ISSN: 2664-9640

Impacts of a lockdown against the COVID-19 pandemic on the air quality in Wuhan, China

Yujia Hong [1,2]

[1]Wuhan Britain-China School, Wuhan 430034, China

[2]Wuhan Foreign Languages School, Wuhan 430022, China

Abstract

Wuhan City was ordered into lockdown by the Chinese government from January 23 to April 7, 2020 due to the COVID-19 pandemic. The aim of this article was to assess the impact of the lockdown on the air quality of the city. The author collected and analyzed data from air quality monitoring stations in Wuhan to determine the variations of air pollutants concentration during 2015-2021. The contemporaneous daily average concentrations of pollutants in two quanta (T1: January 23 to April 7 each year; T2: other days each year) during the three periods (2015–2019, 2020, 2021) were compared. The results are as follows. (1) In theT1 quantum, there were marked changes ofthe average concentrations in 2020 compared with the data during 2015-2019 ($PM_{2.5}$, -44.30%; PM_{10}, -46.60%; SO_2, -46.12%; CO, - 18.54%; NO_2, -56.56%; O_3, 18.36%) . (2) In the T2 quantum, there were relatively small changes of the average concentrations in 2020 compared with the data during 2015-2019 ($PM_{2.5}$, -24. 69%; PM_{10}, -27.82%; SO_2, -28.14%; CO, -16.48%; NO_2, -12.76%; O_3, -3.22%). (3) When the changes of pollutants concentration that occurred in two quanta were compared, it is easily to find that the change ranges in T1 quantum is larger than that in T2 quantum except CO, so the lockdown of Wuhan City was seen to have a significant effect on the city's air quality.

Keywords

COVID- 19 · Air quality · Wuhan City · Lockdown.

1. Introduction

The coronavirus disease (COVID-19) has spread widely worldwide since it was firstly diagnosed on December 27, 2019 and was reported on December 31, 2019 in Wuhan City, China (Huang et al., 2020). On March 11, 2020, the World Health Organization declared the COVID-19, which is caused by the novel coronavirus SARS-CoV-2, was a pandemic (WHO, 2020). In response to the rapid increase ofCOVID-19 cases, the Chinese government sealed the entire city ofWuhan for 76 days from January 23 to April 7, 2020.This was the first time in human history that a large city was locked down due to an epidemic. The social, economic,and environmental impacts caused by the COVID- 19 pandemic have been widely studied by scholars worldwide. Lockdowns oftowns, cities, and nations to prevent the spread of COVID-19 in 2020 can also affected global air quality (Josephson et al., 2021; Lal et al., 2020; Wang and Su, 2020; Wang et al., 2021; Zambrano-Monserrate et al., 2020). For example, He et al. (2021) revealed the impact of COVID-19 lockdowns on air pollutants (PM2.5, NO2, and O3) at global, continental, and national scales.

A city blockade involved preventing traffic movement and banning people from moving out of the city. Toprevent the spread of COVID-19, various educational institutions were also closed and many isolation areas established (Wilder-Smith and Freedman, 2020). In the last ten days ofJanuary 2020, strict traffic restrictions were implemented in Wuhan City and motor vehicle emissions in the urban area were reduced to the maximum extent possible. Observations

ISSN: 2664-9640

showed that the composition of the atmosphere in eastern China changed significantly between January and February 2020.

This study examined the change trends of the concentrations of major air pollutants in Wuhan City before, during, and after the lockdown (2015–2019, 2020, 2021), and evaluated the impact of lockdown to control epidemic spreading on air quality of the city.

2. Research areas, data resources and methods

Wuhan City is the capital of Hubei Province and the largest metropolis in Central China (Figure 1). The Yangtze and Hanjiang rivers–the third-largest river in the world and its largest tributary–run through the center of the city. Wuhan City is divided into three parts, with Wuchang, Hankou, and Hanyang towns stretching across the two rivers. Over 13 districts covering an area of 8,467 km^2 come under the jurisdiction of the city with its 11 million permanent residents, 83 universities, and many large industrial emission sources such as steel and chemical factories. It is also an important aviation and railway transportation hub in China.

The data of concentrations of PM2.5, PM10, CO, NO2, SO2 and O3 were obtained from Chinese environmental monitoring stations (http://www.cnemc.cn/), with hourly monitoring data selected from nine air quality monitoring sites in Wuhan from January 1, 2015, to April 30, 2021 (Table 1). Data were used to calculate the daily average concentrations of each pollutant and estimate the data change trends from 2015 to 2021.

