A Review on Current Status of Urban Air Pollution in Ho Chi Minh city and Ha Noi

Hiện trạng ô nhiễm môi trường không khí trong đô thị tại thành phố Hồ Chí Minh và Hà Nội

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Abstract

Air pollution is getting worse in Viet Nam in recent years, particularly in big cities. The most important source of pollution are traffic and industrial activities. This paper reviews air pollution situation in Ho Chi Minh city and Ha Noi. We also recommend policies to tackle the problem: (i) upgrade the national air quality standard, (ii) install systematic and high-quality network of monitor stations, and (iii) remove means of transport that unmet emission regulations.

Keywords: urban air pollution in Viet Nam; air pollution Ha Noi; air pollution Ho Chi Minh city.

Tóm tắt

Ô nhiễm không khí ngày càng trở nên nghiêm trọng tại Việt Nam, đặc biệt là tại trung tâm các đô thị lớn. Nguồn gây ô nhiễm chính là do hoạt động giao thông và công nghiệp. Bài báo này tổng quan hiện trạng ô nhiễm không khí tại thành phố Hồ Chí Minh và Hà Nội. Chúng tôi cũng đề xuất một số giải pháp hành chính có thể thực hiện để giảm ô nhiễm không khí: (i) nâng chuẩn chất lượng môi trường không khí, (ii) xây dựng một cách có hệ thống các trạm đo đạc chất lượng không khí, (iii) loại bỏ các phương tiện tham gia giao thông không tuân thủ chuẩn chất lượng khí thải.

Từ khóa: Ô nhiễm không khí đô thị tại Việt Nam; ô nhiễm không khí ở Hà Nội; ô nhiễm không khí ở thành phố Hồ Chí Minh.

1. Introduction

Clean air contains mainly molecular nitrogen, oxygen, water, argon, carbon dioxide and very low concentration of other gases as reported in table 1. However, economic development, urbanization, transportation, industrial activity and natural phenomena may inhibit people around the world, especially in urban area, from enjoying clean air, which is contaminated by excessive amount of toxic gases such as carbon monoxide, nitrogen dioxide, nitric oxide, ozone, sulfur dioxide and

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hydrocarbon as well as metal and particulate matter (PM). Indeed, air pollution is a major concern in many countries such as India [1] and China [2].

Table 1. Gaseous composition of clean, dry atmosphere [3].

	ppm (vol.)	$\mu g \, m^{-3}$
Nitrogen	780,000	8.95×10^8
Oxygen	209,400	2.74×10^8
Water	–	–
Argon	9300	1.52×10^7
Carbon dioxide	315	5.67×10^5
Neon	18	1.49×10^4
Helium	5.2	8.50×10^2
Methane	1.0–1.2	$6.56-7.87 \times 10^2$
Krypton	1.0	3.43×10^3
Nitrous oxide	0.5	9.00×10^2
Hydrogen	0.5	4.13×10^1
Xenon	0.08	4.29×10^2
Organic vapors	c. 0.02	–

Air pollution damages both people health and the economy. World Health Organization (WHO) reported that air pollution affects all countries and one out of nine deaths is associated with air pollution [4]. Similarly, the Institute for Health Metrics and Evaluation reported that air pollution is among the top risk factors leading to death (figure 1) [5].
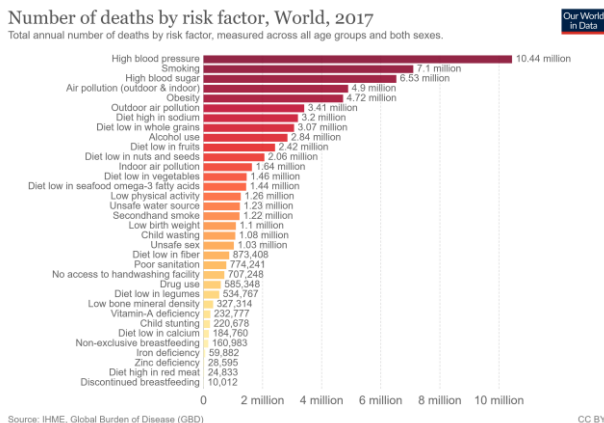

Figure 1. Air pollution is among the most deathly risky factors [5].

