# GreenID

## Air Quality in Viet Nam - First Half of 2016

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# 1. Introduction

Air pollution is a very important environmental and social issue and, at the same time, it is a complex problem posing multiple challenges in terms of management and mitigation. Air pollutants are emitted from anthropogenic and natural sources; they may be either emitted directly or formed in the atmosphere; they have a number of impacts on health, ecosystems, the built environment and climate; they may be transported or formed over long distances; and they may affect large areas. Air pollution poses one of the single largest environmental health risk in Vietnam today. Some air pollutants persist in the environment for long periods of time. They may accumulate in the environment as well as in the food chain, affecting humans and animals not only via air intake, but also via water and food intake. Effective action to reduce impacts of air pollution effective actions need to be implemented. Therefore a good understanding of its causes, how pollutants are transported and transformed in the atmosphere, and how they impact on humans, ecosystems and the climate need to be estimated and translated into an effective planning.

The current report presents an overview and analysis of air quality in the two biggest cities in Vietnam (Hanoi and Ho Chi Minh City) and focus on the latest year with available and processed data, namely 2016. It compares the status quo with Vietnam's national requirement; it's equivalent to WHO as well as to the U.S. Air Quality Index (AQI). It also gives an overview of the effects of air pollution on human health and on ecosystems. Due to data restrictions this first half year report is just able to cover the status of air quality in Hanoi and Ho Chi Minh City and is limited to particular matter concentration.

Photo: Air Pollution | World Bank Photo Collection /cc by 2.0

The present analysis indicates that air quality policies need to be improved and violations need to be monitored and punished with the full vigour of law in order to reduce emissions and improve air quality in Vietnam. Thus, substantial challenges remain and considerable impacts on human health and environment persist. A large proportion of Vietnamese population and ecosystems are still exposed to air pollution in exceedance of Vietnamese standards.

Effective air quality policies require action and cooperation on global, regional, national and inter-provincial levels which must reach across most economic sectors and engage the public. Holistic solutions must be found and involve technological development, structural changes including the optimization of infrastructures and urban planning as well as behavioural changes. These will be necessary to achieve protection of the natural capital and to support economic prosperity, human well-being and social development.



# 2. Viet Nam's air quality today

## 2.1. Data Availability

The Ministry of Natural Resources and Environment (MONRE) measures the main pollutant in three cities by having one stationary system for each city. The data are available online and accessible for public. So far, MONRE does not provide a history of hourly measured data. Therefore this data were not usable for this report. The U.S. Embassy in Hanoi (since end of 2015) and U.S. Consulate in Ho Chi Minh City (since beginning of 2016) are measuring the PM 2.5 concentration on an hourly bases and provide public access to the historical data under its Air Now program. Besides, some institutions such as United Nations International School of Hanoi share their measurement results with public mainly focusing on PM 2.5 concentrations. A limited amount of private initiatives give online access to their hourly data. Thus, an analysis of air quality is not available for the entire country. However, by covering Hanoi and Ho Chi Minh City the available data and the analysis is still relevant for almost 16 Million inhabitants equal to around 18% of Vietnam's population. GreenID together with its partners form the Vietnam Sustainable Energy Alliance (VSEA) is working on a wider coverage in the country to provide a comprehensive picture of Vietnam's air quality for the future.

Furthermore the data availability for Ozone (O3), Nitrogen dioxide (NO2), Benzo[a]pyrene (BaP) and other pollutants such as Sulphur dioxide, carbon monoxide, toxic metals and benzene is not given yet. The historical track record for the first half of 2016 for each of this pollutant is measured by MONRE but is not accessible to the public so far. Therefore this first report focusses on particulate matter and just gives an overview about the concentration of the pollutions in Vietnam. As a result, the report focusses Hanoi and Ho Chi Minh City, using data from Air Now Program of the U.S. Department of State to ensure comparability.

As mentioned in Paragraph 4.2 in the National Technical Regulation on Ambient Air Quality (QCVN 05/2013 / BTNMT) the political responsibility is with the Environmental Management State Agency. This agency is responsible for guiding, checking and monitoring the work in order to carry out this standard.

## 2.2. Particulate matter

Particulate matter (PM) is both directly emitted to the atmosphere (primary PM) and formed in the atmosphere (secondary PM). The chief precursor gases for secondary PM are SO2, NOx (a family of gases that include nitrogen monoxide (NO) and NO2), NH3 and volatile organic compounds (VOCs; a class of chemical compounds whose molecules contain carbon). The main precursor gases NH3, SO2 and NOx react in the atmosphere to form ammonium, sulphate and nitrate compounds. These compounds form new particles in the air or condense onto pre-existing ones and form so-called secondary inorganic aerosols. Certain VOCs are oxidised to form less volatile compounds, which form secondary organic aerosols (EU, 2015).

Solid or liquid particles from unburnt matter are always emitted from combustion processes. The emission of such particles have been defined and measured in various ways. Generally, suspended particulate matter (SPM) refers to particles of all sizes in the air. SPM is a complex mixture of organic substances present in the atmosphere, both as solid particles and liquid droplets. They include

fumes, smoke, dust and aerosols. Health impacts of PM vary depending on size and concentration of particles. For regulatory purposes and for estimating health impacts PM is measured and classified by what is called the respiratory fraction of particles:

- PM10 refers to particles with a diameter of less than 10 microns. These are commonly called coarse particles - they contain dust from roads and industries as well as particles formed under combustion. Depending on their size coarse particles can lodge in the trachea (upper throat) or in the bronchi.
- PM2.5 refers to particles with a diameter of less than 2.5 microns. These are usually called fine particles and contain secondary aerosols, combustion particles, recondensed organic metallic vapour and acid components. Fine particles can reach all the way down to the alveoli in the lungs.
- PM0.1 refers to particles with a diameter of less than 0.1 microns and are called ultra-fine particles. Ultra-fine particles - still in the early stages of research - are usually exhaled but can penetrate into the bloodstream.

