

CHANGES IN AIR QUALITY DURING COVID-19 SOCIAL DISTANCING IN HA NOI CITY

Ngo Thi Thuy⁽¹⁾, Tran Van Tra⁽²⁾, Cung Hong Viet⁽¹⁾, Nguyen Dinh Hoang⁽¹⁾

⁽¹⁾Viet Nam Institute of Meteorology Hydrology and Climate Change

⁽²⁾Water Resources Institute

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Abstract: *The COVID-19 pandemic has changed people's lives in many ways. Under the impact of COVID-19, the economy and society face challenges to recover. To control the spread of the COVID-19 epidemic, Viet Nam and countries around the world have restricted unnecessary travelling and transportations. The regulations on social distancing have significantly changed people's habits, activities, living and working styles. Many studies have shown that social distancing has significantly changed air quality. This study was conducted to assess the change of air quality in Ha Noi during the social distancing period. The evaluation is built based on measurements at air monitoring stations in the period before and after social distancing in 2021. The results show a significant improvement of air quality compared to its situation before social distancing at most of the air monitoring stations. The average daily VN_AQI index at Nguyen Van Cu station (Long Bien district), Kim Lien (Dong Da district), Tan Mai (Hoang Mai district) and Tay Mo (Nam Tu Liem district) and Minh Khai (Bac Tu Liem district) in the first 8 months of 2021 dropped from 97 (near unhealthy grade for sensitive groups) to 52 (near good) in averaged. The concentration of other pollutants (PM_{10} , $PM_{2.5}$) at other stations also show a significant decrease compared to the previous time.*

Keywords: *Air quality, monitoring stations, COVID-19, social distancing.*

1. Introduction

The coronavirus (SARS-CoV-2) was first detected in Wuhan City, China, in December 2019 and rapidly spread in 2020 and 2021 to most of countries in over the world. To control the spreading of the virus, countries have imposed social distancing which resulted in dramatically decrease in transportation and travelling. Besides, it is reported that people in some cities themselves have avoided unnecessary going out during the pandemic. Clearer skies during the social distancing period were observed with normal eyes in some cities.

Viet Nam recorded the earliest cases on 23 January 2020 and reached 635,000 cases currently [12]. The country now is in the fourth wave of COVID-19 with the longest social distancing period since 27 April 2021. Restrictions

released through dispatches and directions included; (a) people to stay at home, except for limited purposes; (b) suspending schools and promoting online education; (c) closing of all non-essential businesses and public venues; and (c) stopping all gatherings of more than two people in public [5, 6, 7].

Social distancing or lock-down in many countries is considered as a reason changes air quality in cities and industrial zones due to shutting down of power plants, transportation and manufactures. The air quality change during COVID-19 in China [2, 9, 10, 11, 21], USA [15], Brazil [3, 17], Spain [18] and Morocco [14] shows significant improvement in several air pollutants such as particulate matter (PM_{10} , $PM_{2.5}$), nitrogen dioxide (NO_2), carbon monoxide (CO) and SO_2 .

In this study, the air quality of Ha Noi is assessed by six pollutants including PM_{10} , $PM_{2.5}$, NO_x , SO_2 , CO and O_3 collected from 11 stations in Ha Noi. The VN_AQI index is also calculated following Decision No.1459/QD-TNMT [4] at

Corresponding author: Ngo Thi Thuy
E-mail: tide4586@gmail.com

Nguyen Van Cu, Kim Lien, Tan Mai and Tay Mo stations to assess the composite air quality in Ha Noi. A comparison between air quality measurements during social distancing months and observation in previous periods is also implemented to retrieve the impact of COVID-19 pandemic on air pollution.

2. Data and Methodology

2.1. Study area

Ha Noi, the capital of Viet Nam, is located in the Red River Delta. The city occupies an area of 3,358.6 km² [12] and being the second largest city in Viet Nam. Ha Noi consists of 12 urban districts, 1 district-level town and 17 rural districts. Population of Ha Noi is about 8,053,700, including 49.2% of population living in urban areas and 50.8% in rural areas [8]. The city has experienced a construction boom with numerous skyscrapers and roads connecting citadel areas with industrial zones and rural areas.

