AIR QUALITY IN HO CHI MINH CITY, VIET NAM

Hiep Nguyen Duc*

This paper reviews the state of air quality in Ho Chi Minh City as revealed by studies conducted by several organizations in recent years. A comparison is made between the air quality of the Ho Chi Minh City and that of some other cities in the region. It is shown that air quality, both indoor and outdoor (ambient), has been deteriorating in recent years, mainly because of increases in the number of vehicles and industries in and around the city.

Compared with other cities such as Beijing, Tokyo, Bangkok and Manila, the level of sulphur dioxide (SO_2) pollution is lower, while the levels of carbon monoxide (CO) and nitrogen dioxide (NO_2) are approaching the levels of these cities. In the case of particle pollution, the peak particle level at some heavy traffic sites in Ho Chi Minh City is high and exceeds the levels of Bangkok and Manila. The lead pollution is less severe than that of Bangkok, but it is likely to increase if concrete action is not taken.

The experience gained by other cities in the area of environmental management could be used to prevent serious degradation in air quality in the city. Measures that could be incorporated readily into an integrated air quality and transport management plan are discussed.

INTRODUCTION

Ho Chi Minh City is a major city in Viet Nam with a population of 4.7 million (1994) and a natural growth rate of 1.49 per cent, excluding migrants (mainly from the country areas) and temporary residents. It has an area of about 2,056 km^2 and an average population density of 2,282 inhabitants/km^2. The tropical climate has a yearly

* New South Wales Environment Protection Authority, P.O. Box 29, Lidcombe, NSW 2141.

average temperature of 27˚C and relative humidity of 77.8 per cent (Tuan 1996).

As in other bustling and growing cities in the region, the main source of air pollution is motor vehicles. Besides motor vehicles, industrial sources in the city and surrounding areas of Dong Nai Province are also contributing to the air pollution problem, which is particularly acute in the residential areas around these sources.

As currently projected, with an estimated annual population growth rate of 1.63 per cent the population of the city will easily exceed 5 million by the year 2000. This means that the city is in the category of supercities. Although Ho Chi Minh City is not yet in the league of megacities such as with Bangkok, Jakarta, Beijing or Manila, the high economic growth of recent years has been accompanied by a rapid degradation of environmental quality. Frequent visitors to the city are usually struck by the rapidly increasing traffic volume and worsening congestion, which resemble the traffic situation of Bangkok in the 1980s.

With air pollution in the city increasing, a number of organizations in the city have recently conducted some initial studies on air quality and the effects of air pollution on the population. Permanent monitoring stations have not yet been established, but data are collected occasionally, for a number of days, at a number of sites in the city. These sites are mainly near roads with heavy traffic. The collected data are not yet comprehensive enough to provide an overall picture, but do provide some indications of the state of air quality in Ho Chi Minh City.

I. AIR POLLUTION DUE TO MOTOR VEHICLES

Recent data gathered from a number of monitoring stations operated by the Centre for Environmental Technology and Management (CEFINEA) of Ho Chi Minh University of Technology has been published (Tuan 1996; Trung 1996; and Dang 1995). These data show that many air pollutants such as carbon monoxide (CO), nitrogen dioxide (NO_2) and particles have concentrations exceeding the standard levels. The noise level is also persistently high.

During one particular day, on 25 April 1996, the data measured at the intersection of Dinh Tien Hoang and Dien Bien Phu Streets show that the maximum hourly concentration of particles was 3.6 mg/m^3, 12 times the current Vietnamese standard (Trung 1996).

The concentration of CO measured on 25 April 1996 was 62.65 mg/m^3, 1.5 times above the standard. Similarly, the NO_2 concentration measured on 23 April 1996 exceeded the standard by 1.5 times. The average noise level was between 76 and 86 dBA, with a peak of 98 dBA while the standard for residential area is 60 dBA (Trung 1996).

The main cause of air pollution in the city is motor vehicles. In 1996, the city had more than 1.1 million motor vehicles, of which motorcycles were more than 1 million. Currently, there are about 1.1 million motorcycles and 101,000 cars. Each month, more than 1,000 vehicles are added to the city traffic. Most of these vehicles currently use leaded petrol. Table 1 shows the breakdown of the different types of vehicle registered in 1997.

Table 1. Vehicles registered in Ho Chi Minh City, 1997

Type	*Number*
Trucks	14 073
Company-operated buses	591
Vans and small trucks	1 082
Small buses	1 601
Cars	194 777
Standard car taxis	2 712
Three-wheeled taxis	1 935
Motorcycles	1 288 754

Approximately 200,000 tons of petrol fuel and 190,000 tons of diesel fuel are consumed each year. The estimated emission into the airshed is about 2,200 tons of SO_2 and 25 tons of lead.

The large increase in the number of vehicles reflects the economic growth in the past ten years. During peak traffic periods on Cach Mang Thang Tam Street, the vehicle density count is now 10,000 per hour, compared to 5,800 per hour in 1990, and only 2,800 per hour in 1985 (Tuan 1996). The growth of traffic however has not been matched by the upgrading and construction of new roads. The traffic density in some of the congested streets in 1994 is presented in table 2.