Visible smoke comprises particles of PM10 size or larger. The particles with greatest health effects are those within the "respirable range" which is between PM10 and PM0.1. The respirable range contains particles that can penetrate deep into the lungs and deposit there; particles smaller than PM0.1 are usually exhaled. Fine and ultra-fine particles (PM2.5 and PM0.1) are not visible to the eye (2.5 microns is approximately 1/30 the size of a human hair) (UNEP. 2016).

The National Technical Regulation on Ambient Air Quality (Gov. Vietnam, 2013) sets limit values for both short-term (24 hours) and long-term (annual) PM10 and PM2.5 concentrations.

Compared to international standards such as the EU Air Quality Directives (EU, 2004; EU, 2008) or air quality guidelines set by WHO (AQGs), Vietnam's air quality standards for PM (Table 1) are quite low. Regarding PM10, the WHO and EU standards are three times lower than the ones in Vietnam. However, the recommended WHO AQGs should be considered as an acceptable and achievable objective to minimise health effects.

Besides the mentioned regulations in Table 1, the U.S. Environmental Protection Agency has established an index based on the main pollutants. The Air Quality Index (AQI) is an index for reporting daily air quality established by U.S. Environmental Protection Agency. AQI gives an easy to understand indication how clean or unhealthy the air on special locations is and which associated health effects might be a concern. The AQI focuses on health effects that public experience within few hours or days after breathing unhealthy air. The AQI is calculated for four major air pollutants regulated by the U.S. Clean Air Act:

- ground level ozone
- particle pollution
- carbon monoxide
- sulfur dioxide

The purpose of AQI is to raise awareness and give people the opportunity to understand what local air quality means to their health. To make it easier to read and understand the AQI is divided into six levels of health concerns (Table 2) (EPA, 2014).

### 2.2.1 Particulate matter in Hanoi

The Vietnamese daily limit (50 µg/m3) and target values for particulate matter (PM) with a diameter of 2.5 µm or less (PM2.5) continued to be exceeded on 72 days in the first half of 2016 in Hanoi. The stricter WHO AQG daily limit value for PM2.5 was exceeded on 158 days (Table 3). On hourly bases the limits were exceeded for 1,658 hours following Vietnam's standard value and 3,665 hours regarding WHO AQG.

**Table 1: Air quality limit and target values for PM10 and PM2.5 as given in the National Technical Regulation on Ambient Air Quality in Vietnam, EU Ambient Air Quality Directive and WHO AQGs**

| Size fraction // Averaging period | Vietnam | EU | WHO |
|---|---|---|---|
| **PM10 // 1 day** | 150 µg/m$^3$ | 50 µg/m$^3$ | 50 µg/m$^3$ (a) |
| **PM10 // Calendar year** | 50 µg/m$^3$ | 40 µg/m$^3$ | 20 µg/m$^3$ |
| **PM2.5 // 1 day** | 50 µg/m$^3$ | n/a | 25 µg/m$^3$ (a) |
| **PM2.5 // Calendar year** | 25 µg/m$^3$ | 25 µg/m$^3$ | 10 µg/m$^3$ |

The midpoint 24-hour average concentration of PM2.5 peaked for two hours (4 am and 5 am) on 21st January 2016 with values of 155.4 µg/m3 and AQI of 206 equalling the very unhealthy level (Table 4). Over the first six months a steady decrease of monthly peak values with an exception in June can be seen.

The hours excessing Vietnamese reference concentration in Hanoi are concentrated in the first quarter of 2016. There are nine incidents with average concentration of PM2.5 three times higher (150 µg/m3 or above) than the national reference (50 µg/m3). In 318 cases the concentration of PM2.5 was at least two times higher than the

**Table 2: Six levels of health concerns based on U.S. AQI**

| AQI | Air Pollution Level | Health Implications | Cautionary Statement (for PM2.5) |
|---|---|---|---|
| **0 - 50** | Good | Air quality is considered satisfactory, and air pollution poses little or no risk | None |
| **51 -100** | Moderate | Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution. | Active children and adults, and people with respiratory disease, such as asthma, should limit prolonged outdoor exertion. |
| **101-150** | Unhealthy for Sensitive Groups | Members of sensitive groups may experience health effects. The general public is not likely to be affected. | Active children and adults, and people with respiratory disease, such as asthma, should limit prolonged outdoor exertion. |
| **151-200** | Unhealthy | Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects | Active children and adults, and people with respiratory disease, such as asthma, should avoid prolonged outdoor exertion; everyone else, especially children, should limit prolonged outdoor exertion |
| **201-300** | Very Unhealthy | Health warnings of emergency conditions. The entire population is more likely to be affected. | Active children and adults, and people with respiratory disease, such as asthma, should avoid all outdoor exertion; everyone else, especially children, should limit outdoor exertion. |
| **300+** | Hazardous | Health alert: everyone may experience more serious health effects | Everyone should avoid all outdoor exertion |

**Table 3: Percentage of days that urban population in Hanoi exposed to air pollutant concentrations above certain Vietnamese and WHO reference concentrations (first half of 2016)**

| Pollutant in µg/m3 | Vietnam reference value | Number of incidents limit exceeded | WHO AQG | Number of incidents limit exceeded |
|---|---|---|---|---|
| **PM2.5** | 24-hour (50) | 72 (40%) | 24-hour (25) | 158 (87%) |
| **M10** | 24-hour (150) | n.a. | 24-hour (50) | n.a. |
| **O3** | 8-hour (120) | n.a. | 8-hour (100) | n.a. |
| **NO2** | 1-Year (40) | n.a. | 1-Year (40) | n.a. |
| **SO2** | 1-hour (350) | n.a. | 24-hour (20) | n.a. |

< 25% | 25–75% | > 75%

**Notes:** **The data for all pollutions are not public available on a historical level)**

The reference concentrations include Vietnam's limit or target levels, WHO air quality guidelines (AQG) and estimated reference levels. The reference concentrations in brackets are in µg/m³.

national reference (Figure 1). Since May 2016 the PM2.5 concentration is mainly below national reference which somehow underlines the trend of improving air quality in the second quarter of 2016. Comparing PM2.5 concentration with stricter WHO AQR reference, the concentration was 2,384 hours at least two times higher than WHO standards.