The city has a humid subtropical climate with a plentiful rainy season from May to October. The average annual rainfall is 1,612 mm with around 85% of rainfall in rainy season. The mean temperature in Ha Noi is 23.6°C accompanying with relative humidity of more than 80%. The hottest month is July and the coldest month is January.

In recent years, the problem of air pollution has been becoming an attention of not only scientific researchers but also authorities and local residents. The danger, potential harm to health and the impact on daily life hit the top news. At air quality monitoring stations located in Ha Noi, the air quality index (AQI) frequently fluctuates around the unhealthy threshold. Most recently, the Global Air Quality Report by IQAir AirVisual in cooperation with Greenpeace in Southeast Asia shows that, in the data collected in some cities at some time, Ha Noi is the second most polluted city in Southeast Asia, as shown by the index of substances that adversely affect the air, exceeding the level recommended by WHO [10, 20]. Although this information was later inaccurately confirmed by the Viet Nam Environment Administration due to the representativeness of the samples, the air pollution in Viet Nam and especially Ha Noi is

undoubtable and is getting worse, shown in many reports such as the National Environmental Report on the air environment (2013), the National Environmental Report on the urban environment (2016).

2.2. Status of COVID-19 pandemic and lockdown periods in Ha Noi

According to the data from Ha Noi CDC, Ha Noi has 3,695 COVID-19 cases in the third and fourth waves of COVID-19 in 2021 (up to 9th September, 2021). In which, there were 35 cases in the third wave from 28 January to 17 February and 3,660 cases in the fourth wave lasting from 29th April to 9th September. To control the covid pandemic and promote socio-economic development, the Ha Noi People Committee released many documents that restrict activities of local residents. The critical documents are summarized as follows.

- 4 May 2021: Ha Noi Department of Education and Training were temporarily suspended all schools and education at all levels following the direction of the Ha Noi People's Committee at Official Dispatch No. 04/CD-UBND dated April 29, Dispatch No. 05/CD-UBND dated May 2 and Dispatch No. 06/CD-UBND dated May 3.

- 00h 5 May 2021: Temporarily suspending operations at cinemas, movie centers, massage service facilities, spas, gyms, stadiums, etc., to minimize crowded events, large parties and meals (weddings, anniversaries, birthdays, grand openings...);

- 12h 25 May: Temporarily suspending operation of some business and services such as restaurants, on-site food and beverage service establishments (only for take-out sales), do not organize meals and festivals with large crowds; Barber shops and hairdressers. Completely stop playing, exercising, and gathering at parks, flower gardens and public places.

- 13 July 2021: Dispatch No. 14/CD-CTUBND stops non-essential business activities" Restaurants, on-site food service establishments, only for takeout, stop thoroughly hair shops, enjoy activities at public and public places.

- 14 July 2021: Vehicles traveling from 14 provinces and cities with epidemics include: Ho Chi Minh City, Binh Duong, Dong Nai, Khanh Hoa,

Phu Yen, Dak Lak, Quang Ngai, Quang Nam, Da Nang, Hue, Ha Tinh, Nghe An, Thanh Hoa, Ha Nam requested to turn back, not to move into Ha Noi.

- From 24 July 2021: All unnecessary services are restricted, moving allowance is required with all citizens.

