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COVID-19 Lock-down and Air Quality Enhancement in Kabul

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Abstract: COVID-19 has spread rapidly all over the world and affects most people. Lock-down due to the COVID-19 has enhanced air quality in most populated cities of the world. In this study, the air quality of Kabul city pre-COVID-19 and post-COVID-19 is assessed. Five parameters (pollutants) in air quality have been assessed which are: suspended particles with the diameter (PM10, PM2.5), carbon monoxide (CO), sulfur oxide (SO_2), nitrogen dioxide (NO_2), and ozone (O_3). The air quality parameters have been compared with their National Air Quality Standard values. The air quality of Kabul pre-COVID-19 was hazardous and not healthy. In post-COVID-19 lock-down the air quality of the city has enhanced. The air quality of Afghanistan is not safe, especially in major cities. Kabul is the capital of the country which is suffering from poor air quality.
Keywords: Air quality, COVID-19, Particulate Matter, Nitrogen Dioxide, Sulfur Oxide, Ozone

INTRODUCTION

Since the beginning of March 2020, COVID-19 (Coronavirus) has spread rapidly all over Afghanistan. The air quality of Afghanistan is not safe, especially in major cities. Contributors to poor air quality in Afghanistan include industrial pollution, vehicle emissions, and poor quality fuel. Pollution can increase during winter months (Dec-Feb) due to increased use of polluting fuels (wood, coal, kerosene) and inefficient technologies to heat homes.

Many studies related to COVID-19 effects on air quality have been conducted over the world. COVID-19 has enhanced air quality all around the world especially in major cities. In Hat Yai city of Thailand during the lock-down of COVID-19 NO_2 concentration decreased by 33.7%. PM2.5, PM10 and O_3 decreased by 21.8%, 22.9% and 12.5% respectively. Furthermore, average NO_2, CO, and PM2.5 for April 2020 exhibit the lowest values in the last decade[1].

Sharma et al.[2] conducted a study during the lockdown for Indian major cities (Delhi, Mumbai, Kolkata, and Bangalore) a reduction in concentration was found for all pollutants. During the lockdown phase in Delhi when compared to pre-lockdown declines in PM2.5 (41%) PM10 (52%), NO_2 (51%), and CO (28%) were observed. Air quality in India Delhi city compared to 2019 improved during the lockdown, with reductions of PM10 (60%), PM2.5 (39%), NO_2 (53%), and CO (30%)[3]. During the lockdown period in Brazil (São Paulo) CO, NO, NO_2, and O_3 concentrations reduced by 65, 77, 54, and 30%, respectively[4]. Due to lockdown near Wuhan city of China, about 30% of reduction in NO_2 concentrations was observed. A reduction in CO_2 concentration was also observed at 25% in China and 6% worldwide[5].

Air quality in 2020 due to the Covid-19 lockdown improved by 11% across 330 cities of China and about 50% in New York (USA) when compared with 2019 data[6]. Zambrano-Monserrate et al.[7] studied the positive and negative impacts of the COVID-19 lockdown on the environment in severely affected countries such as China, the USA, Italy, and Spain. Lock-down led to reduced air pollutant concentrations in these affected countries. In Italy, cities with more than 100 days of air pollution (i.e. surpassing PM10 or O_3 limits) showed higher average numbers of Covid-19 infected individuals than in cities with less than 100 days of air pollution[8].

Wu et al.[9] found that the long-term average exposure to PM2.5 increased the risk of COVID-19 death in the United States. In Almaty (Kazakhstan) due to the COVID-19 lock-down reductions in PM2.5 (21%), CO (49%), and NO_2 (35%) were observed compared to 2018–2019[10]. In Salé City of Morocco Otmani et al.[11] conducted a study on air pollutants before and during the COVID-19

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lockdown period. Reduction in PM10, SO_2, and NO_2 concentrations was observed respectively 75, 49, and 96%.

In this study, the air quality of Kabul city pre-COVID-19 and post-COVID-19 is assessed. Five parameters (pollutants) in air quality have been assessed which are: suspended particles with the diameter (PM10, PM2.5), carbon monoxide (CO), sulfur oxide (SO_2), nitrogen dioxide (NO_2), and ozone (O_3). The air quality parameters have been compared with their NAQS values.

The following are some of the causes of air pollution in Kabul:

Specific Natural Factors of Air Pollution

- Effects of climate change;
- The geographical location of Kabul among the mountains;
- Occurrence of thermal inversion operation (reverse temperature change with increasing altitude) in winter.

Physical Factors of Air Pollution

Fixed factors of air pollution: Industrial factories, business centers, residential areas, manufacturing and industrial factories, clay kilns, hospitals and clinics, pumping stations, restaurants and wedding hotels, bakeries, markets and restaurants, baths/sinks, etc.

Movable or Mobile Agents of Air Pollution

Motor Vehicles

Mobile sources of air pollution in Kabul are vehicles, which are increasing in number in proportion to the increasing population. According to the official statistics of Kabul General Traffic Management, about 444,176 vehicles of various types such as taxis, trucks, buses, private and government vehicles pass through Kabul city daily, which is one of the major sources of air pollution in the city.

MATERIALS AND METHODS

Study Area

Kabul is located in a valley between the mountains and is one of the cities in the world that is located at the highest altitude (1800 meters) and is surrounded by the Paghman, Logar, Charikar, and Tangi Gharo mountain ranges. Its climate is arid and continental.

According to the Central Statistics and Information Office of Afghanistan, the country's population in 2018 amounted to 31.6 million of which 15% (4.74 million) live in Kabul city. Therefore, the increase in population in Kabul is one of the driving forces on environmental components such as water, air, and soil. In addition to the increase in population in Kabul, the city has rapidly experienced the process of reconstruction since 2001. Which is mostly unplanned and currently most of the environmental problems originate from here.