The Air Quality Index AQI is splited in six levels of health concerns (Table 2). Nine days in the first half of 2016 does not provide sufficient data. Thus, the amount of relevant days in the first half of 2016 is reduced to 173 days. None of the remaining days is located in the very unhealthy level; however, 8 hours in January reached this level. More than 100 days or 58% of the days in the first half of 2016 are within the unhealthy section (including levels of unhealthy and unhealthy for sensitive group). Thus, the healthy section (including the level of moderate and healthy) was reached on 72 days or 42% of days. Days within the unhealthy section just appeared in the first quarter 2016. The air quality in the second quarter improved significant (Table 5).

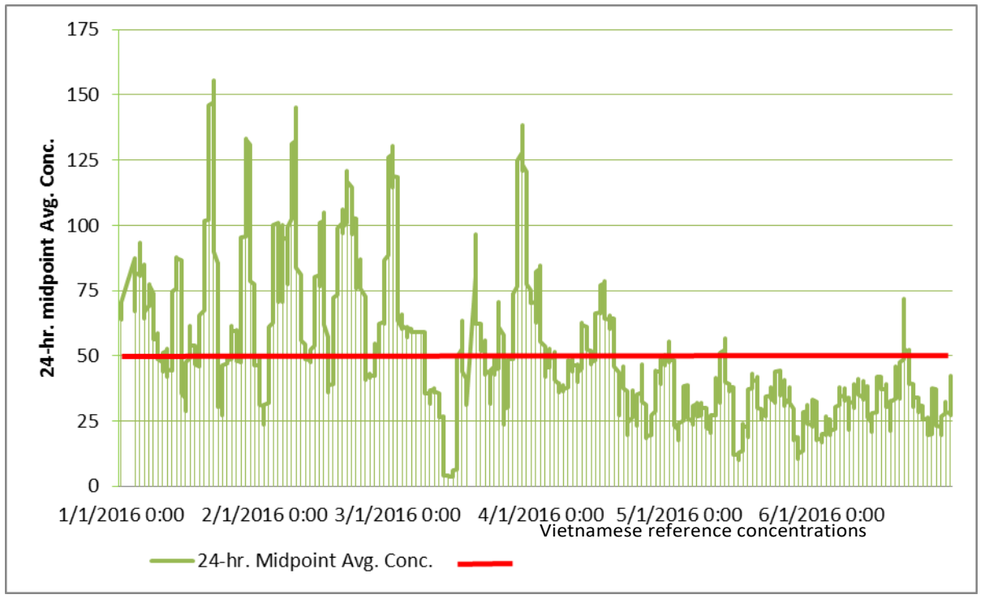
With a low in February with less than 5% of moderate or healthy hours, the air quality is steadily increasing over the month. 50% of the hours in the first four month are within the rage of Unhealthy and very unhealthy. However, since May this segment stands for less than 30% of all hours. Healthy hours remain on a low level during the entire month with a peak of nearly 10% of

**Table 4: Overview of peaking air quality in first half of 2016 in Hanoi**

| Category | Jan | Feb | March | April | May | June |
|---|---|---|---|---|---|---|
| **Peak AQI** | 206 | 197 | 194 | 166 | 152 | 160 |
| **Peak PM 2.5** | 155 | 145 | 138 | 84 | 57 | 72 |
| **Peak day** | 21.01. | 08.02 | 28.03 | 01.04 | 11.05 | 19.06 |



**Figure 1: Hourly midpoint 24-hour average concentration of PM2.5 in the first half of 2016 in Hanoi in comparison with Vietnamese reference concentrations**




hours in March. The moderate level was below 10% for the first two month, increased above 10% for March and April and stands for more than 60% of hours in May and June.

In summary, it can be stated that the air quality in Hanoi in the first quarter of the year can be considered as not healthy. Air quality increased on moderate level within the second quarter. However, the average level of health concerns based on AQI was only reached in May and June on a moderate level. In the first four month of the year, the air quality was unhealthy for sensitive groups or even un.healthy in February Compared

**Table 5: Categorised daily average AQI for the first half of 2016 in Hanoi**

| Average AQI level per day | First half 2016 | Jan | Feb | March | April | May | June |
|---|---|---|---|---|---|---|---|
| **Healthy** | **9** | 0 | 0 | 2 | 6 | 1 | 0 |
| **Moderate** | **63** | 2 | 1 | 5 | 18 | 20 | 17 |
| **Unhealty for sensitive group** | **58** | 14 | 9 | 8 | 6 | 10 | 11 |
| **Unhealthy** | **43** | 11 | 19 | 13 | 0 | 0 | 0 |
| **Very unhealthy** | **0** | 0 | 0 | 0 | 0 | 0 | 0 |
| **No sufficient data** | **9** | 4 | 0 | 3 | 0 | 0 | 2 |