2.3. Data

By 2016, there are 12 automatic air quality monitoring stations in Ha Noi including 10 stations under the management of the Ha Noi Department of Natural Resources and Environment (started in 2017), 01 station under the management of the Viet Nam Environment Administration (since 2010), and 01 monitoring stations managed by the US Embassy (Figure 1). By July 2019, the French Embassy installed

an air monitoring station, measuring $PM_{2.5}$ concentration at the embassy campus. By May 2020, THT Co., Ltd. (Korea) sponsored and handed over to Ha Noi 24 automatic air monitoring sensor stations. Up to this point, the total number of monitoring stations in the city is 37 [22]. Nevertheless, due to the lack of data availability, only 11 stations' data (Table 1) are analyzed in this report. In this study, the air quality of Ha Noi city is assessed using the six components including PM_{10} , $PM_{2.5}$, CO , O_3 , NO_x and SO_2 . Among 11 stations, there are 3 stations observe all of six air pollution components others do not have data of SO_2 and O_3 . The stations and observation data used in this study from ground stations are listed in Tables 1 and 2.

Table 1. Air pollution stations in Ha Noi city

No.	ID	Station	Address
1	CCBVM	Ha Noi Environmental Protection Department	Trung Hoa, Cau Giay district
2	MKhai	Minh Khai	People's Committee of Minh Khai Ward, Bac Tu Liem District
3	HDau	Hang Dau	Police Department of Hang Ma Ward
4	HKiem	Hoan Kiem	Police Department of Hoan Kiem district
5	KLien	Kim Lien	Kim Lien Kindergarten
6	MDinh	My Dinh	Nam Tu Liem Power Company
7	PVD	Pham Van Dong	36A Pham Van Dong street
8	TCong	Thanh Cong	Thanh Cong lake park
9	TMai	Tan Mai	People's Committee of Hoang Van Thu Ward
10	TMo	Tay Mo	Tay Mo commune, Nam Tu Liem district
11	NVC	Nguyen Van Cu	556 Nguyen Van Cu street

Table 2. Availability of air pollution data in Ha Noi city

No.	Stn ID	PM_{10}	$PM_{2.5}$	NO_x	SO_2	O_3	CO
1	CCBVM	2017 - 2018	2018				
2	MKhai	2017 - 2018, 2021	2018, 2021				
3	HDau	2017 - 2018	2018	-	-	-	2018
4	HKiem	2017 - 2018	2018	-	-	-	2018
5	KLien	2017 - 2018, 2021	2018, 2021	-	-	-	2018
6	MDinh	2017 - 2018	2018	-	-	-	2018
7	PVD	2017 - 2018	2018	-	-	-	2018
8	TCong	2017 - 2018	2018	-	-	-	2018
9	TMai	2017 - 2018, 2021	2018, 2021	-	-	-	2018
10	TMo	2017 - 2018, 2021	2018, 2021	-	-	-	2018
11	NVC	2010 - 2019, 2021					

Sine the data is not synchronous, the observation before 2021 is used to assess the air quality before COVID-19 pandemic while

the data observed from January to August 2021 is representative for air quality during COVID-19.

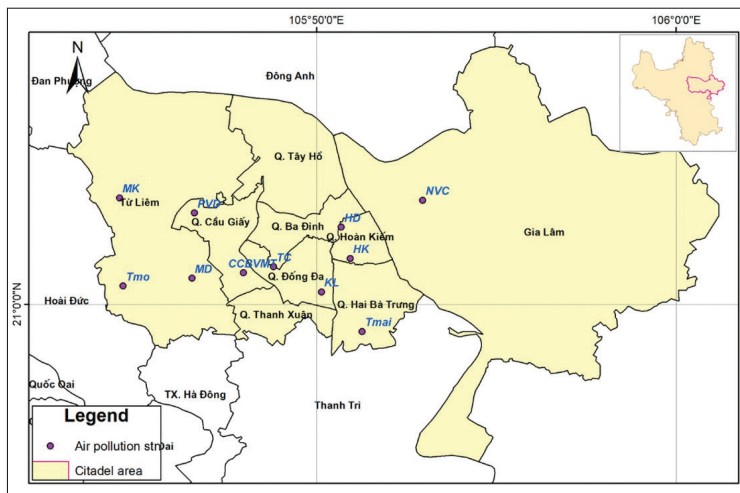


Figure 1. Map of the air pollution stations in the core area of Ha Noi city

2.4. Air quality index calculation

According to Decision No. 1459/QĐ-TCMT, Viet Nam Air Quality Index (abbreviated as VN_AQI) is an index calculated from monitoring parameters of pollutants in the air in Viet Nam, in order to indicate air quality status and its impact on human health, expressed through a scale. In

