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Impact of the COVID-19 pandemic and control measures on air quality and aerosol light absorption in Southwestern China

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HIGHLIGHTS
- During the COVID-19 lockdown, PM2.5, PM10, SO2, NOx, and BC decreased by 30–50%.
- The decrease of NOx caused the rise of O3 by up to 2.3 times due to the VOCs-limitation.
- Basic power generation and industry provided ~47% of NOx and 68% of PM2.5 during winter.
- BrC accounted for 54.0% of the aerosol absorption coefficient at 370 nm during the lockdown.
- The fraction of fossil fuel in BC concentrations dropped to 0.43.

GRAPHICAL ABSTRACT

China has been performing nationwide social lockdown by releasing the Level 1 response to major public health emergencies (RMPHE) to struggle against the COVID-19 (SARS-CoV-2) outbreak since late January 2020. During the Level 1 RMPHE, social production and public transport were maintained at minimal levels, and residents stayed in and worked from home. The universal impact of anthropogenic activities on air pollution can be evaluated by comparing it with air quality under such extreme conditions. We investigated the concentration of both gaseous and particulate pollutants and aerosol light absorption at different levels of (RMPHE) in an urban area of southwestern China. During the lockdown, PM2.5, PM10, SO2, NOx, and BC decreased by 30–50%, compared to the pre-Level 1 RMPHE period. Meanwhile, the decrease of NOx caused the rise of O3 by up to 2.3 times due to the volatile organic compounds (VOCs) limitation. The aerosol light absorption coefficient at multiple wavelengths decreased by 50%, and AAE decreased by 20% during the Level 1 RMPHE. BrC played essential roles in light absorption after the RMPHE was announced, accounting for 54.0% of the aerosol absorption coefficient at 370 nm. Moreover, the lockdown down-weighted the fraction of fossil fuel in BC concentrations to 0.43 (minima). This study characterizes air pollution at the most basic level and can provide policymakers with references for the “baseline.”

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1. Introduction

The ongoing COVID-19 (also known as SARS-CoV-2) outbreak has caused a global pandemic since late December 2019 (Wu et al., 2020). COVID-19 has been classified as a Category B infectious disease but managed as a Category A disease. The Chinese Central Government has released policies for the control and prevention of the COVID-19 pandemic. More than 30 provincial governments released a Level 1 response to major public health emergencies (RMPHE) in late January. According to the Law of the People’s Republic of China on the Prevention and Control of Infectious Disease, the Level 1 RMPHE demands a complete prohibition of social and other gatherings, a total shutdown of schools, industries, businesses and unnecessary traffic (civil aviation, private cars, and buses), and for residents to stay at home.

In most provinces, during the Level 1 RMPHE, only the activities that keep society running were permitted, such as power generation and the transportation of supplies. Residents were asked to maintain social distancing, stay in, and work from home. Going out to buy supplies only when necessary. The universal impact of anthropogenic activities on air pollution can be evaluated by comparing it with air quality under lockdown periods (Le et al., 2020).

Air quality is sensitive to anthropogenic emissions. The strict lockdown measures reduced daily CO2 emissions globally by up to 25% (Le Quéré et al., 2020). In European Economic Area countries, the lockdown was responsible for about 54% of nonmethane volatile organic compounds (NMVOC), 51% of NOx, 30% of PM2.5, and 25% of SO2 emissions (Cheval et al., 2020). In China, according to satellite and ground-based observations, these specific emissions were reduced by up to 90% during the city lockdown period (Le et al., 2020).

On a global scale, pollutants such as NOx and PM2.5 decreased in major cities in China, South Korea, Europe (Milan, Paris, Warsaw, etc.) and South and North America (Bauwens et al., 2020; Ma and Kang, 2020; Siciliano et al., 2020). However, with the remarkable reduction of emissions during the COVID-19 outbreak, unexpected air pollution rose in multiple areas in China, such as the Beijing-Tianjin-Hebei and Yangtze River Delta regions (Chang et al., 2020; Le et al., 2020; Wang et al., 2020). Le et al. (2020) proposed that the air pollution was caused by the anomalously high humidity promoting heterogeneous aerosol chemistry, along with stagnant airflow and continuous emissions from power plants and petrochemical facilities, contributing to severe haze formation. Huang et al. (2020) also proposed that decreases in NOx emissions from transportation increased ozone and nighttime NOx radical formation, and these increases in atmospheric oxidizing capacity facilitated the formation of secondary particulate matter.