**Figure 2: Categorised hourly average AQI in the first half of 2016 in Hanoi**

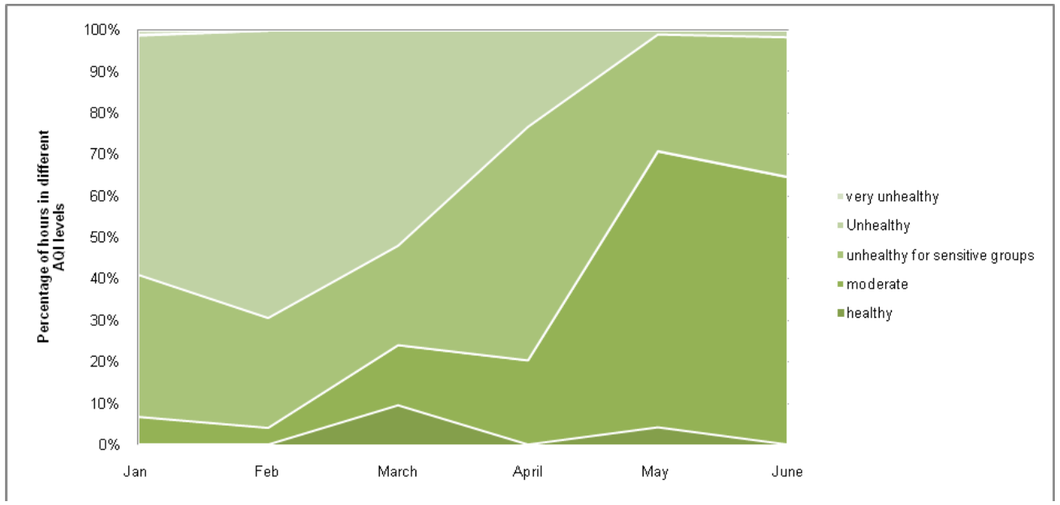



**Table 6: Summary of air quality categories for the first half of 2016 in Hanoi**

| Category | Jan | Feb | March | April | May | June |
|---|---|---|---|---|---|---|
| **Average AQI** | 149 | 155 | 128 | 123 | 89 | 94 |
| **Average AQI Level** | Unhealthy Sensitive group | Unhealthy | Unhealthy Sensitive group | Unhealthy Sensitive group | Moderate | Moderate |
| **Average PM 2.5** | 68 | 77 | 54 | 47 | 30 | 32 |
| **Days violating national regulation** | 19 | 23 | 16 | 09 | 0 | 0 |
| **Days of violating WHO regulation** | 25 | 29 | 24 | 28 | 23 | 23 |
| **No sufficent data** | 4 | 0 | 3- | 0 | 0 | 2 |

< 25% | 25–75% | > 75%

**Table 7: Percentage of days urban population in HCMC exposed to air pollutant concentrations above certain Vietnam and WHO reference concentrations (first half of 2016)**

| Pollutant in µg/m3 | Vietnam reference value | Number of incidents limit exceeded | WHO AQG | Number of incidents limit exceeded |
|---|---|---|---|---|
| **PM2.5** | 24-hour (50) | 5 (2%) | 24-hour (25) | 70 (29%) |
| **PM10** | 24-hour (150) | n.a. | 24-hour (50) | n.a. |
| **O3** | 8-hour (120) | n.a. | 8-hour (100) | n.a. |
| **NO2** | 1-Year (40) | n.a. | 1-Year (40) | n.a. |
| **SO2** | 1-hour (350) | n.a. | 24-hour (20) | n.a. |

< 25% | 25–75% | > 75%

**Notes:** **The data for all pollutions are not public available on a historical level**

The reference concentrations include Vietnam limit or target levels, WHO air quality guidelines (AQG) and estimated reference levels.
The reference concentrations in brackets are in µg/m³.

with WHO standards the picture is even worth. The WHO AQR reference was violated in each month for more than 75% of days.

### 2.2.2 Particulate matter in Ho Chi Minh City

The Vietnamese daily limit (50 µg/m3) and target values for particulate matter (PM) with a diameter of 2.5 µm or less (PM2.5) continued to be exceeded on 5 days in the first half of 2016 in Ho Chi Minh City which is equal to less than 2% of days in the first half of 2016. The stricter WHO AQG daily limit value for PM2.5 was exceeded on 70 days equal with 29% of days in 2016 (Table 7).

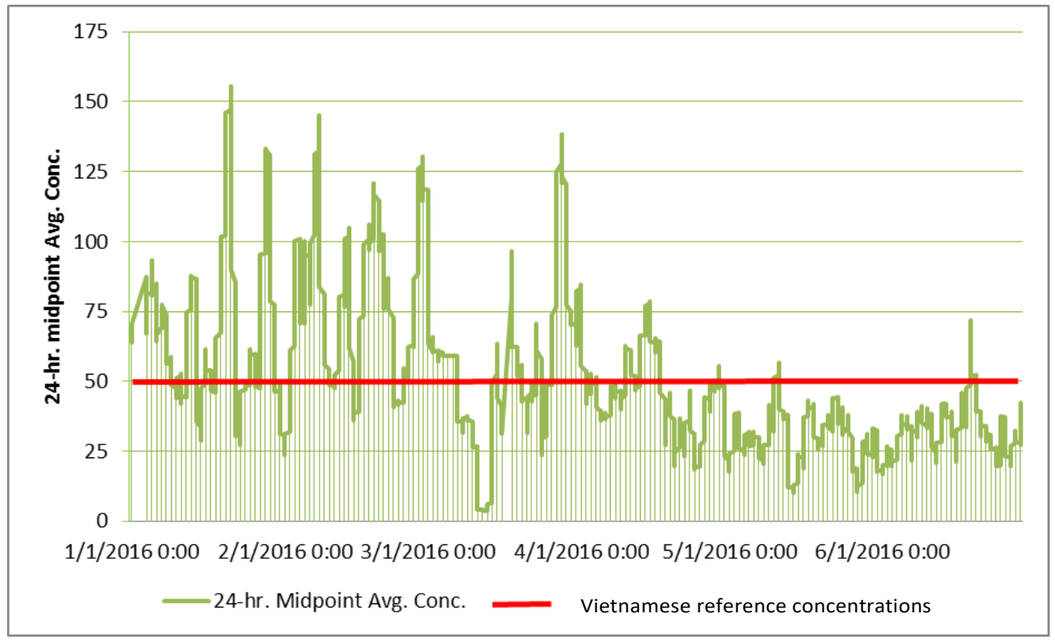
The midpoint 24-hour average concentration of PM2.5 peaked for two hours (6 pm and 7 pm) on 24.June 2016 with values of 65.7µg/m3 and AQI of 156 equalling the very unhealthy level (Table 8). Over the first six month monthly peaks in AQI around 150 points can be seen excepting April with an AQI of only 113 points.

