Impact of SARS-CoV-2 on Ambient Air Particulate Matter in Tehran

Sasan Faridi1,2#, Fatemeh Yousefian1,2#, Sadegh Niazi3, Mohammad Rezvani Ghahhari2, Mohammad Sadegh Hassanvand1,2*, Kazem Naddafi1,2*

1 Centre for Air Pollution Research (CAPR), Institute for Environmental Research (IER), Tehran University of Medical Sciences, Tehran, Iran
2 Department of Environmental Health Engineering, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran
3 International Laboratory for Air Quality and Health, School of Earth and Atmospheric Sciences, Science and Engineering Faculty, Queensland University of Technology (QUT), Brisbane, Queensland, Australia

ABSTRACT

The pandemic caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has indirectly produced both positive and negative effects on the environment, particularly in terms of air quality. Our study aimed to determine these effects in the city of Tehran by comparing the ambient PM$_{2.5}$ and PM$_{10}$ levels recorded at 22 air quality monitoring stations during the outbreak (20 February–2 April 2020) with those from the corresponding period last year (20 February–3 April 2019). Contrary to expectation, the average concentrations of both the PM$_{2.5}$ and the PM$_{10}$ were markedly higher during the former, increasing by 20.5% and 15.7%, respectively, for the first month of the outbreak (20 February–19 March 2020) and by 23.5% and 20.0% for the subsequent Nowruz New Year holidays (late March till early April), which resulted in overall increases of 20.5% and 16.5% for the entire period. The non-integrated responses to the pandemic, including the failure to close administrative centers and, in particular, the recommendation to maintain social distancing by reducing public transportation use (prompting citizens to travel by private vehicle), have worsened the ambient air quality in Tehran, providing an exceptional opportunity to evaluate the direct/indirect influence of air quality policies and emission control measures on PM$_{2.5}$ and PM$_{10}$. Because of the significant association between the lethality of coronavirus disease 2019 (COVID-19) and exposure to ambient air pollution, the rise in airborne PM$_{2.5}$ during this outbreak may increase the mortality rate of SARS-CoV-2.

Keywords: SARS-CoV-2; COVID-19; Ambient air quality; PM$_{2.5}$; PM$_{10}$; Tehran.

INTRODUCTION

The first official announcement of death in Iran due to the coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was reported on 19 February 2020 (Faridi et al., 2020; Takian et al., 2020). As of 20 February, restricting social contact, reducing public transportation, closing down administrative centers, universities, schools, businesses and religion public places were recommended by the Iran Ministry of Health and Medical Education, but we observed two or three weeks’ time lag to implement the aforementioned recommendations (not lockdown) in Iran, specifically in Tehran megacity. Compared to other megacities around the world, particularly in China, Italy, Spain, France, Germany, England and USA (Frontera et al., 2020; Tobias et al., 2020; Zambrano-Monserrat et al., 2020), lockdown measures were not adopted during the SARS-CoV-2 outbreak in Tehran. As a result, Tehran with the highest confirmed COVID-19 cases and associated deaths experienced an emergency situation during this outbreak and ranked the first place among all cities in Iran (Faridi et al., 2020). Tehran, with the daytime population of more than 12 million people and about 9 million residents, is the capital and most populous city of Iran. The city has faced high levels of ambient air PM$_{2.5}$ and PM$_{10}$ during the past few decades due to transportation of more than 4 million vehicles in the megacity, as well as its proximity to a large number of industrial sources (Heger and Sarraf, 2018; Shamspour et al., 2019; Yousefian et al., 2020). During the SARS-CoV-2 outbreak in Tehran in particular over the first month, the reduction of using the public transportation recommended by public health bodies at the national and subnational levels to minimize the close contact led to a remarkable increases of private transportation. The aim of this study was to

#These authors contributed equally to this work.

*Corresponding author.

E-mail address: Hassanvand@tums.ac.ir (MS. Hassanvand);
Knadafi@tums.ac.ir (K. Naddafi)

Copyright The Author’s institution. This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are cited.
compare the concentrations of ambient air PM$_{10}$ and PM$_{2.5}$ in Tehran during the SARS-CoV-2 outbreak and over the same period of last year.