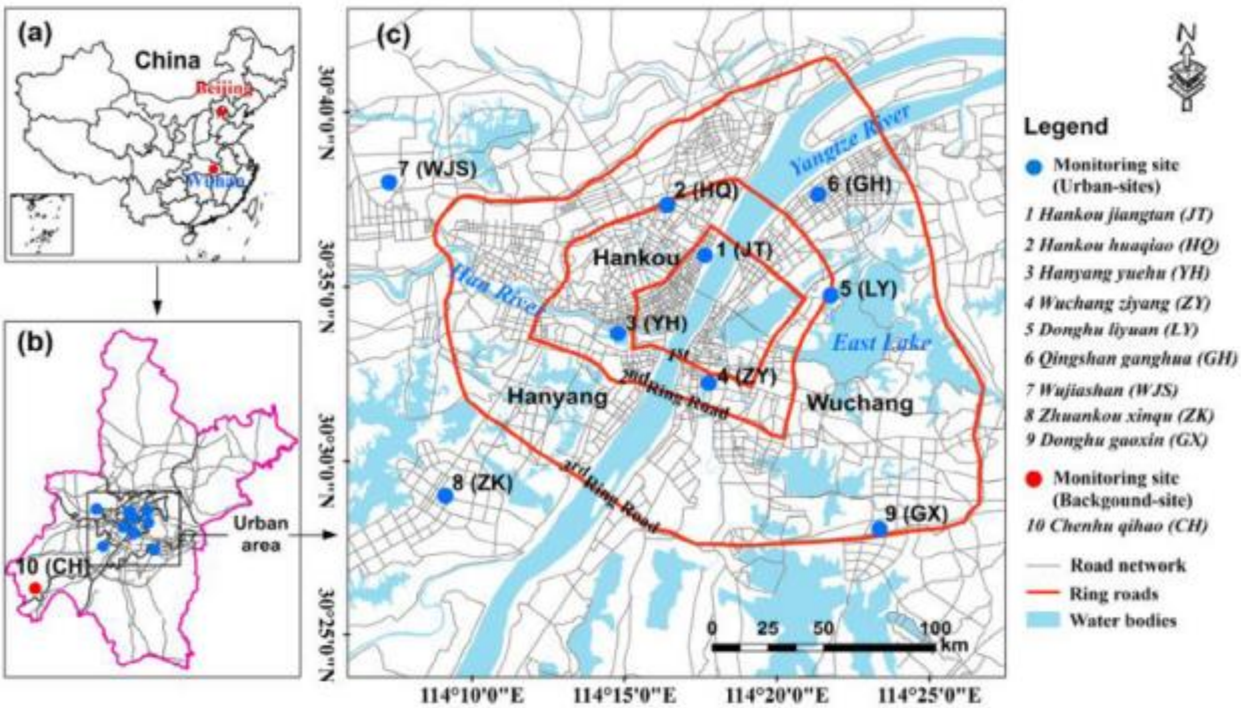

Figure 1 Geographical locations of air quality monitoring sites in Wuhan City

ISSN: 2664-9640

Table 1 Detailed descriptions of air quality monitoring sites in Wuhan City

NO.	Site Name	Site Code	Location	Function	Population density (people/km²)
1	Hankou jiang-tan	JT	Inside the 1st ring road	Scenery, transportation	14,000
2	Hankou hua-qiao	HQ	Near the 2nd ring road	Residential, transportation	14,000
3	Hanyang yue-hu	YH	Near the 1st ring road	Scenery, transportation	5,700
4	Wuchang zi-yang	ZY	Near the 1st ring road	Residential, transportation	14,000
5	Donghu li-yuan	LY	Near the 2nd ring road	Scenery	14,000
6	Qingshan gang-hua	GH	Outside the 2nd ring road	Industrial, transportation	7,500
7	Wu-jia-shan	WJS	Outside the 3rd ring road	Industrial, residential	1,100
8	Zhuankou xin-qu	ZK	Outside the 3rd ring road	Industrial, residential	600
9	Donghu gao-xin	GX	Near the 3rd ring road	Industrial,	400
10	Chenhu qi-hao	CH	About 50 km away from the urban area	Nature reserve	-

