GreenID

AIR QUALITY
REPORT
2018

ACKNOWLEDGMENT

First of all, GreenID would like to express our sincerely thanks to Prof. Dr. Hoang Xuan Co, Dr. Hoang Duong Tung and Dr. Ly Bich Thuy for contributing to this report. Your contributions are very meaningful and help to fulfill our report and Mr. Nguyen Hieu, founder of the Puritrak company, has contributed data to the report.

We would like to thank the Northern Centre for Environmental Monitoring - Vietnam Environment Administration for sharing information about the analysis result of air quality situation in some monitoring stations around Hanoi in 2018. This information helps us to have more data in the report and provides a more comprehensive picture about the air quality of Hanoi.

This is the third consecutive year that we make this report about air quality and we have received much encouragement from the community. The positive feedback and contributions have motivated us to continue our effort as a contributor to the air quality improvement.

This report could not have been completed without these aforementioned contributions of the experts, partners and the community. Once again, we thank you all!

DATA DISCLAIMER

This report included the data of the PM$_{2.5}$ and the AQI from stations from the U.S embassy from Hanoi and Ho Chi Minh city (HCMC) as well as monitoring devices from Puritak and AirVisual Pro. This report also summarized the analyzing result on air quality from the Northern Centre for Environmental Monitoring. During this report, GreenID has understood the needs of data all over the country to create a broader picture about the air quality. We welcome all ideas and contributions as we seek to build more partnerships with organizations that have an interest in this field in order to raise the community's awareness.

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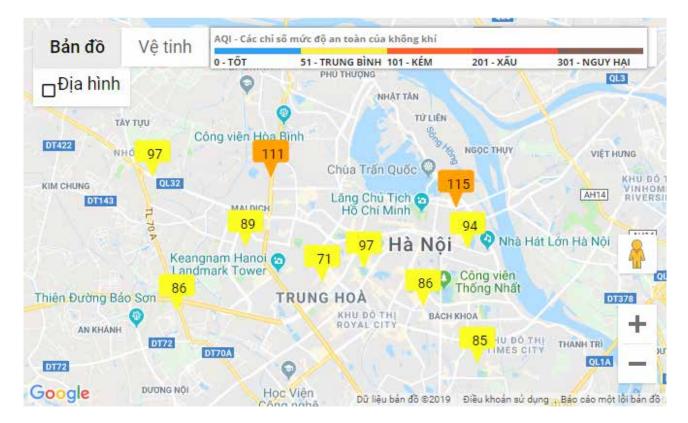
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EXECUTIVE SUMMARY

Air pollution is one of the most urgent challenges facing our planet's health and environment today, estimated to contribute to 7 million premature deaths every year[1]. Polluted air presents the world's 4th leading contributing cause of early deaths and burdens the global economy with an estimated annual cost of US$225 billion[2].

Air pollution contribute to
7 million premature deaths every year

Over the last three years, GreenID has launched the periodical Air Quality Reports (AQRs) to provide information and contribute to knowledge on air pollution control measures. This report provides multidimensional information on air pollution and is a follow-up action by GreenID that contributes to the joint effort to provide information to the community and promote action to improve air quality and protect public health.

The Air Quality Report 2018 is based on air quality data from public monitoring sources, with a focus on data published in real-time or near real-time. Like in the previous years we relied on the data provided on an hourly basis by the U.S. Embassy in Hanoi and the U.S.

Consulate in Ho Chi Minh City. Additionally, in 2018, we were able to summarize data from air quality monitors operated by individuals and private organizations and refer the analysis result of Northern Centre for Environmental Monitoring to have a more comprehensive picture.

GreenID has been striving to synthesize the most diverse and complete data as much as possible from many sources with the desire to provide objective and comprehensive information on the air quality situation. We do not confirm that the available collected data may fully reflect the current status of air quality. Although it is still difficult to fully access the data sources, the report is still of reference for the community and opens further research on this issue.

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[1] WHO (2014), "Public Health, Environmental and Social Determinants of Health (PHE)"

[2] http://www.worldbank.org/en/news/press-release/2016/09/08/air-pollution-deaths-cost-global-economy-225-billion

From different sources of data, the report showed that annual average $PM_{2.5}$ concentration of Hanoi in 2018 at 40.1 µg/m^3(3) in excess of National Technical Regulation QCVN (25 µg/(m^3.year)). Particularly at the US Embassy monitoring station, the average annual $PM_{2.5}$ concentrations reached 40.6 µg/m^3 which is 1.5 times higher than the National Regulation (25 µg/(m^3.year)) and 4 times higher than the WHO AQG (10 µg/(m^3.year)). When analyzing data by day, the number of days with a high average level of $PM_{2.5}$ concentrations still accounts for a large number, at the US Embassy station, there are 88 days corresponding to 24% of the days in the year exceeding the limit of National Regulation (50 µg/(m^3.day)) and if compared with the more stringent recommendation of WHO (25 µg/(m^3.day)), this number is 232 days, accounting for 64% of the days in the year.

Analysis data from 10 different stations of Hanoi People's Committee also showed that Hanoi urban area is being polluted by dust and $PM_{2.5}$ still have highest level of pollution [10]. The level of particulate pollution is different among locations, monitoring stations at Minh Khai and Pham Van Dong streets have the highest number of days which exceeded the limit in National Regulation respectively 129 days (35% of total days) and 109 days (30% of total days).

The variation of air quality during the last 3 years was recorded having significant reduction in term of $PM_{2.5}$ pollutions from 50.5 µg/m^3 in 2016, 42.6 µg/m^3 in 2017 to 40.6 µg/m^3 in 2018 (data from US Embassy). Analysis results in the past 3 years also figured out that air pollution in Hanoi changes seasonally. The days which have high level of $PM_{2.5}$ concentrated are in winter months as this period is often influenced by air masses from the East and Northeast. In contrast, the summer months from May to September in Hanoi have good air quality and are below the limits of the National Regulations.

Monitoring stations at
Minh Khai & Pham Van Dong streets
have the highest number of days
which exceeded the limit in National Regulation

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[3] Average value of $PM_{2.5}$ concentrations calculated from data of US Embassy, Northern Center for Environmental Monitoring and monitoring devices of Puritrak.

Air quality in HCMC remained at the "Moderate" level and much better than in Hanoi. Similar to Hanoi, air quality in this southern city improved with $PM_{2.5}$ concentrations and Air Quality Index decreasing compared to the last two years.

In recent years, significant efforts have been asserted by the State, government, agencies, organizations and individuals and many solutions have been implemented to improve air quality. The public awareness on air pollution has been improved significantly as it now knows about the situation and proactively take health protection measures. Although, many challenges still exist and stronger measures need to be taken, air pollution is a complex issue that requires coordination and participation of stakeholders from government and agencies, research institutes, businesses and public. Most importantly, we need to take action today!

In this report, GreenID also proposes

THE FOLLOWING RECOMMENDATIONS:

01 Develop specialized and effective legal regulations on air pollution (Clean Air Act) to provide legal framework and specific guideline for air quality management in Vietnam.

02 Set-up more automatic air monitoring stations and use low-cost air sensors to raise public awareness and give warnings of air pollution.

03 Effectively control emission sources with focus on major sources, including industrial activities like power, cement, steel, etc.; consider using financial tools for control of the sources.

04 Promote low-emission economic sectors, and issue policies and mechanisms to support the application of green technologies, particularly in the energy, transport and industrial sectors.

05 Each citizen takes initiative in improving their knowledge and updating information on this issue to take measures to protect their health, contribute initiatives to improve air quality to accompany efforts from the government.

BACKGROUND INFORMATION
ON AIR QUALITY

AIR

AIR is a mixture of gases which have no color or smell. It comprises about 78% nitrogen, 21% oxygen, less than 1% argon, carbon dioxide, and other gases. The average adult at rest inhales and exhales about 10-20 cubic meters of air per day and a child consumes a double amount of that.[4]

AIR POLLUTION

AIR POLLUTION refers to changes in natural properties of indoor or outdoor air caused by a single or multiple chemical, physical or biological agents, making the atmosphere become incompatible with environmental technical standards and adversely affect people and creatures.[8]

PM

PM or Particulate Matter is a complex mixture of extremely small particles and liquid droplets in the atmosphere. Particle pollution includes PM_{10} (inhalable particles with an aerodynamic diameter smaller than 10 micrometers); $PM_{2.5}$ (inhalable fine dust with an aerodynamic diameter smaller than 2.5 micrometers), and $PM_{1.0}$ (inhalable ultrafine dust with an aerodynamic diameter of less than 1 micrometer).

[4] https://www.thoughtco.com/definition-of-air-in-science-604751

AIR QUALITY INDEX (AQI)

AIR QUALITY INDEX (AQI) is used to keep track of daily air quality. It was first introduced by the U.S. Environmental Protection Agency (EPA). Some other countries, including Vietnam, have their own air quality indices like the Air Pollution Index (API) and the Pollution Standards Index (PSI). In 2011, the Vietnam Environment Administration (VEA) under the Ministry of Natural Resources and Environment (MONRE) promulgated the technical guidance on AQI computation which takes into account parameters like PM_{10}, SO_2, CO, NO_x, and O_3 as stipulated in the National Technical Regulation on Ambient Air Quality QCVN 05/2009/BTNMT.
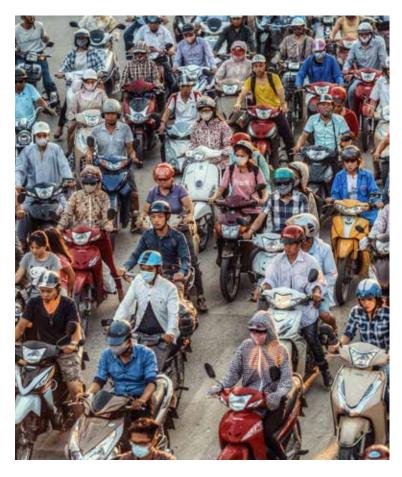
The Air Quality, Index is measured on a scale to indicate the level of health risks associated with local air quality. The U.S. EPA's AQI focuses on health effects that people may experience within a few hours or days after breathing polluted air and it is divided into six categories. The higher the index is the bigger health impacts are. For more information, please go to: www.airnow.gov.

STATUS OF AIR QUALITY
IN HANOI & HO CHI MINH CITY

DATA SOURCES

Data sources for the evaluation of air quality in Vietnam are limited. Although automatic air quality monitoring stations (AQMSs) for data collection have been in place, they are of low quantity and scattered in some big cities.

Since 2009 the MONRE Center for Environmental Monitoring (CEM) developed a network of automatic AQMSs in big cities, including: Hanoi (Nguyen Van Cu station), Da Nang, Khanh Hoa, Phu Tho, Quang Ninh, and Hue. Cities and provinces of Dong Nai, Vinh Phuc, Quang Ninh and Hanoi also invested to set up local automatic air quality monitoring stations. Since January 2017, ten air quality monitoring stations (AQMS) have been installed in Hanoi by its People's Committee including 02 automatic stations and 08 sensor stations. Data collected from the stations are made available to the public and can be accessed online. The U.S. Embassy in Hanoi (the Embassy's Chancery building at Number 7 Lang Ha Street) and the U.S. Consulate in Ho Chi Minh City (Number 4, Le Duan Street) provide hourly particulate matter concentration measurements which are made available to the public via the AirNow Program. The Air Quality Index (AQI) is also propagated by organizations, including the United Nations International School of Hanoi (UNIS Hanoi). A number of companies have developed their outdoor air quality monitoring systems to provide the community with information about air quality current status. Annex I provides detailed information on some air monitoring locations in Hanoi (locations, devices and related parameters).