Table 2. Traffic density on selected streets, Ho Chi Minh City, 1994

Street	*Traffic density (vehicles/hour)*
Ba Thang Hai	13 000
Tran Hung Dao	12 500
Hung Vuong	10 015
Ly Thuong Kiet	11 306

Source: Tuan, Nguyen Dinh, 1996. Current situation of air pollution in Ho Chi Minh City, Viet Nam. Proceedings of the Asia-Pacific Conference on Sustainable Energy and Environment Technology, held in Singapore, 19-21 June, pp. 242-248.

In 1980 hourly average particle levels in traffic streets were about 3 to 3.1 mg/m^3 during the rainy season and about 3.2 to 3.4 mg/m^3 during the dry season. However, in 1990 at the same locations, hourly average levels increased to 5 to 5.1 mg/m^3 during the rainy season and 7.8 to 8 mg/m^3 during the dry season. The corresponding increase for SO_2 was from 0.8 mg/m^3 in 1980 to 0.97 mg/m^3 in 1990 (Trung 1996).

A recent study by CEFINEA (Tuan 1996) on the daily variations in some air pollutant concentrations due to traffic emissions shows the following results:

(a) For CO, the daily average concentration at important traffic intersections was between 2 and 10 mg/m^3, with a maximum hourly value of up to 23.3 mg/m^3.

(b) The daily average concentration of NO_2 was between 0.05 and 0.25 mg/m^3. The peak hourly value reached 0.726 mg/m^3 at the intersection of Dinh Tien Hoang and Dien Bien Phu Streets, and 0.6 mg/m^3 at Hang Xanh roundabout.

(c) Dust particle concentrations ranged from 0.8 to 15 mg/m^3 at different hours of the day, with a maximum concentration of 37 mg/m^3 measured at the intersection of Dinh Tien Hoang and Dien Bien Phu Streets on 15 March 1995.

(d) Lead concentrations at a number of sites varied between almost nil and 0.41 mg/m^3 at different times of day. The ratio of lead-containing samples to total analysed samples was low.

(e) Air pollutant concentrations varied depending on the month, due to seasonal effects. At the Minh Phung Hau Giang intersection, the average monthly concentration for CO was 0.06 to 4 mg/m^3, for NO_2 0.05 to 0.3 mg/m^3 and for total suspended particulates (TSP) 0.4 to 1 mg/m^3. In the dry season the average concentration was 2-3 times higher than that in the rainy season.

II. AIR POLLUTION FROM INDUSTRIAL SOURCES

Industries also contribute significantly to air pollution, especially in the surrounding areas. Many of these sources of pollution are small factories, and have very high indoor pollutant levels. There are 700 large industrial sources and about 24,000 small-scale factories in and around the city. The large industrial sources are mainly concentrated in the Nha Be and Thu Duc areas. The small factories, mainly family businesses, are scattered across all districts, with the largest concentration in districts 5, 6, 11 and Tan Binh (Tuan 1996).

Almost all of these sources are located in residential areas. Much of the equipment and technology is old and has been in operation for over 10 years. Some is more than 25 years old and not fitted with any pollution-control devices (Tuan 1996). A recently conducted survey showed that many foreign joint ventures operating with outdated imported equipment are causing considerable environmental pollution (Dong 1995).

An investigation conducted by CEFINEA (Tuan 1996) showed that the total dust concentration (TSP) was very high in the indoor environment of almost all industries, especially in the construction materials and metallurgical industries.

Total annual emissions of pollutants to the airshed due to industrial fuel consumption are estimated at 30,000 tons of SO_2, 5,750 tons of NO_2 and 1,650 tons of particulate. In addition, the metallurgical industries produce 2,840 to 4,260 tons of particulate and 994 to 1,420 tons of CO per year (Tuan 1996).

In 1995, of 43 factories on an environmental blacklist, 30 per cent were in Thu Duc, an industrial growth area in the north of Ho Chi Minh City. Two major companies, Posvina and PS (a toothpaste manufacturer), are emitting large quantities of acid gases each day to the surrounding residential areas (Dang et al. 1995). Residents complained about the pollution from these sources and the issue of pollution was also publicized in the media, for example the factory operated by Miliket noodle company was mentioned. In the Ho Chi Minh City suburb of Tan Binh, a steel factory operated by Southern Steel Corporation (Cong ty Thep mien Nam) was also the object of complaints (Dung 1995).

The ambient air pollutant concentrations around several industrial sources are shown in table 3 (Tuan 1996). A number of these sources, for example the Tan Binh Steel Works and the Miliket Noodle Company, exceeded ambient standards for dust, SO_2 and CO.

Since 1996, more industrial parks open each year in the north, in the Thu Duc-Bien Hoa area, in the south, in Nha Be (south Saigon) and recently in the north-east Hoc Mon area. All types of industry are established in these areas and they operate year round. From a meteorological point of view, the location of these industrial parks is not conducive to air pollutants being dispersed quickly from the urban area of Ho Chi Minh City.

As measured at Tan Son Nhat meteorological station from 1952 to 1981, on an average during the dry season, winds come mainly from the north, south and south-east with wind speeds ranging from 2.2 m/s to 3.3 m/s. During the rainy season, however, the winds come mainly from the west and south-west, with wind speeds in the range of 3.3 m/s to 3.7 m/s.

Air quality is much improved by the effect of rain (as shown by measurements at a number of monitoring stations in the city). The location of the industrial areas in the north and the south of the city will have an adverse effect on the air quality in Ho Chi Minh City. It is more appropriate to locate industrial zones in the under developed west and north-west areas of the city, such as Hoc Mon or Cu Chi. Recently, a few industries have been established but no priority has been accorded to infrastructure investment in those areas.

