Impact of COVID – 19 Restrictions on Air Quality Levels on Samsun, Turkey

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Abstract

The outbreak of the novel coronavirus SARS-CoV-2 (hereafter COVID19) has changed the daily routines of people around the world. The first case of COVID19 was confirmed on December, 2019 whilst, it was confirmed on 11 March 2020 in Turkey. After the number of cases reached 4500 per day by 10 April, the government declared more restrictive lockdown measures for 31 metropolitan cities and it was implemented for the following weekends, national and religious holidays. The change in concentrations of CO, NO_x, NO_2 and PM_{10}, during these measures with respect to pre – lockdown period and for different level of measures for Samsun, the biggest city of Karadeniz Region were investigated in this study. The daily mean concentrations of CO, NO_x, NO_2 and PM_{10}, obtained for the Tekkekoy station due to data completeness greater than 95 percent for all pollutants. Average CO, NO_x and NO_2 concentrations during lock down period, declined with respect to pre-lock down period whilst PM_{10} increased 3 percent. The average concentrations of all the pollutants decreased when the level of restrictions increased during COVID19 lockdown period. The number of days exceed WHO limit for PM_{10} were decreased during lockdown period of 16 days with respect to pre-lockdown period of 19 days. There is only positive weak relationship between mobility decrease rate and NO_2 concentrations.

Keywords: COVID-19, Air pollution, Turkey, Samsun.

1. Introduction

First positive case of SARS-CoV-2 (hereinafter COVID - 19) detected in Turkey on the 11th of March 2020. After the confirmation of the first case, some measures like stay at home order, airway transportation were implied by the Turkish government. However, the number of cases reached 4500 on 10th of April. Than, more strict measures were applied for 30 crowded cities including Samsun. These measures are lockdown on weekends, cancellation of intercity travels, etc.

Several studies declared the improvement of air quality due the partial and total lockdowns related to COVID – 19(e.g.Baldasano, 2020; Collivignarelli et al. 2020; Nakada and Urban, 2020; Tobias et al.2020; Sahin, 2020; Siciliano et al. 2020; Xu et al. 2020). Tobias et al. (2020) showed the improvement of air quality in Barcelona related to quarantine measures. Siciliano et al. (2020) investigated the improvement of ozone levels in Rio de Janeiro, Brazil. Xu et al (2020) shewed the increase of air quality in terms of reduction in the concentrations of $PM_{2.5}$, PM_{10}, SO_2, CO and

NO$_2$ in China. Besides, Siciliano et al. (2020) discussed the impact of the partial lockdown on the ozone levels in the city of Rio de Janeiro, Brazil. Additonally, Tobias et al. (2020) showed that quarantine measures led to an improvement in air quality in Barcelona. Studies in several European cities such as Barcelona, Istanbul, Madrid, Milan, Munich also reported improvement in air quality. Sahin (2020) reported reductions in PM$_{10}$ (32-43%), PM$_{2.5}$ (19-47%), NO$_2$ (29-44%), CO(40-58%), and SO$_2$ (34-69%), respectively in Istanbul, the megacity in Turkey.

Meanwhile, a few studies included mobility to understand the effect of traffic on air quality during the COVID 19 measures (Li and Tartarini, 2020; Wang et al., 2020). Li and Tartarini (2020) found a significant correlation between mobility and trends of PM$_{2.5}$ and NO$_2$ for Singapore. Wang et al. (2020) declared that mobility and airborne particulate matter has an impact on the risk of COVID-19 transmisison.

Samsun, located in central part of the Black Sea Region of Turkey is the most crowded and developing city of the Region. In this study, the change of air pollutant concentrations during lockdown in Turkey is investigated. The effect of mobility is considered as well.

2. Material and Method

Samsun, located in central part of the Black Sea Region of Turkey is the most crowded and developing city of the Region (Figure 1). Its population is 1.356.000 by the end of 2020 (TUIK, 2021) and it is the 16th crowded city of Turkey. It is surrounded by the Black Sea in north and by Ordu city east, Tokat and Amasya in south and Sinop and Çorum cities in west. The city has an area of about 9,725 km^2, and 45% of this area is mountains, 37% plateaus and 18% plains.