Measured Air Quality Parameters of Kabul City

Air pollution in Kabul city increases every year from winter to mid-May. The National Environmental Protection Agency (NEPA) using its equipment of air quality in Kabul during 2019 for taking air quality data from different areas of Kabul (the second, fourth, fifth, sixth, eighth, eleventh, and sixteenth districts).

Five types of gases and suspended particles (parameters) has been obtained:

1. Suspended particle (Particulate Matter–PM2.5, PM10) $\mu g/m^3$
2. Sulfur dioxide gas (SO_2) $\mu g/m^3$
3. Nitrogen oxides (NO_2) $\mu g/m^3$
4. Carbon monoxide (CO) mg/m^3
5. Ozone (O_3) $\mu g/m^3$

According to the Afghan National Air Quality Standard (NAQS), there are mainly five parameters (pollutants) in air quality which are: Suspended particles with the diameter (PM10, PM2.5), carbon monoxide (CO), sulfur oxide (SO2), nitrogen dioxide (NO2) and ozone (O3), whose standard sizes are 75, 150, 30, 50, 80 and 100, respectively. Common air quality parameters and NAQS are shown in Table 1.

Table 1. Common air quality parameters and national air quality standard

Common Air Quality Parameters					
O_3	NO_2	SO_2	CO	PM_{10}	$PM_{2.5}$
µg/m³	µg/m³	µg/m³	mg/m³	µg/m³	µg/m³
8 hrs	24 hrs	24 hrs	1 hr	24 hrs	24 hrs
National Air Quality Standard (NAQS)					
100	**80**	**50**	**30**	**150**	**75**

RESULTS AND DISCUSSIONS

As can be seen in Figure 1, the increase in air pollution has started in October 2019, the Air Quality Index (AQI) of which shows a very unhealthy condition for nitrogen dioxide. One of the reasons is the passage of vehicles. It is also at its highest in the November and December months of 2019 and relatively low in January 2020. It is seen in January that the amount of air pollution decreases with the elimination of the phenomenon of reversing the air masses, increasing rainfall, and rising temperatures.

In March and April of 2020, the air quality concentration is significantly lower than the NAQS due to the prolonged rains and rising temperatures in the lock-down conditions of Kabul city. Small and big guilds can be considered as one of the factors in reducing air pollution in Kabul. In Table 2 AQI numerical values and meaning is shown.

Table 2. Air Quality Index numerical values and meaning

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0 to 50	Air quality is considered satisfactory, and air pollution poses little or no risk
Moderate	51 to 100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151 to 200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201 to 300	Health warnings of emergency conditions. The entire population is more likely to be affected.
Hazardous	301 to 500	Health alert: everyone may experience more serious health effects.

Source: www.aqicn.org

However, as it can be seen in the obtained air quality in Kabul, the air quality in May 2020 to the middle of June 2020 only the amount of PM2.5 is relatively high compared to the NAQS, but other pollutants are low. Reasons for the rise of PM2.5 are removal of restrictions such as patrolling vehicles (which is spread by the passage of these vehicles due to the creaminess of alleys and some roads around the soil), the activities of small and big guilds can be also one of the factors.

AIR POLLUTION IN KABUL IN THE LAST THREE MONTHS OF 2019 AND THE FIRST FIVE MONTHS OF 2020

Pre-COVID-19

October 2019

First of all, it should be noted that the air quality data obtained by the mobile devices of the NEPA do not represent the average level of air pollution in the entire city of Kabul.

The obtained data show that in 7 days on average PM2.5 is below and 19 days higher than the standard level. The amount of CO during October is below the NAQS. The amount of SO2 is two days above the standard and other days below the standard. The amount of NO2 is 15 days higher than the standard level which is caused by vehicle traffic during the day and night in the city. Finally, the level of O3 is consistently below the standard level for two days, except for two days is higher than the standard level due to the lack of favorable natural conditions (sunshine and stagnant air movement) for its formation.

November 2019

The obtained data show that in the average 2 days the PM2.5 is below and the rest of the days are higher than the standard level. The amount of CO during November is below the NAQS. The amount of SO2 is 6 days below and the rest of the days is above the standard level. The amount of NO2 is above the standard level which is caused by the traffic of vehicles. Finally, the amount of O3 is 7 days higher than the standard level and the rest of the days is low due to the unfavorable natural conditions (sunshine and stagnant air movement) for its formation.

Air quality and AQI (October 2019-March 2020) are illustrated in Figure 1. As it is shown in Figure 1 the air quality Pre-COVID-19 is very unhealthy and hazardous. In March 2020 due to the lock-down of COVID-19, there is an enhancement in air quality from hazardous to unhealthy to sensitive groups.