Source: Nguyen Thai Thach

The report data are mainly collected from automatic real-time air quality monitoring stations operated by the U.S. Embassy in Hanoi and the U.S. Consulate in HCMC. Data from Puritrak outdoor air quality monitoring system are also adopted. As the system was installed and began operations at the beginning of 2018, statistics collected since May 2018 are used to ensure data stability. They include air quality sensor stations providing data on such parameters as temperatures, humidity, PM_{10} and $PM_{2.5}$ concentrations. The air quality sensors also accommodate the computation of AQI using the U.S. EPA's method and $PM_{2.5}$ concentrations measured at a certain point of time. In general, data credibility of sensor equipment cannot be compared with that of expensive, accurate measurement systems under regular maintenance and calibration. Nonetheless, within the scope of this report, the equipment can be used to keep track of trends, give warnings, and raise awareness of air pollution[5].

Data from ten air quality measurement stations operated by the Hanoi People's Committee and recent air quality analysis results from the Northern Center for Environmental Monitoring are also synthesized to create a more comprehensive view of the current air quality status in the capital city. We always try to utilize all public available resources to give the best available picture as much as we can. **Although the collected data is not yet able to provide full indications of air quality in Hanoi and Ho Chi Minh city and more measuring stations need to be established and hourly historical data need to be provided and used more openly, this report can give warnings of air quality in Vietnam's two important cities.**

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[5] See Annex I for the details of air quality monitoring equipment

DATA COLLECTION AND ANALYSIS

Although there are other air pollutants besides $PM_{2.5}$, including sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), ultrafine particulate matter, etc. which cause severe adverse health risks, super small-sized $PM_{2.5}$ is seen as the agent that has huge impacts on public health and is the leading contributor to global premature deaths attributed to ambient air pollution. In addition, according to recent air quality reports, particle pollution remains an outstanding issue [16]. In Hanoi, $PM_{2.5}$ concentrations remain a parameter with the highest level of air pollution indications among others (PM_{10}, CO, SO_2, NO_2, O_3, and SO_2) [10]. As a result of limited data for other parameters, this report focuses on air quality analysis and evaluation based on $PM_{2.5}$ concentrations in Hanoi and HCMC.

Hourly, daily and annual averages of data are computed. Criteria for air quality evaluation are based on the National Technical Regulation on Ambient Air Quality (QCVN 05/2013/BTNMT) and the WHO Air Quality Guidelines (WHO AQGs).

	$PM_{2.5}$	PM_{10}	Nitrogen dioxide (NO_2)	Sulfur dioxide (SO_2)	Ozone (O_3)
Vietnam	25 µg/(m³.year) 50 µg/(m³.24h)	50 µg/(m³.year) 150 µg/(m³.24h)	40 µg/(m³.year) 100 µg/(m³.24h) 200 µg/(m³.1h)	50 µg/(m³.year) 125 µg/(m³.24h) 350 µg/(m³.1h)	200 µg/(m³.1h) 120 µg/(m³.8h)
WHO air quality guidelines	10 µg/(m³.year) 25 µg/(m³.24h)	20 µg/(m³.year) 50 µg/(m³.24h)	40 µg/(m³.year). 200 µg/(m³.24h)	20 µg/(m³.year) 500 µg/(m³.24h)	100 µg/(m³.8h)
Annex 2 WHO temporary goals	25 µg/(m³.year) 50 µg/(m³.24h)	50 µg/(m³.year) 100 µg/(m³.24h)	No specified	50 µg/(m³.24h).	No specified
EU	25 µg/(m³.year)	20 µg/(m³.year). 125 µg/(m³.24h)	40 µg/(m³.year). 200 µg/(m³.24h)	50 µg/(m³.year) 125 µg/(m³.24h) 350 µg/(m³.1h)	180 µg/(m³.1h) 120 µg/(m³.8h)

Table 1. Vietnam's National Technical Regulation
on Ambient Air Quality versus relevant international standards [3, 5, 14]

Apart from $PM_{2.5}$ concentration figures, data connected with the Air Quality Index (AQI) are also analyzed in this report. The Air Quality Index (AQI) adopted in the current report is the U.S. EPA's AQI. The MONRE Vietnam Environment Administration (VEA) promulgated the technical guidance for computation of the AQI in 2011 based on experience of other countries like the United States, European countries, Japan, Singapore, etc.

In general, the application of AQI computation for individual air pollutant (SO_2, $PM_{2.5}$, PM_{10}, NO_x, CO, O_3, etc.) and the selection of the highest value to represent overall air quality are recorded in the computation methods adopted in both U.S. and Vietnam. Having said that, there are differences in the two countries' methods. While the determination of the U.S. EPA's AQI values depends on potential health impacts of air pollutants, Vietnam AQI values are defined based on the difference between the measurement results of pollutants compared with the applicable national standards.

Differences between the U.S. and Vietnam's AQI computation are summarized in the following figure. With average $PM_{2.5}$ concentrations falling between 0 and 82.4 µg/m³ AQI computed according to Vietnam's National Technical Regulation tends to be lower than that calculated using the U.S. method while the opposite is true for average $PM_{2.5}$ concentrations beyond the range.
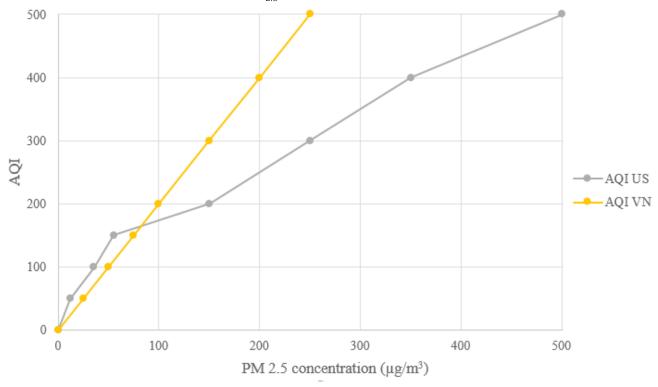
Figure 1. Differences in concentration limits for each AQI value
between US and Vietnam calculations [2, 4, 17]

It should be noted that for AQI computation based on initial $PM_{2.5}$ concentrations, both U.S. EPA's and Vietnam's air quality indices use the average concentrations of $PM_{2.5}$ within the first twenty-four hours. As a result, a limitation to the AQI computation method lies in subsequent delayed warnings, which is inconsistent with AQI's purpose of giving timely warnings to the public. As a remedy, the U.S. Environmental Protection Agency (EPA) advanced their AQI computation method and came up with the NowCast Calculator since 2015, with which hourly and real-time AQI calculation is performed right at the time when $PM_{2.5}$ concentrations statistics are fed into the tool[6]. The VEA's Center for Environmental Monitoring (CEM) proposed a new AQI calculation method for Vietnam based on the National Technical Regulation, using $PM_{2.5}$ concentration forecasts and similar values as the U.S.'s method to overcome limitations of the current computation method and give timely warnings on air quality to the public.

Within the report's scope, the U.S. EPA's AQI is adopted for the following reasons:

AQI in this report is analyzed by hours and Air Quality Index calculation with NowCast can use values adopted by the U.S. to give warnings on air quality based on hourly PM2.5 concentrations.

Within the scope of the report, the U.S. method is applied by air quality monitoring stations and monitoring equipment system for AQI calculation and warnings for users.

[6] https://www3.epa.gov/airnow/ani/pm25_aqi_reporting_nowcast_overview.pdf

AIR QUALITY IN HANOI

Particulate pollution ($PM_{2.5}$) remained a big issue in Hanoi in 2018. Data derived from air quality monitors operated by the U.S. Embassy and those installed by Puritrak in different locations (in Ba Dinh, Bac Tu Liem, Cau Giay, Dong Da, Hai Ba Trung and Long Bien) and analysis result of Northern Center for Environmental Monitoring showed that the annual average concentration of $PM_{2.5}$ still at high level (40.1 μg/m^3) (Table 3), in excess regarding the permitted limit set by the National Technical Regulation QCVN 05/2013/BTNMT (25 μg/m^3).

At the U.S. Embassy station, $PM_{2.5}$ concentrations reached 40.6 μg/m^3 - 1.5 times as much as the National Technical Regulation (25 μg/(m^3.year)) and 4 times higher than the WHO AQGs (10 μg/m^3) (See Table 3). As can be seen in daily data analysis results, there were many days around the year when $PM_{2.5}$ concentrations were at high levels. To be specific, 88 days (24% of total days throughout the year) of high $PM_{2.5}$ levels were recorded by the U.S. Embassy's air quality monitoring station, in excess of the permitted limit set in

the National Technical Regulation (50 μg/m^3). The number amounted to 232 days (64%) under a more stringent recommendation (WHO AQGs) (Table 2).

In Long Bien District (according to data from Puritrak), in particular, within merely seven months (May to December 2018) of data collection and analysis, the number of days having average $PM_{2.5}$ levels exceeding the National Technical Regulation was 108/245 days, accounting for 44% of the total days in the analysis period.

Data from ten monitoring stations operated by Hanoi Environmental Protection Agency (Hanoi EPA) reveal that Hanoi urban area is being polluted and $PM_{2.5}$ still have the highest pollution level among parameters [10]. The level of particulate pollution is different among locations. Monitoring stations at Minh Khai and Pham Van Dong streets have the highest number of days which exceeded the limit in National Technical Regulation respectively 129 days (35% of total days) and 109 days (30%

of total days) (Table 4). Current sources of dust pollution in urban areas are mainly from local sources (transport, construction, industrial production) and some sources of remote transport (fine dust from public production sectors, industrial use of fossil fuels, forest fires and from some neighboring countries)[7].

Monitoring station	U.S. Embassy Hanoi	Ba Dinh	Bac Tu Liem	Nam Tu Liem	Cau Giay	Dong Da	Long Bien
Average PM$_{2.5}$ concentrations (µg/m³)	40.6	50.3	44.5	43.7	50.9	40.3	55.6
Number of days with PM levels exceeding National Regulation	88	88	61	60	80	49	108
Number of days with PM levels exceeding WHO AQGs	232	178	146	138	170	149	209

Table 2. Overview of air quality in areas in Hanoi in 2018
Data sources: U.S. Embassy and Puritrak's sensor monitoring stations

Note: *The data in Ba Dinh, Bac Tu Liem, Nam Tu Liem, Cau Giay, Dong Da, Long Bien were collected from sensors installed by Puritrak company from May 2018. Detailed information of these above devices is shown in annex II.*

No	Location	PM$_{2.5}$ (µg/m³)
1.	556 Nguyen Van Cu	37.7
2.	US Embassy	40.6
	Average(*)	36.3
	Average (**)	40.1

Table 3. Summarize of PM$_{2.5}$ annual average concentration in 2018 in Hanoi

Legend:
(*) Average value of PM2.5 concentrations from 12 stations (10 stations of Hanoi EPA, 01 station from US Embassy and 01 station from Northern Center for Environmental Monitoring)
(**) Average value of PM$_{2.5}$ concentrations from 12 stations above and devices of Puritrak.

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[7] Sources: Northern Center for Environmental Monitoring, Air Quality in Hanoi in 2018 and the first 3 months of 2019, Environmental Newsletters No 4/2019.