**METHODS**

We obtained hourly air quality data of PM$_{10}$ and PM$_{2.5}$, as the most common ambient air pollutants in Tehran, from 22 active ambient air quality monitoring stations (AQMSs; Fig. 1) belonging to the Tehran Air Quality Control Company for the period of 20 February–2 April 2020 as the SARS-CoV-2 outbreak and 20 February–3 April 2019 as the same period of last year. The air quality data processing was conducted based on our previous publications elsewhere (Faridi et al., 2018, 2019; Yousefian et al., 2020). After air quality data processing, 15 and 16 eligible AQMSs were used to calculate the averages of ambient PM$_{2.5}$ and PM$_{10}$ in Tehran at the city level, respectively. The results were compared in three defined scenarios as follows: 1) the period between 20 February 2020 and 19 March 2020 (the first month of SARS-CoV-2 outbreak in Iran) in comparison to the same period of last year (20 February–20 March 2019); 2) Nowruz Iranian New Year holidays from 20 March 2020 to 2 April 2020 compared to 21 March–3 April 2019 and 3) during the whole study period, 20 February–2 April 2020, in comparison to 20 February–3 April 2019. In addition to the comparing of the results at the city level, we investigated the aforementioned scenarios at two stations with the highest (Shad abad) and lowest (Zone 2) ambient air particulate matter concentrations (Faridi et al., 2019). To validate the results of the impact of SARS-CoV-2 on ambient air PM$_{2.5}$ and PM$_{10}$ in Tehran, the most important meteorological parameters, including wind speed, wind direction, temperature, precipitation and the number of rainy days, were investigated at three mentioned scenarios during the SARS-CoV-2 outbreak in comparison to the same period of last year. In fact, meteorological parameters were used for qualitative interpretation of the effect of SARS-CoV-2 on the ambient PM$_{2.5}$ and PM$_{10}$ level. The purpose of this comparison was to make sure the unfavorable or stagnant meteorological conditions did not indirectly increase the ambient air PM$_{2.5}$ and PM$_{10}$ concentrations during the outbreak in the city (Dantas et al., 2020; Kerimray et al., 2020).

**RESULTS AND DISCUSSION**

Tables 1–3 compare the ambient air PM$_{2.5}$ and PM$_{10}$ concentrations at three different scenarios. As shown in Table 1, the average concentration of PM$_{2.5}$ and PM$_{10}$ increased from 24.0 and 57.5 µg m$^{-3}$ during the same period of last year to 28.9 and 66.5 µg m$^{-3}$ over the first month of SARS-CoV-2 outbreak in Tehran, respectively. In fact, an increase of 5.0 µg m$^{-3}$ (20.4%) and 9.0 µg m$^{-3}$ (15.7%) in average concentrations of ambient PM$_{2.5}$ and PM$_{10}$ was experienced during the first month of SARS-CoV-2 outbreak in comparison to the same period of last year in Tehran. As the most polluted AQMS in Tehran according to our previous study (Faridi et al., 2019), Shad abad ambient air monitoring station recorded the average concentrations of ambient PM$_{2.5}$ and PM$_{10}$ equal to 37.6 and 89.5 µg m$^{-3}$ in the first month of SARS-CoV-2 outbreak, whereas these figures for ambient PM$_{2.5}$ and PM$_{10}$ were 28.4 and 70.1 µg m$^{-3}$ in the same period of last year, respectively. Zone 2 AQMS in north of the city which normally recorded the lowest amount of pollutants (Faridi et al., 2019) experienced a noticeable increase of nearly 75.5% and 49.0% in the average concentrations for ambient PM$_{2.5}$ and PM$_{10}$ over the first month of SARS-CoV-2 outbreak compared to the same period of last year. SARS-CoV-2 outbreak caused a significant increase equal to 3.0 and 5.0 µg m$^{-3}$ in ambient PM$_{2.5}$ and PM$_{10}$ average concentrations.
Table 1. Ambient PM$_{2.5}$ and PM$_{10}$ concentrations in Tehran during the SARS-CoV-2 outbreak (20 February–19 March 2020) in comparison to their concentrations in the same period of last year (20 February–20 March 2019) as the first scenario (the first month of SARS-CoV-2 outbreak in Iran).