The hours excessing Vietnamese reference concentration in HCMC are concentrated in the second quarter of 2016. However, such incidents don't happen on a regular basis or for long periods and are equal to 122 hours. The PM2.5 concentration in the entire first half of 2016 is mainly below national reference. Comparing that PM2.5 concentration with stricter WHO AQR reference, the concentration in 1, hours is higher than WHO standards.

**Table 8: Overview about peaking air quality in the first half of 2016 in HCMC**

| Category | Jan | Feb | March | April | May | June |
|---|---|---|---|---|---|---|
| **Peak AQI** | n/a | 152 | 150 | 113 | 154 | 156 |
| **Peak PM2.5** | n/a | 56.8 | 55.3 | 40 | 60.4 | 65.7 |
| **Peak day** | n/a. | 09.02 | 29.03 | 15.04 | 19.05 | 24.06 |

**Figure 3: Hourly midpoint 24-hour average concentration of PM2.5 in the first half of 2016 in HCMC in comparison with Vietnamese reference concentrations**



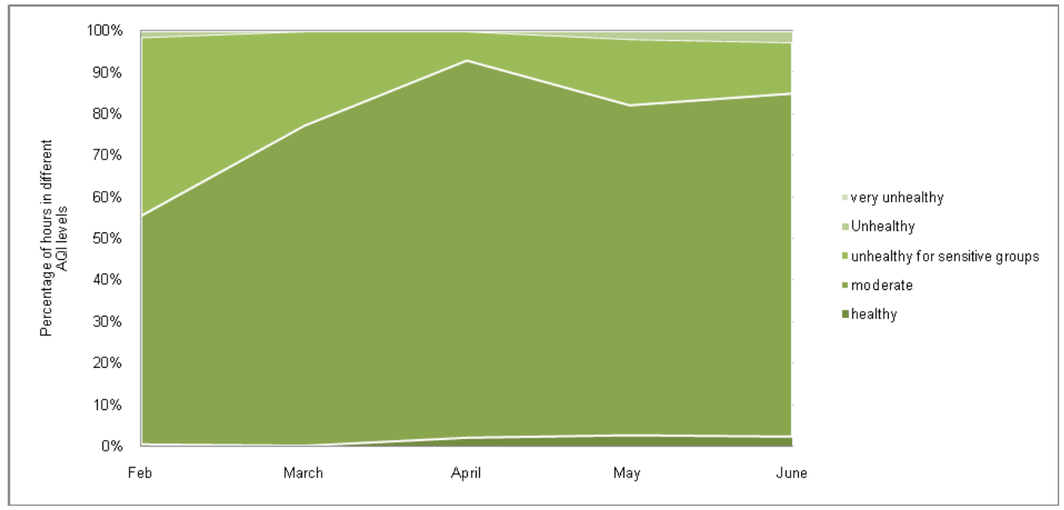

The Air Quality Index AQI is splited in six levels of health concerns (Table 2). The measurement in HCMC started in February and eleven days in the first half of 2016 (February to June) does not provide sufficient data. Thus, the amount of relevant days in the first half of 2016 is reduced to 142 days. None of the remaining days is located in the very unhealthy level. Only 24 days or 11% of days in the first half of 2016 are within the he unhealthy section (including levels of unhealthy and unhealthy for sensitive

**Table 9: Categorised daily average AQI in the first half of 2016 in HCMC**

| Average AQI level per day | First half 2016 | Jan | Feb | March | April | May | June |
|---|---|---|---|---|---|---|---|
| **Healthy** | **9** | n/a | 0 | 0 | 0 | 0 | 0 |
| **Moderate** | **63** | n/a | 18 | 31 | 28 | 26 | 23 |
| **Unhealthy for sensitive group** | **58** | n/a | 6 | 0 | 2 | 4 | 3 |
| **Unhealthy** | **43** | n/a | 0 | 0 | 0 | 0 | 0 |
| **Very unhealthy** | **0** | n/a | 0 | 0 | 0 | 0 | 0 |
| **No sufficent data** | 11 | n/a | 5 | 0 | 0 | 0 | 4 |



**Figure 4: Categorised hourly average AQI in the first half of 2016 in HCMC**




group). Thus, the healthy section (including the level of moderate and healthy) was reached on 127 days or 89% of days. All 127 days are counted as moderate whereas none of the days can be marked as a healthy day. The air quality in HCMC can be stated as quite stable in the first half of 2016 (Table 9).

**Table 10: Summary of air quality categories in the first half of 2016 in HCMC**

| Category | Jan | Feb | March | April | May | June |
|---|---|---|---|---|---|---|
| **Average AQI** | n/a | 95 | 89 | 73 | 77 | 81 |
| **Average AQI Level** | n/a | Moderate | Moderate | Moderate | Moderate | Moderate |
| **Average PM2.5** | n/a | 77 | 54 | 47 | 30 | 32 |
| **Days violating national regulation** | n/a | 02 | 01 | 0 | 01 | 01 |
| **Days of violating WHO regulation** | n/a | 22 | 18 | 08 | 08 | 14 |
| **No sufficent data** | n/a | 5 | 0 | 0 | 0 | 4 |

< 25% | 25–75% | > 75%


Photo: Greenpeace

Both unhealthy and healthy hours are underrepresented in HCMC. None of the two segment are representative for more than 3% of hours in each month. 75% of the hours in the first half of 2016 are within the moderate segment. As a counterpart, nearly 20% of the hours in the first half of 2016 are within unhealthy for sensitive groups segment.

To sum it up, air quality in HCMC was stable in a moderate level and much better in comparison to Hanoi.