No	Location	Number of days which have 24h average of PM$_{2.5}$ concentration exceeding National Regulation	Number of days meet National Regulation	Total of measured days
1.	Kim Lien	1	359	361
2.	My Đinh	0	361	361
3.	Hang Đau	56	305	361
4.	Hoan Kiem	0	361	361
5.	Thanh Cong	24	337	361
6.	Pham Van Đong	109	252	361
7.	Minh Khai	129	232	361
8.	Tay Mo	5	356	361
9.	Hanoi EPA	16	345	361
10.	Tan Mai	0	361	361
11.	556 Nguyen Van Cu	88	266	354

Table 4. Summary statistic data on number of days which have 24h average PM$_{2.5}$ concentration exceeding National Regulation

Source: Northern Centre for Environmental Monitoring

Hourly PM$_{2.5}$ concentrations were used for the evaluation of changes in the particulate matter during the day (See Figure 2). Accordingly, there was a downward trend in the particulate matter between 11am to 4 pm before the PM concentrations increased again from 5 pm.
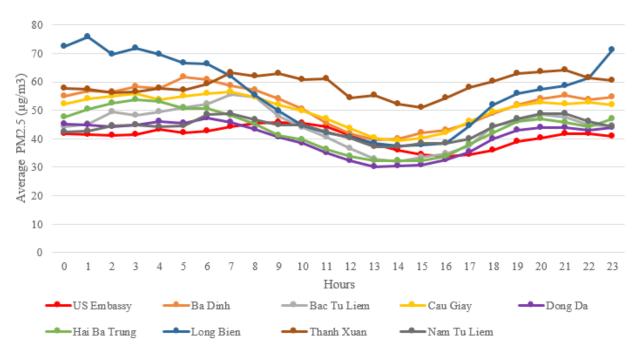

Figure 2. Hourly PM$_{2.5}$ concentrations in Hanoi's air quality monitoring stations

Sources: US Embassy Hanoi and Puritrak stations

Figure 3 showed the 24h average PM$_{2.5}$ concentrations in 2018, we can see that, PM$_{2.5}$ values reached high level in first 3 months and last 3 months of the year. From May to September, air quality is better, PM$_{2.5}$ values mostly met the limit of National Regulation.
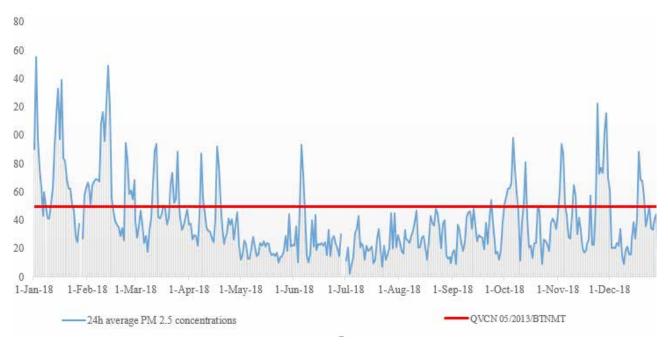
Figure 3: Changes in average daily PM$_{2.5}$ levels in 2018
Data source: the U.S. Embassy station

Health impacts of PM$_{2.5}$ concentrations in the air were demonstrated in the six categories of the Air Quality Index (AQI) with higher AQI numerical values implying greater impacts on human health. Air quality warnings were given per hour of a day via the hourly AQI. Data compiled from monitoring stations in Hanoi show that the "Moderate" and "Unhealthy for Sensitive Groups" AQI levels of health concern dominated (Table 5). "Unhealthy" AQI accounted for 20-25% of the total hours in the year and jumped up to more than 30% in Long Bien and Thanh Xuan stations. The "Very Unhealthy" and "Hazardous" groups made up a fractional amount of about 1-2%. "Hazardous" level of AQI was absent in the U.S. Embassy and Dong Da station' s data.

Calculations of AQI VN per hour in Hanoi including 01 station of VEA (Nguyen Van Cu) and 10 stations under Hanoi EPA: Minh Khai, Hang Dau, Hoan Kiem, Kim Lien, My Dinh, Pham Van Dong, Thanh Cong, Tay Mai, Tay Mo, environmental protection department. The AQI per hour in these station is mostly at moderate level (moderate AQI held 68%), there was no AQI at hazardous level, hours at very unhealthy AQI were at a few too, Minh Khai and Pham Van Dong stations had the most % of unhealthy AQI at 23-35%.[8]

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[8] Sources: Northern Centre for Environmental Monitoring, Air Quality in Hanoi in 2018 and the first 3 months of 2019, Environmental Newsletters No 4/2019.

	U.S. Embassy Hanoi	Ba Dinh	Bac Tu Liem	Cau Giay	Dong Da	Hai Ba Trung	Long Bien	Thanh Xuan	Nam Tu Liem
Good	8.6%	5.7%	8.3%	5.9%	8.7%	7.5%	4.8%	2.8%	8.8%
Moderate	46.9%	28.5%	34.1%	28.3%	38.2%	35.5%	26.2%	19.6%	29.5%
Unhealthy for Sensitive Groups	23.2%	32.8%	32.5%	32.4%	33.0%	33.1%	30.3%	38.1%	35.1%
Unhealthy	20.3%	31.3%	23.8%	31.5%	19.5%	22.7%	35.1%	36.3%	26.1%
Very Unhealthy	1.0%	1.6%	1.1%	1.8%	0.7%	1.1%	3.1%	2.8%	0.5%
Hazardous	0%	0.1%	0.1%	0.1%	0%	0.1%	0.5%	0.3%	0%

Table 5. Hourly AQI categorization by location in 2018

The 2016, 2017 and 2018 $PM_{2.5}$ concentration data were analyzed to define changes in air quality over the years. Most air quality monitoring stations in Hanoi began operations in 2018 so the major source of data for analysis is from the Embassy's station at 7 Lang Ha Street.

Data collected from the U.S. Embassy's station point to a gradual decrease in $PM_{2.5}$ concentrations every year from 50.5 µg/m³ in 2016 to 42.6 µg/m³ in 2017 and 40.6 µg/m³ in 2018, indicating an improvement in air quality of the capital city. However, the figures were from a single station, they failed to reflect Hanoi's overall air quality. Repeating the trend in the two previous years, air quality fluctuated over different periods of the year, showing improvements in Quarters 2 and 3 before deteriorating in the remaining quarters. This was because the weather conditions changed over seasons, affecting the dispersion of air pollutants; temperature inversion occurred in winter and upper air masses had higher temperatures, preventing pollutant dispersion in an upward direction. Besides pollution sources within Hanoi like transportation and construction activities, the northeast monsoon was attributed to the transport of air pollutants from the neighboring country of China as well as industrial parks and power plants in the East, affecting the city's air quality. Transport of air pollutants by the northeast monsoon during winter (typically in January) built up air pollution and fine dust in the country's North[9].[15]

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[9] Ministry of Natural Resources and Environment (2016), National Environment Status report in period of 2010 - 2015

We also compared the Air Quality Index collected from US Embassy monitoring station in 2016, 2017 and 2018 to estimate the trend of air quality year by year in hourly basis.

Air quality was improved in 2016-2017 with "Good" and "Moderate" levels of the index rising close to 10% while no significant changes were seen in the index over the next two years despite a slight fall in the $PM_{2.5}$ levels. To compensate for 2018's lower ratio of "Good" AQI level compared to 2017's, the "Unhealthy" level showed more positive signs accompanied with a drop in the "Very Unhealthy" air quality level during peak hours. "Very Unhealthy" AQI level with the purple color code made up 1% in 2018 (0.4% less than that in 2017).

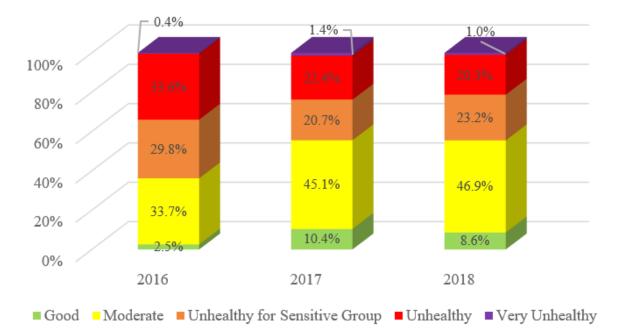*Figure 4. 2016, 2017, and 2018 Air Quality Index (AQI)*

In short, Hanoi's air quality in 2018 was ranked unhealthy with high $PM_{2.5}$ pollution and more serious pollution conditions in winter than in summer. It can be implied from the evaluation of air quality data collected from the U.S. Embassy stations and 10 others of the Hanoi People's Committee that air pollution in the capital city requires greater attention.

AIR QUALITY IN HO CHI MINH CITY

According to data compiled from stations in Ho Chi Minh City, its air quality remained at the "Moderate" level with the annual $PM_{2.5}$ concentrations at the U.S. Consulate's station averaged at 26.4 µg/m³, in excess of the permitted limit of the National Technical Regulation (25 µg/m³) and tripled the WHO AQGs limit (10 µg/m³). The mean level of $PM_{2.5}$ concentrations registered for District 7 (38.7 µg/m³) outnumbered those in other stations (Table 6).

As shown in daily data analysis results, 48 days (13% of total days) of high PM2.5 levels were recorded by the U.S. Consulate's air quality monitoring station in Ho Chi Minh City. The number amounted to 177 days (48%) under the WHO AQGs' more stringent standards.

	U.S. Consulate in Ho Chi Minh City	District 1	District 5	District 7	Saigon Star International School	Lycée Francais International Marguerite Duras
Average AQI	80	86	94	106	91	85
Average AQI level	Moderate	Moderate	Moderate	Unhealthy for Sensitive Groups	Moderate	Moderate
Average PM$_{2.5}$ concentrations (µg/m³)	26.4	29.9	33.2	38.7	28.4	29.2
Number of days with PM$_{2.5}$ levels exceeding the National Regulation	23	17	18	35	20	18
Number of days with PM levels exceeding the WHO AQGs	164	83	105	173	111	107

Table 6. Overview of air quality in areas in Ho Chi Minh City in 2018

Hourly $PM_{2.5}$ concentrations were used for the evaluation of changes in the particulate matter during the day (See Figure 5). The average $PM_{2.5}$ levels varied during the day by location. Areas in the U.S. Consulate, District 7 and the two international schools experienced relatively similar changing models in $PM_{2.5}$ concentrations with the levels tending to pick up between 7 am and 10 am, dropping slightly in the subsequent hours and then remaining steady since 5 pm.
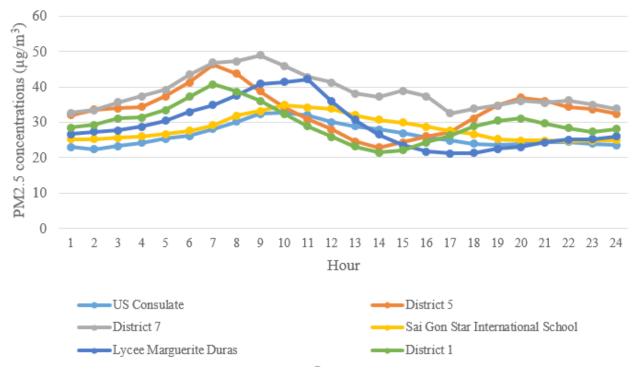
Figure 5. Average PM 2.5 levels by hour of the day in HCMC

Health impacts of PM$_{2.5}$ concentrations in the air were demonstrated in the six categories of the Air Quality Index (AQI) with a higher AQI numerical values implying greater impacts on human health. Most monitoring stations had good AQI categories (rated as "Good" and "Moderate") accounted for more than 70% of the total hours. District 7 was an exceptional case, recording the highest ratio of "Unhealthy for Sensitive Groups" level. The "Very Unhealthy" category made up the smallest proportion of less than 1% in all stations and the "Hazardous" category was absent.