Atmospheric aerosols impair visibility, change the earth’s radiation balance, and affect human health (Ban-Weiss et al., 2011; Kim et al., 2015; Poschl, 2005). Light scattering and light absorption are the two basic optical properties of aerosols (Kim and Ramanathan, 2008; Rosenfeld, 1999). Light-scattering aerosols that can cool the atmosphere are mainly composed of ammonium, sulfate, nitrate, and most organics (Tao et al., 2017). Light-absorbing aerosols, however, contain the two major components of black carbon and brown carbon (Bond and Bergstrom, 2006).

Black carbon (BC) and brown carbon (BrC) are significant contributors of light-absorbing carbonaceous aerosols. BC has been recognized as the third most crucial climate-changing agent which absorbs solar radiation from the ultraviolet (UV) to infrared spectrum (Bond and Bergstrom, 2006; Bond et al., 2013). BrC can absorb radiation in the UV and visible ranges (Moosmüller et al., 2011; Peng et al., 2020b). Both BC and BrC can be emitted by anthropogenic sources due to incomplete combustion, and their characterization can be used as an indicator of economic activities among industry, traffic, and residential behaviors. The characterization of these pollutants can be used to evaluate the impact of the lockdown caused by the Level 1 RMPHE due to the outbreak of COVID-19.

The ongoing COVID-19 pandemic and following lockdown for control and prevention of the infectious disease severely influenced social activities, leading to impacts on air, water, and soil pollutions. The in-depth analysis of the impacts is required to understand air pollution in such an extreme condition that the anthropogenic emissions are ultimately diminished. Such studies are also important to improve our knowledge on the running of global societies, giving perspective on the impacts of anthropogenic activities on Earth’s system. The aim of the study is to investigate the impact of COVID-19 pandemic and the lockdown on the air quality and aerosol light absorption in Southwestern China. The influence of different levels of RMPHE on air quality is also evaluated. The study also implies more sustainable ways on improving air quality after recovering from the COVID-19 outbreak.

2. Methods

2.1. Sampling site

The sampling site is located at the Chongqing Institute of Green and Intelligent Technology, Chinese Academy of Science (106.55°E, 29.81°N) at ground level. It is situated in the north of Chongqing. There are no power plants or coal-using industries nearby. The site is influenced by local biomass burning for heating or cooking during winter, as well as local traffic. This site was specifically chosen for background air quality observation. As shown in Figs. S1, S2, and S3, locally, the wind direction was predominantly from the north and northwest, and the air mass passing the sampling site was mainly from the east, north, and southwest. Therefore, the sampling site can represent a mixed background of cities, rural, and industrial areas in the Sichuan Basin region.

A comprehensive observation of light absorption was conducted from January 17th to April 1st. Aside from the multiple levels of RMPHE, there were also other important milestones. On February 9th, industries were allowed to reopen to produce medical supplies. Therefore, the period from January 24th (announcement of the Level 1 RMPHE) to February 9th can be considered the strictest lockdown period. As such, in Fig. 2, we separate the Level 1 RMPHE into two parts: January 24th to February 9th and February 10th to March 15th, and the results also indicate that the concentrations of most pollutants were minimized under the strictest conditions of the lockdown.

2.2. Instrumentation and data analysis

Air quality data including NO, NO2, SO2, O3, and CO were collected using gas monitors (Thermo Inc., models 42i, 43i, 49i, and 48i respectively). The meteorological parameters and total solar radiation were recorded using a Luft WSS01-UMB.