Figure 1 Samsun and its location in Turkey

There are 6 air quality monitoring stations in the city operated by Central Black Sea Clean Air Center. However only Tekkekoy station has the data completeness greater than 95% during

COVID-19 measures. PM_{10}, CO, NO_x and NO_2 are monitored in Tekkekoy station. The information about Tekkekoy station is seen in Table 1. The change in concentrations of air pollutants during COVID 19 measures and the number of exceedances of the limit values according to World Health Organization (WHO, 2006) are calculated. According to WHO guidelines limit of PM_{10} for 24-h is 50 µg/m^3 while NO_2 limit for 1-h is 200 µg/m^3. So, only the exceedance numbers for PM_{10} and NO_2 are calculated.

Table 1 Description of the air pollutants in Tekkekoy Station

Station	PM_{10}	CO	NO_x	NO_2
Tekkekoy	2019 - 2020	2019 - 2020	2019 - 2020	2019 - 2020

Some periods are defined according to the COVID – 19 measures in order to make the comparison of air pollutant concentrations. Some periods were chosen to make the comparisons of the pollutant concentrations. The period from 1 January to 17 March 2020 is defined Pre-Lockdown, the period from 18 March to 1 June 2020 is defined Lockdown. The change for the concentrations of pollutants were analyzed for three different steps. Firstly, the change of concentrations and exceedance numbers during lockdown with respect to the pre-lockdown are investigated.

Secondly, the change in concentration levels of air pollutants during lockdown is investigated by dividing the lockdown period into two parts: the first one covers the dates that full lockdown measures were applied for metropolitan cities and the second covers the remaining lockdown days. Thirdly, the concentrations during lockdown are compared to the same period in previous year.

In the last part of the study, Google (2020) mobility data were used to analyze the effect of mobility on the air quality. These data are represented as the percent change from a baseline in six categories. The baseline is the median value of mobility data covering the period from 3 January – 6 February, 2020. The mobility data is explained in six different categories as introduced by (Google, 2020) but only work place mobility data are used to represent the traffic change.

3. Results

3.1 Comparison of Lockdown and Pre-Lockdown Period

Daily concentrations of CO, NO_2, NO_x and PM_{10} for the period from January 1 to June 1, 2020 are seen in Figure 2. The decline of the concentrations of CO, NO_2 and NO_x are clear while the change of the concentration of PM10 is not clear. The mean concentrations before lockdown and during lockdown are seen in Table 2. As seen in Table 2, the mean concentration of CO, NO_2 and NO_x declined 72, 37 and 35 percent while the mean concentration of PM_{10} increased 3 percent during lockdown according to the before lock down period.
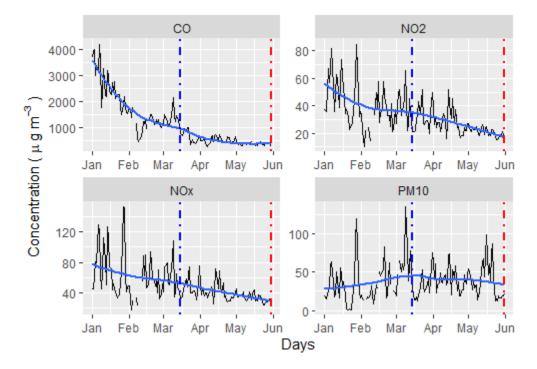
Figure 2 The daily mean concentration of air pollutants from January 1 to June 1, 2020. Blue dashed vertical line represents the start of measures and red dashed vertical line represents the end of measures.

Table 2 The mean concentrations before and during lockdown and percent change

Pollutant	Before Lockdown ($\mu g/m^3$)	Lockdown ($\mu g/m^3$)	Change (%)
CO	1807	496	-73
NO_2	41	26	-37
NO_x	62	40	-35
PM_{10}	37	38	+3

The number of exceedances for NO_2 and PM_{10} are seen in Table 3. NO_2 didn't exceed the WHO limits for both before lockdown and lockdown period. PM_{10} concentrations exceeded the WHO limits 19 times before lock down and 16 times during lockdown although mean concentrations of PM_{10} increased during lockdown according to the pre-lockdown period. The days that exceeded the WHO limits decreased 16 percent during lockdown with respect to pre –lockdown period.

Table 3 Number of exceedences for NO_2 and PM_{10}

Pollutant	Before Lockdown	Lockdown	Change (%)
NO_2	0	0	-
PM_{10}	19	16	-16

3.2 Comparison of the sub-periods in lockdown period

The mean concentrations of air pollutants during full lockdown measures and remaining days and percent change during full lockdown days with respect to remaining days are seen in Table 4. As seen in the Table 4, concentration of all the pollutants decreased. CO concentration decreased just 1% during full lockdown measures with respect to the remaining days of lockdown. NO_2, NO_x and PM_{10} decreased 25, 20 and 18%, respectively.