# 3. Sources of air pollution

The main air pollution problem in both developed and rapidly industrialising countries has usually been high levels of smoke, emitted sulphur dioxide and combustion of sulphur-containing fossil fuels such as coal used for domestic and industrial purposes. Thus, emissions of PM2.5 and Benzo[a] pyrene (BaP) from coal and biomass combustion in households remain already on a high level and commercial and institutional buildings are still increasing. Furthermore, traffic emissions are a major threat to clean air. Petrol and diesel powered motor vehicles emit a wide variety of pollutants, mainly carbon monoxide (CO), oxides of nitrogen (NOx), volatile organic compounds (VOCs) and particulate matter (PM10) which have an increasing impact on urban air quality. In addition, pollutants from these sources may not only prove a problem in immediate vicinity of these sources but can also be transported over long distances.

Photochemical reactions caused by action of sunlight on nitrogen dioxide (NO2) and VOCs usually emitted from road vehicles, lead to the formation of ozone. Ozone is a secondary pollutant which often impacts rural areas far from the original emission site as a result of long-range transport (DERAF, 2013).

In Vietnam, transport, industry, power plants, agriculture, households and waste management all contribute to air pollution. With the economic transition in the last decade emissions of the main air pollutants in Vietnam have increased since 1989 resulting in worse air quality across the region.

Vietnam's air quality is projected to worsen by increasing individual transport, building activities and economic growth while poor enforcement of air quality control measurements and low environmental standards. Coal-fired power plants will become one of the major source of air pollution in the future caused by massive extension on fossil fuel-based generation capacity as defined in revised Power Development Plan 7 (revised PDP7) (MOIT, 2016). Increasing pollution control, a full implementation of existing legislation and a revision of existing legislation have to be the first steps in improving air quality. Further efforts to reduce emissions of air pollutants are necessary to assure full compliance with current Vietnamese air quality standards set to protect human health and environment. In a second step, existing air quality standards in Vietnam need to be revised and harmonized with international standards.

Photo: GreenID

# 4. Impacts of air pollution

A variety of air pollutants have known or suspected harmful effects on human health and environment. In most areas of Vietnam these pollutants are principally the products of combustion from space heating, power generation or motor vehicle traffic. Pollutants of these sources may not only prove a problem in the immediate vicinity of these sources but can also travel over long distances. Thus, air pollution continues to have significant impacts on the health of Vietnam's population, particularly in urban areas. It also has considerable economic impacts by cutting lives short, increasing medical costs and reducing productivity through lost working days across the economy.

## 4.1. Health effects

Generally the young and people in a good state of health are unlikely to have any serious short-term effects in moderate air pollution levels. However, elevated levels and/or long-term exposure to air pollution can lead to serious symptoms and conditions affecting human health (Table 11). This mainly affects the respiratory and inflammatory systems but can also lead to more serious conditions such as heart disease and cancer. People with lung or heart problems may be more susceptible to the effects of air pollution.

The table below shows types of health effects experienced by the most common pollutants at elevated levels (Table 11).

Air pollution is the single largest environmental health risk in Vietnam, even before road injury (Table 12). Recent estimates suggest that the disease burden resulting from air pollution is substantial (WHO, 2014a). Heart diseases and strokes are the most common reasons for premature death attributable to air pollution and are responsible for 80% of premature death; followed by lung diseases and lung cancer (WHO, 2014a). In addition to causing premature death, air pollution increases the incidence of a wide range of diseases (e.g. respiratory and cardiovascular diseases and cancer), with both long and short-term health effects. Air pollution as a whole and PM as a separate component of air pollution mixtures have recently been classified as carcinogenic (IARC, 2013). Estimates of health impacts attributable caused by exposure to air pollution indicate that PM2.5 concentrations in 2012 have been responsible for about 432,000 premature deaths originating from long-term exposure in Europe (EU, 2016).

**Table 11: Types of health effects experienced by the most common pollutants (DERAF, 2013b)**

| Pollutant | Health effects at very high levels |
|---|---|
| **Particles** | Fine particles can be carried deep into the lungs where they can cause inflammation and a worsening of heart and lung diseases |
| **Nitrogen Dioxide/ Sulphur Dioxide/ Ozone** | These gases irritate the airways of the lungs, increasing the symptoms of those suffering from lung diseases |
| **Carbon Monoxide** | This gas prevents the uptake of oxygen by the blood. This can lead to a significant reduction in the supply of oxygen to the heart, particularly in people suffering from heart disease |

**Table 12: Top 10 Causes of Death in 2012 (WHO,2012)**

| Rank | Cause | Percentage | Increasing risk due to air pollution |
|---|---|---|---|
| **1.** | Stroke | 22% | Yes |
| **2.** | Ischemic Heart Disease | 7% | Yes |
| **3.** | Chronic Obstructive Pulmonary Disease | 5% | Yes |
| **4.** | Lower Respiratory Infections | 5% | Yes |
| **5.** | Road Injury | 4% | No |
| **6.** | Liver Cancer | 4% | No |
| **7.** | Trachea, Bronchus, Lung Cancers | 4% | Yes |
| **8.** | Tuberculosis | 3% | No |
| **9.** | Cirrhosis | 3% | No |
| **10.** | Diabetes | 3% | No |

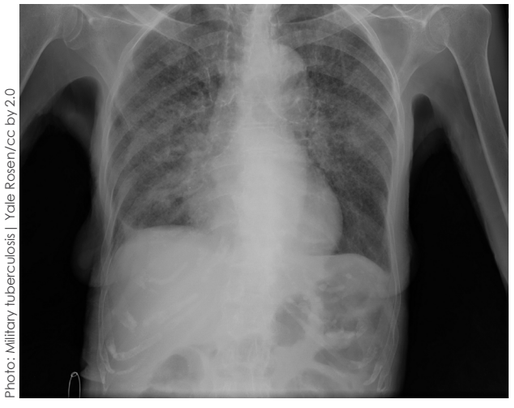


Photo: Military tuberculosis | Yale Rosen/cc by 2.0

The proportion of population affected by less severe health impacts is much larger than the proportion of population affected by more serious health impacts (e.g. those leading to premature deaths). In spite of this, the severe outcomes (such as increased risk of mortality and reduced life expectancy) are most often considered in epidemiological studies and health risk assessments, because of better data availability for severe effects (EEA, 2013).