<table>
<thead>
<tr>
<th>AQMS</th>
<th>PM$_{2.5}$</th>
<th>PM$_{2.5}$</th>
<th>PM$_{10}$</th>
<th>PM$_{10}$</th>
<th>Variation for PM$_{2.5}$</th>
<th>Variation for PM$_{10}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SARS-CoV-2</td>
<td>The same</td>
<td>SARS-CoV-2</td>
<td>The same</td>
<td>µg m$^{-3}$ (%)</td>
<td>µg m$^{-3}$ (%)</td>
</tr>
<tr>
<td></td>
<td>outbreak</td>
<td>period of</td>
<td>outbreak</td>
<td>period of</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>last year</td>
<td></td>
<td>last year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shad abad</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25$^{th}$</td>
<td>22.0</td>
<td>17.0</td>
<td>58.0</td>
<td>46.0</td>
<td>+5.0</td>
<td>+29.41</td>
</tr>
<tr>
<td>Average</td>
<td>37.6</td>
<td>28.4</td>
<td>89.5</td>
<td>70.1</td>
<td>+9.2</td>
<td>+32.39</td>
</tr>
<tr>
<td>50$^{th}$</td>
<td>32.0</td>
<td>25.0</td>
<td>82.0</td>
<td>64.0</td>
<td>+7.0</td>
<td>+28.00</td>
</tr>
<tr>
<td>75$^{th}$</td>
<td>48.0</td>
<td>37.0</td>
<td>115.0</td>
<td>88.0</td>
<td>+11.0</td>
<td>+29.73</td>
</tr>
<tr>
<td>Zone 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25$^{th}$</td>
<td>14.0</td>
<td>9.0</td>
<td>45.0</td>
<td>30.0</td>
<td>+5.0</td>
<td>+55.56</td>
</tr>
<tr>
<td>Average</td>
<td>27.0</td>
<td>15.4</td>
<td>60.9</td>
<td>40.9</td>
<td>+11.6</td>
<td>+75.32</td>
</tr>
<tr>
<td>50$^{th}$</td>
<td>22.0</td>
<td>14.0</td>
<td>58.0</td>
<td>39.0</td>
<td>+8.0</td>
<td>+57.14</td>
</tr>
<tr>
<td>75$^{th}$</td>
<td>35.0</td>
<td>19.0</td>
<td>77.0</td>
<td>49.0</td>
<td>+16.0</td>
<td>+84.21</td>
</tr>
<tr>
<td>Tehran</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25$^{th}$</td>
<td>18.0</td>
<td>16.9</td>
<td>47.7</td>
<td>43.2</td>
<td>+1.1</td>
<td>+6.51</td>
</tr>
<tr>
<td>Average</td>
<td>28.9</td>
<td>24.0</td>
<td>66.5</td>
<td>57.5</td>
<td>+4.9</td>
<td>+20.42</td>
</tr>
<tr>
<td>50$^{th}$</td>
<td>25.5</td>
<td>22.9</td>
<td>63.6</td>
<td>55.3</td>
<td>+2.6</td>
<td>+11.35</td>
</tr>
<tr>
<td>75$^{th}$</td>
<td>36.6</td>
<td>29.6</td>
<td>82.0</td>
<td>69.4</td>
<td>+7.0</td>
<td>+23.65</td>
</tr>
</tbody>
</table>

Table 2. Ambient PM$_{2.5}$ and PM$_{10}$ concentrations in Tehran during the SARS-CoV-2 outbreak (20 March–2 April 2020) in comparison to their concentrations in the same period of last year (21 March–3 April 2019) as the second scenario (Nowruz Persian New Year holidays).