Even though the direct causal relationship between mortality rate and ambient air pollution has not been fully established, epidemiological studies have confirmed that ambient air pollution is an important contributor to high mortality rate [6]. It is reported that ambient air pollution has annually caused 4.2 million deaths worldwide, while household air pollution caused 2.8 million [7]. It is estimated that by 2060 ambient air pollution will cause between 6 to 9 million deaths per year. Polluted air, by the same token, has also led to many serious diseases and the most common are respiratory infection, chronic obstructive pulmonary disease, heart disease and stroke, and lung cancer [7].

Air pollution also induced huge economic losses, estimated to be US$21 billion globally expressed in terms of healthcare cost in 2015 and this number is projected to be US$176 billion in 2060 [8].

Air pollution in Viet Nam has been becoming a highly concern [9]. Its consequences are devastating regarding public health that the Minister of Health must recently issue a warning about the seriousness of air pollution, urging citizens to be cautious and vigilantly protect themselves [10]. According to recent reports [4] and studies [11][12], the pollution of air, particularly in urban area, has led to many diseases and deaths. In 2019, IQAir reported that in the Southeast Asia, Viet Nam is the second most polluted countries based on PM2.5 concentration, just after Indonesia [13]. The report also indicated that Hanoi, together with Jakarta, overtook Beijing for the first time and become among the world's most polluted capital cities. Similarly, Yale University ranks Vietnam at 132nd position over 180 countries/regions according to level of air pollution [14].

In deed, the situation in some cities is worsening, in particular the urban area of Ha Noi (HN) and Ho Chi Minh City (HCMC). HCMC has a population of about 9 million, hosting 16 industrial zones, 3 free-trade zones and numerous factories [15], accounting for 20% GDP of Viet Nam. Its streets are loaded with about 9 million vehicles predominated by 8.5 million motorcycles [16] and at rush hour, more than 4 million of them run on streets carrying roughly 5 million people [17]. On average, each household in HCMC possesses 2.3 motorcycles [18] and this number increases moderately every year. Other types of vehicles have been increasing rapidly, particularly automobiles. In 2019, the city has more than 800000 automobiles [19], increased by 15% since mid-2018.

HN is the second populous city in Viet Nam, after HCMC. In April 2019, its population reached 8 million. The number of active vehicles in Hanoi is about 6 million as of 2017 and 90% of them is motorcycles [20], the rest is automobiles. On economics, the capital accounts for 16.46% of national GDP and runs 17 industrial zones including a high-tech park [21].

2. Ambient Air Quality Standard and Monitoring in Viet Nam

2.1. Ambient Air Quality Standard

Viet Nam established the ambient air quality standard in 2013 (table 2), specifying concentration of the most common pollutants. Obviously, Viet Nam's standard is lenient than WHO's due to economic growth demand, trying hard to gain industrial country status for decades and the country aims to achieve that status by 2030. To meet that goal, the government loosens the environmental standard as a condition to attract foreign investors who undoubtedly welcome a less strict regulation to bring in low-tech manufacturing facilities. These companies can release harmful substances and PM into the environment, polluting air or/and water. For instance, Vedan illegally released untreated wastewater directly into Thi Vai River in 2008. Likewise, Formosa Ha Tinh Steel ignored the law and discharged toxic industrial wasted into the ocean, created mass fish death in 2016.

Table 2: The air quality standard of Viet Nam [22] in comparison with WHO's

Air pollutants	Viet Nam ($\mu g/m^3$)	WHO ($\mu g/m^3$)
Particulate matter (PM)		
PM2.5 annual mean	25	10
PM2.5 24-hour mean	50	25
PM10 annual mean	50	20
PM10 24-hour mean	150	50
Ozone (O$_3$)		
8-hour mean	120	100
1-hour mean	200	--
Nitrogen dioxide (NO$_2$)		
annual mean	40	40
24-hour mean	100	--
1-hour mean	200	200

Sulfur dioxide (SO₂)

annual mean	50	--
24-hour mean	125	20
1-hour mean	350	--
10-minute mean	--	500

Carbon monoxide (CO)

8-hour mean	10000	10000
1-hour mean	30000	30000

In addition to the standard, Viet Nam has just issued a guideline in November 2019 (table 3) regarding Air Quality Index (AQI) [23], which is developed by United States Environmental Protection Agency. AQI is considered as an effective way to communicate to the public the air quality and its health effects based on color-code and unitless.