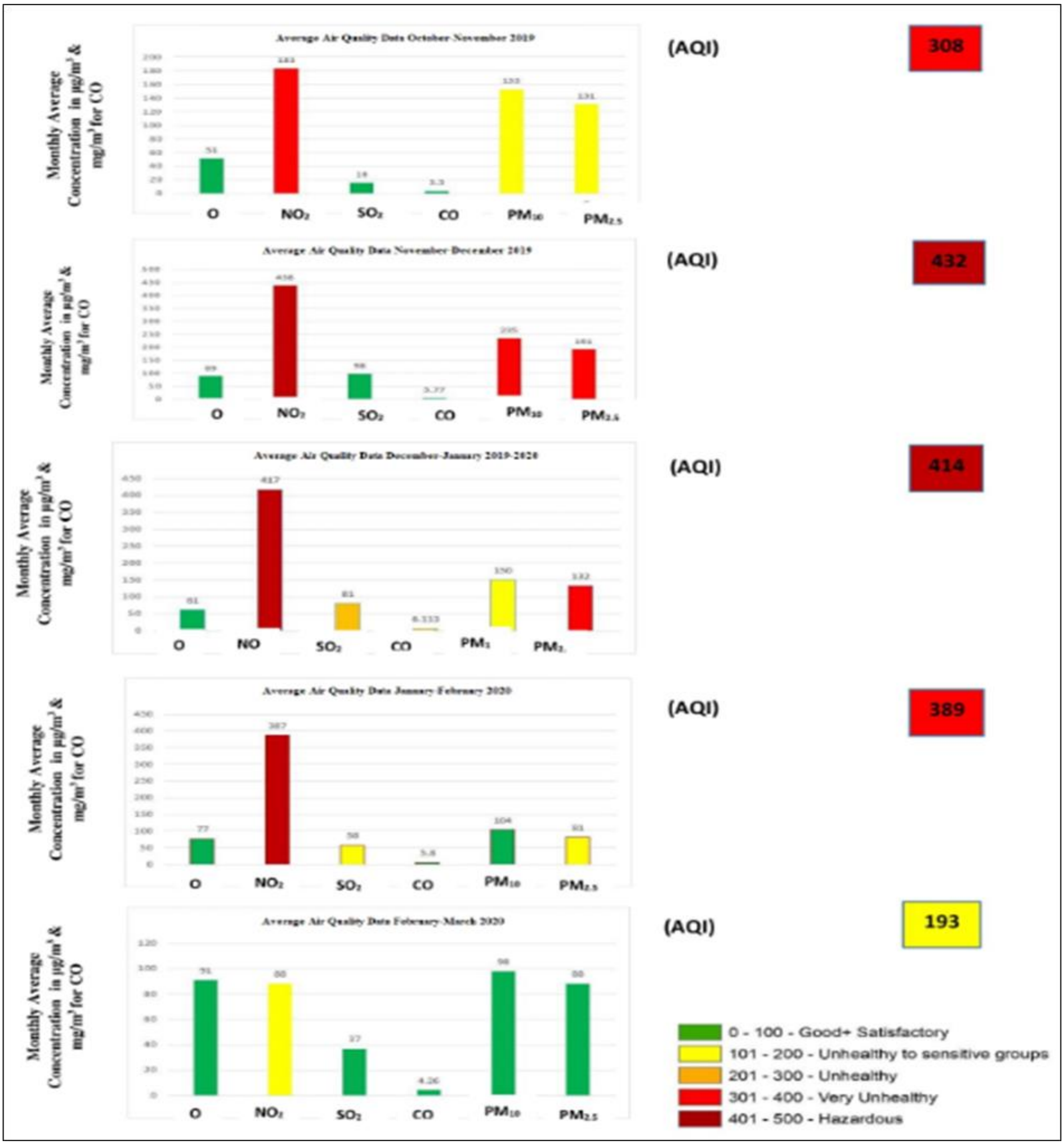

Figure 1. Air Quality and Air Quality Index (AQI) (October 2019-March 2020)

December 2019

The obtained data show that on average 11 days of PM2.5 below the standard limit and 19 days higher than the standard limit, PM10 is 19 days below the standard, and 11 days it is higher than the standard. The amount of CO is below the NAQS. The amount of SO2 is 19 days above the standard and other days below the standard. The amount of NO2 is above the standard, which is caused by the traffic of vehicles. Finally, the amount of surface O3 is consistently below the standard level, except for one day, due to the unfavorable natural conditions (sunshine and stagnant air movement) for its formation. AQI (March-June 2020) is illustrated in Figure 2. The lowest values during March-April of AQI are due to the COVID-19 lockdown.