<table>
<thead>
<tr>
<th>AQMS</th>
<th>PM$_{2.5}$</th>
<th>PM$_{2.5}$</th>
<th>PM$_{10}$</th>
<th>PM$_{10}$</th>
<th>Variation for PM$_{2.5}$</th>
<th>Variation for PM$_{10}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SARS-CoV-2</td>
<td>The same</td>
<td>SARS-CoV-2</td>
<td>The same</td>
<td>µg m$^{-3}$ (%)</td>
<td>µg m$^{-3}$ (%)</td>
</tr>
<tr>
<td></td>
<td>outbreak</td>
<td>period of</td>
<td>outbreak</td>
<td>period of</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>last year</td>
<td></td>
<td>last year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shad abad</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25$^{th}$</td>
<td>10.0</td>
<td>9.0</td>
<td>24.0</td>
<td>23.0</td>
<td>+1.0</td>
<td>+11.11</td>
</tr>
<tr>
<td>Average</td>
<td>16.7</td>
<td>13.8</td>
<td>37.5</td>
<td>32.7</td>
<td>+2.9</td>
<td>+21.01</td>
</tr>
<tr>
<td>50$^{th}$</td>
<td>14.0</td>
<td>12.0</td>
<td>34.0</td>
<td>30.0</td>
<td>+2.0</td>
<td>+16.67</td>
</tr>
<tr>
<td>75$^{th}$</td>
<td>21.0</td>
<td>17.0</td>
<td>47.0</td>
<td>39.0</td>
<td>+4.0</td>
<td>+23.53</td>
</tr>
<tr>
<td>Zone 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25$^{th}$</td>
<td>7.0</td>
<td>5.0</td>
<td>22.0</td>
<td>13.0</td>
<td>+2.0</td>
<td>+40.00</td>
</tr>
<tr>
<td>Average</td>
<td>13.3</td>
<td>8.1</td>
<td>32.5</td>
<td>21.5</td>
<td>+5.2</td>
<td>+64.20</td>
</tr>
<tr>
<td>50$^{th}$</td>
<td>11.0</td>
<td>7.0</td>
<td>30.0</td>
<td>19.0</td>
<td>+4.0</td>
<td>+57.14</td>
</tr>
<tr>
<td>75$^{th}$</td>
<td>17.0</td>
<td>11.0</td>
<td>39.0</td>
<td>26.0</td>
<td>+6.0</td>
<td>+54.55</td>
</tr>
<tr>
<td>Tehran</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25$^{th}$</td>
<td>9.1</td>
<td>8.0</td>
<td>19.5</td>
<td>18.7</td>
<td>+1.1</td>
<td>+13.75</td>
</tr>
<tr>
<td>Average</td>
<td>14.2</td>
<td>11.5</td>
<td>30.1</td>
<td>25.1</td>
<td>+2.7</td>
<td>+23.48</td>
</tr>
<tr>
<td>50$^{th}$</td>
<td>12.2</td>
<td>11.0</td>
<td>28.9</td>
<td>23.6</td>
<td>+1.2</td>
<td>+10.91</td>
</tr>
<tr>
<td>75$^{th}$</td>
<td>18.4</td>
<td>13.7</td>
<td>36.3</td>
<td>29.0</td>
<td>+4.7</td>
<td>+34.31</td>
</tr>
</tbody>
</table>

