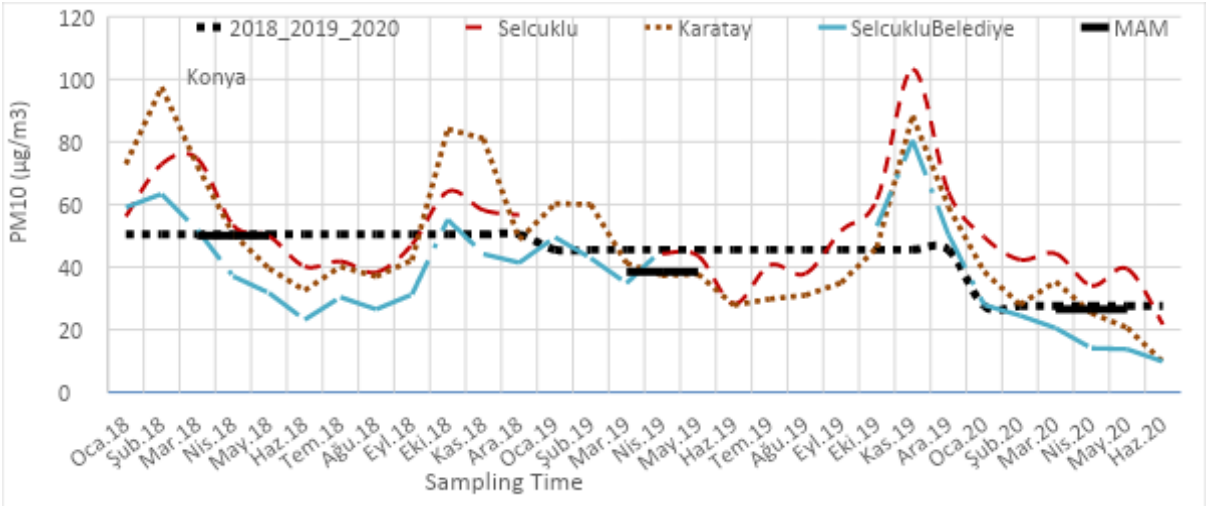


**Figure 7**. $PM_{10}$ values of three air quality sampling stations Selcuklu, Karatay and Selcuklu Belediye in Konya city centre during first half period of 2020 year. Solid line ( ▬MAM) shows a Covid-19 outbreak period and the other two are the same period in 2018 and 2019 years respectively. Dashed line (-----) mean of each year 2018, 2019 and 2020.

It is seen that the air quality increases covid-19 outbreak period (01 January 2018, 15 June 2020) and then returns to normal levels during the period when curfew is restricted for measures taken due to the covid-19 outbreak. The restrictions that cause the reduction of vehicle exhaust emissions, which are important factors in the formation of some air pollutants, are thought to be effective in improving the air quality. It is clear that there is a significant decrement of $SO_2$, $NO_2$ CO values decreased but $O_3$ values were increased (Tables 3-6). Minus values (-) show decrease and plus (+) values are increased. In this study, we estimate the impact of COVID-19 on air pollution by using Eq. (1) given by [16];

Percentage of Difference (%) or PD = ((A – B) / B) x 100. Eq. (1)

Where;
A = Concentration of air pollution recorded during the MCO in 2020
B = The concentration of air pollution recorded in the same period in 2019 or 2018

The Percentage of Difference (%) or PD value of each pollutant, namely $SO_2$, $NO_2$ CO, $O_3$ and $PM_{10}$, were computed for Konya air quality data by comparing 2020 data with 2018 and 2019 data, as shown in Tables 3-7. Minus values (-) show decrement of concentrations, and (+) values were an increment of pollutants. In general, $SO_2$ and $NO_2$ and $PM_{10}$ concentrations decrease with -12.3%, -14% and 2-4%, respectively. Meanwhile, $O_3$ and CO show an increment of percentage with +33% and + 21%, respectively, for both pollutants. The same phenomena have been reported previously, such as by [16] in Malaysia and by [22] effects of the season on the percentage of different pollutant levels vary between pollutants that may need further investigations and other techniques. However, $O_3$ pollutants are shown consistently to increase in all seasons.