this guidance, AQI is applied to two types: The daily AQI is a representative value of air quality in a day; the hourly AQI is the AQI value representing the air quality for 1 hour. The Air Quality Index is calculated on a scale (6 ranges of AQI values) corresponding to icons and colors to warn of air quality and its impact on human health.

Table 3. AQI Quality Index Score Scale

AQI range	Air quality category	Color	Color code RGB
0 - 50	Good	Green	0;228;0
51 - 100	Moderate	Yellow	255;255;0
101 - 150	Unhealthy for sensitive groups	Orange	255;126;0
151 - 200	Unhealthy	Red	255;0;0
201 - 300	Very unhealthy	Purple	143;63;151
301-500	Hazardous	Maroon	126;0;35

In this study, the daily VN_AQI is calculated using the hourly and daily observation of SO₂, CO, NO₂, O₃, PM₁₀, and PM_{2.5}. VN_AQI calculation method requires at least 01 of 02 parameters PM₁₀, PM_{2.5} in the calculation formula. Specifically, the daily AQI value is calculated based on the following values:

- PM_{2.5} and PM₁₀ parameters: 24-hour average value.
- Parameter O₃: The maximum 1-hour average value of the day and the maximum 8-hour average value of the day.
- Parameters SO₂, NO₂ and CO: The maximum 1-hour average value of the day.

3. Results and Discussion

3.1. General distribution of air quality in Ha Noi

Since the collected data is nonsynchronous the assessment is implemented for PM_{10} at 10 stations from May 2017 to Dec 2018 and for all six mentioned components at Nguyen Van Cu (NVC) station from 2010 to 2019. The results are illustrated in Figure 2.

The average PM_{10} concentration in 24 hours at most of station in Ha Noi city is under the threshold indicated in Viet Nam Technical Standard (QCVN 05:2013/BTNMT). However, the concentration is far higher than the guideline of WHO [20]. When consider hourly distribution of PM_{10} , the analysis shows peaks at 8 am and 7 pm at most of station through Ha Noi city (Figure 3).

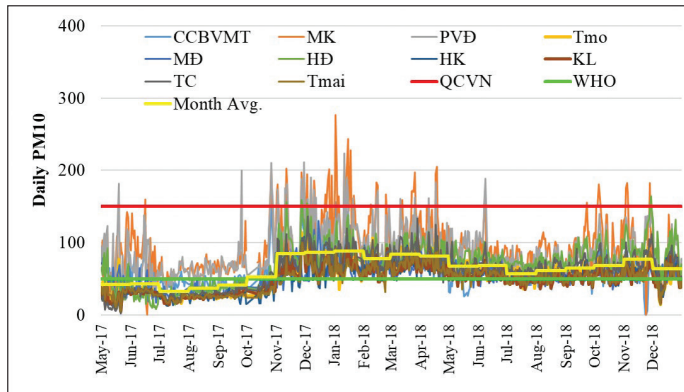


Figure 2. Change in daily PM_{10} concentration at stations from May 2017 to Dec 2018

