Aiymgul Kerimray, Nassiba Baimatova, Olga P. Ibragimova,
Bauyrzhan Bukenov, Bulat Kenessov, Pavel Plotitsyn, Ferhat Karaca

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

Reported by Nassiba Baimatova, PhD, Postdoctoral researcher

at 17th session of the Joint Task Force on Environmental Statistics and Indicators, 26 October 2020

© Baimatova et al., 2020

Science of the Total Environment 730 (2020) 139179

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

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

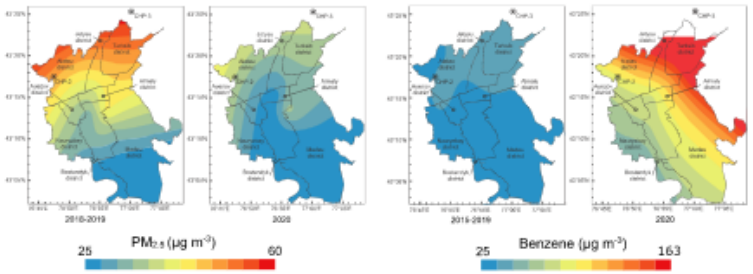
Aiymgul Kerimray [a], Nassiba Baimatova [a,*], Olga P. Ibragimova [a], Bauyrzhan Bukenov [a], Bulat Kenessov [a], Pavel Plotitsyn [b], Ferhat Karaca [c,d]

[a] Center of Physical Chemical Methods of Research and Analysis, Al-Farabi Kazakh National University, Almaty, Kazakhstan
[b] Airkaz.org, Almaty, Kazakhstan
[c] Department of Civil and Environmental Engineering, Nazarbayev University, Nur-Sultan, Kazakhstan
[d] The Environment & Resource Efficiency Cluster, Nazarbayev University, Nur-Sultan, Kazakhstan

HIGHLIGHTS

- $PM_{2.5}$ concentration reduced by 21% with spatial variations of 6–34% compared to the average of the same days in 2018–2019
- CO and NO_2 concentrations reduced by 49% and 35%, respectively
- O_3 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



ARTICLE INFO

Article history:
Received 21 April 2020
Received in revised form 29 April 2020
Accepted 1 May 2020
Available online xxxx

Keywords:
Air quality
Pollution
Almaty
SARS-CoV-2

ABSTRACT

Number of cities worlwide 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 $PM_{2.5}$, NO_2, SO_2, CO, O_3, and BTEX were compared between the periods before and during the lockdown. During the lockdown, the $PM_{2.5}$ concentration was reduced by 21% with spatial variations of 6–34% compared to the average on 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 NO_2 concentrations by 49% and 35%, respectively, but an increase in O_3 levels by 15% compared to the prior 17 days before the lockdown. The concentrations

https://www.sciencedirect.com/science/article/pii/S0048969720326966

et al., 2020

The air quality in Almaty is one of the lowest in Kazakhstan

December 2015

September 2017

21 days in 2018 the $PM_{2.5}$ concentrations exceeded 250 $\mu g/m^3$ at least at one station (Kerimray et al.,2020)

© Baimatova et al., 2020

Source of information used in study

AIRKAZ.ORG

- Daily $PM_{2.5}$ February 21 – March 18, 2018-2020

7 stations of a total of 31 stations

AL-FARABI KAZAKH NATIONAL UNIVERSITY

"Ecology of Biosphere" lab
http://cfhma.kz/ecobio/en

- Benzene, toluene, ethylbenzene and o-xylene (BTEX)