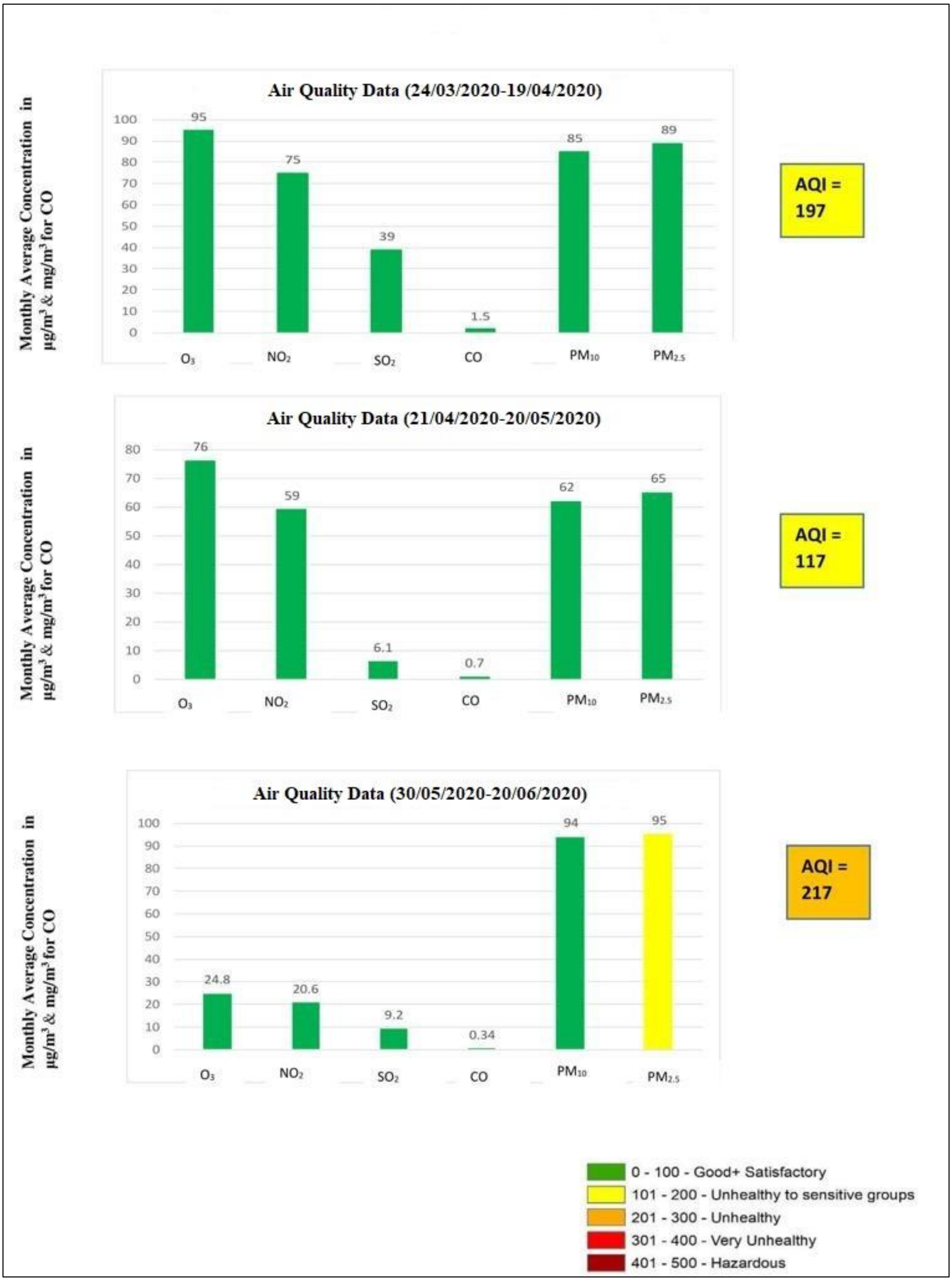

Figure 2. Air Quality and Air Quality Index (AQI) (March-June 2020)

January 2020

The obtained data show that on average 16 days PM2.5 is below and 14 days higher than the standard level. The amount of CO is below the NAQS. The amount of SO2 is 12 days above the standard and other days below the standard. The amount of NO2 is 2 days low and 28 days high above the standard, which is caused by vehicle traffic. Finally, the amount of surface O3 is 5 days higher and the rest of the days are consistently below the standard level and the reason is the unfavorable natural conditions (sunshine and stagnant air movement) for its formation.

February 2020

The obtained data show the average number of PM2.5 is 10 days below the standard and the rest of the days are higher than the standard level. This is due to the recent rains and due to the creaminess of the roads and the passage of vehicles. The amount of CO in February except for one day is below the NAQS. The amount of SO2 for 4 days is relatively high above the standard level and other days below the standard level. The amount of NO2 was 8 days above the standard level and the rest of the days were below the standard level. Finally, the level of surface O3 is above the standard level for 7 days and below the standard level for the rest of the days due to the unfavorable natural conditions (sunshine and stagnant air movement) for its formation.

Post-COVID-19

March 2020 (Lock-down Start)

During March the average PM2.5 and PM10 have decreased significantly. Among the reasons are recent rains and COVID-19 lock-down which have decreased vehicle traffic. The amount of CO, SO2, NO2, and surface O3 in March is also below NAQS which is caused by frequent rains. The lock-down in Kabul has decreased the activities of different guilds and reduced vehicle traffic in the city. These factors have caused a significant reduction in air pollution in Kabul compared to recent months in 2019. O3 concentration and NAQS for O3 (March-July) are illustrated in Figure 3. Due to the lock-down, a reduction can be seen in O3.

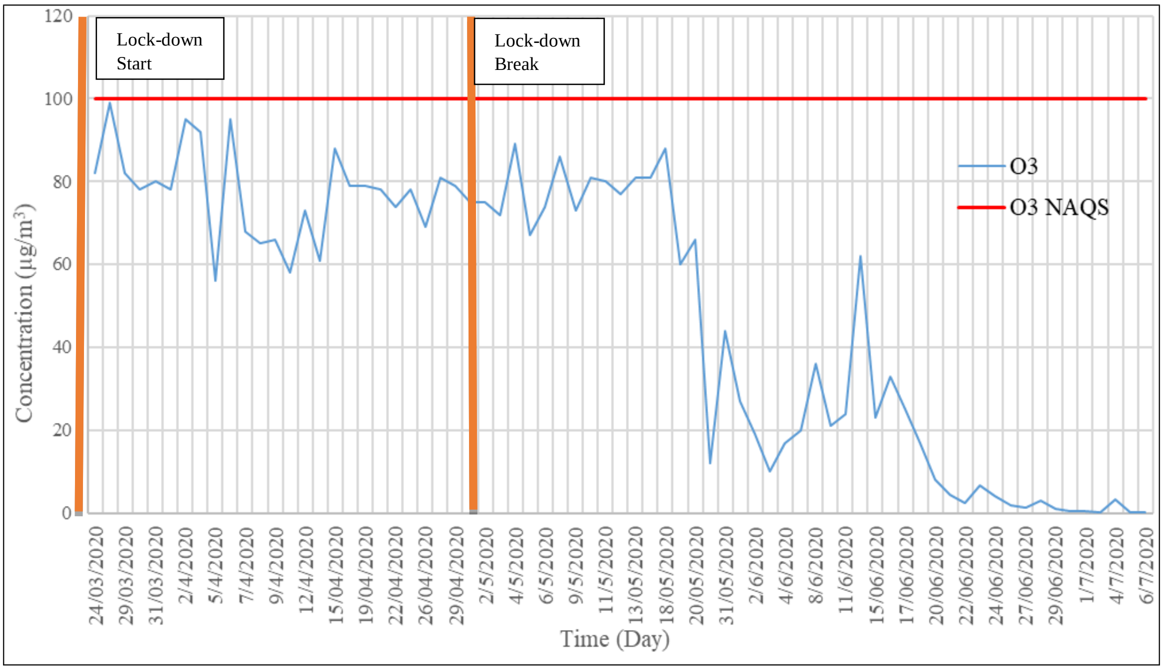

Figure 3. O_3 concentration and National Air Quality Standard (NAQS) for O_3 (March-July)