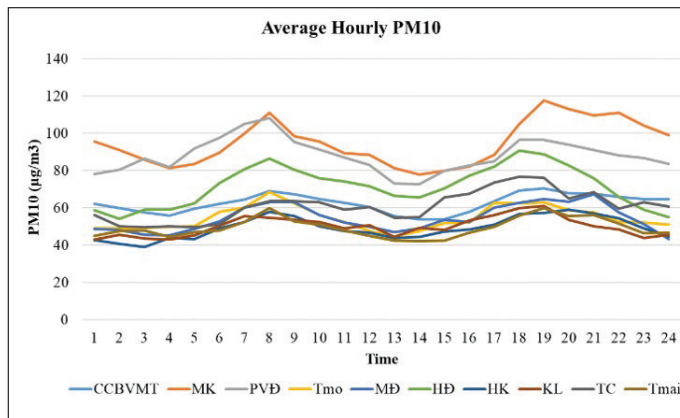


Figure 3. Distribution of PM_{10} concentration in a day

The analysis at NVC station in 10 years of observation shows an improvement trend of air

pollution in VN_AQI (Figure 4) from relatively unhealthy in 2010 to moderate level in 2019.

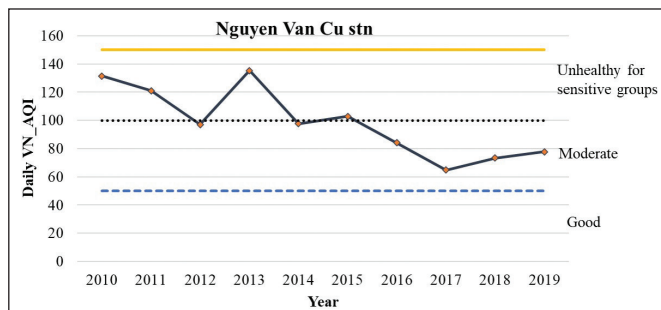


Figure 4. Change in PM_{10} concentration at NVC over time

3.2. Changes of air quality during COVID-19

Due to social distancing in 2021, the air quality of Ha Noi is significantly improved. The analysis of PM_{10} and $PM_{2.5}$ concentration at most stations in Ha Noi show a remarkable decrease from March to August 2021, except at Minh Khai station (Bac Tu Liem district)

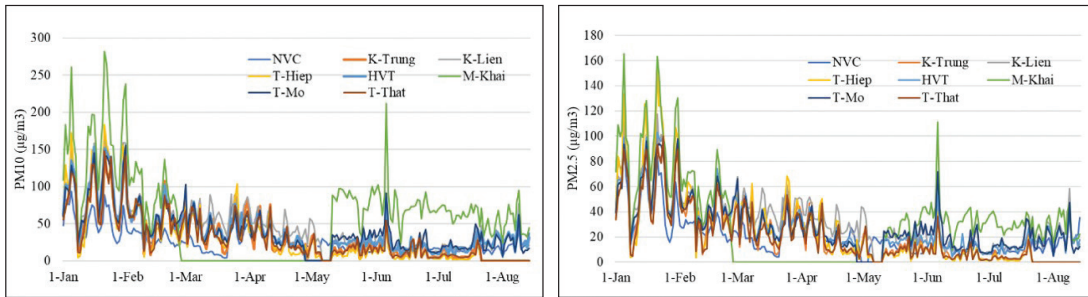


Figure 5. The change of PM_{10} (left) and $PM_{2.5}$ (right) at Ha Noi's stations in 2021

To analyze the change of VN_AQI during social distancing periods of 2021, the observation of six pollutant components at four stations inside Ha Noi citadel area including Nguyen Van Cu (NVC), Kim Lien (K-Lien), Tan Mai (T-Mai) and Tay Mo (T-Mo) are collected (detailed in Table 2). From January 2021, the VN_AQI at these stations were around moderate to good quality. In monthly scale the average daily VN_AQI in 2021 was improved much more than before (Figure 6). Specifically, the monthly average AQI in 2021 (orange solid line) is lower than mean monthly average (red dash line). At the beginning 2021, Ha Noi experienced the 3rd wave of COVID-19 that corresponding to the start of AQI decrease. The index dropped from around 100 to 50 during Lunar New Year break and maintained in next months. After the 3rd wave of COVID-19 cases, the economic activities in Ha Noi had been recovering before facing the 4th wave from 27th April, 2021. In this period, the average AQI in Ha Noi (black solid line) fluctuated between 50 to 100 corresponding to moderate grade. At NVC, the AQI during this two month was in a slightly increasing episode.