Single measurements during 3 days in March and April at 6 sites, 2015-2020

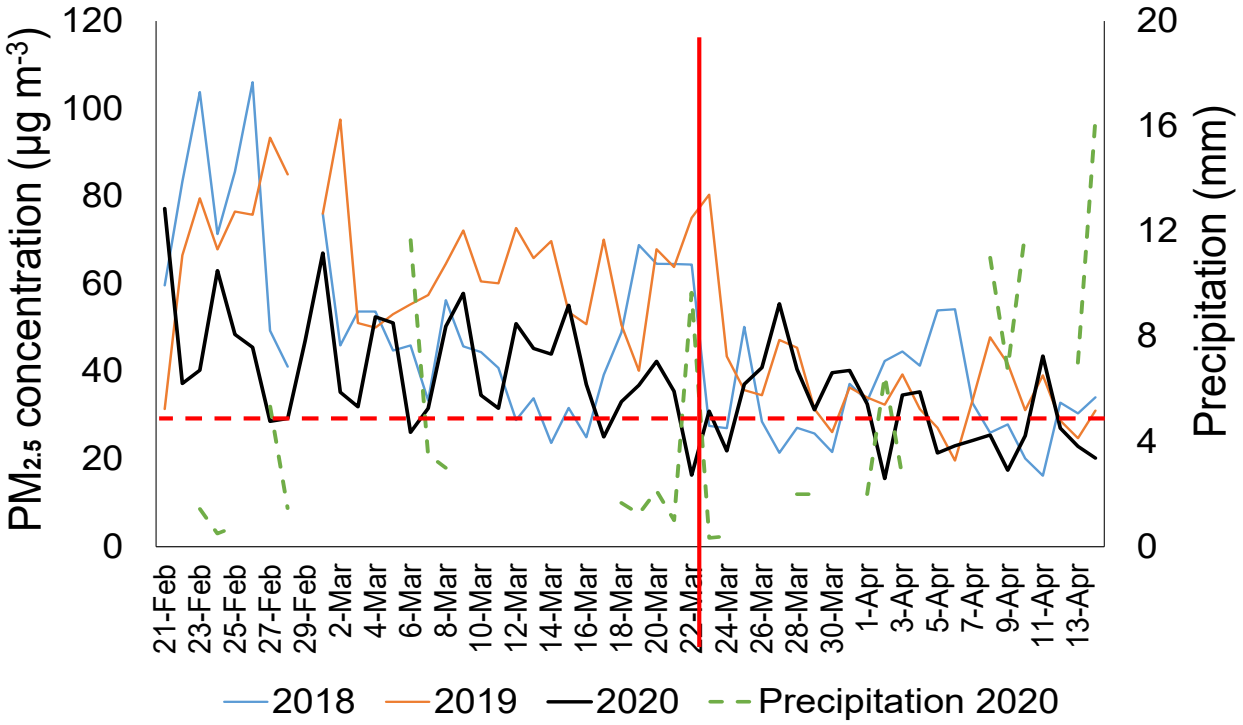
SKYMAX

- CO, SO_2, O_3, NO_2 March 2 – April 14, 2020, from one station

Kerimray et al, STOTEN, 2020

© Baimatova et al., 2020

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

© *Baimatova et al., 2020*

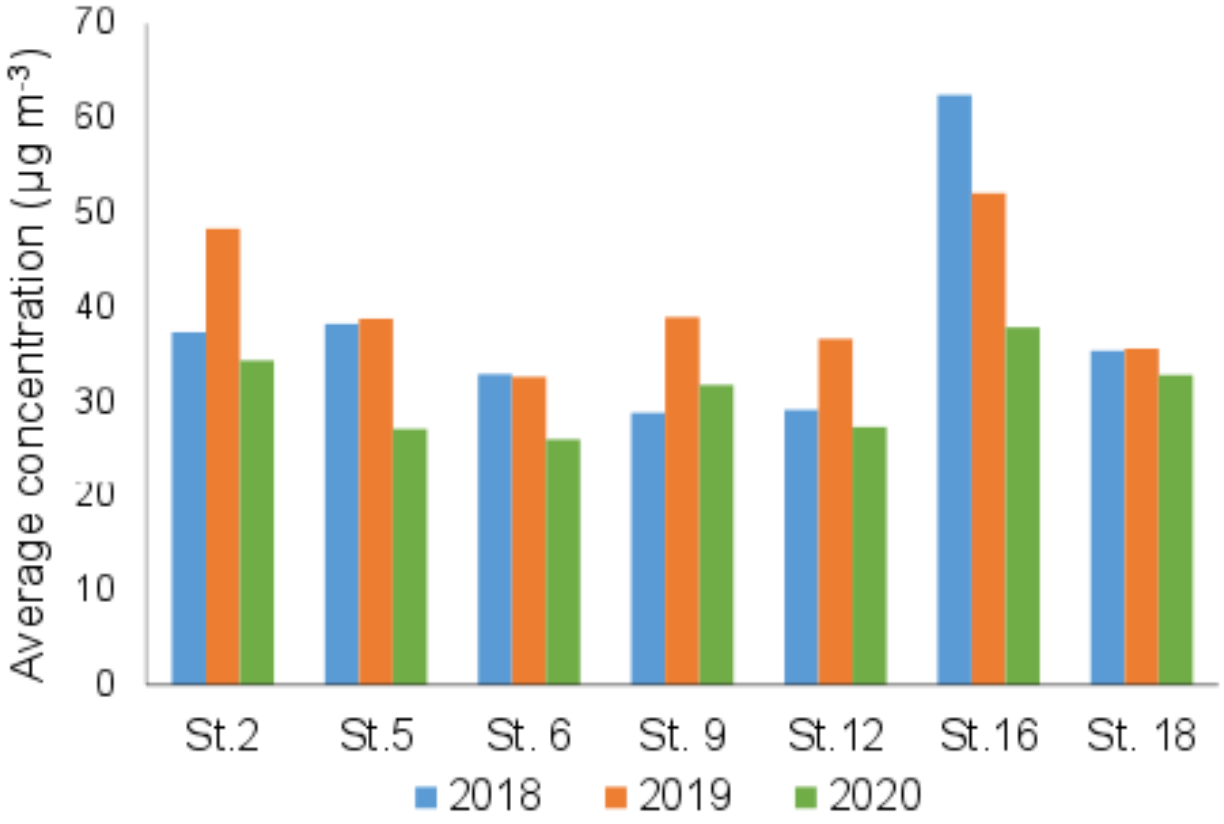