in Nowruz New Year holidays compared to Nowruz time of last year (Table 2). In fact, the SARS-CoV-2 outbreak led to a rise of about 23.5% and 20.0% in the ambient air PM$_{2.5}$ and PM$_{10}$ concentrations in comparison to the last two Nowruz New Year holidays. Moreover, the SARS-CoV-2 caused a growth of 3.0 and 5.0 µg m$^{-3}$ in the ambient air PM$_{2.5}$ and PM$_{10}$ concentrations at Shad abad AQMS, whereas the average concentrations of ambient PM$_{2.5}$ and PM$_{10}$ increased from 8.1 and 21.5 µg m$^{-3}$ to 13.3 and 32.5 µg m$^{-3}$ at Zone 2 AQMS, respectively (Table 2). As can be seen in Table 3, the average concentrations of ambient PM$_{2.5}$ at Shad abad and Zone 2 AQMSs increased by 4.1 (20.5%), 7.1 (30.1%) and 9.5 (72.5%) µg m$^{-3}$ during the SARS-CoV-2 outbreak in the third scenario (the whole study period) in comparison to the same period of last year. In general, over the SARS-CoV-2 outbreak in Tehran, the ambient PM$_{10}$ concentrations increased from 46.9, 34.2 and 57.9 µg m$^{-3}$ to 54.6, 51.9 and 72.6 µg m$^{-3}$ for Tehran city, Zone 2 and Shad abad AQMSs, a considerable rise equal to 16.4%, 51.7% and 25.4%, respectively. Detailed information (25$^{th}$, 50$^{th}$ and 75$^{th}$ percentiles) regarding the ambient PM$_{2.5}$ and PM$_{10}$ concentrations in Tehran during the SARS-CoV-2 outbreak
days is presented in Tables 1–3. Detailed information on the meteorological parameters (wind speed, wind direction, temperature (minimum, average, maximum), precipitation and the number of rainy days) during the investigated scenarios is summarized in Table 4. As shown in Table 4, the average temperature during the three scenarios of SARS-CoV-2 outbreak was 12.3°C, 12.2°C and 12.2°C, while it was 9.4°C, 11.4°C and 10.1°C during the same period of last year, respectively. Additionally, the average of wind speed during the three scenarios of SARS-CoV-2 (3.0, 4.0 and 3.2 m s⁻¹ for Scenario I, II and III, respectively) was approximately similar to those figures over the same period of last year (3.0, 3.3 and 3.4 m s⁻¹). The number of rainy days during the three scenarios of SARS-CoV-2 outbreak was 8.0, 8.0 and 16.0 days, while it was 5.0, 6.0 and 11.0 days at the same period of last year. Lastly, the prevailing wind direction during the periods under investigation was from the west of Tehran city (Fig. 2).

This study critically highlights the negative indirect effect of SARS-CoV-2 outbreak on the average concentration of ambient air PM_{2.5} and PM_{10} as the most notable air pollutants in Tehran. We investigated the changes in ambient air PM_{2.5} and PM_{10} concentrations due to the SARS-CoV-2 outbreak compared to the same period of last year through three different period time scenarios. The first scenario of investigation was across the first month of SARS-CoV-2 outbreak from

### Table 3. Ambient PM_{2.5} and PM_{10} concentrations in Tehran during the SARS-CoV-2 outbreak (20 February – 2 April 2020) in comparison to their concentrations in the same period of last year (20 February – 3 April 2019) as the third scenario (the whole study period).

<table>
<thead>
<tr>
<th>AQMS</th>
<th>PM_{2.5} SARS-CoV-2 outbreak</th>
<th>The same period of last year</th>
<th>PM_{2.5} SARS-CoV-2 outbreak</th>
<th>The same period of last year</th>
<th>Variation for PM_{2.5}</th>
<th>Variation for PM_{10}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shad abad</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25th percentile</td>
<td>16.0</td>
<td>12.0</td>
<td>38.8</td>
<td>32.0</td>
<td>+4.0</td>
<td>+33.3</td>
</tr>
<tr>
<td>Average</td>
<td>30.7</td>
<td>23.6</td>
<td>72.6</td>
<td>57.9</td>
<td>+7.1</td>
<td>+30.08</td>
</tr>
<tr>
<td>50th percentile</td>
<td>25.0</td>
<td>20.0</td>
<td>63.0</td>
<td>50.0</td>
<td>+5.0</td>
<td>+25.00</td>
</tr>
<tr>
<td>75th percentile</td>
<td>36.0</td>
<td>31.0</td>
<td>99.2</td>
<td>75.0</td>
<td>+5.0</td>
<td>+16.13</td>
</tr>
<tr>
<td>Zone 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25th percentile</td>
<td>10.0</td>
<td>7.0</td>
<td>32.0</td>
<td>20.0</td>
<td>+3.0</td>
<td>+42.86</td>
</tr>
<tr>
<td>Average</td>
<td>22.6</td>
<td>13.1</td>
<td>51.9</td>
<td>34.2</td>
<td>+9.5</td>
<td>+72.52</td>
</tr>
<tr>
<td>50th percentile</td>
<td>18.0</td>
<td>12.0</td>
<td>48.0</td>
<td>32.0</td>
<td>+6.0</td>
<td>+50.00</td>
</tr>
<tr>
<td>75th percentile</td>
<td>29.0</td>
<td>17.0</td>
<td>67.0</td>
<td>44.0</td>
<td>+12.0</td>
<td>+70.59</td>
</tr>
<tr>
<td>Tehran</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25th percentile</td>
<td>13.3</td>
<td>11.7</td>
<td>31.6</td>
<td>27.3</td>
<td>+1.6</td>
<td>+13.68</td>
</tr>
<tr>
<td>Average</td>
<td>24.1</td>
<td>20.0</td>
<td>54.6</td>
<td>46.9</td>
<td>+4.1</td>
<td>+20.50</td>
</tr>
<tr>
<td>50th percentile</td>
<td>20.6</td>
<td>17.9</td>
<td>49.9</td>
<td>44.6</td>
<td>+2.7</td>
<td>+15.08</td>
</tr>
<tr>
<td>75th percentile</td>
<td>31.4</td>
<td>26.6</td>
<td>74.6</td>
<td>62.2</td>
<td>+4.8</td>
<td>+18.05</td>
</tr>
</tbody>
</table>