In Figure 4 NO2 concentration and NAQS for NO2 (March-July) are illustrated. A reduction can be seen due to the COVID-19 lock-down in NO2 concentration. In March and April of 2020, the air quality concentration is significantly lower than the NAQS due to the prolonged rains and rising temperatures in the lock-down conditions of Kabul city. Small and big guilds can be considered as one of the factors in reducing air pollution in Kabul.

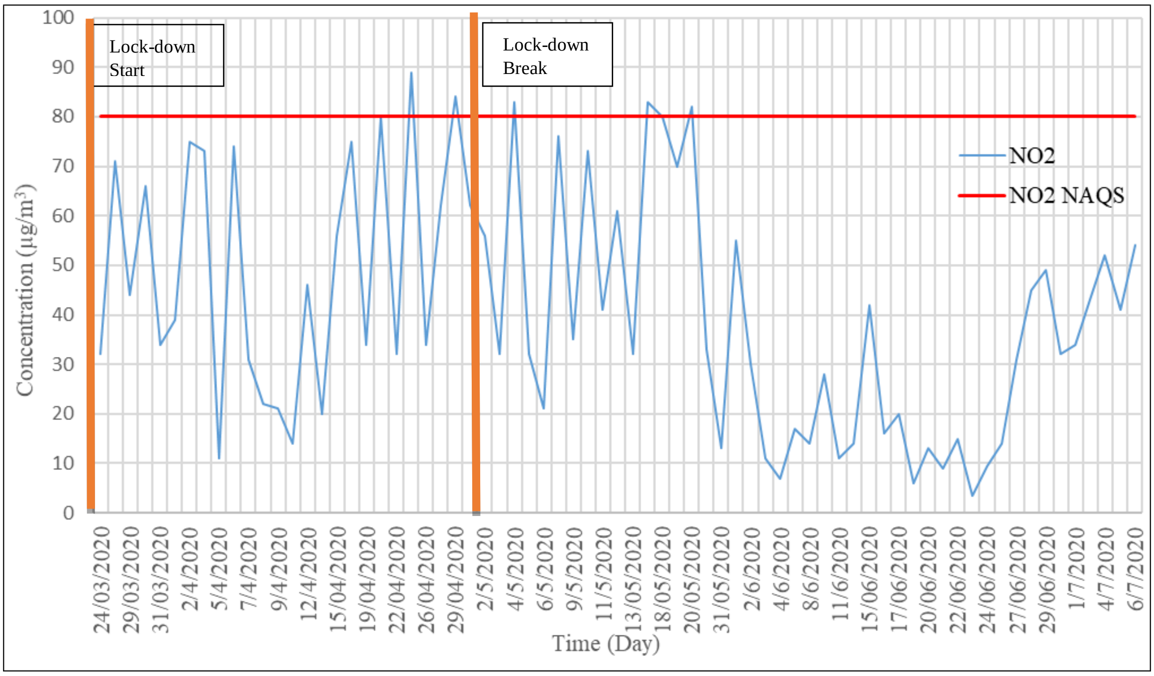

Figure 4. NO_2 concentration and National Air Quality Standard for NO_2 (March-July)

April 2020 (Lock-down)

During April the average of PM2.5 is lower except for eight days which is relatively higher than NAQS. It is due to the recent rains and lock-down which have decreased vehicle traffic. The amount of CO, SO2, and surface O3 in April is below the NAQS. Except for NO2 which four days is relatively excessive. During April frequent rains, lock-down, lack of activities of various guilds, relative warming of the air, and reduce traffic have enhanced air quality in the city. These factors have caused a significant reduction in air pollution in Kabul compared to recent months in 2019. SO2 concentration and NAQS for SO2 (March-July) are illustrated in Figure 5.