Table 3: AQI and color code

AQI value	AQI category	AQI color	Health message
0-50	Good	Green	None
51-100	Moderate	Yellow	Unusually sensitive people **should reduce** prolonged or heavy exertion
101-150	Unhealthy for sensitive group	Orange	Sensitive groups **should reduce** prolonged or heavy exertion
151-200	Unhealthy	Red	Sensitive groups **should avoid** prolonged or heavy exertion; general public **should reduce** prolonged or heavy exertion
201-300	Very unhealthy	Purple	Sensitive groups **should avoid** all physical activity outdoors; general public **should avoid** prolonged or heavy exertion
301-500	Hazardous	Maroon	Everyone **should avoid** all physical activity outdoors

2.2. Ambient Air Quality Monitoring

To enforce compliance with regulations, a good network of air quality monitoring stations is crucial. It provides reliable data to assess air quality. The data must satisfactorily tell (i) what are the pollutants? (ii) how much for each of them? and (iii) how the pollutant concentrations vary in time and space, taking into account the breathing zone of the population. In addition, each station does not measure all pollutants because the monitoring objectives may be different for each site. For example, the U.S. monitor primarily the six most common pollutants [24]. New York city monitors selectively the contaminants depending on the priori objectives [25]. Similarly, in Ireland, some stations just monitor

ozone, others measure both PM and gaseous pollutants and a few stations measure only PM10 and PM2.5.

This means that if a city wants to monitor its air quality, it needs a network consisting of adequate number of stations installed at the right sites. Typically, stations have been installed in "hot-spot" positions such as roadside, industrial zone and residential area. Countries usually have guideline on site selection for stations [26]. In spite of its importance, this method does not provide systematic and reliable data because pollutant concentrations fluctuate in time and space due to the changeable emission rates and the turbulence of atmosphere. In other words, air pollution has never respected administrative borders.

For that reason, Air quality monitoring program must be accompanied by quality assurance and quality control activities to ensure the program aligns with the monitoring objectives. Australia, for instance, specifies clearly the criteria to ensure the quality of data collected: precise, accurate, representative and comparable [27]. Likewise, Montana (Canada) implements rigorous quality assurance process [28].

Unfortunately, not all cities in the world can afford this expensive investment. Moreover, rules for an optimal network of stations has not been accepted widely for different purposes and priorities of monitoring. For example, New South Wales classifies monitoring sites into peak, neighborhood and background while considering many parameters before selecting a site [29]. Likewise, New York city also considers many criteria for site selection such as population, geographical coverage, air quality trends, special purpose monitors, for health related and scientific research [30].

In Viet Nam, the network of monitor stations is thin. Nationally, Vietnam Environment Administration operates just six automatic stations installed in six cities and National Centre for Hydro - Meteorological Forecasting operates 10 stations, set up in 9 provinces [31].

Until 2018, HCMC has only 20 manually-operated stations [32], measuring total suspended particles, PM10, CO, SO_2, NO_2, noise, temperature, humidity and wind direction (figure 2). The stations monitor twice daily, for 10 days per month. It is difficult to confirm the reliability of such measurements let alone the data reported in popular news. The monitoring stations are installed mainly as roadside, a few for residential area, industrial zone and neighborhood green park.
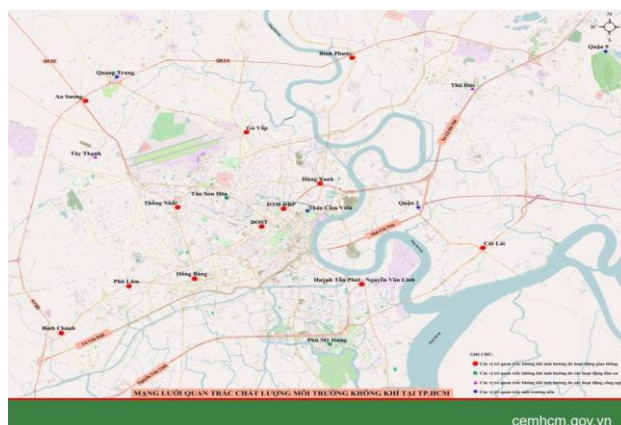

Figure 2. Positions of monitoring stations (red spots) in Ho Chi Minh city [32]

Hanoi has even a smaller number of stations. As of 2019, Hanoi has only 11, and only two of them meet the technical quality standard [33] and the others are low-cost sensors. Besides, National University of Hanoi operated 18 low-cost sensor stations and US Embassy has one, measuring PM [34].