Data Sources: Xu et al., Aerosol and Air Quality Research, 17: 741–751, 2017

Daily (24h or 8h) data from January 23 to April 7 of three periods (2015-2019, 2020, 2021) were used to calculate the average concentrations of each pollutant in T1 quantum (January 23 to April 7 each year, T1). Similarly, data from other days of each period were used to calculate the average concentrations of each pollutant in T2 quantum (Other days each year, T2). Furthermore, the variations of the average concentrations were determined to assess the relative change (%) by comparing the data in 2020 to the data during 2015-2019, and the data in 2021-if it be released- to the data in 2020.

3. Results and discussion

This research compared the evolution of the daily average concentrations of PM2.5, PM10, SO2, CO, NO2 and O3 in Wuhan City in T1 quantum and T2 quantum during 2015–2021 (Figure 2, Table 2).

In 2020, the average concentrations of PM2.5, PM10, SO2, CO, NO2 and O3 changed by -44.30%, -46.60%,-46.12%, -18.54%, -56.56% and 18.36% respectively in T1 quantum, and changed by -24.69%, -27.82%, -28.14%, -16.48%, -12.76% and -3.22% respectively in T2 quantum, versus the five-year average values (2015–2019). Obviously, there occurred a sharp down of air pollutants concentration in 2020 except O3. In T1 quantum, the land surface O3 level increased by a big margin. From 2020 to 2021, the average concentrations of PM2.5, PM10 and NO2 increased by 21.41%, 39.53% and 82.68% and the O3 level decreased by 20.89% respectively in T1 quantum. But the values of SO2 and CO have little change in the same time. We all know that the principal sources of air SO2 is coal combustion and factory emissions, and the main source of NO2 is motor vehicle exhaust. As to air PM2.5 and PM10, they come from the chimneys, road dust raising and vehicle emissions. So, the reductions of PM2.5, PM10, SO2 and NO2 concentrations in 2020 indicates the reductions of industrial activities and traffic flows during the COVID-19 epidemic. Once the strict epidemic control measures were ended, the industrial productions and other human activities were going to resume, which would result in the increase of air pollutants. The slight changes of SO2 and CO probably have to do with the air pollution control plans implemented in China.

A comparison of the changes that occurred in T1 and T2 quantum showed that the lockdown policy had asignificant effect on the concentrations of all pollutants except CO. From Table 2, we can note that the change rates of air pollutants pendulated between -56.56% and +18.36% in T1 quantum, and fluctuated between -28.14% and -3.22% in T2 quantum. Because the T1 quantum of 2020 was just the lockdown time of Wuhan City and the T2 quantum was a relatively normal time of the city, the differences of change rates between T1 and T2 can inflect the different effects of human activities on air pollutants concentration. In other words, the change rates which is out of range in normal time directly inflect there occurred significant impacts of the lockdown against COVID-19 pandemic on air quality in Wuhan City.

From Figure 2, the monthly change characteristics of air pollutants is also can be easily seen. SO2 decreased in T1 quantum but increased afterward, and this may be related to the continuous use of coal for heating in winter and the production activities that took place in related industries (Wang et al. 2020b). Similarly, PM2.5, PM10, NO2 and CO concentrations also increased after August. The O3 curves roughly presented a opposite trend. With the gradual increase of near-surface temperature and ultraviolet solar radiation levels, the O3 formed rate increased and thus the O3 concentration increased steadily. Although NOx emissions decreased in February 2020, the near-surface temperature and ultraviolet radiation levels were significantly higher than those in the same time of the previous year, and this could cause the increase of O3 production significantly (Wang et al., 2019).

In general, concentrations of PM2.5, PM10, SO2, CO and NO2 decreased in 2020 compared with the five-year (2015–2019) average values due to the decrease of traffic, industry productions and other human activities which were held back by epidemic. To evaluate how far does the lockdown effect on each air pollutant, this research identified the different change rates between special and normal quantum.