Average $PM_{2.5}$ concentrations

Year	February 21 – 18 March	March 19 – April 14	Percent change
	$PM_{2.5}$ concentration ($\mu g/m^3$)		
2018	53	38	-28%
2019	66	40	-39%
2020	44	31	-29%

Kerimray et al, STOTEN, 2020

© *Baimatova et al., 2020*

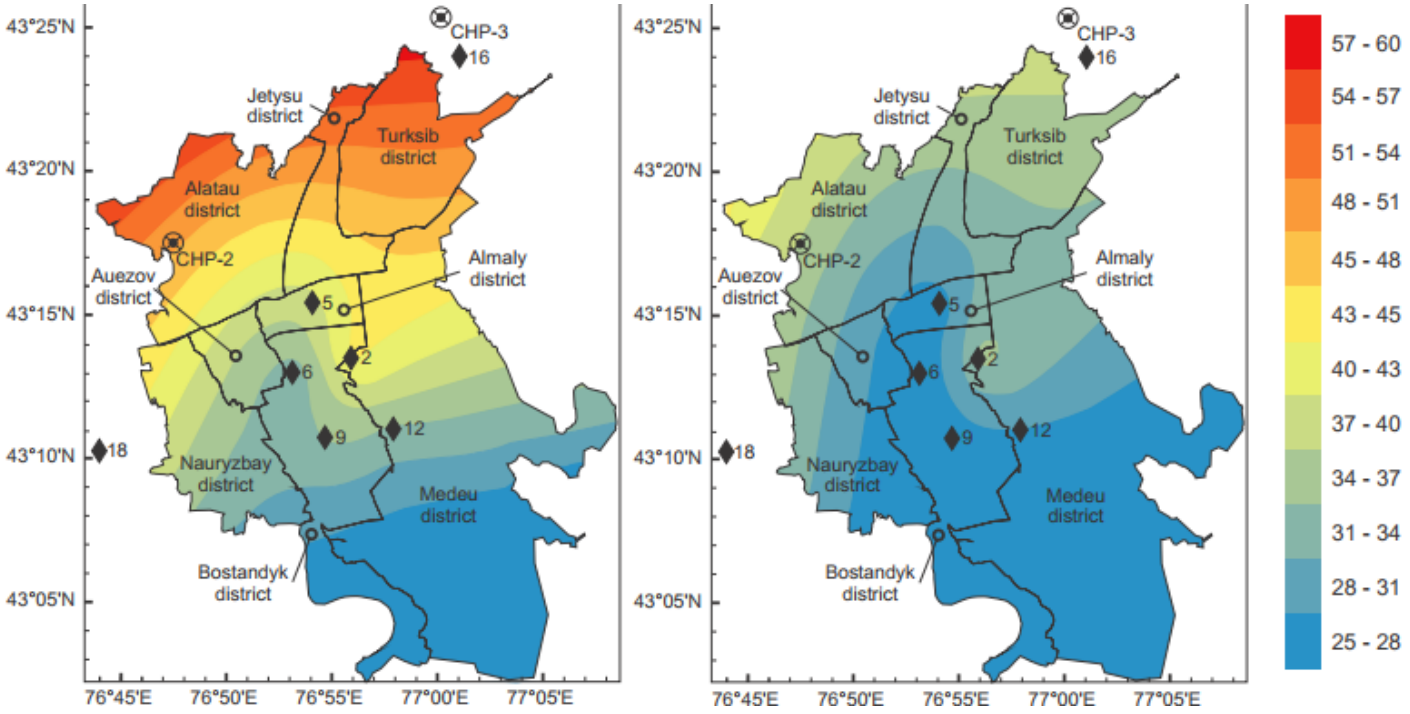
$PM_{2.5}$ spatial reductions varied between 6% and 34% during the lockdown



Kerimray et al, STOTEN, 2020.