A seven-band aethalometer (Magee Scientific Inc., Model AE-33) was used to determine aerosol light absorption at 370, 470, 520, 590, 660, 880, and 950 nm. The aethalometer was associated with a PM2.5 inlet at a flow rate of 5 L min⁻¹. The methods of data acquisition, compensation of attenuation (ATN), and calculation of BC concentration and Absorption Ångström exponent (AAE) can be found in the literature (Qiu et al., 2019). The mass absorption cross-section (MAC) values used in this study are 18.47, 14.54, 13.14, 11.58, 10.35, 7.77, and 7.19 m² g⁻¹ for the wavelength ranges of 370, 470, 520, 590, 660, 880, and 950 nm respectively. The wavelength-dependent absorption coefficient of black carbon at a specific λ is determined by:

\[ b_{\text{abs}}(\lambda) = BC(\lambda) \times \text{MAC}(\lambda) \]  

(1)

AAE can be used to determine the wavelength dependence of aerosol light properties (Laskin et al., 2015). AAE can be affected by aerosol size distribution, chemical composition, and mixing state (Weingartner et al., 2003). A typical AAE for BC is ~1, but it can reach up to 9.5 for BrC (Lack and Langridge, 2013). The AAE of BrC varies in different locations and
seasons worldwide. Light properties can also be used to quantitatively determine the sources of BC (Sandradewi et al., 2008b).

AAE is acquired via the following fitting (Moosmüller et al., 2011):

\[ O_{\text{abs}}(\lambda) = \lambda^{-\text{AAE}} \]

(2)

Assuming that BrC has negligible absorption at long wavelengths such as 880 nm and 950 nm, the contribution of BrC to total light absorption can be calculated by subtracting the light absorption of BC from the total absorption at all wavelengths (Liu et al., 2015).

\[ B_{\text{abs, BrC}}(\lambda) = B_{\text{abs, total}}(\lambda) - B_{\text{abs, BC}}(\lambda) \]

(3)

A similar procedure is performed at 520 nm, 590 nm and 660 nm to obtain a fit for the light absorption of BrC.

3. Results and discussion

3.1. Impact of COVID-19 pandemic and its prevention on air quality

Chongqing Municipality announced the Level 1 RMPHE on January 24th, 2020, the same day as the Chinese Spring Festival. A sector of the industry manufacturing supplies for COVID-19 prevention was allowed to open on February 9th, 2020. Level 2 and 3 RMPHE were announced on March 15th and March 24th respectively. After March 24th, all business was restored.

Fig. 1 shows the time series of PM2.5, gases, babs, and AAE data in different phases of the COVID-19 pandemic from January 17th to April 1st. Generally, SO2, NO, PM10, PM2.5, and CO were 1.2 ± 1.9 ppb, 2.5 ± 2.2 ppb, 5.3 ± 3.5 ppb, 48.3 ± 22.5 μg m⁻³, 35.9 ± 31.0 μg m⁻³, and 594.0 ± 150.8 ppb (Table 1). The concentrations of gases, PM2.5, and PM10 before the Level 1 RMPHE were set as the baseline to normalize the concentration data at different levels of RMPHE, as shown in Fig. 2. During the strictest control measures from the Level 1 RMPHE to February 9th, 2020, PM2.5, NO2, SO2, and BC decreased to 58%, 52%, 49%, 74%, and 61% respectively; the concentrations were then restored to 72%, 74%, 80%, 90%, and 82% between February 10th and March 15th (when the Level 2 RMPHE was announced) (Fig. 2). After the Level 2 RMPHE, SO2, NO2, and PM10 rose to 220%, and 105% compared with before the Level 1 RMPHE. In short, the prevention and control measures caused a remarkable decrease in air pollutants. During the Level 1 RMPHE, SO2, NO2, and PM10 increased up to 54.3% during the Level 1 RMPHE, then decreased to 42.6% during the Level 3 RMPHE. The fraction of babs (370 nm) and babs (880 nm) significantly to 67% and 55% respectively until February 9th, with total solar radiation increasing from 35.5 w m⁻² to 53.6 w m⁻². The average AAE (370–880 nm) was 1.9 ± 0.3, showing a decreasing trend from 2.0 to 1.6 from before Level 1 to Level 3 RMPHE.

Both BC and BrC were the most important light absorbers at multiple wavelengths. babs, BrC (370 nm) was 73.9, 61.9, 48.5, and 19.3 M m⁻² during the different RMPHE. The contributions of BC and BrC at multiple wavelengths between 370 and 880 are shown in Fig. 4. BC accounted for 49.4% of total absorption at 370 nm before the Level 1 RMPHE, increased up to 54.3% during the Level 1 RMPHE, then decreased to 42.6% during the Level 3 RMPHE. The fraction of babs, BrC (370 nm) was much higher than in Guangzhou (Qin et al., 2018) and Lhasa (Zhu et al., 2017), Nanjing (Yang et al., 2018), Chengdu, and Chongqing (Peng et al., 2020a; Peng et al., 2020b).