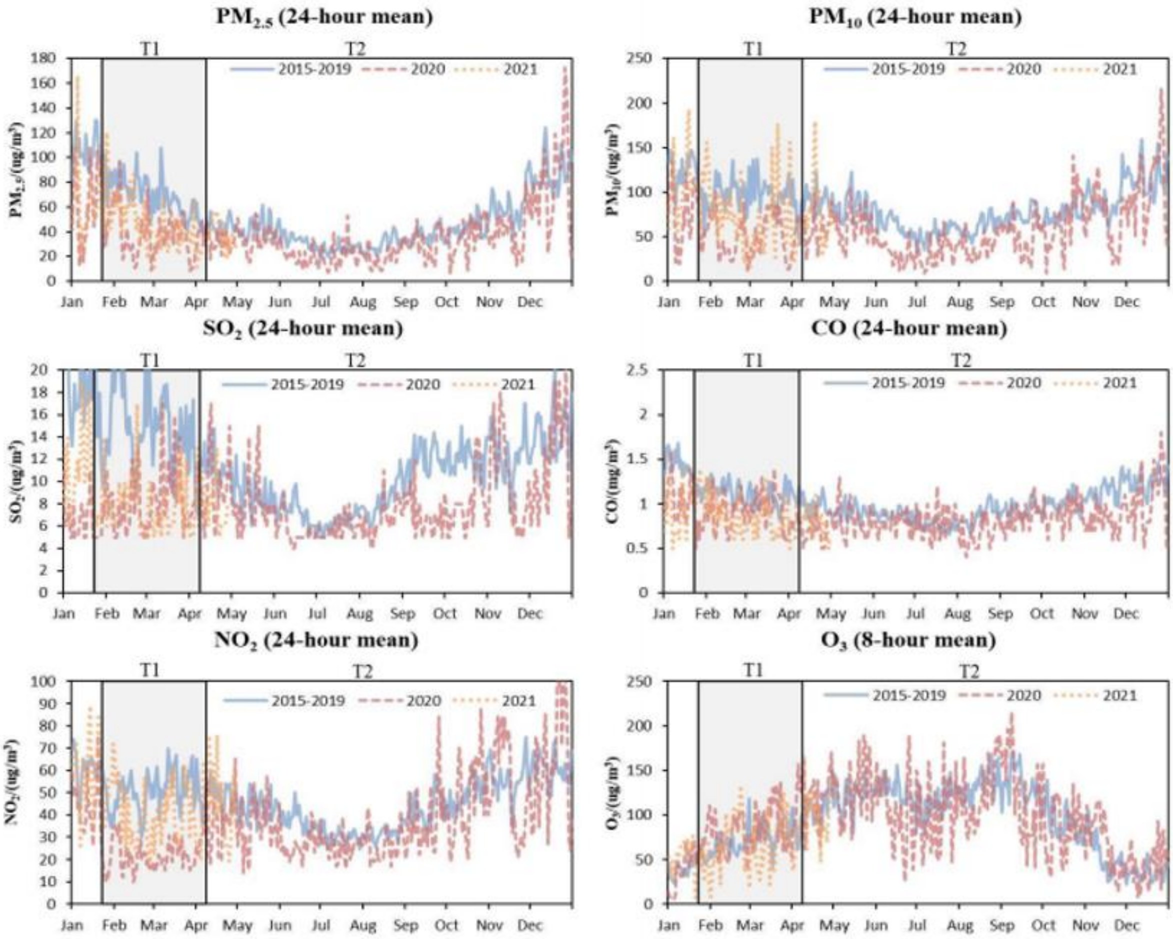

Figure 2 Daily average concentrations of the air pollutants (μg/m3) in Wuhan, China during 2015–2021

Table 2 The changes of average concentrations of air pollutants in Wuhan, China

quantum	2015–2019 average values (μg/m^3)	2020 (μg/m^3)	2021 (μg/m^3)	Change value (μg/m^3)		Change rate (%)	
				A	B	A	B
T1							
PM2.5	68.74	38.29	46.49	-30.45	8.20	-44.30	21.41
PM10	96.57	51.57	71.96	-45.01	20.39	-46.60	39.53
SO2	15.02	8.09	7.88	-6.93	-0.21	-46.12	-2.60
CO	1.11	0.90	0.86	-0.21	-0.04	-18.54	-4.44
NO2	50.50	21.93	40.07	-28.56	18.13	-56.56	82.68
O3_8 h	72.08	85.32	67.49	13.24	-17.82	18.36	-20.89
T2							
PM2.5	49.49	37.27	-	-12.22	-	-24.69	-
PM10	81.97	59.16	-	-22.81	-	-27.82	-
SO2	10.96	7.88	-	-3.08	-	-28.14	-
CO	1.01	0.84	-	-0.17	-	-16.48	-
NO2	45.66	39.83	-	-5.82	-	-12.76	-
O3_8 h	97.35	94.22	-	-3.13	-	-3.22	-
			-		-		-