Table 3. Air pollutant concentrations around selected factories in Ho Chi Minh City (mg/m^3)

No.	*Industry and sampling site*	*Dust (TSP)*	*SO_2*	*CO*	*NO_2*	*Others*
1	Chana Textile-Outside factory, distance 25 m	0.18	0.142	0.08		
2	Phuong Dong Detergent-Outside factory, distance of 15 m	0.4	0.42	0.3		
3	Quan Khu 7 Cement Outside factory, distance of 40 m	0.8	0.26	0.055	1.78	
	Outside factory, distance of 120 m	0.4	0.22	0.022	0.66	
4	Tan Binh Metallurgy					
	Outside, distance of 40 m	0.51	0.76	0.4		
	Administrative area	1.3	0.36	0.154		
5	Nha Be Metallurgy					
	Administration area	0.3		0.277		
6	Milipa Instant Noodle					Hydro-carbons:
	Outside	0.7	0.35	0.1	3	15
	Standard (daily average)	0.2	0.3	5	0.1	

Source: Tuan, Nguyen Dinh, 1996. Current situation of air pollution in Ho Chi Minh City, Viet Nam. Proceedings of the Asia-Pacific Conference on Sustainable Energy and Environment Technology, held in Singapore, 19-21 June, pp. 242-248.

III. HEALTH EFFECTS OF AIR POLLUTION

It is known that some primary pollutants such as particles PM_{10} and $PM_{2.5}$ (particulate matter less than 10 and less than 2.5 microns in diameter, respectively) nitrogen oxides, sulphur dioxide and carbon monoxide, and secondary pollutants such as ozone have adverse effects on people’s health. These range from respiratory problems to diseases such as sinusitis, bronchitis and asthma. Particles have also been shown to cause an increase in the mortality rate. People with asthma and respiratory diseases are highly susceptible to particles, nitrogen oxides, sulphur dioxide and ozone. In addition, lead particles have serious effects on children’s growth and development. Children with high lead levels are deficient in weight and tend to have a low count of red blood cells. Their IQ levels are also inferior to those with lower lead levels.

There is an extensive literature on studies of the health effects of air pollutants. Most of the studies were conducted in developed countries such as the United States of America and Germany. Recently, the results of these studies have been used to establish revised guidelines and standards for many pollutants such as ozone, carbon monoxide and particles PM_{10} and $PM_{2.5}$. The economic impact of air pollution and the benefits of setting lower level standards for particles are both substantial (Ostro 1998).

In Viet Nam and other countries of the region, the health aspect of air pollution is now acknowledged as an important public health issue. Studies have been conducted and published. The results show that exposure to high levels of pollutants have adverse effects on quality of life.

The health effect of air pollution on traffic police officers was recently studied by the Labour Protection Unit of Ho Chi Minh City (Dang 1995). Due to extended exposure to high levels of air and noise pollution, 2.9 per cent of traffic policemen were infected with tuberculosis, compared to an average infection rate of 0.075 per cent. The rate (presumably using yearly data) of ear, nose, and throat infection was 76 per cent and 32 per cent of traffic policemen had a reduced hearing ability.

There are currently no known studies conducted by the health authorities in Ho Chi Minh City on the effects of gaseous pollutants or particles on asthma or on the death rate. Nor are the levels of lead in blood due to vehicle emissions known.

In Bangkok 40 per cent of traffic policemen have chronic lung ailments. Many of them wrap scarves or white cloths around their mouths and noses. A Public Health Ministry study of 214 people who regularly use buses found that 26 per cent of them suffered ill effects from CO. These people were exposed to a CO level of 67 parts per million (ppm) against the standard of 10 ppm (*Bangkok Post*, 18 March 1996). This does not include the effects of gaseous gases such as the highly toxic and mutagenic polycyclic aromatic hydrocarbons. A comprehensive study (*Bangkok Post*, 18 March 1996) on lead levels in the blood of children has shown that the average lead level was 17 micrograms/decilitre before the introduction of unleaded petrol in 1991, and it came down to 9.23 micrograms/decilitre by 1996. The acceptable level, as specified by the Centers for Disease Control and Prevention of the United States of America, is 10 micrograms/decilitre.

A similar study, called the Urban Air Project, conducted by the Department of Environment and Natural Resources of the Philippines in 1994, showed that out of a sample group of 170,000 people in cities exposed to lead pollution and traffic, 762 (or 0.45 per cent) had varying degrees of coronary disease, and another 91,207 (or more than 50 per cent) suffered from hypertension. This study also showed that at least 39 per cent of the lead pollution came from cars and 58 per cent came from public utility vehicles (APEC 1996). In Jakarta, air pollution in industrial and heavy traffic areas has been identified as a significant contributor to the increased incidence of lung disease (Mangunnegoro 1996).

A study on the effects of particulate pollution in Jakarta, funded by the World Bank, estimated that exposure to particulate concentrations above the World Health Organization (WHO) standard caused an additional 1,200-2,300 deaths, 184,000-541,000 asthma attacks and 5.3-11.8 million lost work days in 1989 (Ostro 1992).