© Baimatova et al., 2020

Spatial distribution of $PM_{2.5}$ concentration between March 19 to April 14



2018-2019 **2020**

The number of days exceeding the daily WHO limits (25 μg/m^3)

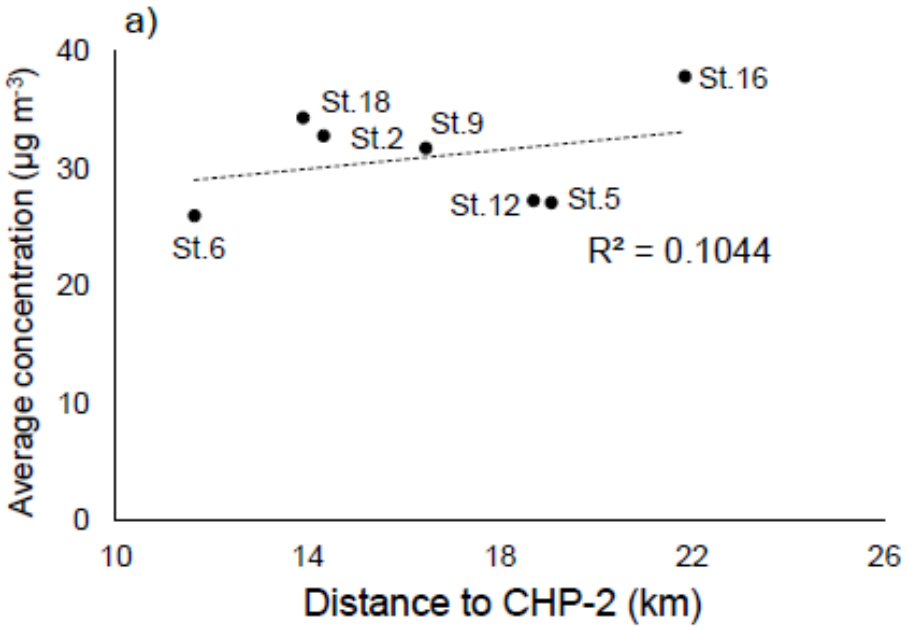
2018 – 23 days

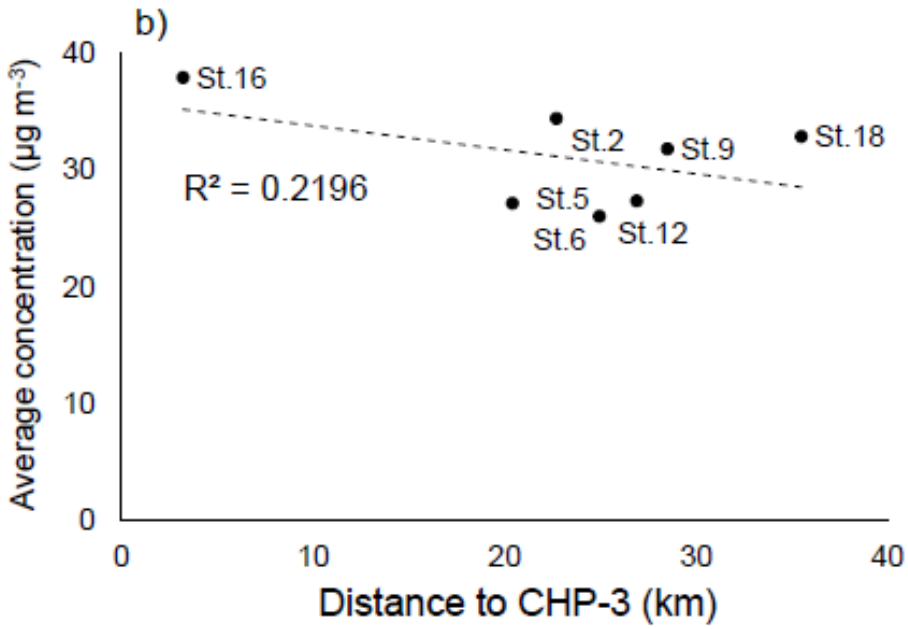
2019 – 25 days

2020 – 18 days

© *Baimatova et al., 2020*

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





Kerimray et al, STOTEN, 2020

© *Baimatova et al., 2020*

Simple, fast method for VOCs determination in air

“Ecology of Biosphere” lab

Talanta 154 (2016) 46–52

Contents lists available at ScienceDirect

Talanta

journal homepage: www.elsevier.com/locate/talanta

Simple and accurate quantification of BTEX in ambient air by SPME and GC–MS

Nassiba Baimatova [a], Bulat Kenessov [a,*], Jacek A. Koziel [b], Lars Carlsen [c], Marat Bektassov [a], Olga P. Demyanenko [a]

[a] Al-Farabi Kazakh National University, Faculty of Chemistry and Chemical Engineering, Center of Physical Chemical Methods of Research and Analysis, Almaty, Kazakhstan
[b] Iowa State University, Department of Agricultural and Biosystems Engineering, Ames, IA 50011, USA
[c] Awareness Center, Trekroner, DK-4000 Roskilde, Denmark

ARTICLE INFO

Article history:
Received 6 January 2016
Received in revised form
12 March 2016
Accepted 15 March 2016
Available online 16 March 2016

Keywords:
Solid-phase microextraction
GC–MS
Standard addition
BTEX
Ambient air pollution
Air analysis