4. Conclusions

It was found that lockdown of Wuhan City in T1 quantum 2020 had a significant effect on the concentrations of all pollutants except CO. The average concentrations of PM2.5, PM10, SO2 and NO2 in T1 2020 decreased significantly compared with values during the same time in 2015-2019 and 2021 due to the decrease of human activities. When the lockdown ended, the resume of human activities including industry productions and traffics, coupled with the air pollution control policies implemented in China, led to an increase trend of the concentration of PM2.5, PM10, NO2 in the early 2021.

Acknowledgements:

The author is thankful to Prof. Sun Keqin (China University of Geosciences, Beijing), Dr. Zhuang Yanhua (Chinese Academy of Sciences) and Ms. Tian Ya for their kind direction and help to this research.

References

[1] Huang, Chaolin, Wang Yeming, Li Xingwang, Ren Lili, Zhao Jianping, Hu Yi, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. The Lancet . 2020, 395:497–506.

[2] WHO (World Health Organization). WHO director-General's opening remarks at the media briefing on COVID19 – 11 march 2020.https://www.who.int/dg/speeches/ detail/who-director-general-s-opening-re-marks-at-the-media-briefing-on-covid- 19— 11-march-2020, Accessed date: 21 April 2020.

[3] Wang Daoping, Hubacek Klaus, Liang Xi, Coffman D'Maris, Hallegatte Stephane, Guan Dabo. Reply to: Observed impacts of the COVID- 19 pandemic on global trade . Nature Human Behaviour . 2021, 5: 308-309 .

[4] Josephson Anna, Kilic Talip, Michler Jeffrey D. Socioeconomic impacts of COVID- 19 in low-income countries. Nature Human Behaviour . 2021,5:557-565 .

[5] Preet Lal,Amit Kumar, Shubham Kumar, Sheetal Kumari, Purabi Saikia, Arun Dayanandan, Dibyendu Adhikari, M.L. Khan. The dark cloud with a silver lining: Assessing the impact of the SARS COVID- 19 pandemic on the global environment. Science of the Total Environment . 2020,732, 139297 .

[6] Wang Qiang, Su Min. A preliminary assessment of the impact of COVID- 19 on environment – A case study of China. Science of the Total Environment . 2020,728, 138915 .

[7] Zambrano-Monserrate Manuel A., Ruano María Alejandra, Sanchez-Alcalde Luis. Indirect effects of COVID- 19 on the environment. Science of the Total Environment . 2020,728,138813 .

[8] He Chao, Hong Song, Zhang Lu, Mu Hang, Xin Aixuan, Zhou Yiqi, Liu Jinke, Liu Nanjian, Su Yuming, Tian Ya, Ke Biqin, Wang Yanwen, Yang Lu. Global, continental, and national variation in PM2.5, O3, and NO2 concentrations during the early 2020 COVID- 19 lockdown. Atmospheric Pollution Research . 2021,12(3):136- 145.

[9] Wilder-Smith A., Freedman D.O. Isolation, quarantine, social distancing and community containment: Pivotal role for old-style public health measures in the novel coronavirus (2019-nCoV) outbreak. Journal of Travel Medicine . 2020, 27, taaa020.

[10] Wang Liqiang, Li mengying, Yu Shaocai, Chen Xue, Li Zhen, Zhang Yibo, Jiang Linhui, Xia Yan, Li Jiali, Liu Weiping, Li Pengfei, Lichtfouse Eric, Rosenfeld Daniel, Seinfeld John H . Unexpected rise of ozone in urban and rural areas, and sulfur dioxide in rural areas during the coronavirus city lockdown in Hangzhou, China: implications for air quality. Environmental Chemistry Letters . 2020, 18(5):1713– 1723.

[11] [11]Wang Wenjie, Li Xin, Shao Min, Hu Min, Zeng Limin, Wu Yusheng, Tan Tianyi. The impact of aerosols on photolysis frequencies and ozone production in Beijing during the 4-year period 2012–2015. Atmospheric Chemistry and Physics.2019, 19(14):9413-9429.