In addition to stations operated by public agencies, private businesses also owned many small sensor stations. But the number of stations is not as important as the accuracy and reliability of collected data which depends on many factors, including the equipment, the frequency, the position of measurement (height and location) and the time of day that measurement conducted (morning, rush hour, evening), and

the weather condition. Indeed, studies have shown that low-cost sensor stations do not provide reliable data [35]. Clearly, Viet Nam not only needs more high-quality monitoring stations, but also a national program for air quality management to provide reliable data. In fact, Ministry of Natural Resources and Environment (MONRE) is currently trying to establish a better national network [36].

3. Current Status of Urban Air Quality in Hanoi and HCHC

In 2007, MONRE published the first report on urban air quality in Viet Nam [37]. The latest report published in 2014 for period 2008 - 2013, which has been regarded as the most comprehensive on the topic until today [38], telling PM was the most predominant pollutant in urban area, caused mainly by vehicle emission and construction activities. Other gaseous pollutants such as sulfur dioxide, nitrogen dioxide, and carbon monoxide were within the allowable ranges according to national standard.

Among the most common pollutants is PM - small particles consisting of solids and liquid droplets suspended in the air, which is considered as the most harmful to human health because they can deeply penetrate into the lung and bloodstream as fine particles [39]. These particulates varied in morphology and chemical composition [40][41], depending on the sources that release them or the formation processes happen in the air. There are two kinds of PM: primary and secondary particles [42]. The former is released directly from the source, whereas the latter is formed in the air from precursor gaseous species. Based on size, PM is categorized as PM10 (coarse particles), PM2.5 (fine particles) and sometime as ultrafine particles with aerodynamic diameter less than 100 nm. Occasionally, total suspended particles (TSP), having diameter less than 40 - 50 micrometers, is considered for monitoring.

Recognizing the danger of PM, Viet Nam legislation requires PM10 and PM2.5 to be monitored by public agencies. Other important pollutants are also monitored including nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO) and ozone (O_3) [43].

3.1. Air pollution in Hanoi

Annual mean concentration of PM10 in the period 2010-2018 in Hanoi is 46,2 - 100,8 $\mu g/m^3$, and that of PM2.5 is 35,5 - 59,4 $\mu g/m^3$ [44]. Within this same period, the 24-hour mean concentrations of both types of PM exceed the national standard threshold. However, the concentration of PM varied with time and space. The concentration of PM was higher in the winter, from October to March, and lower in the summer due to the effect of the weather, wind and rain. The concentration of PM10 was always higher than that of PM2.5. In the winter, concentration of PM10 varied from 60 to more than 90 $\mu g/m^3$, whilst PM2.5 fluctuated between 40 and 65 $\mu g/m^3$. The concentration in the summer was smaller than that in winter by roughly 30%, and the reason was attributed to weather condition.

The amount of PM in the air depends on traffic, which is crowed at rush hour (from 7:00 to 8:00 am and 6:00 to 7:00 pm). Whereas, the concentration of PM is low at noon and around midnight. Occasionally, PM concentration soars up very high at some positions. For example, at rush hour in the morning of 3 March 2016, the 1-hour mean concentration of PM2.5 at US Embassy in Hanoi was 383 $\mu g/m^3$, while the PM10 at Nguyen Van Cu station was spike at 270 $\mu g/m^3$ [45]. Surely, these values do not represent the background concentration of PM in urban area of Hanoi, which spreads more than 300 km^2.