## 4.2. Exposure and impacts on Vietnam's ecosystems

Air pollution has several important environmental impacts and may directly affect vegetation as well as the quality of water, soil and the ecosystem services that they support. The most harmful air pollutants in terms of damage to ecosystems

Photo: Laura Nagel

are O3, ammonia (NH3) and NOx. For example, ground-level O3 damages agricultural crops, forests and plants by reducing their growth rates. Other pollutants, such as nitrogen oxides (a family of gases collectively known as NOx), SO2 and ammonia (NH3) contribute to acidification of soil, lakes and rivers, causing loss of animal and plant life. In addition to causing acidification, NH3 and NOx emissions also disrupt land and aquatic ecosystems by introducing excessive amounts of nutrient nitrogen. This gives rise to eutrophication, which is an oversupply of nutrients that can lead to changes in species diversity and to invasions of new species.

### 4.3. Climate change

Several air pollutants are also climate forcers, which have a potential impact on the planet's climate and global warming in short-term (i.e. decades). Tropospheric O3 and black carbon (BC), a constituent of PM, are examples of air pollutants that are short-lived climate forcers and that contribute directly to global warming. Other PM components, such as organic carbon, ammonium (NH4), sulphate (SO4) and nitrate (NO3 ), have a cooling effect.

Measures to cut BC emissions, along with those of other pollutants that cause tropospheric O3 formation such as methane (CH4) which is a greenhouse gas (GHG) itself, will help to reduce health and ecosystem impacts and the extent of global climate warming. Air quality and climate change should therefore be tackled together by policies and measures that have been developed through an integrated approach.



# 5. Air quality and coal-fired generation

Emissions from coal-fired power plants contribute to all major health-damaging air pollutants, with largest impacts generally resulting of formation of particulate matter (PM2.5 particles from power plants), sulfur dioxide and nitrous oxide emissions. In most countries coal-fired power plants are the biggest source of toxic mercury emissions, as well as one of the largest sources of nitrogen oxides, coal dust and soot. According to a research by Natural Resources Defence Council in the U.S and Tsinghua University located in Beijing, China coal burning was responsible for 670,000 premature deaths in China in 2012 and approximately 60%of overall death toll attributed to air pollution (NRDC and Tsinghua University 2015). Other studies estimate premature deaths from coal pollution at 80,000 – 115,000 in India (Goenka and Guttikunda 2013), 13,200 in the United States (Schneider and Banks 2010), and 23,300 in the European Union plus Serbia and Turkey (Jensen 2013).

Air pollutants emitted from coal plants can be transported by wind, spreading over hundreds of kilometres. This pollution increases the risk of serious illnesses like lung cancer, stroke, heart disease, chronic respiratory ailments and acute respiratory infection. Infants, pregnant women and the elderly are most vulnerable to acute effects of air pollution (Illinois 2013).

A health survey from Harvard researchers released in September 2015 estimated that coal-fired power plants in Vietnam lead to 4,300 premature deaths every year. Based on PDP7, numbers could raise to 25,000 if the proposed pipeline will be built in the future (Greenpeace Southeast Asia 2015). Even though there is a decrease in planned coal-fired generation capacity in revised PDP7, the trend remains.

Photo: Laura Nagel

# 6. Recommendations

## 6.1 Reduce pollutants

To tackle air pollution and increase air quality in the main cities as well as in the entire country all sources of man-made pollutants caused by electricity production, transportation, heavy industry, waste burning and construction need to be reduced dramatically.

## 6.2 Coal-fired power plant

As a first and urgent action existing coal-fired power plants need to be closely monitoring their emissions and be forced to respect law and environmental regulations. Daily data of automatic monitoring systems installed in coal-fired power plants must be open for public access. The authorities must protect the public by fining dirty plants for law violations and emissions exceeding legal limits.. Power plant operators need to hold responsible for any damages to local communities and surrounding areas.

Secondly, existing emission limits need to be adjusted to international standards to force existing power plants to invest in the cleanest available solution to reduce pollutants to a minimum.

If plants cannot respect the law they should be closed down; oldest and dirtiest plants that failed to adopt the best available technology that exists to limit their toxic emissions should likewise be closed.

Reducing emissions from existing fossil fuel-fired power plants has a major impact on existing and future emissions in Vietnam. In addition to the existing 26 coal-fired power plants, about 40 coal-fired power plants are under construction and planned to be built until 2030. According to the analysis by Harvard University, Vietnam will undergo around 25,000 premature deaths each year due to pollution from coal-fired plants if all planned coal power plants start operating. An entirely unnecessary loss of life, as renewable energy and the latest energy-efficient solutions enable us to keep lights on without coal. With this in mind, Vietnam must cancel its plan to build more power plants.

In sum, monitoring and regulations on air pollutants from coal-fired power plants need to be strengthened and public health need to be more prioritised in power development planning.

### 6.2.1 Laws

Vietnam needs a Clean Air Act. The laws must squarely and specifically address the harms of coal-fired power plants. NOx and SO2 cause formation of secondary PM2.5 through chemical reactions in the atmosphere. The impact of air pollution from coal-fired power plants on PM2.5 need to be covered in a suitable way.

The Ministry of Environment and the Ministry of Health need to play a stronger role in ongoing environmental impact assessment of coal-fired power plant projects and conduct thorough examinations of damages caused by these plants. Each power generator should be required to carry out an epidemiological survey on health impacts on local residents and environmental pollution near the power plant, publish results transparently and come up with strong, long-term measures to reduce damages.

### 6.2.2 Penalties

Penalties for power plants generating air pollutants exceeding the standards should be strengthened with more stringent measures to monitor air pollutant emission and impose heavy fines on power plants concerned. Vietnam must levy penalty surcharges for NOx (one of precursors to secondary formations of PM2.5) in order to incentivize power producers not to break law and exceed emission limits, Vietnam must appropriately fine and sanction them responsible for excess emission of air pollutants.