Table 4 The mean concentrations during full lockdown measures and remaining days and percent change.

Pollutant	Full Lockdown days ($\mu g/m^3$)	Remaining Days ($\mu g/m^3$)	Change (%)
CO	497	491	-1
NO_2	28	21	-25
NO_x	41	33	-20
PM_{10}	40	31	-18

3.3 Comparison of the lockdown concentrations with the same period of 2019

The mean concentrations of the air pollutants during lockdown period and the same period in 2019 are seen in Table 5. NO_2 concentrations didn't change during lockdown with respect to 2019. CO and NO_x increased 4 and 2.5 percent, respectively whilst PM_{10} decreased 21 percent.

Table 5 The average pollutant concentrations during lockdown and the same period of the previous year

Pollutant	2019 ($\mu g/m^3$)	2020 ($\mu g/m^3$)	Change (%)
CO	474	496	+4
NO_2	26	26	0
NO_x	39	40	+2.5
PM_{10}	48	38	-21

3.4 Relationship between mobility and air pollution

Time series of the mobility data and daily average NO_x, NO_2 and PM_{10} concentrations during the lockdown period is seen in Figure 3. CO concentrations are not plotted due the greater values of CO. As seen in the Figure 3, overall average of work mobility change in Samsun is 49%. The peak mobility values in the figure represent the full lockdown measures applied for metropolitan cities. During these peaks, declines in mean concentration of air pollutants are obvious.
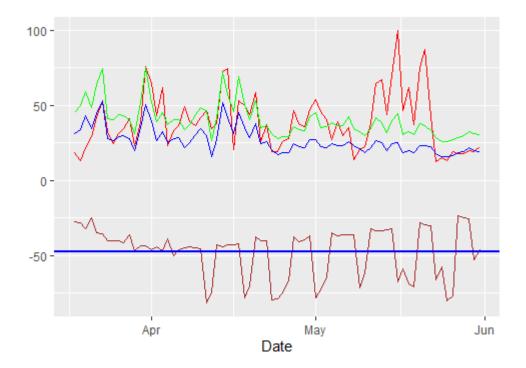
Figure 3 Time series of the mobility during the LDM with respect to 1 January – 16 February 2020 (negative values in y axis, blue line represents the average mobility change during LDM period.) and PM_{10} (red), NO_x (green) and NO_2 (blue) concentrations during LDM (positive values).

The correlation between mobility change and pollutant concentrations were calculated and tested via Pearson's test and the results are shown in Table 6. The correlation coefficients between mobility and CO, NO_x and PM_{10} are 0.15, 0.27 and 0.08, respectively and are not statistically significant. The correlation coefficient between mobility and NO2 is 0.30 and it is statistically significant at 99% confidence level.

Table 6 Pearson's correlation coefficients between work mobility and pollutant concentrations

	CO	**NO_x**	**NO_2**	**PM_{10}**
Correlation Coefficient	0.15	0.27	0.30*	0.08

4. Conclusion

Daily routines of people in all countries changed by COVID – 19. In Turkey after the confirmation of the first case on March 11, 2020 authorities implemented some rules like shut down of airway transportation, online education. However by 10 April the number of cases reached 4500 and more restrictive measoures were imposed on 31 major cities including Samsun. The change of concentrations of CO, NO_x, NO_2 and PM_{10} in Samsun during these measures and their relationship with decrease in mobility are investigated in this study. The main findings are:

1-) The mean concentration of CO, NO_2 and NO_x declined 72, 37 and 35 percent while the mean concentration of PM_{10} increased 3 percent during lockdown according to the before lock down period. PM_{10} concentrations exceeded the WHO limits 19 times before lock down and 16 times during lockdown although mean concentrations of PM_{10} increased during lockdown according to the pre-lockdown period.

2-) The mean concentration of all the pollutants decreased during full lockdown measures compared the remaining lockdown days in different levels. CO concentration decreased just 1% during full lockdown measures with respect to the remaining days of lockdown. NO_2, NO_x and PM_{10} decreased 25, 20 and 18%, respectively.

3) NO_2 concentrations didn't change during lockdown with respect to 2019. CO and NO_x increased 4 and 2.5 percent, respectively whilst PM_{10} decreased 21 percent.

4) The correlation between mobility change and pollutant concentrations were calculated and tested via Pearson's test. Only the correlation coefficient between mobility and NO_2 is statistically significant at 99% confidence level with the value of 0.30.

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