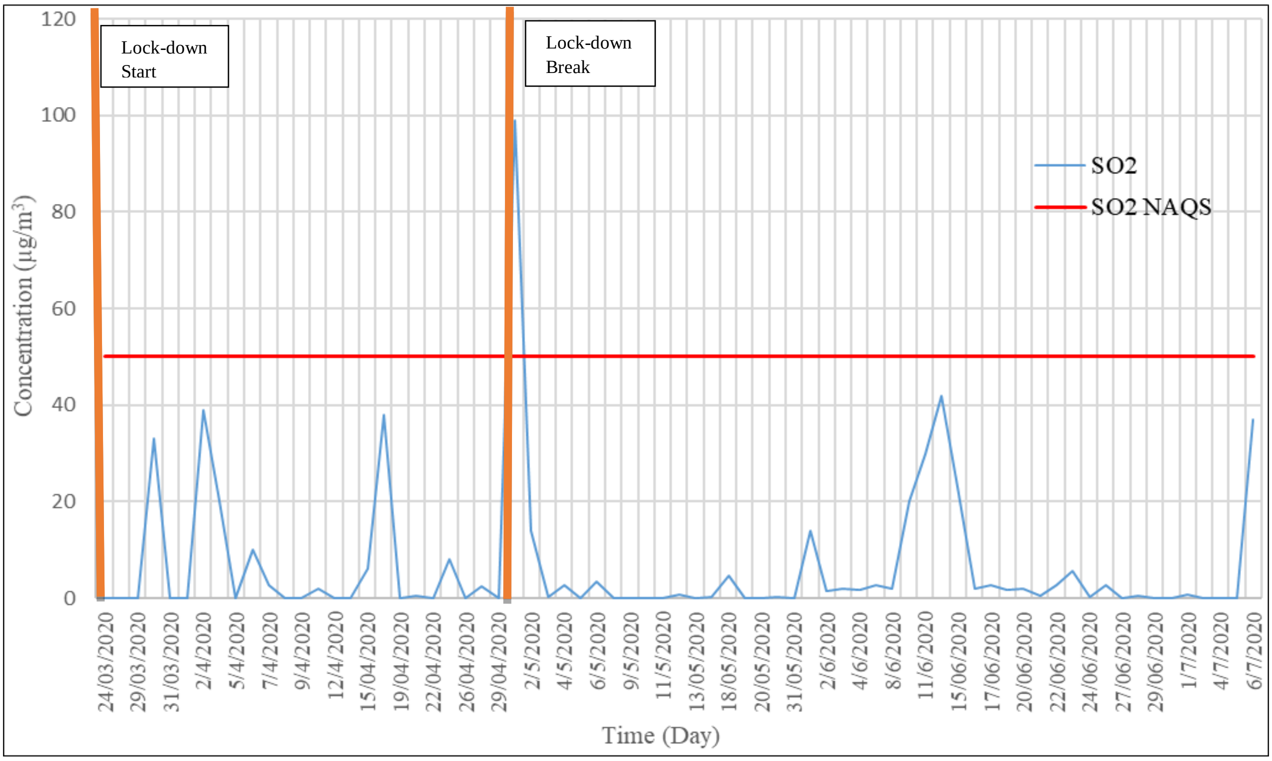

Figure 5. SO_2 concentration and National Air Quality Standard for SO_2 (March-July)

CO concentration and National Air Quality Standard for CO (March-July) are illustrated in Figure 6.

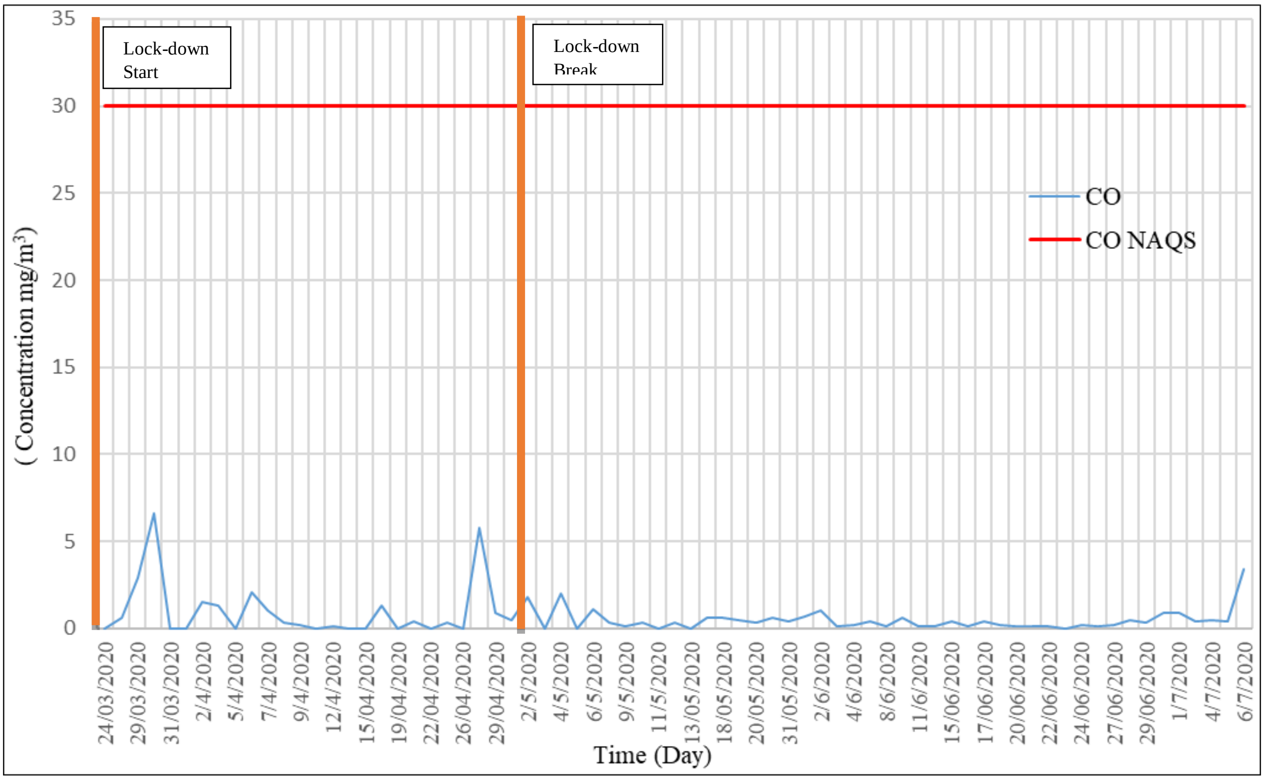

Figure 6. CO concentration and National Air Quality Standard for CO (March-July)

May 2020 (Lock-down Break)

During May the average PM2.5 is relatively higher on other days except for two days which is relatively lower than NAQS. It is due to the break of lock-down. The amount of CO, SO2, NO2, and surface O3 in May is below the standard level due to frequent rains, lack of activities of various guilds, relative warming of the air, and the reduction of traffic in the city. These factors have caused a significant reduction in air pollution in Kabul compared to recent months in 2019. PM10 concentration and National Air Quality Standard for PM10 (March-July) are illustrated in Figure 7. There is an increase in PM10 concentration due to the lock-down break.

