Assessing air quality changes in large cities during COVID-19 lockdowns: the impacts of traffic-free urban conditions in Almaty, Kazakhstan

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Assessing air quality changes in large cities during COVID-19 lockdowns: The impacts of traffic-free urban conditions in Almaty, Kazakhstan

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HIGHLIGHTS

• PM2.5 concentration reduced by 21% with spatial variations of 6–34% compared to the average of the same days in 2018–2019
• CO and NO2 concentrations reduced by 49% and 35%, respectively
• O3 concentrations increased by 15% compared to the preceding 17 days before the lockdown
• Concentrations of benzene and toluene were 2–3 times higher than in the same seasons of 2015–2019.

GRAPHICAL ABSTRACT

ABSTRACT

Number of cities worldwide experienced air quality improvements during COVID-19 lockdowns; however, such changes may have been different in places with major contributions from nontraffic related sources. In Almaty, a city-scale quarantine came into force on March 19, 2020, which was a week after the first COVID-19 case was registered in Kazakhstan. This study aims to analyze the effect of the lockdown from March 19 to April 14, 2020 (27 days), on the concentrations of air pollutants in Almaty. Daily concentrations of PM2.5, NO2, SO2, CO, O3, and BTEX were compared between the periods before and during the lockdown. During the lockdown, the PM2.5 concentration was reduced by 21% with spatial variations of 6–34% compared to the average of the same days in 2018–2019, and still, it exceeded WHO daily limit values for 18 days. There were also substantial reductions in CO and NO2 concentrations by 49% and 35%, respectively, but an increase in O3 levels by 15% compared to the prior 17 days before the lockdown. The concentrations...
The air quality in Almaty is one of the lowest in Kazakhstan

21 days in 2018 the PM$_{2.5}$ concentrations exceeded 250 $\mu$g/m$^3$ at least at one station (Kerimray et al., 2020)
Source of information used in study

- Daily PM$_{2.5}$ February 21 – March 18, 2018-2020
  7 stations of a total of 31 stations

- Benzene, toluene, ethylbenzene and o-xylene (BTEX)
  Single measurements during 3 days in March and April at 6 sites, 2015-2020

- CO, SO$_2$, O$_3$, NO$_2$ March 2 – April 14, 2020, from one station
Impact of the lockdown on the PM$_{2.5}$ concentration

The average temperatures
- 2018 – 11.2°C
- 2019 – 11.6°C
- 2020 – 8.7°C

Rains:
- Before lockdown 2020: 9 days out of 27
- Lockdown period 2020: 16 days out of 27

Kerimray et al., STOTEN, 2020
## Average PM$_{2.5}$ concentrations

| Year | February 21 – 18 March | March 19 – April 14 | Percent change |
|------|------------------------|---------------------|----------------|
| 2018 | 53                     | 38                  | -28%           |
| 2019 | 66                     | 40                  | -39%           |
| 2020 | 44                     | 31                  | -29%           |
PM$_{2.5}$ spatial reductions varied between 6% and 34% during the lockdown.
Spatial distribution of PM$_{2.5}$ concentration between March 19 to April 14

The number of days exceeding the daily WHO limits (25 μg/m$^3$)
2018 – 23 days
2019 – 25 days
2020 – 18 days

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Correlation of PM$_{2.5}$ concentration with the distance to CHPs

Kerimray et al, STOTEN, 2020

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Simple, fast method for VOCs determination in air

“Ecology of Biosphere” lab

Baimatova et al., Talanta, 2016
The averages for benzene (101 μg/m$^3$) and toluene (67 μg/m$^3$) were 3 and 2 times higher, while those for ethylbenzene (1.0 μg/m$^3$) and o-xylene (1.6 μg/m$^3$) were 4 and 2.7 times lower in 2020 than during the same sampling period in 2015–2019.
Correlation of BTEX concentrations and elevation above sea level and distance to CHP-3

Kerimray et al., STOTEN, 2020
Average concentration of benzene in three days of spring in 2015–2019 and 2020

Highly elevated concentrations of benzene and toluene on three sampling days during the lockdown (101 and 67 μg/m³) and the toluene-to-benzene ratios suggest that these compounds originated from coal-related sources such as power plants and households and to possible episodic cases of garbage burning, bathhouses, and bus fleet stations.
Toluene-to-benzene ratios (T/B) in ambient air in March–April of 2015–2020 in Almaty

- T/B > 1 – vehicle emissions
- T/B < 1 – coal combustion

Kerimray et al, STOTEN, 2020
Concentrations of NO$_2$, SO$_2$, CO, O$_3$

| Time period                        | NO$_2$ | SO$_2$ | CO   | O$_3$ |
|-----------------------------------|--------|--------|------|-------|
| Average concentration (μg/m$^3$)   |        |        |      |       |
| March 2 – March 18 (before lockdown) | 37     | 49     | 674  | 30    |
| March 19 – April 14 (lockdown period) | 24     | 52     | 343  | 34    |
| Percent reduction                 | -35%   | 7%     | -49% | 15%   |

- A significant decrease concentrations of CO and NO$_2$ during lockdown compared to 17 days before lockdown may be due to a combination of lack of transport and seasonal weather changes.
- An increase in O$_3$ by 15%, which can be explained by the higher levels of solar activity during the period of the lockdown.
- Transport emissions did not affect SO$_2$ levels.
Conclusions

• This research demonstrates the complicated nature of air pollution in Almaty, which urgently needs further investigation through spatial inventories and source-apportionment studies.

• The SARS-CoV-2 lockdown period was a unique opportunity to test how any possible reductions in urban transport parameters may improve the air quality in the city.

• The results suggest that even traffic-free conditions could not cause substantial reductions in pollution levels since several primary emission sources dominate the pollution profile over the city.

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Thank you for your attention!