In Kaohsiung, Taiwan, where factories are the major source of air pollution, a study showed that people living within three kilometres of the industrial area have a 6-fold increase in the risk of lung cancer (Ko 1996). It also showed an increase in the incidence of brain tumours of 2-4 times among inhabitants close to a petrochemical plant, a higher rate of leukaemia, and cancers of the lung, kidney, and urinary bladder. Another study (Chen et al. 1998) showed that schoolchildren in urban and industrial areas had significantly more respiratory problems and diseases than to those in rural areas.

The higher level of sulphur dioxide in ambient air has been associated with a higher mortality rate in Seoul, where vulnerable old people have a higher risk of premature death (Lee and Schwartz 1999). In Beijing, the high level of sulphur dioxide in winter was significantly associated with increased mortality. The risk of total mortality was estimated to increase by 11 per cent with each doubling of the sulphur dioxide concentration. The effects of doubling sulphur dioxide levels were significant for chronic obstructive disease (29 per cent), pulmonary heart disease (19 per cent) and cardiovascular disease (11 per cent) (Xu et al. 1994).

IV. COMPARISON WITH OTHER REGIONAL CITIES

Compared with other cities in the region which have also experienced rapid economic growth in recent decades, the air pollution problem in Ho Chi Minh City is not so serious, but it is likely to become a serious problem unless preventive measures are taken.

As the population is rapidly increasing and vehicle usage continues to grow, the air pollution at some sections of the city, especially near heavy traffic or highly congested roads, will reach the levels of those of the highly polluted cities in the region. In megacities, defined as cities having populations of over 10 million by the year 2000, such as Beijing, Bangkok, Jakarta and Manila, the present situation is already alarming.

In each country the air quality standard is usually defined by the national environment organization and tends to differ from country to country. It is therefore useful to use the WHO recommended standards to compare air quality. The standards of selected countries and the WHO standards are shown in the table in the annex.

It is difficult to compare the air quality of various cities using average values measured at specific locations, as these locations may not be representative of the whole airshed region. The method of measurement can also vary. A reference standard such as that used by the United States Environmental Protection Agency (EPA) is often adopted, but more often the instrumentation and quality assurance protocol are different. For example, during the author's visit to one monitoring location in Ho Chi Minh City, the instrumentation for measuring nitrogen oxides was made in-house by CEFINEA and no calibration was done on a daily basis. Furthermore, the exposure of the population to air pollutants is hard to measure. Nevertheless, it is informative to compare the air quality of some cities using the values of the worst pollution events that happen at specific locations within them.

A. Particles

Total suspended particulate (TSP) pollution is reported to be serious in major cities in Asia, including Bangkok, Manila, Jakarta, Beijing, Seoul, Bombay and Calcutta (WHO UNEP 1992).

The particulate levels in Bangkok and Jakarta were so bad that the World Bank called for “immediate action” to tackle the problem in these two cities (Towprayoon et al. 1996; Gras et al. undated). One in six people in Bangkok now suffer from allergies because of the high level of particles in the air (Towprayoon et al. 1996). The levels of particles at some traffic sites are very high. Measured hourly values have been reported to be as high as 2.18 mg/m^3 at one site (Towprayoon et al. 1996). The average annual level near the commercial centre of Jakarta between 1980 to 1987 was around 0.4-0.5 mg/m^3 (Gras et al. undated), which is 8 times above the annual level recommended by WHO.

In Manila, the daily average concentration of particles is 3 times the standard level of the WHO and the Philippines of 0.15 mg/m^3 (Montesines 1994). The TSP level in Beijing is very high during the winter season due to the use of coal as the main source of heating and power generation. According to the National Environmental Protection Agency of China, the annual consumption of 33 million tons of coal in Beijing frequently reduces visibility in the city to as little as a quarter of a mile (*International Environment Reporter*, 21 January 1998). Ando et al. (1996) reported that the 1991 average monthly value in Beijing was about 0.217 mg/m^3, and the maximum hourly particle level around the residential area approached a level of 0.8 mg/m^3. Even during the summer, as in 1985, the monthly particle level was approaching 0.2 mg/m^3. Statistics recently released by WHO (*International Environment Reporter*, 21 January 1998) show that in some of the larger cities of China, the annual average level of suspended particulate is between 0.3 and 0.4 mg/m^3.

There is little data on particle levels in the residential areas of Ho Chi Minh City. However, data from some heavy traffic sites showed that the average peak hourly value of TSP was of the order of 6 mg/m^3 (Trung 1996). This was very high compared to the peak value of about 0.4 mg/m^3 measured at the main traffic roads in Tokyo (Ando et al. 1996). Away from street level, at one site measured from the top of an eight-storey building, the monthly average ranged from 75 to 150 $\mu g/m^3$

between 1993 and 1994 (Hien et al. 1997). Even at that distance from the street, the annual average already exceeded the annual WHO standard of 60-90 µg/m^3.

The monthly average level of TSP reached 1 mg/m^3 during the dry season at one street crossing (Tuan 1996). From this average monthly value, the daily average can be assumed to be similar. This is about 6 times the WHO standard. A maximum hourly value of 15 mg/m^3 was recorded at another street. This was much higher than the maximum level reported in Bangkok from traffic sites.

It is clear that particle air pollution from vehicles is a serious problem in Ho Chi Minh City. It is significantly higher than that of some other cities such as Bangkok and Manila, but it is still less than certain cities in China such as Beijing. In addition to vehicular traffic, the recent construction boom at many sites in Ho Chi Minh City has also contributed significantly to the level of particle pollution (Hien et al. 1999).