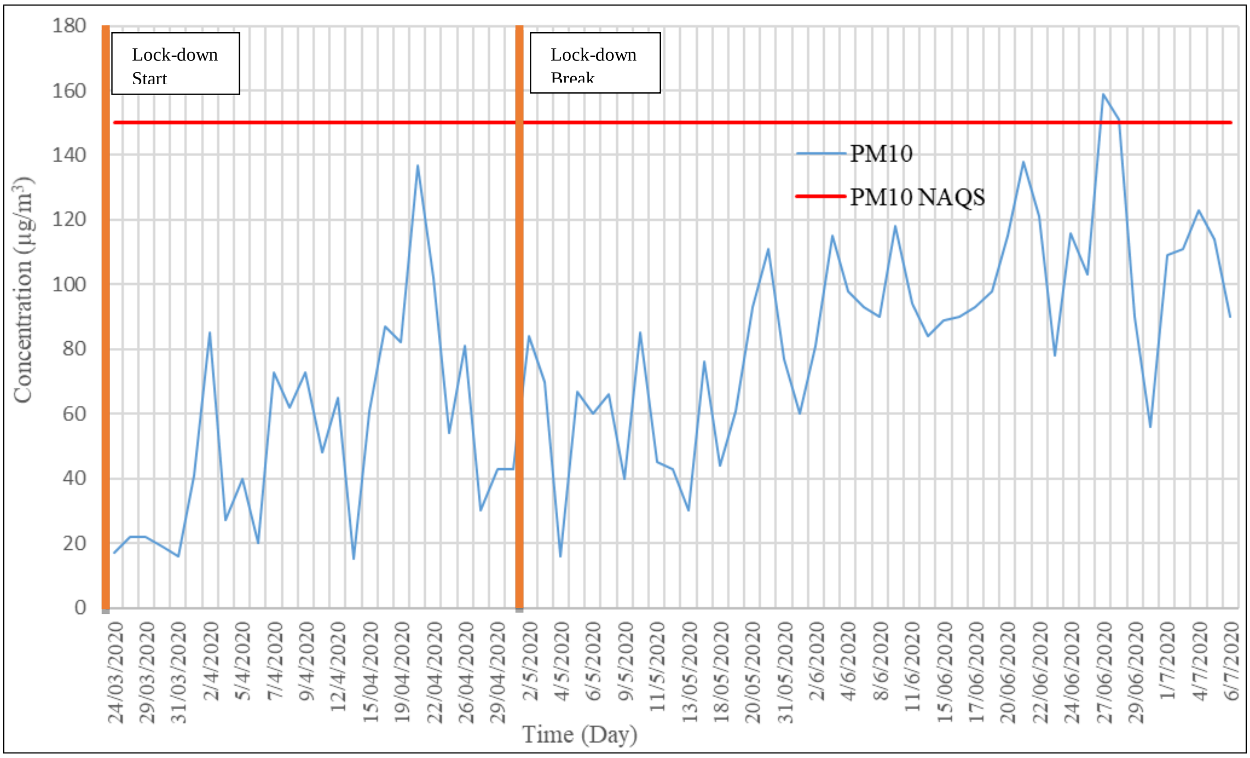

Figure 7. PM10 concentration and National Air Quality Standard for PM10 (March-July)

PM2.5 concentration and National Air Quality Standard for PM2.5 (March-July) are illustrated in Figure 8. As shown in Figure 8 there is a decrease in PM2.5 concentration after the lock-down period and an increase is seen after lock-down breaking.