ABSTRACT

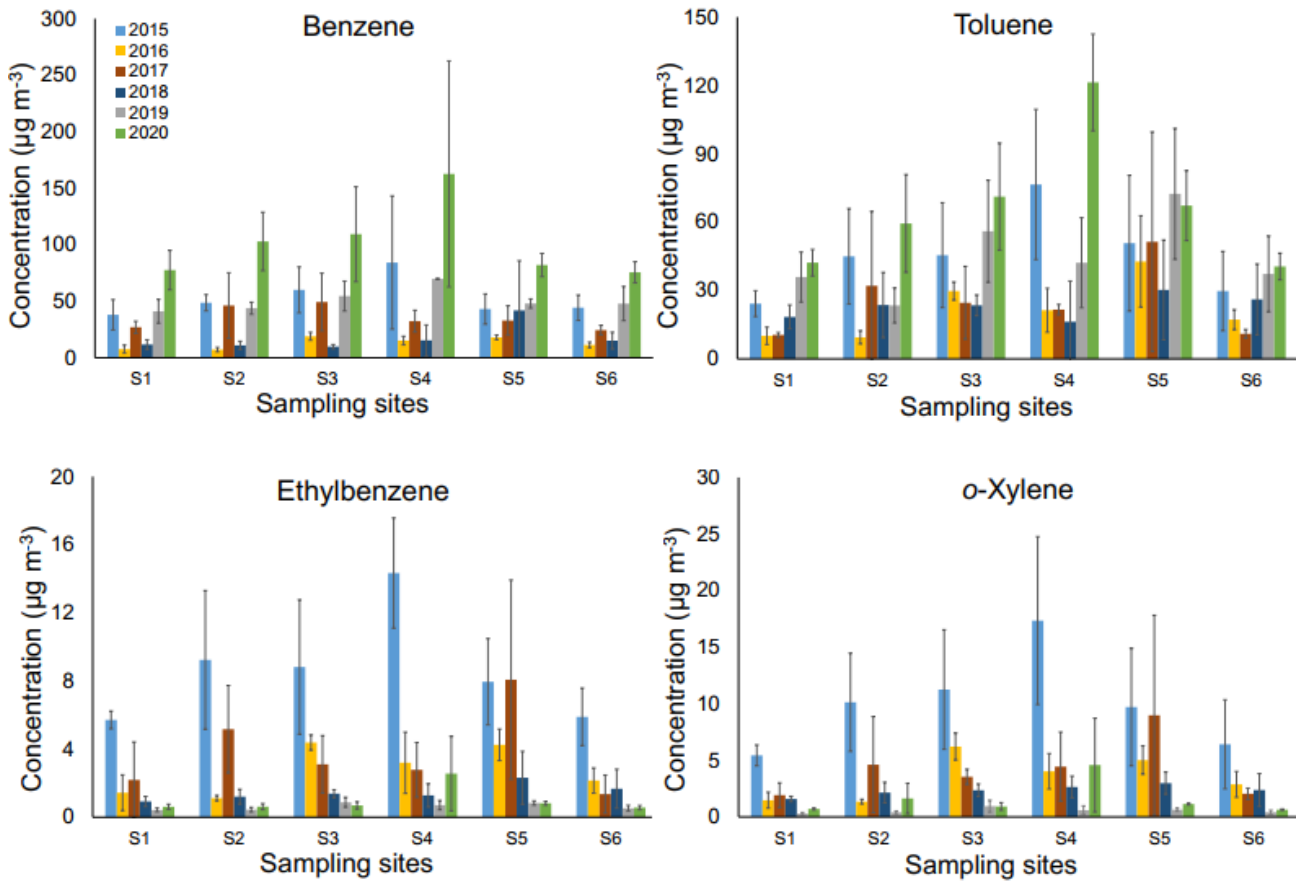
Benzene, toluene, ethylbenzene and xylenes (BTEX) comprise one of the most ubiquitous and hazardous groups of ambient air pollutants of concern. Application of standard analytical methods for quantification of BTEX is limited by the complexity of sampling and sample preparation equipment, and budget requirements. Methods based on SPME represent simpler alternative, but still require complex calibration procedures. The objective of this research was to develop a simpler, low-budget, and accurate method for quantification of BTEX in ambient air based on SPME and GC–MS. Standard 20-mL headspace vials were used for field air sampling and calibration. To avoid challenges with obtaining and working with 'zero' air, slope factors of external standard calibration were determined using standard addition and inherently polluted lab air. For polydimethylsiloxane (PDMS) fiber, differences between the slope factors of calibration plots obtained using lab and outdoor air were below 34%. PDMS fiber provided higher precision during calibration while the use of Carboxen/PDMS fiber resulted in lower detection limits for benzene and toluene. To provide sufficient accuracy, the use of 20 mL vials requires triplicate sampling and analysis. The method was successfully applied for analysis of 108 ambient air samples from Almaty, Kazakhstan. Average concentrations of benzene, toluene, ethylbenzene and o-xylene were 53, 57, 11 and 14 μg m^{-3}, respectively. The developed method can be modified for further quantification of a wider range of volatile organic compounds in air. In addition, the new method is amenable to automation.