By contrast, as regards the indoor environment in Ho Chi Minh City, as there has been a recent switch in domestic cooking fuel from oil and wood to cheaper natural gas, particle and carbon monoxide exposure levels have been reduced.

B. Fine particles (PM_{10} and $PM_{2.5}$)

Fine particles are the respirable components of TSP. PM_{10} and $PM_{2.5}$ are particulate matter with aerodynamic diameters of less than 10 µm and 2.5 µm respectively. They are major sources of public health concern. At present, fine particles are not measured in many cities, but we can estimate fine particle levels using the data available for cities which have similar emission characteristics.

As mentioned before, in Ho Chi Minh City, away from the street, at a site on the top of an eight-storey building, the TSP level was about 100 µg/m^3 as measured by the Dalat Nuclear Research Institute (Hien et al. 1997). At this height, it can be assumed that most TSP came from PM_{10}. If this site can be considered representative of the whole city, then the annual value for PM_{10} was of the order of 0.1 mg/m^3. This is comparable to an annual average of 0.07 mg/m^3 measured in Taipei in 1994 (Ko 1996).

In a recent preliminary study conducted jointly by the Korean Ministry of the Environment and the United States EPA (Report 905-R-95-011), it has been reported that the daily average of ultrafine particulate matter ($PM_{2.5}$) measured at two sites in Seoul were about 74 and 180 µg/m^3 respectively. Approximately 50 per cent of PM_{10} samples were made up of $PM_{2.5}$. That means that the level of TSP including fine particles PM_{10} and $PM_{2.5}$ can reach up to 1 mg/m^3. The WHO standard for fine particles PM_{10} is 0.07 mg/m^3.

A detailed study of the fine particle level in Jakarta carried out by the Indonesian Environmental Impact Management Agency with AusAID help (J. Gras et al. undated) has shown that the average monthly level of PM_{10} in the centre of Jakarta was between 0.04 mg/m^3 in the wet season and 0.08 mg/m^3 in the dry season. The maximum daily average can reach a value of 0.14 mg/m^3. The average monthly level of fine particle $PM_{2.5}$ was between 0.02 mg/m^3 (wet season) and 0.04 mg/m^3 (dry season).

If this data is extrapolated for other cities (such as Ho Chi Minh City, which, like Jakarta, has a high proportion of motorcycles and 3-wheeled vehicles), it is clear that all major cities in the region, including Ho Chi Minh City, have fine particle levels many times exceeding the WHO standard for PM_{10}. The latest statistics released by WHO in 1998 show that annual mean concentrations of PM_{10} in South-east Asia range from 0.1 to 0.3 mg/m^3 (*International Environment Reporter* 1998).

C. Lead

The daily lead concentrations measured at various sites in Ho Chi Minh City have been reported as being from trace value ~0 up to 0.41 mg/m^3 (Tuan 1996). The daily average at some sites could therefore be very high. It is likely that the yearly averages for a number of sites exceeded the WHO annual standard. However, at one particular site, as measured by Dalat Nuclear Research Institute, for the period of 1993-1994, the average monthly lead concentrations measured in the dry season were 0.199 µg/m^3 and 0.159 µg/m^3 in the rainy season (Hien et al. 1997). The annual average at this site was ~0.18 µg/m^3, which was below the annual WHO standard.

This level is still high but not as bad as those in Bangkok. In the Yaowarat area, the annual lead level was recorded as 0.96 mg/m^3 in

1996 (*Bangkok Post*, March 1996) even long after the introduction of unleaded petrol in 1991. Before 1991 the lead Level was as high as 2.34 mg/m^3. Other cities also recorded high levels of lead concentrations: for example the annual lead level in Manila exceeded the level recommended by WHO (Montesines 1994) and the average annual lead concentrations in Lahore, Pakistan, at traffic sites was 0.004 mg/m^3, which was three times the recommended WHO standard (Smith et al. 1996).

It is expected that the lead pollution in Ho Chi Minh City will worsen unless the Government introduces the use of unleaded petrol.

D. Sulphur dioxide

WHO reports that Beijing and Seoul currently have serious sulphur dioxide (SO_2) pollution. The WHO guidelines are often exceeded by more than a factor of two (WHO and UNEP 1992). In Beijing, coal-fired power stations and the use of coal for domestic heating contribute significantly to SO_2 pollution in the winter. In one study, conducted in December 1991, the measured average monthly ambient SO_2 concentration in a residential area was 0.233 mg/m^3, which was about 5 times that measured around main roads in Tokyo (Ando et al. 1996). The extensive use of coal for energy has produced serious SO_2 and CO_2 pollution in many major cities of China. It also causes an acid rain problem, even in the neighbouring countries of Korea, Japan, Taiwan and the Philippines (Littlefield 1996).

Ho Chi Minh City does not have a SO_2 problem, as the only main SO_2 sources are some large factories located in the Thu Duc area. The main power source is hydroelectricity and most domestic usage is of natural gas or electricity. However, concentration levels near some traffic sites and factories are very high. For example, outside the Tan Binh factory the measured maximum hourly concentration was 0.76 mg/m^3 at 40 m (Tuan 1996), 2 times higher than the WHO guideline standard.