	U.S. Consulate in Ho Chi Minh City	District 5	District 7	Saigon Star International School	Lycée Français International Marguerite Duras
Good	12.6%	7.1%	4.7%	12.3%	10.8%
Moderate	65.7%	55.7%	38.5%	61.7%	64.1%
Unhealthy for Sensitive Groups	15.6%	26.2%	42.0%	17.5%	15.5%
Unhealthy	6.1%	10.9%	14.7%	8.4%	9.7%
Very Unhealthy	0.0%	0.2%	0.1%	0%	0%
Hazardous	0%	0%	0%	0%	0%

Table 7. Hourly AQI categorization in HCMC

Like findings in the previous Air Quality Reports, Ho Chi Minh city's air quality remained better than Hanoi's. In fact, there was a slight improvement in Ho Chi Minh City's air quality with $PM_{2.5}$ concentrations shrank to 26.4 µg/m³ (from 28 µg/m³ in 2016 and 29.6 µg/m³ in 2017) and the number of clean hours hiked.
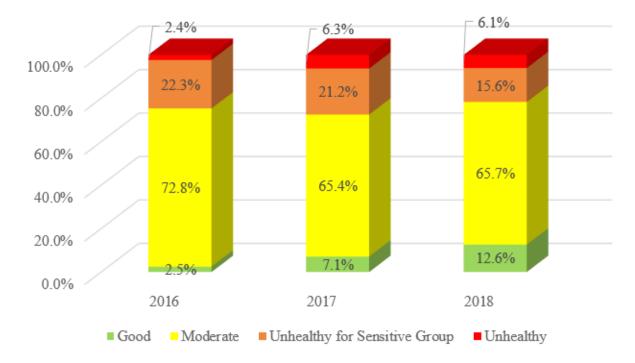

Figure 6. Air quality index in the past 3 years in Ho Chi Minh city.

ROUGHLY IDENTIFY THE SOURCES LOCATION CONTRIBUTING TO AIR POLLUTION IN HANOI AND HCMC

Methods

We analyzed the sources of the worst air pollution episodes experienced in 2018 to identify the potential source regions of the pollution. We identified the three-hour periods with the lowest and the highest pollution levels during the period and used the HYSPLIT atmospheric model developed by the U.S. National Oceanic and Atmospheric Administration to trace the trajectories of the air masses that arrived in Hanoi and Ho Chi Minh City during those hours. Emission sources along these trajectories can make a contribution to the pollution events. The thresholds for low and high pollution were chosen for each city so as to identify a sufficient number of low and high pollution periods for analysis.

To identify the largest air pollutant emission source regions, we calculated average SO_2 and NO2 levels in the atmosphere from satellite data sources (ESA TROPOMI NO_2 data and NASA OMI SO2 data[10]). SO_2 is a pollutant that is closely associated with coal-burning, while NO_2 is emitted from all fuel burning, including coal, oil, gas, and biomass combustion. SO_2 and NO_2 emissions contribute significantly to $PM_{2.5}$ levels, because these pollutants form $PM_{2.5}$ particles in the atmosphere, and they also serve as indicators of the locations of emission sources. We also looked at $PM_{2.5}$ emissions based on the EDGAR emissions database; primary $PM_{2.5}$ emissions in Vietnam are dominated by the household and transport sectors.

In the HYSPLIT model, the simulations which ran for the 1st 96 and 72 hours were used as cluster. The trajectories which had an altitude of more than 300m were eliminated by the sources of emission from the locals may be small.

The important thing to remember is that in reality if the block of air comes from a specified source that is related to the high pollution does not mean that the area of the source has the most polluted air. Speed, humidity, and temperature change systematically with the direction of the wind, and these conditions affect the accumulation in the block of air and form polluted air like secondary $PM_{2.5}$. The most visible conclusion from the trajectories is that the sources of pollution that follow the trajectories have contributed to the rate of air pollution in cities and so if we solve these sources of pollution we will be considered to have contributed in improving the air quality.

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[10] These satellites measure the earth's radiance at different wavelengths; this data is used to analyze the content of trace gases such as SO2 and NOx in the atmosphere based on their absorption spectra. Maps in this report are processed from daily Level-2 data products provided by NASA and Dutch Royal Meteorological Institute KNMI.

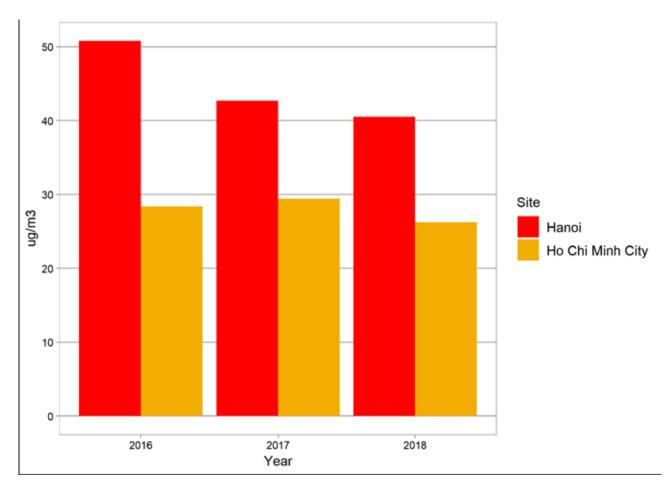*Figure 7. Average PM$_{2.5}$ levels by year*
(according to data from US Embassy in Hanoi and US Consulate in HCMC)
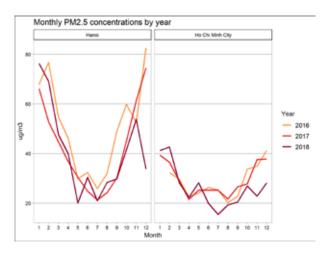

Figure 8. Monthly PM$_{2.5}$
concentrations by year
(according to data from US Embassy in Hanoi
and US Consulate in HCMC)
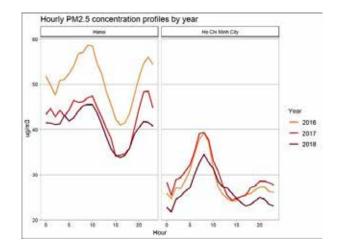
Figure 9. Average PM$_{2.5}$ levels
by hour of the day
day (according to data from US Embassy in
Hanoi and US Consulate in HCMC)

Hanoi

Besides the city itself, Vietnam's largest coal-fired power plant clusters to the east (Hai Phong, Quang Ninh), and the concentration of heavy industry, including cement and chemicals, in Ninh Binh to the south, were major emission sources affecting air quality in the city. SO_2 and NO_2 levels in these areas exceeded those in the city itself, indicating higher emissions. Furthermore, both SO_2 and NO_2 levels in these two clusters increased substantially over this decade, with likely negative implications for air quality in northern Vietnam, including Hanoi (Figure 10).

Figure 10 shows significant increase of these pollutants over the past 5 years. Dobson unit is used to measure. The higher the unit is, the greater concentration of the pollutant is.

There are also significant emission sources in China at the north. The SO_2 and NO_2 levels around these sources fell dramatically over the past decade.

While air quality in 2018 remained poor, average PM2.5 levels fell in Hanoi from 2016 to 2018. The reduction was predominantly due to lower levels during 4-5 pm before increasing again in the next hours. Pollution in winter is also higher than in summer (Figure 8) as indicated above.
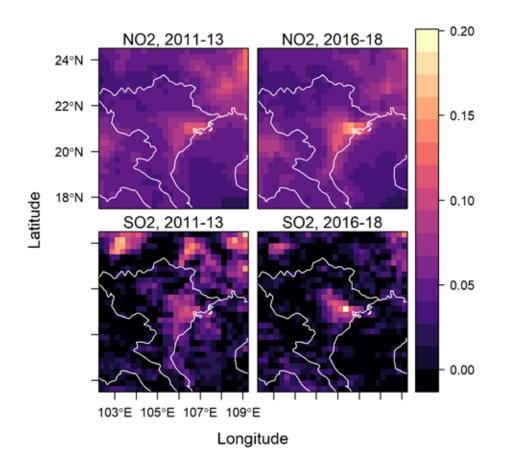
Figure 10. Average NO₂ and SO₂ levels over northern Vietnam in period of 2011 – 2013 (on the left) and in period of 2016 – 2018 (on the right) derived from ESA TROPOMI satellite data.
Dobson unit.
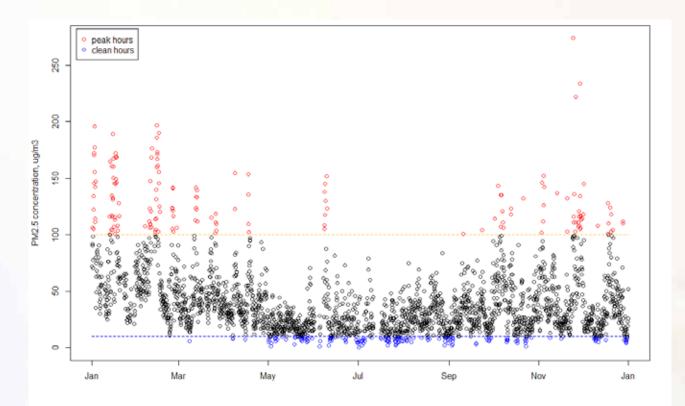
*Figure 11. 3-hour periods with PM_{2.5} level below 10µg/m³
were designated as 'clean hours' (169 trajectories); periods with PM_{2.5} above 100µg/m³
were designated as 'peak' pollution hours (167 trajectories).*

Figure 11 showed some 3-hours period with PM$_{2.5}$ concentrations at low level and high level were selected to simulate and compare air massive trajectories. In this figure, the red dots represented for "peak hour" which have PM$_{2.5}$ concentrations higher than 100 µg/m³, these dots included 167 periods corresponding with 167 trajectories. The blue dots represented for "clean hour" with PM$_{2.5}$ concentrations lower than 10 µg/m³, these dots included 169 periods corresponding to 169 trajectories.
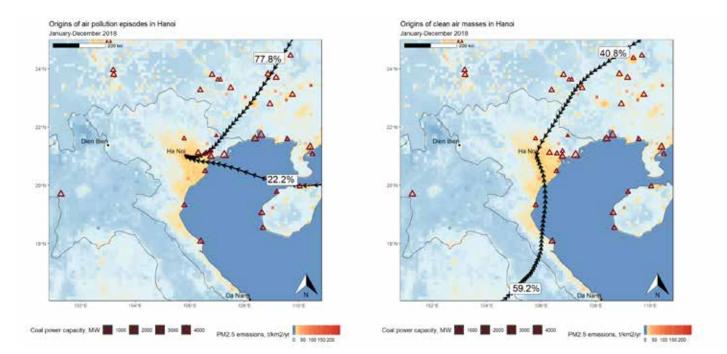
*Figure 12. Trajectory clusters associated with high pollution peaks
and low pollution periods in Hanoi in 2018.*
Note: The percentage labels indicate the share of periods associated with each cluster.

HYSPLIT analysis: the trajectory of air masses arriving in Hanoi during the polluted hours and clean hours were clustered using the HYSPLIT cluster analysis which groups similar trajectories together. Two trajectory clusters were associated with all the pollution peaks, both passing through the Quang Ninh area with a large concentration of coal-fired power plants and industry. During clean hours, air masses were arriving along two different trajectories, either from the north (41% of the analyzed periods) or from the south (59%), bypassing the major regional emission source regions around Hanoi (Figure 12).