In the 4th wave of COVID-19, the daily routine changed a lot. Schools at all levels were temporarily suspended, entertainment activities and on-site restaurants were not allowed. The

(Figure 5). Even though containing a peak concentration in Jun, the general trend at Minh Khai station represents remarkable decrease comparing to before pandemic. The overall PM_{10} and $PM_{2.5}$ in all stations are far lower than the threshold according to QCVN 05:2013/BTNMT.

partial social distancing was applied in Ha Noi city to restrict unessential activities. The average VN_AQI in May and June were at the good level and far smaller than multi-year mean average VN_AQI at most of considered stations except for Minh Khai station (Bac Tu Liem ward). At this station, the VN_AQI during social distancing period was lower than before and similar to the mean average. From the 4th wave of COVID's cases, a slight decrease of VN_AQI was recorded in most of stations comparing to the 3rd wave and the period after the 3rd wave as well (Figure 6). When comparing to the average trend in same period (red dash line), the VN_AQI during the 4th wave (orange line) illustrates a significant decrease in all months from May to August.

From 24 July a full social distancing was implemented in Ha Noi city, people were recommended stay home and the moving allowance reports are required. More specific, the 1st social distancing is from 24th July to 7th August, the 2nd is to 22nd August, the 3rd is to 6th September and the fourth until 21st September. In the 1st social distancing period (from 24 July) The VN_AQI present a slightly increase compared to preceding months. Even though this abnormal trend might be local, the delivery exploration should be considered as one of reasons.

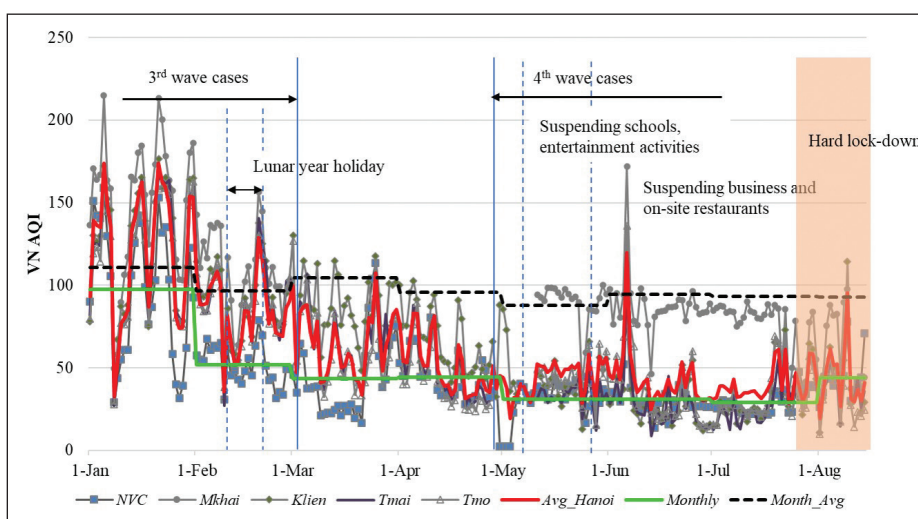


Figure 6. The change of daily AQI at some stations during COVID-19 pandemic

4. Conclusion

The study assessed the change of air quality at eight monitoring stations in Ha Noi during social distancing periods in 2021. The PM_{10} and $PM_{2.5}$ concentration at these stations show obvious decrease from January to August 2021. The comparison of VN_AQI at four stations inside Ha Noi during eight early months of 2021 also present dropping down between 2021

with multi-year average trend and between the first two months (January and February) with the remaining of the collection. This change of VN_AQI presents a close relation with restrictions in social distancing. The paper utilizes measurements at 11 stations in Ha Noi, however, the data collected is quite short and not synchronously. Due to this, local finding might be retrieved.

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