E. Nitrogen oxides

Data measured by CEFINEA revealed that the level of nitrogen oxides at some traffic sites in Ho Chi Minh City was very high (Tuan 1996).

The monthly average NO_2 for December 1991, measured at various main roads in Tokyo was ~0.111 mg/m^3. In Beijing, for the same period, the ambient monthly average concentration recorded in the residential area was about 0.07 mg/m^3 (Ando et al. 1996).

From the range of daily averages measured at a number of sites in Ho Chi Minh City, a monthly average of about 0.15 mg/m^3 can be inferred. This value is of about the same order as that of Tokyo. This suggests that the main causes of this high level was due to some highly congested roads and the poor emission control of vehicle exhaust system.

F. Carbon monoxide

The main source of CO pollution is motor vehicles, especially older vehicles without catalytic converters. The greater the number of motor vehicles, the greater the CO pollution. In Bangkok the daily average concentration of ambient CO measured at a number of roadside stations is between 8.9 and 20.35 mg/m^3. In one public health study conducted recently at a bus station, people were shown to be exposed to an average hourly concentration of 80 mg/m^3 of CO (*Bangkok Post*, March 1996).

In Ho Chi Minh City the hourly value recorded at a number of traffic sites by CEFINEA ranged from 0 to 23.3 mg/m^3 (Tuan 1996). However, on another day (25 April 1996), the maximum hourly value of CO was 62.65 mg/m^3, which was 1.5 times above the standard. It can be said that the level of CO pollution in Ho Chi Minh City is now approaching that of Bangkok.

G. Ozone

Ozone is a secondary pollutant formed, in the presence of strong sunlight, from the reaction of oxygen with nitrogen oxides and hydrocarbon emitted mainly by motor vehicles. Smog, the combination of ozone and nitrogen oxides, is the most frequent gaseous type of air pollution in the summer. In many cities in Asia it is not unusual to have both particle pollution and smog at the same time.

Ozone pollution is frequently recorded as very high in Hong Kong, China and Taipei. Although ozone is not usually measured in Manila, Bangkok or Jakarta, ozone pollution is believed to be very high in these cities. Emissions from motor vehicles without catalytic converters and the presence of strong sunlight for most hours of the day make it likely that the smog formation and the ozone concentration exceed the WHO standard. It is believed, therefore, that the smog level in Ho Chi Minh City is the same as that of other cities, as the meteorological conditions and the emission characteristics are of a similar nature.

V. CURRENT MEASURES AND RESPONSES

The Government has recognized that the pollution problem is causing a rapid deterioration in the environment. After the Environment Law was adopted in 1994 the Government declared its intention to prosecute all cases of environment violation on 26 April 1995. In July 1995 the People's Committee of Ho Chi Minh City ordered the Office of Science, Technology and Environment (So Cong nghe va Moi truong) to make an inventory of and inspect all industrial air pollution sources in the city. Sources which had serious environmental effects in terms of air, water and noise on surrounding residents were asked to improve or risk having their sites closed down. The names of the 93 worst polluters were published in a blacklist. Some companies were forced to shut down temporarily, including the monosodium glutamate producer Vedan and the processed meat manufacturer Vissan (Levine 1997).

The Committee also started to move factories, especially those in the rubber, plastics, paper and detergent industries, to industrial zones outside the city, mostly in Dong Nai province. This policy is in line with government regulations on industrial, export-processing and high-tech zones. There are currently 10 industrial parks in Dong Nai province.

As regards environmental management, the United Nations Development Programme (UNDP) recently provided US$ 1.12 million funding to a project called "Capacity 21 Trust Fund" to help the Government integrate environmental issues into development policies. Similar programmes have been conducted in China and India. UNDP has estimated that almost US$ 1 billion for clean-up and waste reduction is required to address the growing problem in the Bien Hoa industrial area of the nearby province of Dong Nai, where almost roughly half of the factories have outdated emission controls. Another related UNDP project is to convert some industrial processes (especially in cosmetics) to new processes for the protection of the ozone layer.

In 1995 the Chamber of Commerce and Industry of Viet Nam, with sponsorship from the World Wildlife Fund and UNDP, organized a conference on commercial development and environment. Many environmental specialists reported alarming levels of environmental pollution in many cities in Viet Nam especially in Ho Chi Minh City. Not only air pollution, but also water, ground water and waste pollution are now serious problems that have to be tackled.

In Ho Chi Minh City, the Government also actively pursues a policy of moving houses located near creeks and canals. The policy encourages people to move to new places to protect water and air quality, as well as to promote hygienic city living. Between 30 and 50 per cent of these areas are converted to park land with more tree coverage in order to provide a fresh and clean environment to city residents to enable them to escape the sultry weather and bad air quality. A number of "Green Days" and "Green Weeks" have been initiated, with the participation of youth organizations, to raise environmental awareness (Dang et al. 1995). In 1994 the Government prohibited the production and use of firecrackers during New Year festivities, which has resulted in lower levels of lead and sulfur dioxides in ambient air during the festival months (usually January or February) (Hien et al. 1997).

On the issue of air pollution, a plan to set up a number of permanent air quality monitoring stations in Ho Chi Minh City and in the southern provinces has been actively pursued. More important, the Ho Chi Minh City People's Committee announced an order in March 1996 to enforce the compliance of road vehicles with emission regulations (Trung 1996), which has been enforced by the traffic police department throughout the city since then. In the "Clean and Green" Week of 12 to 19 May 1996, 410 vehicles were booked for emissions offences.