The first two weeks of May 2020, 24-hour mean concentration of PM2.5 in Hanoi varied from just above 10 to 60 $\mu g/m^3$, depending on

measurement sites and days [46]. Regarding standard of Viet Nam, air quality in Hanoi during this period and probably in a few months of the summer will be improved thanks to the heavy rain, which appears often in summer [47].

3.2. Air pollution in HCMC

Air pollution in HCMC has been alarming for many years. Particularly, PM2.5 and its concentration varies greatly. Huy and al. shows that the 24-hour mean concentration from 2013 to 2017 fluctuates from about 15 $\mu g/m^3$ to more than 80 $\mu g/m^3$ and the average value of this period is 28 $\mu g/m^3$, higher than the value set by WHO's guideline. Nevertheless, it is lower than the standard of Viet Nam, which is 50 $\mu g/m^3$. Regarding frequency of measurement, 41% of the time the measured values exceed Viet Nam's standard and 51% exceeds that of WHO's.

PM2.5 concentration also changes with time of the year. From October to February, it has the highest concentration, but lower in other months. Within a day, the concentration fluctuates, too. From 8:00 to 12:00 shows the highest values. From April to September, PM2.5 concentration is lower due to the heavy rain in the summer, washing down the particles, thus the air became cleaner.

Likewise, PM10 is alarming in HCMC. Center for Environmental Management reported that concentration of PM10 varies from 47 to 140 $\mu g/m^3$ for 2014-2017 period, depending on the monitoring sites [48]. The report shows that the concentration of PM10 at roadsides is higher than that at other sites. Even though the data indicates that concentration of PM10 decreased throughout this period, the majority of annual mean concentration values still exceed national standard (50 $\mu g/m^3$).

4. Sources of air pollutants

Air pollutants in urban areas globally originated from traffic, industrial activities, domestic fuel burning, biomass burning, natural sources and unidentified origin [49] and the proportion varies with location.

As mentioned above, there are about 10 million motorbikes active on the road in Ha Noi and Ho Chi Minh city everyday. These vehicles must be the primary source of air pollutant in the cities [50]. PM comes from exhaust emission of internal combustion engine, diesel engine in particular, and the non-emission such as wear of tires and brakes. Worse, numerous old motobikes which do not comform to safety and emission regulation are still active. In 2021, there are more than two millions motorbikes older than 20 years in Ha Noi [51].

Industrial activities contribute too, such as fuel and coal-based power plants, constructions sites and solid waste burning, paint manufacturing and from spraying pesticide and herbicide in farms. Construction sites are considered as a significant contributor to air pollution. Ritual activities as burning joss paper in worship activities, which are rather popular in Viet Nam. Domestic LPG burning in city is also an important source of pollutants which are emitted to the atmosphere. Open burning source and forest fire may be a source because the wind can blow the pollutants across a wide region.

5. Recommendation on public policy

Currently, air quality is governed by law and guideline. However, the standard is not stringent, leading to numerous activities that pollute the atmosphere including the breathing zone. In addition, air quality monitoring in Viet Nam is scarce, making it more difficult to manage. Therefore, it would be good to upgrade the standard, build a network of monitor stations, implement quality control assurance, avoid low-technology industries and eliminate the vehicles that are unmet safety and emission regulations. Low-technology factories

are not energy efficient and tend to release untreated waste (solid, liquid and gas) into the environment. Therefore Government can reinforce law and severely punish companies that deliberately pollute the environment. For example, government investigated and punished Vedan Company in 2008 is an example. Formosa is another. Lifting tax incentive and upgrade environmental standard in Vietnam can deter these companies from operating and polluting the environment in Viet Nam.

In addition, Government shoud gradually eliminate vehicles that are unmet safety and emission regulations. In particular, those run in urban area. Nowaday, technical standard of automobile is regulated systematically but motorcycle is not. By checking the quality of exhaust gases of suspected motorcycles on street, government can reduce the polluted motorcyles accordingly.

6. Conclusion

Air pollution in big cities in Viet Nam is getting worse due to traffic, industrial activities and domestic burn. While the standard is lenient, the network of monitor stations is too thin to manage air quality. Government should upgrade the standards and build a systematic network of monitor stations, covering the major urban area so as to keep tract of the real-time quality of air, particlarly the breathing zone. Safety and emission standard must be established to keep pollutated means of transport out of roads.

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