3.2. Impact of COVID-19 on aerosol light absorption

The average babs (370 nm) was 113 ± 31.4 M m⁻², with 150.2 ± 71.9 M m⁻², 114.6 ± 81.7 M m⁻², 116.2 ± 21.3 M m⁻¹, and 73.0 ± 51.5 M m⁻¹ before Level 1, at Level 1, at Level 2, and at Level 3 RMPHE respectively (Table 1). The babs (370 nm) was higher than in the winter in Guangzhou (56.0 M m⁻¹) (Qin et al., 2018) and Lhasa 53 ± 46 M m⁻¹ (Zhu et al., 2017). The average babs (880 nm) was 23.0 ± 23.3 M m⁻¹, with 35.8 ± 34.1 M m⁻¹, 22.1 ± 11.0 M m⁻¹, 27.7 ± 21.6 M m⁻¹, and 19.4 ± 21.7 M m⁻¹ before Level 1, at Level 1, at Level 2, and at Level 3 RMPHE respectively. Also, the RMPHE lockdown measures reduced both babs (370 nm) and babs (880 nm) significantly to 67% and 55% respectively until February 9th, with total solar radiation increasing from 35.5 w m⁻² to 53.6 w m⁻². The average AAE (370–880 nm) was 1.9 ± 0.3, showing a decreasing trend from 2.0 to 1.6 from before Level 1 to Level 3 RMPHE.

3.3. Source apportionment of fossil fuel burning using aerosol light absorption

Assuming that carbonaceous aerosols were mainly emitted from fossil fuel (ff) and wood-burning (wb), the contribution of babs (λ) can be given by (Sandradewi et al., 2008a; Sandradewi et al., 2008b):

\[ b_{\text{abs}}(\lambda) = b_{\text{abs, ff}}(\lambda) + b_{\text{abs, wb}}(\lambda) \]

(5)

\[ b_{\text{abs, ff}}(\lambda) \] and \[ b_{\text{abs, wb}}(\lambda) \] are the aerosol absorption coefficients of BC from the emissions of fossil fuel combustion and wood burning. If these absorption coefficients are proportional to \( \lambda^{-\alpha} \), then we have:

\[ b_{\text{abs, ff}}(470) = \frac{470}{880} \alpha_{\text{ff}} b_{\text{abs, ff}}(880) \]

(6)

\[ b_{\text{abs, wb}}(470) = \frac{470}{880} \alpha_{\text{wb}} b_{\text{abs, wb}}(880) \]

(7)

If \( \alpha_{\text{ff}} = 2 \) and \( \alpha_{\text{wb}} = 1 \) are applied in accordance with the literature (Kirschstetter and Thatcher, 2012; Prasad et al., 2018), then the contribution from fossil fuel is determined according to the different levels of RMPHE, as shown in Fig. 5. As shown in Fig. 5, the average ratio of BC (BCff) from fossil fuel was 0.47 before the Level 1 RMPHE due to the prevailing biomass burning in the region (Chen et al., 2017). Therefore, during the Level 1 RMPHE, the mean ratio of BCff decreased to 0.43 after February 10th due to the minimum level of traffic caused by the strict control measures. Then, during the Level 2 RMPHE, BCff exceeded the ratio of before the Level 1 RMPHE due to the restoration of traffic. The average of BCff was 0.67, with a maximum fraction of 0.95 during the Level 3 RMPHE.

The average babs, BrC (370 nm) was 73.9, 61.9, 48.5, and 19.3 M m⁻² during the different RMPHE. The contributions of BC and BrC at multiple wavelengths between 370 and 880 are shown in Fig. 4. BC accounted for 49.4% of total absorption at 370 nm before the Level 1 RMPHE, increased up to 54.3% during the Level 1 RMPHE, then decreased to 42.6% during the Level 3 RMPHE. The fraction of babs, BrC (370 nm) was much higher than in Guangzhou (Qin et al., 2018) and Lhasa (Zhu et al., 2017), Nanjing (Yang et al., 2018), Chengdu, and Chongqing (Peng et al., 2020a; Peng et al., 2020b).
The lockdown made them stay longer than in previous years. It is reasonable to extrapolate that household emissions increased. In southwestern China, wildfires are the major source of biomass burning, along with wood-burning, as shown in Fig. S4. According to these fire maps, the wildfire biomass burning spots between different RMPHE were identified as a background. Therefore, household cooking and heating increased the fraction of wood-burning, causing a corresponding decrease in fossil fuel contribution. Moreover, the decrease of fossil fuel for power plants and industries could also decrease the fraction of BCff (Le Quéré et al., 2020).