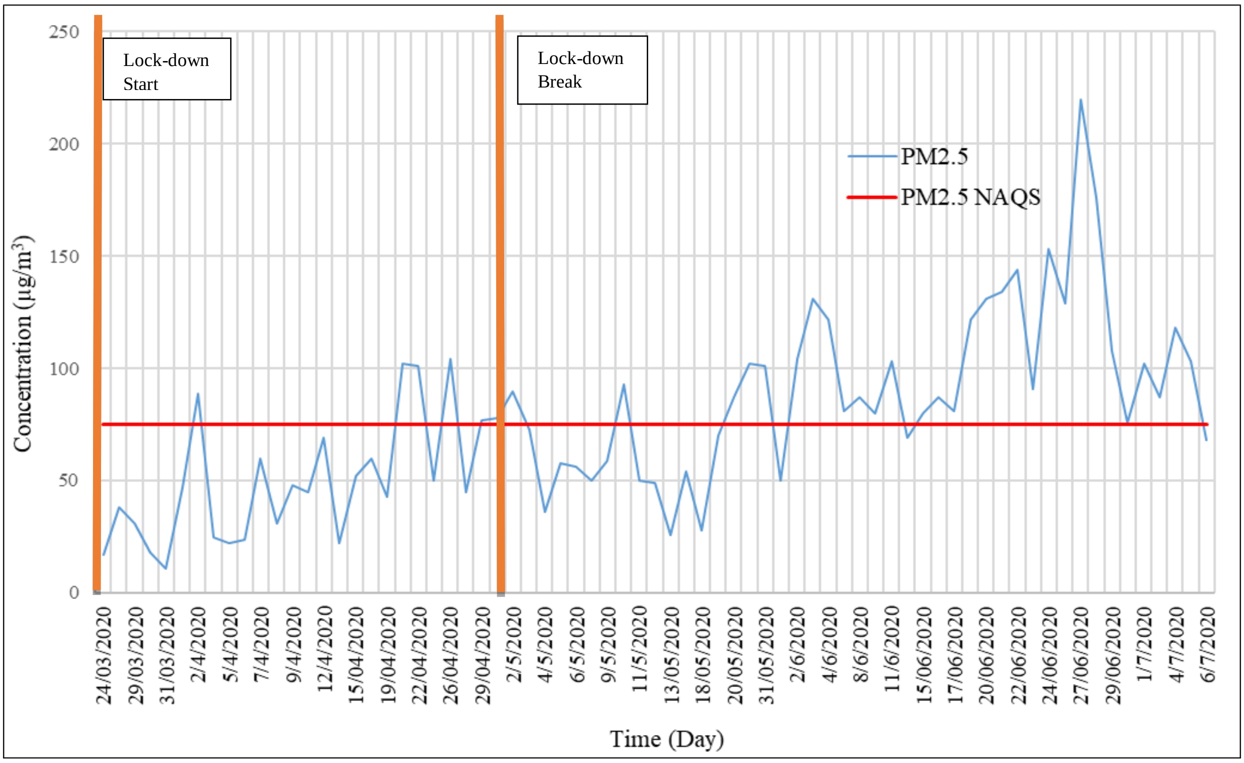

Figure 8. PM2.5 concentration and National Air Quality Standard for PM2.5 (March-July)

Common air quality parameters with their concentrations post-COVID-19 in Kabul (March-July) are illustrated in Figure 9. PM2.5 and PM10 are very sensitive as it can be seen in Figure 9 there is a rapid increase after lock-down breaking. It can be said that the COVID-19 lock-down enhanced air quality in Kabul.

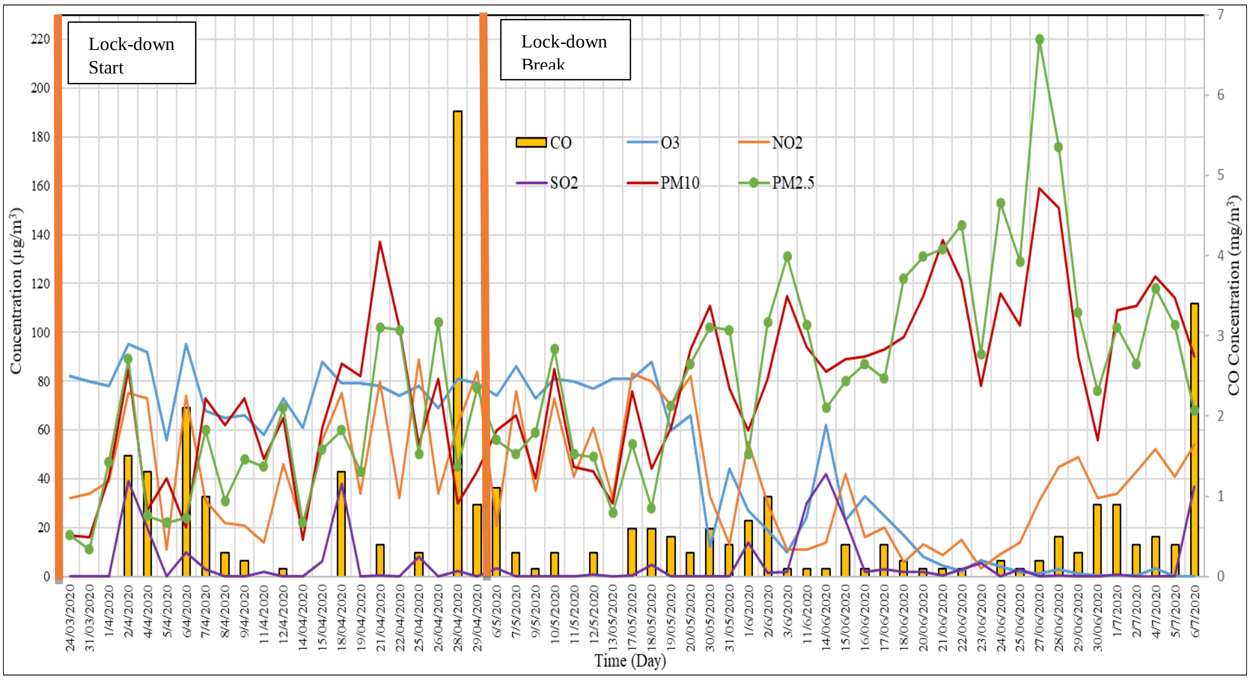

Figure 9. Common air quality parameters with their concentrations post-COVID-19 in Kabul (March-July)

CONCLUSION

Considering the data presented show the amount of air pollution in different parts of Kabul, it can be seen that the amount of air pollution since October 2018 compared to the NAQS in different times and areas has often been higher than the standard. The amount of PM2.5 and PM10 according to the standard within 24 hours should be 150 and 75 µg/m3 of air respectively, but field data at different times and areas in Kabul show that in October, November, and December is very serious. It was higher than the standard, sometimes even more than ten times higher. Also, the amount of SO2 in the NAQS in 24 hours should be lower than 50 µg/m3 of air but field data show the amount of this gas variable in the air of Kabul at different times and areas. SO2 clearly shows that the use of stone slag in high-rise buildings, bathrooms, and residential houses has increased and its particles are suspended in the ambient air due to the natural action of thermal inversion and are easily inhaled by humans. However, in February 2020 and March and April air pollution in Kabul has decreased significantly, the reasons for which were mentioned above. However, in May and June 2020 due to the lock-down breaking, only the average numbers of PM2.5 are relatively high. This is due to the passing of vehicles on dusty roads, the activity of factories and guilds, the creaminess of roads and side streets, the reduction of prolonged rains, and other activities. It should be noted that these data do not indicate the exact situation of air quality in Kabul, because the existing system and equipment of the data acquisition only provide 24 hours a day by mobile devices from some areas of Kabul. To have accurate data following national and international standards of air quality regularly every 24 hours, it is necessary to install fixed air quality devices (stations) in different parts of Kabul to obtain data regularly 24 hours per second.

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