© 2016 Elsevier B.V. All rights reserved.

Baimatova et al., Talanta, 2016

© Baimatova et al., 2020

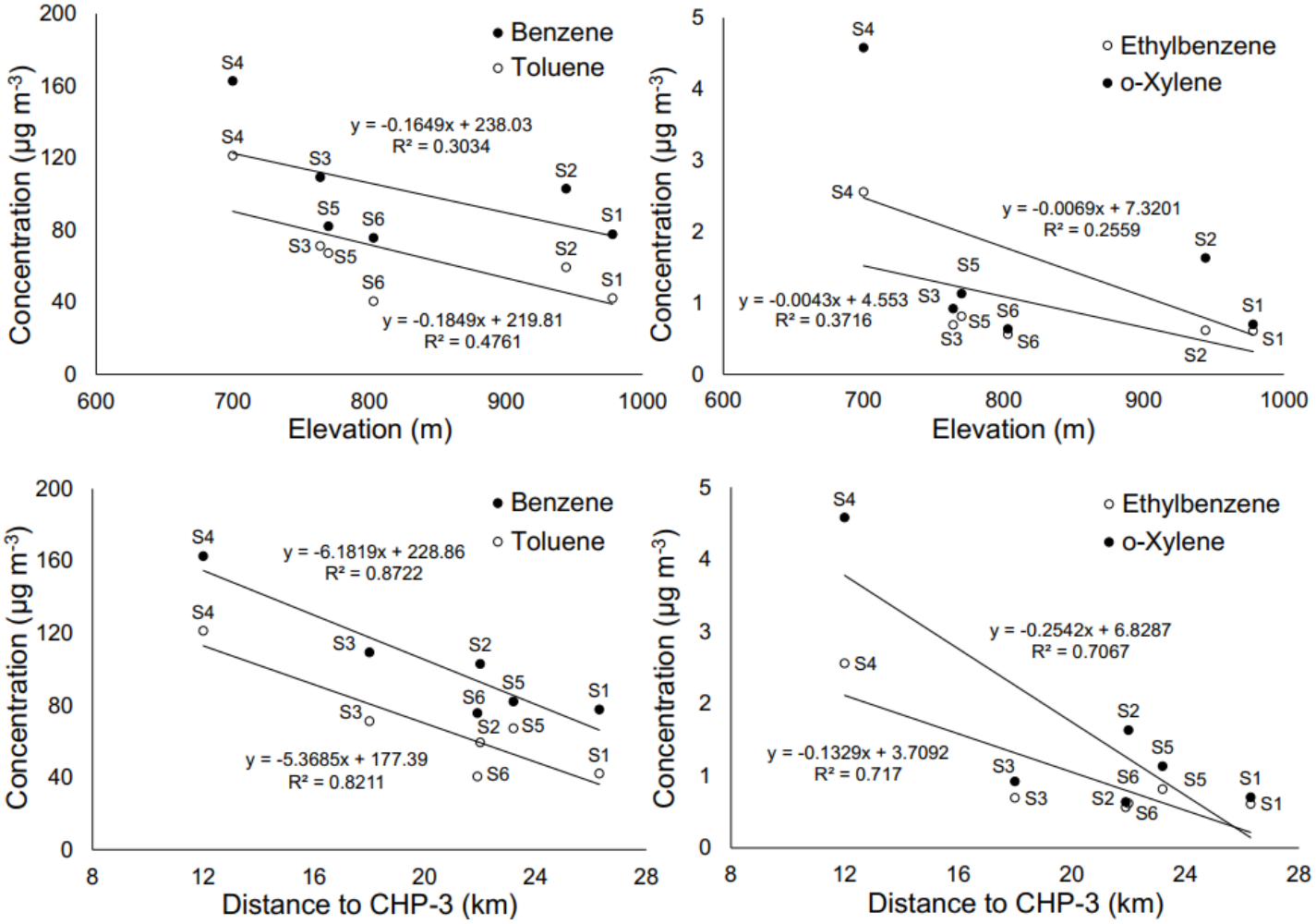
Average BTEX concentrations from 2015 to 2020