**Fig. 1.** Overview of the impact of the Level 1 RMPHE on air quality (PM$_{2.5}$, NO$_x$, SO$_2$, BC, and O$_3$) and light absorption (AAE, b$_{abs}$).

**Table 1**

Summary of gas, meteorological, and light absorption data during winter 2020.

|                  | Before level 1$^a$ | Level 1$^b$  | Level 2$^c$  | Level 3$^d$  | Overall     |
|------------------|--------------------|--------------|--------------|--------------|-------------|
| SO$_2$ (ppb)     | 1.5 ± 1.2          | 1.2 ± 1.9    | 3.2 ± 3.1    | 2.4 ± 1.5    | 1.8 ± 1.6   |
| NO (ppb)         | 9.6 ± 8.8          | 2.5 ± 2.2    | 12.7 ± 11.1  | 14.4 ± 11.9  | 8.8 ± 6.6   |
| NO$_x$ (ppb)     | 7.6 ± 6.4          | 5.3 ± 3.5    | 18.7 ± 8.8   | 23.2 ± 21.4  | 14.5 ± 12.1 |
| O$_3$ (ppb)      | 10.1 ± 8.1         | 15.1 ± 14.5  | 23.2 ± 15.7  | 15.8 ± 14.3  | 15.9 ± 12.9 |
| PM$_{10}$ (µg m$^{-3}$) | 72.2 ± 41.0     | 48.3 ± 22.5  | 75.7 ± 61.4  | 46.7 ± 41.9  | 54.1 ± 44.1 |
| PM$_{2.5}$ (µg m$^{-3}$) | 53.2 ± 21.9      | 35.9 ± 31.0  | 40.7 ± 40.5  | 24.6 ± 21.1  | 35.5 ± 23.2 |
| BC (µg m$^{-3}$) | 3.1 ± 2.2          | 3.3 ± 1.7    | 4.2 ± 3.4    | 2.9 ± 1.9    | 3.8 ± 3.0   |
| CO (ppb)         | 600.1 ± 176.4      | 598.0 ± 150.8| 608.0 ± 105.8| 638.9 ± 221.9| 616.7 ± 261.1|
| b$_{abs}$, 370 (M m$^{-1}$) | 150.2 ± 71.9    | 114.6 ± 81.7 | 116.2 ± 21.3 | 73.0 ± 51.5  | 113.3 ± 31.4|
| b$_{abs}$, 880 (M m$^{-1}$) | 35.8 ± 34.1      | 22.1 ± 11.0  | 27.7 ± 21.6  | 19.4 ± 21.7  | 23.0 ± 23.3 |
| b$_{abs,370},$ BC (M m$^{-1}$) | 75.3 ± 27.6      | 52.3 ± 24.0  | 65.2 ± 24.5  | 37.4 ± 29.8  | 57.5 ± 27.1 |
| b$_{abs,880},$ BC (M m$^{-1}$) | 73.9 ± 39.2      | 61.9 ± 61.6  | 48.5 ± 30.3  | 19.3 ± 18.7  | 50.9 ± 54.7 |
| AAE 370–880      | 2.0 ± 0.4          | 2.0 ± 0.5    | 1.8 ± 0.3    | 1.6 ± 0.1    | 1.9 ± 0.3   |

The values are mean ± standard deviation. The AE33-measured BC can be defined as equivalent BC (eBC) unless otherwise stated (Petzold et al., 2013). The selected wavelengths for BC were typical among BC studies using aethalometers (Harrison et al., 2013; Wang et al., 2011; Zhu et al., 2017).