The Ministry of Science, Technology and the Environment currently has a plan to set up some permanent environmental monitoring stations in many cities, including Hanoi, Hai Phong and Da Nang, with the help of other countries. In Ho Chi Minh City the Ho Chi Minh University of Technology has assisted in this effort by providing some technical help and evaluation.

To contain the problem of air pollution, traffic flow and transport management are important. The Office of Transport in Ho Chi Minh City put a proposal to the People's Committee to increase the capacity of traffic flow at intersections of 12-16 m width by building tunnel at 4.5-5 m depth and 8-8.5 m wide. It is proposed that the first tunnel be built at the intersection of Nam Ky Khoi Nghia and Tran Huy Lieu Streets, which would much improve traffic flows. A feasibility study on the building of a traffic control centre was completed in 1998. This centre will be able to control 48 routes and intersections. Camera systems at 4 intersections and 48 traffic signals in several city districts are also to be installed.

At a seminar organized in 1998 by the People's Committee with the participation of many city organizations and the Overseas Economic Cooperation Fund of Japan, financing for development and planning of urban traffic systems was discussed and proposed. A master plan for transport and communication prepared by the Municipal Department of Communications and Public Works was presented. Under this plan, new main roads linking new urban centres to be developed to the east and south of the city, and a ring road around the city are to be built. Three railway lines are also proposed: from Bien Hoa to Hoa Hung and Phu Lam; from Tan Son Nhat airport to Ben Thanh market (then possibly crossing the Saigon River towards Thu Thiem and the new international airport to be built at Long Thanh, Dong Nai Province); and from Cho Lon to the city centre and Binh Thanh district, then towards the east. This plan is quite ambitious, however. It is not clear how the city can finance this project, even with the help of overseas aid, or keep to the timetable proposed for its implementation.

VI. SOME SUGGESTIONS FOR AN AIR QUALITY MANAGEMENT PLAN IN HO CHI MINH CITY

Ho Chi Minh City can benefit from the experience gained by Asian and other world cities, in dealing with environmental problem in recent years. Many of these cities have similar development patterns resulting from similar strong economic growth. In view of the growing problem in Ho Chi Minh City, the practical measures discussed in the following sections could be considered for incorporation in the air quality management plan.

A. Introduce unleaded petrol and cleaner fuel

Spectacular reductions in lead levels have been achieved in many cities which gradually phased out leaded vehicles. In Bangkok, after unleaded petrol was introduced in July 1991, a 1996 study of newborn babies showed that blood lead levels were one third of those from before the introduction of unleaded petrol (*Bangkok Post,* March 1996). Even in adults, blood lead levels were found to be lower than in neighbouring cities such as Manila and Kuala Lumpur. This can be attributed to lower lead levels in the atmosphere (Shang et al. 1999). Singapore stopped the distribution and sale of leaded petrol in July 1998.

Of all pollution control measures, the reduction of lead is probably the most important gain in terms of benefits to the health of people living in cities, especially children. However, the use of unleaded petrol increases levels of volatile organic compounds such as benzene and toluene in the air. Newer car models can reduce the emission of these pollutants compared to earlier models using unleaded petrol. The testing of exhaust emissions from used motor vehicles in Bangkok has shown that newer models significantly reduce the emission levels of these pollutants (Muttamara et al. 1999).

Consideration should also be given to reformulated gasoline. Reformulated gasoline, or gasoline blended with ethanol or methanol, significantly reduces volatile organic compound emissions from cars. Volatile organic compounds contain many carcinogenic chemicals such as benzene and toluene. Reformulated gasoline had been introduced and used in many cities in the United States, with significant gains such as the reduction of ozone formation. In 1998, the Central Pollution Control Board of India proposed the introduction of reformulated gasoline (with 3 to 5 per cent ethanol or methanol) on an experimental basis in New Delhi.

SO_2 is not of great concern in Ho Chi Minh City, but consideration should be given to encouraging the use of and gradually introducing low-sulphur diesel fuel. Newly acquired commercial trucks and buses should have engines that are able to use low-sulphur fuel. This would reduce SO_2 emissions from buses and utility vehicles, which are the main sources of high SO_2 levels near traffic sites. Low-sulphur diesel fuel was introduced into Thailand in 1991. Bangkok relies on large power plants for electricity and power-generating plants began to use clean coal technology in 1992.

B. Establish standards for emission control of vehicles

All new vehicles (including motorcycles), whether assembled, manufactured locally or imported, should be required to conform to the emission control regulation. The introduction of catalytic converters for motor vehicles should also be considered.

One example of this measure is that of the Ministry of Science, Technology and the Environment and the Pollution Control Department, of Thailand who together set up emission standards for cars in 1992 and for motorcycles in 1993. Since 1995, all buses, three-wheeled cars (tuk-tuks) and boats have been tested for emission compliance before registration.

In India, in an effort to clean up the polluted air of New Delhi, the Supreme Court ruled in 1999 that new cars sold in and around the capital had to conform to Euro II emission standards from April 2000. Indian car manufacturer such as Maruti have announced that they will produce cars that meet the standards.