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

© *Baimatova et al., 2020*

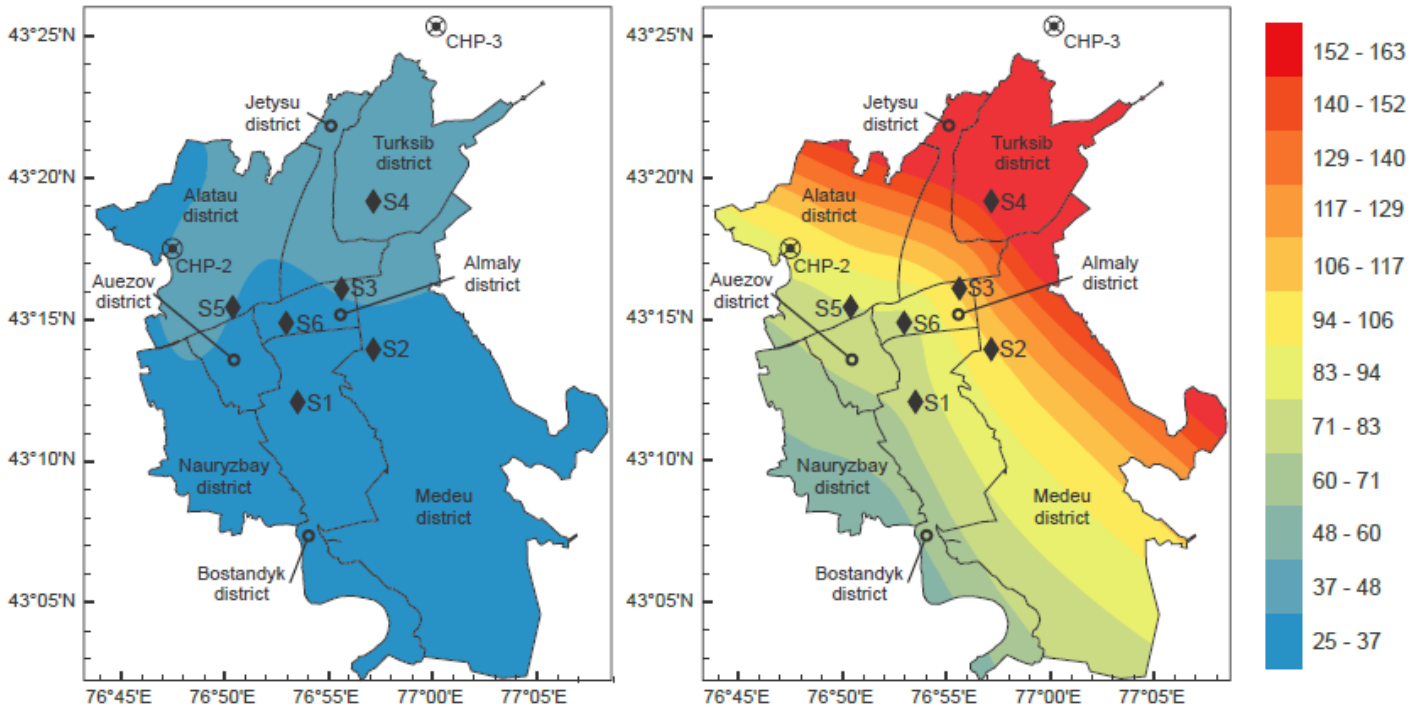
Correlation of BTEX concentrations and elevation above sea level and distance to CHP-3