Ho Chi Minh City

As a major urban area, HCMC itself is the largest emission hotspot in southern Vietnam. Besides urban emissions sources in the city, the industrial and power plant cluster around Phu My on the mouth of the Mekong, to the southeast of the city, is a major source of air pollutant emissions, based on satellite data analysis (Figure 13).

NO_2 levels in the city itself and especially in the industrial area to the southeast have increased substantially during this decade. SO_2 levels are much lower than in northern Vietnam.

Average $PM_{2.5}$ levels peak sharply in the morning hours between 6 and 10 am, likely due to contribution from transport (Figure 9).

$PM_{2.5}$ concentrations in HCMC do not exhibit a clear trend in 2016-2018, staying effectively unchanged (Figure 7). The daily profile of pollution levels is also relatively similar between the different years, but becomes a bit flatter over time (Figure 9).

from the entire region to the northeast of HCMC, up to 400 km away. Residential, urban and industrial sources over the entire coastline from HCMC to Quy Nhon affect air quality during these episodes (Figure 15). Clean air masses were either air masses arriving from the sea (30%) or fast-moving air masses arriving from inland areas in the north (22%) and south (48%), with little time to accumulate pollution from land areas.

This analysis emphasizes the importance of controlling pollution in the immediate vicinity of HCMC such as Bien Hoa, Binh Duong, as well as on the coastal areas such as Ba Ria-Vung Tau to the north.
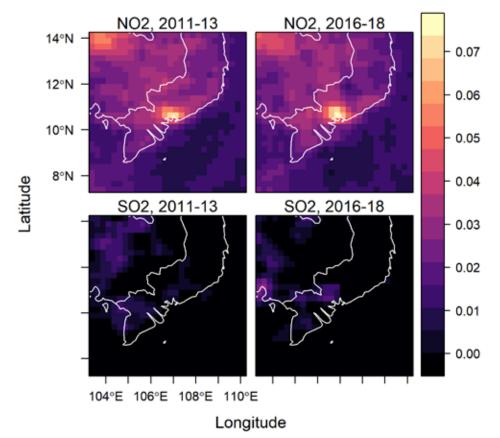
Figure 13. Average NO$_2$ and SO$_2$ levels in southern Vietnam in 2011-13 and 2016-18 derived from NASA OMI satellite data.

Dobson Unit
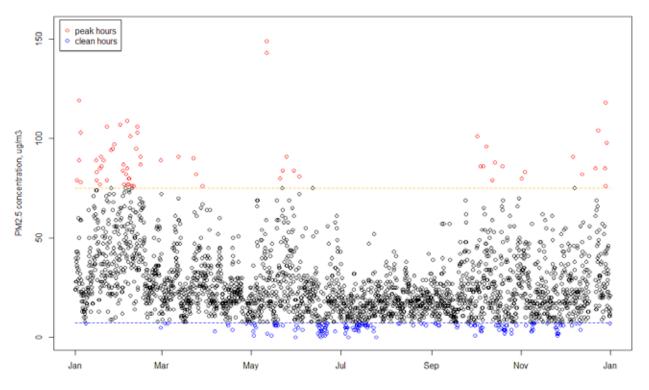
Figure 14. Trajectory clusters associated with high pollution peaks and low pollution periods in Ho Chi Minh city in 2018.

3-hour periods with $PM_{2.5}$ level below 7.5µg/m³ were designated as 'clean hours' (165 trajectories); periods with $PM_{2.5}$ above 75µg/m³ were designated as 'peak' pollution hours (167 trajectories).
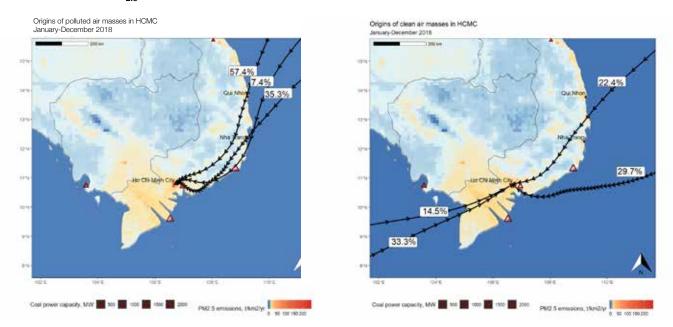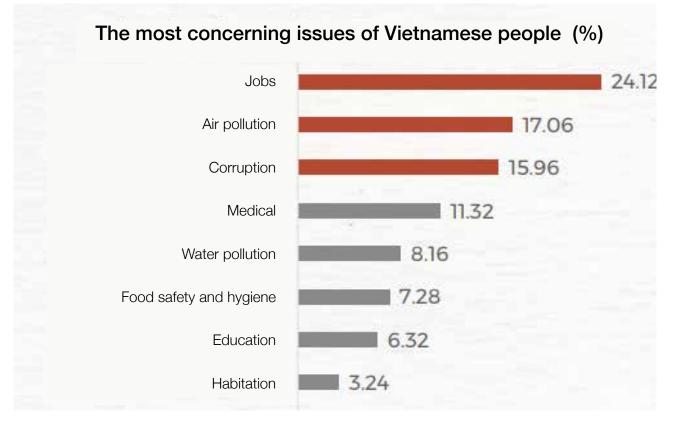
Figure 15. Trajectory clusters associated with high pollution peaks and low pollution periods in Ho Chi Minh City.
Note: The percentage labels indicate the share of periods associated with each cluster.

PUBLIC VIEWS
OF AIR QUALITY

Air pollution has been among people's biggest concerns in recent years. As per GreenID's survey results in 2016 and 2018 in Hanoi and Ho Chi Minh City, 99% of the respondents expressed interest in air quality and only 4% of them were content with the quality. For the period of 2016 – 2018, there is about 36% people showed that they feel air quality have decrease comparing to previous 3 years[11]. In 2018, The Mekong Development Research Institute (MDRI) sources over the entire 1.400 people aged 18 or older uncovers that air pollution was ranked the second biggest concern by Vietnamese people [12]. The increasing concern of people about water and air quality requires the authorities at all levels to pay attention and take timely actions, including mobilizing people to participate in improving environmental conditions at residential area. Public view of Hanoi's current air quality conditions was recorded as follows.

The most concerning issues of Vietnamese people (%)

Issue	%
Jobs	24.12
Air pollution	17.06
Corruption	15.96
Medical	11.32
Water pollution	8.16
Food safety and hygiene	7.28
Education	6.32
Habitation	3.24

Source: Mekong Development Research Institute (MDRI), 2018

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[11] The Vietnam Provincial Governance and Public Administration Performance Report (PAPI) in 2018, http://papi.org.vn/

MR. HUNG (A HANOIAN)

"It is true that clean air is becoming a concerning matter for the whole society in Vietnam and regional countries. At home, I often grow plants and leave the windows open for air circulation. My family members always wear masks when we are out on the streets. Those are our main ways to cope with the situation now. We can just try to raise self-protection awareness to mitigate the impacts of air contamination and encourage other people for less attribution to this kind of pollution. Another point I would like to make is that air protection is of no individual responsibility. Everyone and the whole society should be responsible for it."

MS. VU MINH HIEN
(HANOI MEDICAL COLLEGE)

"Air pollution in Hanoi is serious, I think, because many allergies have been recorded and there is much dust in the air. All doors and windows of my house are often closed but it is very dusty. My two children often suffer from allergic rhinitis due to changing weather and probably particulate matter. The air in areas far from Hanoi is much fresher and more pleasant. I hope my children are well aware of environmental protection and measures for air pollution reduction and energy savings to protect their health."

MS. DO THI THU HUONG (HANOI)

"I think the air in Hanoi is seriously polluted. That people wear masks out on the street has become a common scene and the masks get dirty very quickly. Just that example can tell how polluted the city center has become. We must breathe to live so air contamination is strongly affecting people's health. Living in such a heavy and polluted environment is not just bad for people's health, their lives are also affected. My daughter is in Grade 10 and she has been taking the bus to school since Grade 6. Although my house is far from school, I have no intention of taking her to school by motorbike. I want her to continue using the bus. I also grow plants in my house. I keep the house and surrounding areas clean. Environmental protection does not mean keeping your house clean and ignoring surrounding areas. There are many other things but that is all I can think of at the moment (laugh)."

MS. TRAN HAI YEN
(AN EDUCATIONAL WORKER)

"Generally speaking, the air is polluted as there have been more high-rise buildings, traffic, and smog. I really want to grow trees to reduce air pollution. Living in a clean and fresh atmosphere is certainly better than in a contaminated one. In a polluted environment, we will breathe in unhealthy gases and can acquire diseases very easily. No one wants to suffer from illnesses. We all love to enjoy fresh and secured air."

MS. VAN (VIETNAM ACADEMY FOR ETHNIC MINORITIES)

"My friend posted a warning of the Air Quality Index in Hanoi on Facebook and its high score really startled me. Air pollution seems to be getting more serious. There were days when the color code was all in red. I did not suppose it to be such severe and I have not come up with a satisfactory solution to that problem for my family. I am not sure if this is relevant but some of my foreign friends are more likely to get respiratory conditions when living in Vietnam. They said that the air in their countries is not so polluted as in Vietnam. It makes me rather sad as my children and I cannot choose our birth places. If air pollution is not totally ended, the situation will soon get worse just like China, I am afraid!"

MS. LE LAN KHANH (A BANK CLERK)

"Air pollution in Vietnam is an alarming issue. We almost cannot go out without masks these days. I did not use to get sick when the weather changed but I get ill more often now. Speaking of solutions, I just wish my whole family could move to a new living environment like Ecopark where there is fresh air and green trees. We are unable to do so at the moment. For now, what we can do is not dumping garbage, using masks and buying indoor air purifiers if possible to have more clean air in our house."

It can be seen that air pollution has always been a common interest and a burning issue of great concern in the public. Awareness of air pollution has been significantly improved with people having been equipped themselves with fundamental health protection measures. It may be attributable to numerous governments', institutional and individual efforts in air quality enhancement.

EFFORTS TO
IMPROVE AIR QUALITY

THE GOVERNMENT

In a bid to cope with the situation, governmental, institutional and individual efforts were witnessed in air quality enhancement, especially in urban areas. In 2016, the national action plan for air quality management by 2020, vision to 2025 was approved by the Prime Minister[12], targeting strengthened air quality management via control over emission sources, ambient air quality monitoring, air quality improvement, and ensuring public health. Euro 4 emissions standards have been applied to vehicles in Vietnam since January 1, 2017. Together with legal documents, national technical standards and regulation in regard to air quality have also been reviewed, amended, and promulgated, comprising national technical regulation on ambient air quality, motorcycles emission, and industrial emission.

Investment in 50 air monitoring stations planned for Hanoi

Multiple solutions have been implemented simultaneously to cope with the current air quality conditions in Hanoi, including the plan for environment protection enhancement in the city[13]. Coordination with AIRPARIF (France) has been maintained to realize the technical support project on investigating and evaluating Hanoi's air quality. The "Building Environment Monitoring System in Hanoi" project is underway until 2020, targeting 20 automatic fixed constant air monitoring stations and one mobile station with a view of 50 stations by 2030. These are among efforts to develop a full-scale, comprehensive and constant database system to serve as a scientific basis for accurate evaluation of the city's current air quality status. The system will also facilitate environmental protection agencies to map out plans and build policy proposals for improving the living environment in Hanoi.