### 6.2.3 Monitoring

For Vietnam, the first step to manage PM2.5 effectively is to create a functional air quality monitoring network throughout the country, to identify major emission sources and support research on health, environment and social and economic impacts of PM2.5.

## 6.3 Transportation

Individual transportation needs to become cleaner by increasing standards for motorcycles and cars to international standards step by step with taking public buying power into account and ensure social responsibility.

Electrification is a second step to reduce urban air quality and needs to come along with a bigger share of renewable energy in power mix. If the majority of future generation capacity is based on coal electrification of transportation is not a sustainable solution.

Vietnam citizens purchase more and more big and modern cars. However, infrastructure for public transport needs to be improved and a sustainable transportation strategy for major cities as well as the entire country needs to be developed. Public transport needs to become the main choice for long-distance travels as well as daily transportation. Therefore speed of

Photo: GreenID

transportation and quality needs to be improved and new technologies need to be implemented.

## 6.4 Cooking with solid fuel

The share of people cooking with solid fuel needs to be reduced by offering clean and affordable solutions such as improved cooking stoves or electric cooking. Banning such kinds of cooking methods without offering affordable solutions for poor households needs to be avoided.

## 6.5 Burning waste

Burning residential and agricultural waste on an individual basis must be banned immediately to reduce the avoidable impact on local air quality. Regarding agricultural waste burning, the banning procedure should be accomplished by an awareness raising campaign covering the benefits of composting.

## 6.6 Data availability

The data availability needs to be increased to cover the entire country and the main pollutants.

This information needs to be shared widely and understandable by the authority to give public the chance to protect themselves and change their behaviour.

The historical data of all measurement stations need to be available to the public to give researchers, public and other interested organisations the opportunity to make use of these data and support the authority.

# 7. Tips to protect yourself from unhealthy air

Public awareness is needed and people need to be informed about existing risks and how to protect themselves, their children and family in the most effective way. To protect yourself, GreenID sum up some important and immediate tips:

## Stay in an indoor area with filtered air.

Particle pollution can get indoors, so consider purchasing an air cleaner if you live in an area with high levels of particle pollution.

Air cleaners remove particles and include high-efficiency mechanical filters and electronic air cleaners, such as electrostatic precipitators. Avoid using an air cleaner that works by generating ozone, which will increase the pollution in your home.

If you do not have air cleaners in your home, try to go to a place somewhere that does have an air filtration system. For example, this could be a friend's home if it has air filtration.

## Keep your activity levels low.

Avoid activities that make you breathe faster or more deeply. Better enjoy indoor activities, such as reading or watching TV.

- Run an air conditioner or central air conditioning system if it's certain that your air conditioner does not draw air from outdoors and has a filter. If your air conditioner provides a fresh air option, keep the fresh air intake closed. Make sure the filter is clean enough to allow clean air flow indoors.
- Use an air filter in that room. Avoid using an air cleaner that works by generating ozone. Those types of cleaners will increase the pollution in your home.

## Keep pollution low in your home.

Air cleaners may not be enough. As particle pollution from outdoor air can easily get inside take further steps to avoid adding even more pollution indoors when outdoor PM2.5 levels are high:

- Avoid using anything that burns, such as wood fireplaces, gas logs and even candles or incense sticks.
- Keep the room clean – but don't vacuum unless your vacuum cleaner has a HEPA filter. Vacuuming as well as sweeping stirs up existing particles inside your home. Wet mopping can help reducing dust.
- Don't smoke.

## If you cannot buy filters for your entire home, create a clean room for sleeping.

A good choice is a room with as few windows and doors as possible, such as a bedroom.

- If the room has windows, keep them closed.
- Be cautious when the weather is hot. If it is too hot to stay inside with closed windows, or if you belong to an at-risk group, go somewhere else with filtered air.
- When air quality improves, open the windows to air your home or office out.

## Choose the right mask.

Do not rely on dust masks for protection. Paper "comfort" or dust masks are designed to trap large particles, such as sawdust. These masks will not protect your lungs from small particles such as PM2.5. Scarves or bandanas won't help either.

Disposable respirators known as N-95 or P-100 respirators will help if you have to be outdoors for a period of time. Check if your mask follows the N-95 regulations to ensure that PM2.5 and other pollutants are filtered out.

## Don't burn wood or trash.

Individual trash burning are major local sources of particle pollution and easily to avoid.

## Use less energy in your home.

Generating electricity and other sources of energy creates air pollution. By reducing energy use, you can help to improve air quality, curb greenhouse gas emissions, encourage energy independence and save money. Check out the U.S. Environmental Protection Agency's easy tips for conserving energy at home.

## Try to limit emissions.

Cars, log burning and industrial sources emit pollutants in the air. In the long run, we need to work together to develop systems that help us to improve our air quality. We should try to use public transportation instead of driving and collaborate to reduce our emissions.

## Check the current Air Quality

The Ministry of National Resources and Environment (MONRE) measures the main pollutant in three cities by having one stationary system for each city. The data are available online and accessible for public. So far, MONRE does not provide a history of hourly measured data. The U.S. Embassy in Hanoi (since end of 2015) and U.S. Consulate in Ho Chi Minh City (since beginning of 2016) are measuring the PM 2.5 concentration on an hourly bases and provide public access to the historical data under its Air Now program. Besides, some institutions such as United Nations International School of Hanoi share their measurement results with public mainly focusing on PM 2.5 concentrations. You can find links to see the current status of the air quality in Hanoi and Ho Chi Minh City below:

**Hanoi**
https://www.airnow.gov/index.cfm?action=airnow.global_summary#Vietnam$Hanoi

http://aqicn.org/city/vietnam/hanoi/

**Ho Chi Minh City**
https://www.airnow.gov/index.cfm?action=airnow.global_summary#Vietnam$Ho_Chi_Minh_City

http://aqicn.org/city/vietnam/ho-chi-minh-city/us-consulate/

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