Kerimray et al, STOTEN, 2020

© Baimatova et al., 2020

Average concentration of benzene in three days of spring in 2015–2019 and 2020

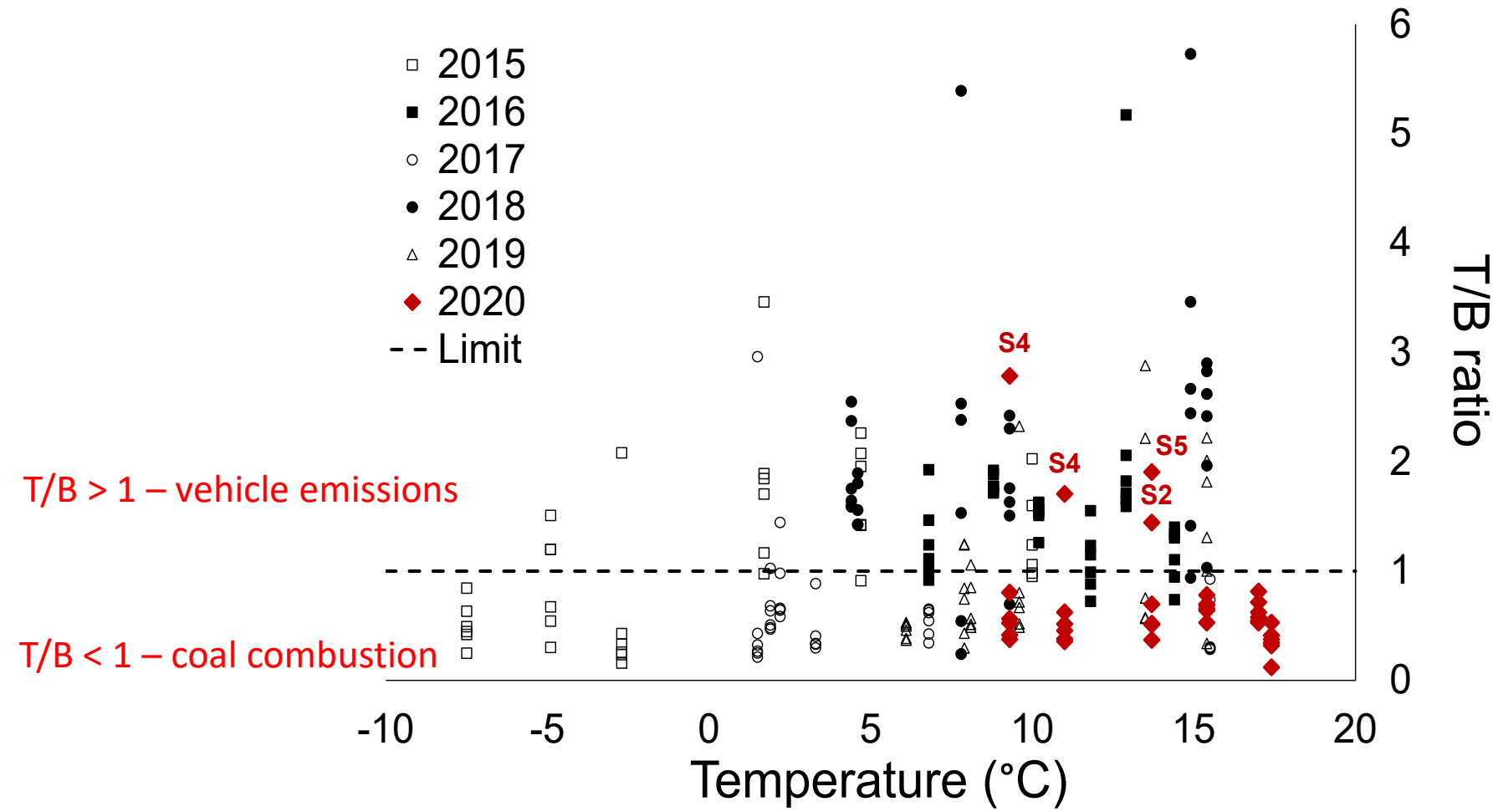


2018-2019 **2020**

Highly elevated concentrations of benzene and toluene on three sampling days during the lockdown (101 and 67 μg/m^3) 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.**

© Baimatova et al., 2020

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

© Baimatova et al., 2020

Concentrations of NO_2, SO_2, CO, O_3

Time period	NO_2	SO_2	CO	O_3
	Average concentration ($\mu g/m^3$)			
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 NO2 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 O3 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.

© *Baimatova et al., 2020*

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.

© Baimatova et al., 2020

Acknowledgement

Al-Farabi Kazakh National University

Airkaz.org

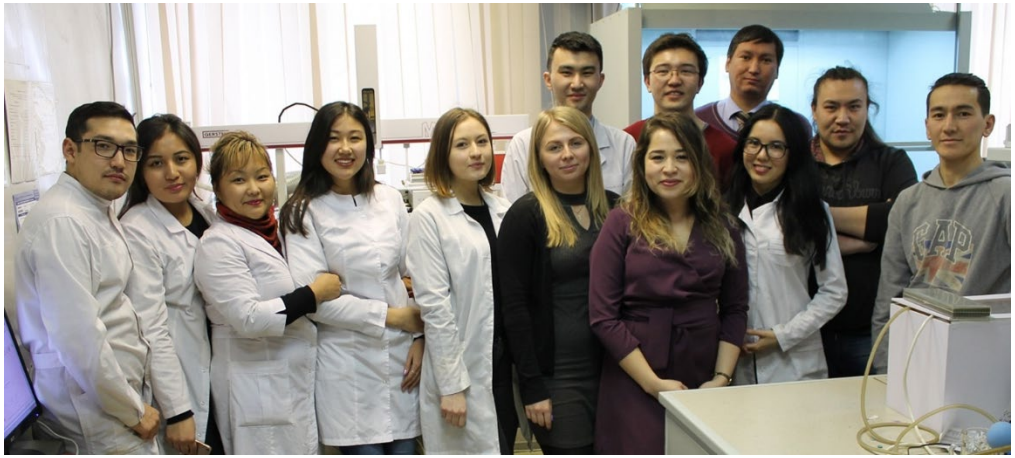
“AirVision.kz” Public Fund

Skymax Technologies

© Baimatova et al., 2020

“Ecology of Biosphere” lab’s Team

http://cfhma.kz/ecobio/en



© Baimatova et al., 2020

Thank you for your attention!