Source: https://doanhnhansaigon.vn

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[12] Prime Minister's Decision No. 985a/QD-TTg on June 1, 2016 Approving the national action plan on air quality management up to 2020, with a vision toward 2025

[13] Resolution No. 11/NQ-TU of the Hanoi Municipal Party Committee and Plan No. 160/KH-UBND of the Hanoi People's Committee

Availability of air quality information to people in Hanoi

Ten air monitoring stations have been installed and put into operation in inner Hanoi, comprising two fixed stations at the Hanoi Environmental Protection Agency (Hanoi EPA) at 17 Trung Yen 3, Cau Giay District and the People's Committee of Minh Khai Ward, Bac Tu Liem District together with eight sensor monitoring stations in Hang Dau, Kim Lien, Hoan Kiem, Pham Van Dong, Tan Mai, Tay Mo, Thanh Cong, and My Dinh. People in Hanoi can track the air quality monitoring index at: moitruongthudo.vn run by the Hanoi Department of Natural Resources and Environment, the city's e-portal (hanoi.gov.vn), the 18:30 News of Hanoi Radio Television, and the daily Hanoi Moi (New Hanoi) Newspaper. Daily AQI (within 24 hours) at ten monitoring stations in Hanoi and data are updated at 11pm every day.

Enhanced air pollution control capacity

The Center for Environmental Monitoring Portal (CEM) for the North is asserting efforts to provide technical support for cities and provinces in technology transfer of online air quality monitoring data from emission units to the national system for surveillance and supervision. Transmission of the data from 53 cities and provinces to the national system is expected in 2019.

In March 2019, the Vietnam Environment Administration (VEA) in collaboration with the School of Environmental Science and Technology (INEST) and the Hanoi University of Science and Technology (HUST) organized the Conference on establishing a network of pollution control officials in Vietnam with a view to bolster their roles and competences and provide human resource development orientation via environmental protection guidance and regulation system. In addition, Japanese experts coordinated and supported Vietnam in human resource development and knowledge enhancement for central and provincial management and specialized officers on environment and pollution control via training courses for pollution control officials in Japan. Environmental protection cooperation with development partners, especially with Japan, opens up an opportunity for Vietnam to access their experience and strengths in settling environmental management issues.

The development of the guidance for Vietnamese air pollution control officers is under way by the Vietnam Environment Administration (VEA), aiming for a document of simple design, high efficiency and practicality. The VEA also targets the completion and introduction of an app-based enterprise-targeted guidance in 2019.

NON-GOVERNMENTAL ORGANIZATIONS (NGOS) AND DEVELOPMENT PARTNERS

Efforts have been made by a number of civil society organizations (CSOs) like the Green Innovation and Development Center (GreenID) to raise awareness and boost air quality improvement solutions. GreenID tries to enhance public participation which is pivotal in tackling air pollution through public information sharing and exchange on air pollution. It is materialized by the publication of periodical reports and air quality bulletins for interested people so that they have the most updated information about air pollution. Furthermore, two campaigns, **"One voice, one breath 2018"** and **"Vietnam Clean Air 2018"**, were respectively launched in May and December 2018 by GreenID. The campaigns helped to raise public awareness of the current status and impacts of air pollution on human health and boost the community's voice and green solutions. Citizen voice about the issue helps to build up expectations for fresher air.

The online media campaign "One Voice One Breath" was initiated by GreenID since 2017. The 2018 campaign is particularly geared to young people and attracts more than 850,000 reaches and 10,000 interactions to activities such as film making contest, photo contest on air pollution, exhibitions, talkshows. With the message "Air is not free" the campaign has contributed to increasing public awareness about the status and impact of air pollution on health, thereby promoting the voice and green solutions from community. One person voices up about the issue, one hope is lit up to improve the air. "Vietnam Clean Air 2018" Campaign with the message "Clean Air - Green Gift - Healthy Family" for all Vietnamese people initiated by GreenID starting from 2018 and is expected to organize annually. At the 2018 Clean Air Day, many wishes for a better air quality were shared by participants joining in different activities. 1,900 people participated

directly, 105,139 reached on fanpage, 10 social and business organizations joined, 26 articles shared about the event. These are encouraging results, motivating us to continue our contribution to improve air quality in Vietnam in the future.

The Clean Air – Green City Project is funded by the United States Agency for International Development (USAID) in July 2017 – June 2020 for implementers comprising Live and Learn for Environment and Community, Center for Supporting Green Development, Green Innovation and Development. The USAID Clean Air Green Cities project addresses air pollution and its health impacts in Hanoi by mobilizing a network of local partners (including youth, schools, communities, civic and social organizations, businesses, and governments) to take collective action and advocate for clean air.

GreenHub as one of the three main partners of the project is responsible for promoting youth and women's waste management and energy technology initiatives related to waste treatment technology and turning waste into energy: Current practice (using coal energy for food processing, pig raising and daily cooking in traditional cooking stoves and small boilers in craft villages) in Hanoi causing serious air pollution, unnecessary carbon emissions and health impacts, especially for poor women and direct kitchen users. GreenHub introduces safer and less emissions options and provides technical and financial support to help grow, improve, and apply technology. Women and youth initiatives will be particularly encouraged and ownership will eventually be transferred to the local community. Activities conducted: (i) Conduct surveys and meetings with local communities to assess needs stakeholder analysis for the purpose of reviewing and selecting appropriate interventions (group women); (ii) Organize at least two events of improved cook stoves with low emissions; (ii) Designing communication materials and model models and (iii) Supporting 140 households using beehive coal stoves to convert to using other types of kitchens more environmentally friendly.

1,900 people participated directly

10 social and business organizations joined

105,139 reached on fanpage

26 articles shared about the event

In the meantime, the network of organizations working on air quality control has performed periodic activities to update information and discuss the situation of air pollution in Vietnam and CSOs' responsibilities in minimizing impacts on public health. The network comprises of the U.S., Germany, France and Switzerland Embassies in Hanoi, Vietnam Sustainable Energy Alliance (VSEA), Vietnam Non-Communicable Diseases Prevention and Control Alliance (NCDs-VN), Research and Training Center for Community Development (RTCCD), Live & Learn, GreenID, and Vietnam Clean Air Partnership (VCAP).

Great efforts have also been made by Vietnam's development partners in air quality monitoring and awareness building. To celebrate the Air Quality Awareness Week, the U.S. Embassy in Hanoi held panel discussions in Hanoi and Ho Chi Minh City attended by leading environmental and health experts. At the end of 2017, the Germany Embassy in Hanoi installed an automatic air quality monitoring stations (AQMS) on Tran Phu Street with a view that the monitoring data would be made available to the public on the Embassy's website (http//:HanoiAir. de) to foster warnings on air quality for local people. Despite this, the equipment failed to work well enough for data provision in 2018. It was expected that two new monitoring devices would be installed, replacing the old one and operating for data provision in 2019.

SCIENTIFIC AND TECHNOLOGICAL COMMUNITIES

Low-cost air sensor monitoring devices are being developed and put into commercial products in Vietnam. In 2017, a research group from the Hanoi University of Science and Technology (HUST) successfully created an air monitor device and got it installed at some schools.

In 2017-2018, FAirKit, a low-cost air quality sensor equipment, was studied and developed by an Internet of Things (IoT) research group managed by FIMO[14]. Its members are alumni of the VNU University of Engineering and Technology (VNU-UET). The equipment accommodates people's awareness of the air quality in their living and working environments and other areas via a mobile app (FairApp) and an online platform (FairWeb). Informed of air quality, users are able to come up with tangible measures for mitigating the impacts of air pollution on human health. FarKits are now erected in the "book streets" and Cho Cau Dong, Hoan Kiem Districts and scheduled for many more installations across Hanoi.

At the end of 2018, D&L Technology Integration And Consulting Joint Stock Company[15] rolled out the PAM Air app that integrates ambient air quality data from monitoring stations operated by the company and consolidate data from the U.S. Embassy in Hanoi. D&L Corporation is conducting research on low-cost air monitors

of various choices and real-time data will be online at www.pamair.org in accompany with the user-friendly app of PAM Air for accessing air quality monitoring statistics.

The 2018 to early 2019 period witnessed a series of technical conferences **on low-cost air quality sensor equipment in connection with air quality evaluation and management; Air Quality Index and related issues in Vietnam.** They are among efforts by the Vietnam Clean Air Partnership (VCAP) and the Clean Air Green Cities project to share information on air quality management and improvement. The goals were to update the current status of researching, manufacturing and using experience of low-cost air quality sensor equipment, their applied standards and calibrations, the use of the equipment from the perspective of state management and community education. The conferences were also chances for discussions on the product quality enhancement, development, and expansion in the future. Existing global and local AQI calculation methods and relevant problems were brought out for analyzing and proposing solutions. The conferences presented opportunities to discuss and facilitate proper understanding of air quality indicators as well as to reach consensus over information publication and use for the community.

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[14] https://fimo.edu.vn/
[15] http://dlcorp.com.vn/

THE COMMUNITY

Over recent years and in 2018, in particular, issues related to air pollution have been up for strong discussions. This topic have been discussed by KOLs such as Rapper Dinh Tien Dat and hot facebooker Mai Quoc An to share their personal viewpoints and community's perspectives of air quality with diverse information provided. Measures like using $PM_{2.5}$ anti pollution masks, air quality monitors, air purifiers and green living have received significant community interest and been widely implemented.

THE MEDIA

The media plays an important role in giving out a wide range of information for the community about the causes and results of air pollution and how to reduce the problem. In 2018, we noticed the actions of the media, newspaper, online newspaper, radio, and television which is to promote topics related to air pollution. Various information about air pollution helps the community to receive and understand this information. This will contribute in creating solutions that help to improve the quality of the air.

Source: VTV.vn

WHAT WILL
WE DO NEXT?

WE NEED TO PUT MORE EFFORT INTO POLICIES

Issue Clean Air Act

Although tangible results have been achieved in Vietnam through legal policy promulgation and the implementation of air quality management and control activities the results remain modest. Section 4, Chapter 4 of the Law on Environmental Protection provides statutory provisions on air environment and Section 5, Chapter 9 on the management and control of dust, gas emissions, noise, vibrations, lights and radiation. Regulations on environmental protection for highly polluted sectors like transportation, construction, industry, etc. are stipulated in the law but they are not sufficient and not applied effectively in reality. Loose legal regulations remain and the law only provides orientations for taking actions.[8, 13]

In regard to by-law documents, Decree No. 38/2015/ND-CP on the management of wastes and scraps regulates the registration for emission sources, permission for discharge activities and constant monitoring of gas emissions applicable for significant industrial gas emission sources primarily in sectors of thermal power generation, chemicals, cement and steel. Nonetheless, Vietnam's regulations on environmental protection are too general as pre-discharge processing of gas emissions is required for institutions, individuals and transport vehicles without specific emission limits being set. Financial tools are not

effectively used to impose special control over large sources of emission. Regulations for emission fee are not yet available while the policies on environmental taxes, fees, and charges are vague.