$^a$ From January 17th to January 24th.
$^b$ From January 25th to March 15th.
$^c$ From March 15th to March 24th.
$^d$ From March 24th to April 1st.
4. Discussion

After the announcement of the Level 1 RMPHE, an unprecedented lockdown was performed all over China. Although there was a massive reduction in energy use, PM2.5 increased by 24% compared to the same period in 2019. The results of this study and others commonly showed that the extreme lockdown inevitably harmed the economy, but was not efficiently helpful in improving air quality (Chang et al., 2020; Cheval et al., 2020; Huang et al., 2020; Le Quéré et al., 2020; Le et al., 2020; Siciliano et al., 2020). In multiple studies, the enhanced secondary pollution of aerosols was caused by the increase in oxidative capacity due to the increase in ozone (Chang et al., 2020; Huang et al., 2020). In the Beijing-Hebei-Tianjin region, the increase of heterogeneous aerosol chemistry promoted aerosol pollution under high relative humidity conditions (Le et al., 2020).

This study also provides implications on air quality management and sustainable development. The impacts of COVID-19 on air quality, carbon emissions, and socio-ecological systems form comprehensive topics that are useful for evaluating more sustainable ways to restart society after recovering from the COVID-19 outbreak. Our results suggest that a social shut down at any cost does not effectively improve air quality in Southwestern China, and the promoted ozone and secondary aerosol levels were unexpected (Wang et al., 2020). Therefore, future mitigation measures of air pollutants in China will eventually depend on the innovation of reducing emissions from industries, traffic, residential activities, and energy consumption. Due to the nature of VOCs-limited areas, the decrease of NOx emission caused severe ozone pollutions. The policymakers should carefully consider the interaction between the pollutants of natural and anthropogenic emissions. Also, the “Global Human Confinement Experiment” provides a unique case for the study of sustainability and the corresponding policy analysis (Bates et al., 2020). Additionally, combined with emission reduction, cases on a global scale can be used to test and improve the current models of both air quality and climate.

This study focuses on essential pollutants, the light-absorbing properties, and sources of BC aerosols. A year-on-year comparison was also performed to understand the pandemic’s impact and its control in Southwestern China. However, there are still limitations. In this study, the sampling site can represent the air quality on a regional scale. Air quality is also important in urban areas such as Chongqing and Chengdu, which are megacities with populations of over 10 million. Furthermore, detailed research of PM2.5 chemical composition and source apportionment is also necessary to explore the changes of primary and secondary contributions due to the arising of ozone during the COVID-19 pandemic. We are preparing works on these aspects in the next steps.

5. Conclusions

In order to control the ongoing COVID-19 pandemic and block the transmission of the virus, strict lockdown measures have been in place since late January 2020. The total lockdown dramatically impacted production, transportation, and consumption in Chinese society. We have analyzed the impact on air quality and aerosol light absorption in a typical urban area of southwestern China. Due to the lockdown, pollutants such as PM2.5, PM10, SO2, NOx, and BC decreased by 30–50%. Meanwhile, the decrease of NOx caused the rise of O3 due to VOC-limited areas. We
conclude that basic power generation, industry, and transport provided ~47% of NOx and 68% of PM2.5. Due to the decrease of PM2.5, the aerosol light absorption coefficient at multiple wavelengths decreased by 50%, and AAE decreased by 20%. BrC played essential roles in light absorption after the RMPHE was announced, accounting for 54.0% of $b_{abs}$ (370 nm). Moreover, the lockdown down-weighted the fraction of fossil fuel in BC concentration from 0.47 to 0.43 (minima). Accompanied by the reopening, the ratio of BCff increased to 0.95. In conclusion, the extreme conditions of air quality caused by COVID-19 and its control measures are providing us with a unique opportunity to evaluate anthropogenic emissions and their subsequent influence.

**CRediT authorship contribution statement**

Yang Chen: Conceptualization, Formal analysis, Writing - original draft, Writing - review & editing, Project administration. Shumin Zhang: Methodology, Formal analysis, Writing - original draft. Chao Peng: Methodology, Formal analysis. Guangming Shi: Methodology, Formal analysis. Mi Tian: Conceptualization, Methodology, Formal analysis, Writing - review & editing. Ru-Jin Huang: Investigation, Validation. Dongmei Guo: Investigation. Huanbo Wang: Investigation. Xiaojiang Yao: Investigation. Fumo Yang: Methodology, Investigation.

**Declaration of competing interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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**Appendix A. Supplementary data**

Supplementary data to this article can be found online at https://doi.org/10.1016/j.scitotenv.2020.141419.

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