### Table 4. Meteorological parameters during the SARS-CoV-2 and the same period of last year at three scenarios.

<table>
<thead>
<tr>
<th>Statistic</th>
<th>SARS-CoV-2 outbreak</th>
<th>The same period of last year (Scenario I)</th>
<th>SARS-CoV-2 outbreak</th>
<th>The same period of last year (Scenario II)</th>
<th>SARS-CoV-2 outbreak</th>
<th>The same period of last year (Scenario III)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WS</td>
<td>T</td>
<td>T-min</td>
<td>T-max</td>
<td>Precipitation</td>
<td>Rainy days</td>
<td>WS</td>
</tr>
<tr>
<td>25th percentile</td>
<td>2.0</td>
<td>9.0</td>
<td>5.5</td>
<td>14.5</td>
<td>0.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Average</td>
<td>3.0</td>
<td>12.3</td>
<td>7.6</td>
<td>16.7</td>
<td>3.1</td>
<td></td>
</tr>
<tr>
<td>50th percentile</td>
<td>3.0</td>
<td>12.3</td>
<td>7.2</td>
<td>16.9</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>75th percentile</td>
<td>4.0</td>
<td>15.9</td>
<td>10.9</td>
<td>19.6</td>
<td>0.3</td>
<td></td>
</tr>
</tbody>
</table>

S: wind speed (m s⁻¹); T: temperature (°C); T-min: minimum temperature (°C); T-max: maximum temperature (°C).
The SARS-CoV-2 outbreak during the period from 20 February 2020 to 19 March 2020 is compared with the same period of the previous year under three scenarios:

1. **Scenario I**: The same period of last year
2. **Scenario II**: The same period of last year during the Nowruz New Year holidays, the longest holiday in Iran (two weeks from late March to early April each year)
3. **Scenario III**: The whole study period (20 February – 2 April 2020)

In addition to studying the average concentrations of ambient air PM$_{2.5}$ and PM$_{10}$ in Tehran at the city level, their concentrations were also compared at two AQMSs (Zone 2 and Shad abad) located at the highest and lowest socioeconomic regions of the city (Rohani-Rasaf et al., 2018). Based on our analysis, the average of ambient

---

**Fig. 2.** Wind rose plot for Tehran during the SARS-CoV-2 and the same period of last year at three scenarios.
Numerous potential socioeconomic factors during the three scenarios of SARS-CoV-2 outbreak as reported by authorities/policy makers. Our results, Zambrano et al. (2020) showed that atmospheric pollution be considered a co-factor in extremely high level of SARS-CoV-2 lethality in Northern Italy? Environ. Pollut. 261: 114465. https://doi.org/10.1016/j.envpol.2020.114465

Received for review, May 14, 2020
Revised, June 3, 2020
Accepted, June 14, 2020