Regulations on fuel quality, control of traffic emissions and exhaust sources are now scattered across different documents and not yet synchronized. There are no specialized legal documents on air protection. It can be said that legal documents on air protection are not focused as much as those on water preservation and solid waste management. [13]

Major responsibility and the distribution of State management over air quality are divided, focal point management remains unclear and responsibilities and tasks are overlapped among relevant Ministries. In detail, the Law on Environmental Protection 2014 fails to state clear provisions on the role of the Ministry of Natural Resources and Environment (MONRE) in supporting the government to take the lead and consolidate state management activities. It also fails to stipulate responsibilities of ministries and industries in coordinating with MONRE in implementing environmental protection tasks which are within their scope of management. [9]

Whilst policies and laws on air pollution control are vague and air quality plans are absent at both central and provincial level, the environmental standards and regulations are not synchronized, indicating a need for sector-specific regulation. This is accompanied with pertaining irrelevant issues, restricted monitoring and inventory of emission sources, lack of comprehensive and regular monitoring programs for rural areas and craft villages. There is no regulation on monitoring businesses' treatment process of exhausted gases during their operations. Moreover, human resources and funding for controlling air pollution are unable to come up with actual demands. Community involvement in air pollution control is low and does not bring about tangible results.

In general, air is not managed as a resource like land and water and policies on air protection are divided and scattered. For those reasons, it is necessary to develop and improve the legal system on air with legal documents and regulations, including regulations on Clean Air Act for more effective air quality control. Once Clean Air Act is available, individuals, institutions and businesses causing big emissions are subject to penalties or fines and charges to recover good air conditions. With such a system in place, ministries and industries will also be able to have better air quality management plans.

Having said that, it cannot be denied that over the past years, a variety of policies, regulations and guidelines have been promulgated to strengthen emission source management and control and air quality enhancement in Vietnam. Measures have been put in place to improve air quality, especially in Hanoi and HCMC. Nevertheless, challenges remain and stronger, more aggressive measures are needed over the coming years.

Set-up more air quality automatic monitoring station

It can be said that the comprehensive assessment of air quality in Vietnam still faces difficulties due to the lack of data. In order to assess the air quality comprehensively, it must be based on data long enough in time and wide enough in space but we still do not have enough monitoring system, the number of monitoring stations is still not a lot of. For urban areas, some big cities such as Hanoi, Ho Chi Minh City and Da Nang have installed automatic air quality stations. However, the data has not been published widely and it's difficult to access publish historical data and used for scientific analysis and community communication. This is a major obstacle to access to information to promptly provide appropriate prevention solutions.

Therefore, it is necessary to strengthen automatic monitoring stations and ensure continuous operation to have data for information collection and analysis. In addition, the publication of historical data from monitoring stations will help researchers, residents and interested organizations have the opportunity to use them effectively and best support the agency government.

Strict control of sources of air pollution

Currently, studies and data indicate that large urban areas in Vietnam are affected by 06 pollution sources including traffic, construction, industrial production, waste and straw burning from agriculture activities and long-range air pollution. In order to effectively control and manage these pollution sources, more research is needed to assess the level of contribution of each source, determining

what is the main source of pollution for having intervention measures to the appropriate source. In addition, for industries that are at high risk of air pollution such as coal, cement, steel, and chemicals, there should be stricter emission control measures. Economic tools to control emissions need to be promoted more effectively, we do not have emission fees, tax policies and environmental fees are unclear.

Emission management according to the total pollutant load

Currently in the world, for developed countries like Japan, the US and OECD countries: environmental pollution (water, air, soil) is managed according to the total amount of pollutant load. The total amount of pollutant load is understood to be the greatest possibility that a region's environment can withstand without endangering health, without reducing the quality of the environment and without affecting the ecosystem. In Vietnam, environmental pollution is managed by environmental standards, each factory only ensures its emissions without regard to the region's load capacity. As a result, the cumulative impact of factories in a region will pollute the surrounding area, so it should be considered to incorporate a management approach based on the total environmental load, ensuring the environment not degraded.

Promote renewable energy development

Producing energy from burning fossil fuels is a major cause of air pollution and greenhouse gas emissions. Vietnam 's power development plan in the future is still heavily dependent on coal power. It is estimated that by 2030, about 40 new coal-fired thermal power plants will be put into operation and spread throughout the country, potentially posing significant risks to air quality management. According to a community survey in the Vietnam Provincial Governance and Public Administration Performance Report (PAPI) in 2018, coal-fired power plants are probably considered to be the cause of increasing local air pollution, many are not available. willing to pay more for coal-fired power because of the risk of air pollution. In general, people are willing to contribute to better environmental conditions. People also welcome an environmentally friendly investment project, people are willing to pay extra money for electricity to get clean electricity as long as the new generation project helps to reduce air pollution and reduce the possibility of being power outage. Therefore, we recommend the government to consider to have a cleaner power structure, increase the share of renewable energy and reduce the use of fossil fuels.

Reduce emissions from traffic

Encouraging people to use public transport, reducing the number of private vehicles, to do this, it is necessary to take measures to improve the infrastructure and public transport systems in the city. In order to reduce emissions, it is necessary to encourage people to use clean fuels, which may apply incentives or subsidies to encourage the use of clean facilities. Strict control of emissions, raising the standard for emissions of personal vehicles such as cars and motorcycles approaching the international standards. Finally, it is necessary to develop a sustainable transport strategy especially in big cities. In addition, transport has a closely related to people's behavior, reducing emissions by cutting unnecessary needs is always a measure that anyone can do, though much less.

APPLY AIR SENSOR TECHNOLOGY TO SUPPORT AIR QUALITY MONITORING

Air quality monitoring, supervising and data collection largely depend on conventional manual monitoring methods at a frequency of four times every year. Accordingly, field sampling and laboratory analysis are performed. Despite being accurate, the methods demand a great amount of time, human resources, chemicals and other equipment. Another drawback lies in the fact that analysis results are normally available after a certain period of time and real-time air quality information is not achieved due to changing environmental parameters.

Another option is using automatic constant monitoring stations to record data. The advantage is the ability to define constant environmental alteration and changes by time and places, accommodating a quick identification of problems linked to environmental quality and protection. Developed countries often build up a dense network of automatic monitoring systems (especially dedicated to air quality control). Monitoring parameters often consist of temperatures, humidity, CO, SO_2, NO_x (NO and NO_2), particulate matter (PM_{10}, $PM_{2.5}$ and $PM_{1.0}$). Air monitoring stations are scattered in Vietnam with data being unable to comprehensively represent and indicate air quality of a whole region. A financial disadvantage of the monitoring method is the requirement of initial investment costs and high operation and maintenance expenditures. Professional and constant training for human resources presents another challenge. [11]

Using low-cost sensors to monitor air quality is a trend in many countries around the world. In the time when there were still too few automatic monitoring stations and the networks of these stations that were not evenly covered in a whole region, the use of sensors as an effective solution to warn of air quality and information for people. Superior in size, flexibility and price than conventional automatic monitors, new air monitoring equipment is easy to install, automated in operation and maintenance and many countries have developed systems of air monitoring sensor equipment. The new sensors enable the community and individuals to contribute to air quality data using their own equipment, compare and contrast with conventional monitoring stations, create a big room for warnings of air quality and facilitate regional air quality monitoring.

Air monitoring sensor equipment has been available in Vietnam for a few years with popular foreign products like Air Visual and Laser Egg. In the meantime, domestic research units, including the Hanoi University of Science and Technology (HUST), the VNU University of Engineering and Technology (VNU-UET) and private companies have created their own monitoring devices accompanied with mobile apps connected to equipment measuring data. App users can keep track of air quality on their mobile phones or computers connected to a network of data collected from various air monitors in the city.

However, air monitoring sensor equipment is not yet popular in Vietnam due to difficulties in calibrations and accreditation. Despite lower credibility of mobile air sensor monitoring equipment than automatic fixed monitoring stations operated by the State, research points out to a common trend of changes in air quality and hence, air sensor monitoring equipment can be used for tracking air quality trends, build public awareness, and give warnings.

An example of the "Citizen Science Project" in applying community-level household sensors for air quality monitoring

Luftdaten.info is a kind of unique example of citizen science was started in Stuttgart, Germany. Together with scientist and expert they developed a self-built air quality sensor that is very cheap and easy to build at home. On their website you can find the construction manual to build your own device and feed you information to the open source database. They are dedicated to the fine dust measurement with the Citizen Science project luftdaten.info. You and thousands of others around the world install self-built sensors outside their home. Luftdaten.info generates a continuously updated particulate matter map from the transmitted data. Fine dust becomes visible.

WHAT PEOPLE CAN DO?

Air pollution is a complex issue that needs the cooperation of different stakeholders, solving the problem of air pollution is not the responsibility of the government, but the people also have an important role in the effort to accompany efforts. First of all, self-initiative to improve knowledge, update information and apply measures to protect health and reduce air pollution. Below we recommend 6 solutions to minimize health impacts and improve air quality. The first 4 solutions mentioned are solutions to respond to air pollution and the last 2 long-term solutions are to improve air quality.

Air quality monitoring

Constant air quality tracking and monitoring is necessary because it provides people with information about the current status of ambient air in order to come up with appropriate self-protection measures from the impacts of air pollution. Many air monitoring apps are available at the moment including AirVisual, AQICN (Air Quality Index: China) Android App, PAM Air, etc. which provide real-time information of air quality current status and forecast as well as recommendations corresponding to air pollution level.

PM$_{2.5}$ Anti Pollution Masks

Currently, more and more people are choosing masks as a solution to protect health from impacts of air pollution. According to a GreenID survey conducted in 2016, the majority of mask users (79.8%) are still dependent on cloth masks and medical masks. These masks are designed to retain from large dust particles and cannot protect your lungs from fine dust such as PM2.5, as well as scarves. Below are our suggestions to choose a right mask:

01 **Anti pollution masks should meet quality and safety requirements:**
- In reference to standards of the National Institute for Occupational Safety and Health (NIOSH), full examination of the following information indicated on packages is needed: NIOSH, manufacturer, standard type (N95, N99 or N100)
- In reference to standards of European Conformity (CE), full examination of the following information indicated on packages is needed: "CE" Marking, manufacturer, EN149:2001 Certificate and standard type (FFP2, FFP3)

02 **Mask and filtering layer manufacturers always take a sample of each and every product for testing. Therefore, the full information provision of filtering layer testing results by manufacturers will guarantee the quality of masks.**

03 **For people working in a hazardous gas-rich environment, N100 and FFP3 with PM1.0 and unhealthy gases filtering function are recommended.**

Air-filtering plants

Growing trees has always been encouraged to create fresh air. Since 1989, the U.S. National Aeronautics and Space Administration (NASA) discovered a list of common plants that provide a natural way of removing indoor air toxic agents such as benzene, formaldehyde, trichloroethylene, xylene, and ammonia. [1]

- Variegated snake plant (Sansevieria trifasciata): Releasing oxygen during the night, removing formaldehyde, trichloroethylene, benzene, and xylene.
- Cedar: Supplying moisture, removing dust, relieving headache.
- Peace lily (Spathiphyllum): Removing benzene, formaldehyde, xylene, tolune, and trichloroethylene.
- Fern (Nephrolepis exaltata): Removing hazardous metals (mercury, arsenic) and pollutants like formaldehyde and xylene.
- Spider plant: Removing benzene, formaldehyde, CO, and xylene from indoor air.
- English ivy (Hedera helix): Growing well in shady locations, removing 58% of fungi and mold, 60% of toxic agents in the air within six hours. It can also filter out volatile organic compounds (VOCs) such as benzene, xylene, formaldehyde, and trichloroethylene.

Em ơi anh hỏi câu này
Khói bụi ô nhiễm ngày ngày vây quanh
Em ơi hãy nói cùng anh
Trồng cây chi để thêm xanh trong nhà?
Anh hỏi thì em thưa nha
Dương xỉ, lưỡi hổ, trầu bà, nha đam
Anh ơi còn một bộ tam
Đồng tiền dừa cảnh phong lan nữa nè.