**Table 3.** The effect of COVID-19 outbreak measures on $SO_2$ concentration (μg/m$^3$) for Konya city center.

| Period | 2018 | 2019 | 2020 | PD (2020:2019) (%) | PD (2020:2018) (%) |
|---|---|---|---|---|---|
| Period 1 (winter) | 21 | 14 | 15 | 5 | -29 |
| Period 2 (spring) | 7 | 8 | 7 | -15 | 5 |
| Period 3 (summer) | 6 | 10 | 7 | -27 | 35 |

**Table 4.** The effect of COVID-19 outbreak measures on $NO_2$ concentration (μg/m$^3$) for Konya city center.

| Period | 2018 | 2019 | 2020 | PD (2020:2019) (%) | PD (2020:2018) (%) |
|---|---|---|---|---|---|
| Period 1 (winter) | NA | 59 | 42 | -28 | NA |
| Period 2 (spring) | 19 | 38 | 31 | -18 | 65 |
| Period 3 (summer) | 11 | 29 | 31 | 4 | 181 |

**Table 5.** The effect of COVID-19 outbreak measures on CO concentration (μg/m$^3$) for Konya city center.

| Period | 2018 | 2019 | 2020 | PD (2020:2019) (%) | PD (2020:2018) (%) |
|---|---|---|---|---|---|
| Period 1 (winter) | 1462 | 910 | 866 | -5 | -41 |
| Period 2 (spring) | 841 | 409 | 510 | 24 | -39 |
| Period 3 (summer) | 638 | 269 | 393 | 46 | -38 |

**Table 6.** The effect of COVID-19 outbreak measures on $O_3$ concentration (μg/m$^3$) for Konya city center.

| Period | 2018 | 2019 | 2020 | PD (2020:2019) (%) | PD (2020:2018) (%) |
|---|---|---|---|---|---|
| Period 1 (winter) | NA | 34 | 37 | 6 | NA |
| Period 2 (spring) | NA | 35 | 54 | 52 | NA |
| Period 3 (summer) | NA | 38 | 57 | 52 | NA |

**Table 7.** The effect of COVID-19 outbreak measures on $PM_{10}$ concentration (μg/m$^3$) for Konya city center.

| Period | 2018 | 2019 | 2020 | PD (2020:2019) (%) | PD (2020:2018) (%) |
|---|---|---|---|---|---|
| Period 1 (winter) | 72 | 59 | 37 | -37 | -49 |
| Period 2 (spring) | 47 | 40 | 23 | -43 | -51 |
| Period 3 (summer) | 30 | 26 | 27 | 7 | -10 |

## 6. Conclusion

During the Covid-19 pandemic quarantine, the restriction of movement of motor vehicles, transportations and closure of industries greatly influenced the concentration of air pollutants. Some measures taken during the Covid-19 pandemic period may turn into permanent habits over time. Comparing between the 2019 and 2020 MCO data, we identified that most of the gases decreased with $NO_2$ (-24 μg/m$^3$), $SO_2$ (-24 μg/m$^3$), CO (-37 μg/m$^3$) and an increment of $O_3$ of +50 μg/m$^3$ which indicates that the MCO and restricted of movement were give an impact to air quality levels in Konya City. Studying the characteristics of $PM_{10}$, CO and $O_3$ was important for improving the quality of life,

physical health and the living environment of inhabitants. However, the factors that influenced these phenomena are still in study in most cities and expanded. The Covid-19 outbreak may be a turning point in combating global climate change as the behaviors of traveling and people's movement are restricted. The improvement in air quality can be considered as the most important gain after the pandemic. Air pollution and climate change have long term effects through complex interactions in the atmosphere and ground level surface of pollutants especially in urban environments. Understanding the spatial variability of pollutant concentrations, especially when looking into before and after MCO, will not only add to our knowledge of the mechanism of air pollution but also provide a scientific reference for implementing targeted control measures. For sustainable environmental and air quality, gains from measures should be continued. With the end of the measures, as in many parts of the world, environmental quality decreases.

## 7. Acknowledgements

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