Cập nhật chất lượng không khí bằng cách quét mã QR tại đây

- Pothos plant (Epipremnum aureum): Removing formaldehyde, absorbing radiation from computers, TV, printers, etc.
- Aloe vera: Indicating air pollution when the leaves start to exhibit brown spots.
- Chinese evergreen (Aglaonema modestum): Growing easily, native to shady habitat, removing benzene and formaldehyde.
- Bamboo palm (Chamaedorea seifrizii): Removing xylene and formaldehyde.
- Weeping fig (Ficus benjamina): Light sensitive, removing various toxic agents in the air like Formaldehyde and xylene.

Indoor air purifiers

There is a big understanding about the air quality indoors is normally better than outdoors, but in reality that is not the case. Air pollution indoors can be more serious than outdoors. The Data in 2016 of WHO shows that air pollution indoors caused 32,730 cases of death in Viet Nam (4,747 cases of respiratory infection, 5,579 cases of lung cancer, 7,618 cases of ischemic heart, 9,125 cases of stroke, and 5661 cases of Chronic obstructive pulmonary disease). However, air pollution indoors is rarely being noticed and has few signs, because people who live in such environments cannot see the danger they are in. Sources of air pollution indoors are normally from: the air outside, cooking activities, bleaches, bacteria, fungi, pollen,…

One of the most effective ways to maintain a high quality of air indoors is to use an air filter. How to choose a good air filter?

Below are factors for consideration for the selection of household air purifiers:
• Applicable area;
• Main using purpose(s) (Mainly for dust or odor removal);
• Filter membrane quality;
• Prices and the possibility of filter membrane replacement after one year of use;
• Warranty, maintenance and after-sale support of the distributor;

Air purifier using and maintenance guide:
• Air purifier maintenance is simple, mostly involving the removal of dust on filter membranes with a dry cloth or a vacuum cleaner. Cleaning the membranes with wet cloth or washing them (except for coarse plastic and metal filters) is strongly prohibited.
• Filter replacement is recommended every six months or one year at maximum. Failure to replace filters over a long period of time should gradually affect device's efficiency.
• Most next-generation air conditioners are equipped with filters for air quality enhancement to some extent. Air conditioner fans also facilitate indoor circulation airflow. This means air conditioners can enhance air filtering.

Ba khen mẹ chăm nhà sạch quá
Bởi có cây xanh lá
Với cả máy lọc khí nữa ha
…
Để bụi bặm đường xa,
phía sau cánh cửa nhà

Máy lọc không khí

Cập nhật chất lượng không khí bằng cách quét mã QR tại đây

GreenID   VIETNAM CLEAN AIR DAY

Air purifier buying guide

Brand name should come first: It is advisable to buy products certified by prestigious organizations, including the U.S. Food and Drug Administration FDA, European Conformity (CE), Vietnam Ministry of Health, Directorate for Standards, Metrology and Quality (STAMEQ), etc.
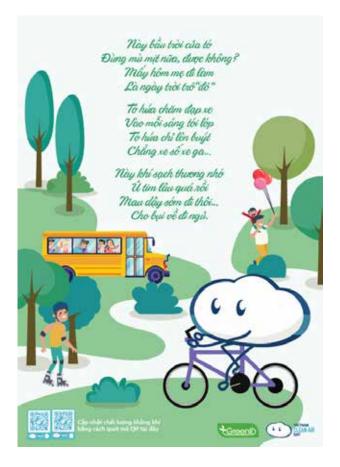
The second step is to examine equipment capacity: Each model of air purifier comes with particular capacity for certain applicable area. The most common applicable area for air purifiers now ranges between 20 to 60 square meters and people should choose suitable air purifiers for the applicable area.
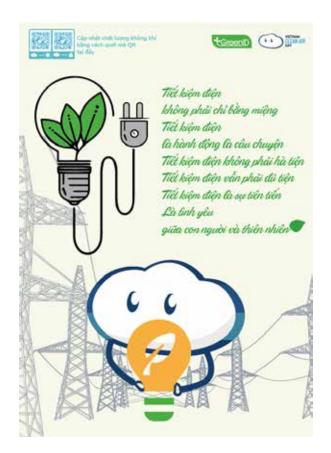
Bedroom use fits models of working capacity applied for an area of **20m²-30m²** such as **Panasonic F-PXF35A, Panasonic F-PXJ30A, Sharp F30E Sharp F40E, Hitachi A3000, and Hitachi A5000**. For living rooms, it is advised to buy air purifiers for areas of **30m²-50m²** with models of higher capacity like **Coway air purifiers, Panasonic F-PXL45A, Panasonic F-PXM55A, Hitachi A6000, Hitachi A7000, Sharp G-50E, and Sharp GM-50E**. For more than 502, air purifier models of higher capacity like Sharp FU-80EV, Hitachi A8000 and Hitachi A9000 are suitable.

Third, select device functions: Air purifiers will have additional functions like heating mode, humidifying, odor, bacteria removal and mosquito catcher, etc. which should also be taken into consideration before purchase.

Public transportation

Abatement of air pollutant emissions from vehicles can be realized via the use of public transport. During unclean days, using public transport is able to partially mitigate the impacts of air pollution in comparison with traveling by motorbikes.

Renewable energy and energy efficiency

Energy is one of the biggest contributors to air pollution due to the dominance of power generation from fossil fuels. Execution of energy conservation and efficiency like turning off unused lights and preferring energy-efficient appliances also contributes to air quality enhancement. Investment in renewable energy (RE) like rooftop PV systems will reduce the dependence on sources of fossil fuels, improve air quality and mitigate greenhouse gases (GHG).

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ANNEX

ANNEX I: INFORMATION OF AIR QUALITY MONITORING STATIONS IN HANOI

No.	Stations/locations	Management unit/ agency	Type of station	Numbers	Time of deployment
1	U.S Embassy - 7 Lang Ha	U.S embassy	A basic monitoring station	$PM_{2.5}$	12/2015
2	556 Nguyen Van Cu, Long Bien, Hanoi	Northern Centre for Environmental Monitoring (NCEM)	A basic monitoring station	$PM_{2.5}$, SO_2, NO_2, PM_{10}, CO	6/2009
3	Kim Lien kindergarten	Hanoi EPA	Sensor station	PM_{10}, $PM_{2.5}$, NO_2/NO/NO_x, CO, SO_2 và O_3	1/2017
4	My Dinh (People's Committee of My Dinh 1 ward)	Hanoi EPA	Sensor station	PM_{10}, $PM_{2.5}$, NO_2/NO/NO_x, CO, SO_2 và O_3	1/2017
5	Hang Dau (Police Station of Hang Ma ward)	Hanoi EPA	Sensor station	PM_{10}, $PM_{2.5}$, NO_2/NO/NO_x, CO, SO_2 và O_3	1/2017
6	Hoan Kiem (Police Station of Hoan Kiem district)	Hanoi EPA	Sensor station	PM_{10}, $PM_{2.5}$, NO_2/NO/NO_x, CO, SO_2 và O_3	1/2017
7	Thanh Cong (Thanh Cong lake)	Hanoi EPA	Sensor station	PM_{10}, $PM_{2.5}$, NO_2/NO/NO_x, CO, SO_2 và O_3	1/2017
8	36A Pham Van Dong	Hanoi EPA	Sensor station	PM_{10}, $PM_{2.5}$, NO_2/NO/NO_x, CO, SO_2 và O_3	1/2017
9	People's Committee of Minh Khai ward - Bac Tu Liem district	Hanoi EPA	Basic monitoring station	PM_{10}, $PM_{2.5}$, NO_2/NO/NO_x, CO, SO_2 và O_3	1/2017

10	People's Committee of Tay Mo ward	Hanoi EPA	Sensor station	PM_{10}, $PM_{2.5}$, NO_2/NO/NO_x, CO, SO_2 và O_3	1/2017
11	Hanoi EPA's office	Hanoi EPA	Basic monitoring station	PM_{10}, $PM_{2.5}$, NO_2/NO/NO_x, CO, SO_2 và O_3	1/2017
12	People' s Committee of Hoang Van Thu ward	Hanoi EPA	Sensor station	PM_{10}, $PM_{2.5}$, NO_2/NO/NO_x, CO, SO_2 và O_3	1/2017

*NOTE:

A basic monitoring station is stations which uses standard methods with high accuracy.

A sensor station uses small and convenient measure head with low cost.

ANNEX II: INFORMATION ABOUT THE STATIONS OF PURITRAK COMPANY WHICH IS USED IN THE REPORT

1. TECHNICAL SPECIFICATIONS

Air monitoring equipment technology

- Measuring criteria: Temperature, humidity, $PM_{1.0}$, $PM_{2.5}$ and PM_{10} concentrations
- Data transmission technology: GSM
- Data storage technology: Google Cloud server
- (Imported) air monitoring sensors: Using optical technology, 100% accredited and certified using the conventional air monitoring equipment of Metone BAM 102 which is the sheer equipment of its kind to be acknowledged and used for environmental monitoring by the U.S. Environmental Protection Agency (EPA).
- Data transmission frequency: 15 minutes
- Electrical power: 12v 90w 2.2.

Installation requirements

- Air monitoring stations are to be installed at level of no more than 50 meters above the ground;
- More than 20 meters away from major transportation systems (comprising major, dense streets);
- Equipment attachment points have open space. Shelters are allowed but the equipment should have direct contact with outdoor air and be free of walling;
- Air monitoring stations can be located in residential areas but be far away from emission sources like chimneys, AC/heating systems, smoke-generating areas (from cigarette and paper burning, etc.). Maintenance is performed every three months.
- Sensors equipped in air monitoring equipment have a lifespan of 24 months.

Display and data conversion

- Data sheets provide PM2.5 AQI which is computed according to the U.S. EPA formula which is recognized and used by the World Health Organization (WHO).
- Data collected are planned to be available online in real time.
- Stations used in this Report meet the following data requirements:
  "Calendar Availability" for 2018 >50%
  "Average Daily Availability"> 41% (equivalent to >10h of readings within 24h) per day that data is available. "Calendar Availability" indicates the percentage of days of the year which have at least one hour's measurement from at least one station. "Average Daily Availability" indicates the mean proportion of 24h for which those calendar days have hourly readings (from at least 1 station).

Station name	Ba Dinh	Bac Tu Liem	Cau Giay	Dong Da	Hai Ba Trung	Long Bien	Nam Tu Liem	District 1	District 5	District 7
Installation location	Lieu Giai, Ba Dinh, Hanoi	Tan Xuan, Bac Tu Liem, Hanoi	Yen Hoa, Cau Giay, Hanoi	Thai Thinh, Dong Da, Hanoi	Thanh Luong, Hai Ba Trung, Hanoi	Vinhome Riverside, Long Bien, Hanoi	Pham Hung, Nam Tu Liem, Hanoi	Tran Khac Chan, Tan Dinh, District 1, HCMC	An Diem Street, Ward 10, District 5, HCMC	Nguyen Van Quy, District 7, HCMC
Positioning	105.811432, 21.031864	21.086355, 105.782312	105.790672, 21.023933	105.839569, 21.014631	105.870514, 21.007608	105.916901; 21.047729	105.7836; 21.007629	106.690926; 10.79363	106.66571; 10.75049	106.730476; 10.738107
Time of implementation	5/2018	5/2018	5/2018	5/2018	5/2018	5/2018	2/2018	6/2018	6/2018	2/2018