According to the Environment Committee of Ho Chi Minh City, up to 85 per cent of road vehicles do not comply with emission regulations. Since the beginning of 1996, traffic police have enforced the emission compliance of road. Some of the difficulties in enforcement are the lack of emission standards and the fine for motorcycles being too low (Trung 1996). A more effective measure would be to check vehicles for emission compliance before registration. The check for emissions should be done before any vehicle can be registered.

As pollution from nitrogen oxides and carbon monoxide is very high in Ho Chi Minh City, the introduction of catalytic converters in the exhaust systems of vehicles would improve the situation. These converters reduce the amount of nitrogen oxides, carbon monoxide and unburnt petrol escaping into the air. In New Delhi consideration is now being given to requiring all engines to be fitted with catalytic converters to reduce unburnt fuel.

Measures, such as the one recently announced by the New Delhi government to ban all taxis, buses and auto rickshaws over 15 years old to combat the daily pollution blanket over the city are too drastic for the situation in Ho Chi Minh City. However, regulations should be introduced to discourage the use older cars and motorcycles.

C. Establish permanent on-line air quality monitoring stations

The monitoring of air quality is the main means of accessing the effectiveness of any air quality management plan, as well as providing information on air quality in the city. The design of the network and the type of pollutants to be measured are considered important factors in assessing the air quality of a particular city. Permanent continuous monitoring stations also provide data on long-term trends in air pollution levels.

Recognizing the importance of air quality monitoring as part of environment management, a number of countries in the region have recently started establishing networks of air quality stations. The largest air quality monitoring network in Asia is in Taiwan, with 66 monitoring stations distributed throughout the large cities of the island, especially in Taipei. In Bangkok the Pollution Control Department started to implement Phase I of a plan to establish permanent monitoring stations in 1993: this involved 8 stations. Phase II will take place over the next few years, and involve 20 more stations.

In Kuala Lumpur air quality monitoring was previously outsourced to private companies, but recently the Government has funded the University of Malaya to set up a few mobile stations to acquire data. This change was made after legal problems arose as the responsibility for data quality assurance was not clarified. As air quality data is essential for successful monitoring of the effects of the implementation of air pollution control strategies, the Government or city authority should always retain responsibility for collecting the information.

In Ho Chi Minh City air quality data is currently measured and collected by different organizations. The Office of Science, Technology and the Environment regularly funds the CEFINEA group at the Ho Chi Minh University of Technology to monitor and evaluate the air data. Due to lack of instruments, only a few pollutants are measured. Some of the instruments are made in-house. The pollutants are measured for a specified period and are manually collected at all sites. The air quality reports are not widely known and available.

D. Develop an information and forecasting service

If an air quality information and forecasting service were established, it could provide timely information to people in the event of high pollution days resulting from particular meteorological conditions. This would also raise general awareness of environmental issues. The air quality reports should be made available publicly.

In China the National Environmental Protection Agency, started to issue weekly comparative air quality reports on major cities in 1998, in a bid to enable the public to supervise the anti-pollution efforts of the Government (*International Environment Reporter* 1998). This is an important step, as it shows the determination of the Government to face the challenge of improving air quality.

As the mass availability of communications and computing technology such as the Internet is expanding rapidly, it would also be effective to make daily information on our quality available on the internet in order to reach a more informed audience. Viet Nam has been linked to the Internet via several fast lines since 1997. Usage of Internet services is increasing in growth centres such as Ho Chi Minh City and Hanoi. Some cities in the region, such as Bangkok and Singapore, already provide this service on a daily basis.

E. Publish names of companies violating environmental standards

The publication of a blacklist, for example, the ten worst companies violating environmental standards would force those companies to improve their images, in addition to having to pay the fines for such violations. This blacklist would also inform the public of the record of these companies in terms of environmental responsibility. The publication of a gold list of companies with the best environment records and practices could be a powerful incentive to companies to strive for better performance.

In Indonesia the environmental protection agency announced such a scheme, called Proper-Prokasih, in 1996. The results suggest that it has had a positive impact on the behaviour of polluters (World Bank 1999). This programme focuses primarily on industrial water pollution, but it could also be extended to air pollution. The following year, the Philippine Department of the Environment and Natural

Resources announced a similar public scheme, called EcoWatch, for both air and water pollution. The EcoWatch programme and its results have been widely reported in the press and have brought a positive public reaction. The success of these case studies has been noted in many countries.

F. Adopt the "polluter-pays" principle and set up a regulatory framework

The adoption of the "polluter pays" principle and the establishment of a regulatory framework would mean that production units, not the State, would be responsible for controlling emissions. To implement this, a strong independent regulatory agency with powers of enforcement would be required. Such a regulatory agency could levy an emission tax for each emission source, based on the amount of emission. The levy could be used partly for monitoring and partly for the improvement of environmental resources or education. Polluters should be penalized to make them less competitive in the market place. Experience shows that such a scheme always benefits the environment because it forces dirty industries to obtain cleaner technology.

The levy based on the emission load could be set up on an annual basis as part of the operating licence requirements. Large manufacturing companies with substantial emissions which could have an impact on air quality in the surrounding areas could be made subject to additional conditions requiring them to monitor air pollutants. Such self-monitoring would be reported to the environmental authority on a regular basis. If any of the air quality guidelines were exceeded, efforts to reduce the load would have to be made. The environmental agency would make its monitoring reports available to the public. This transparent scheme has been adopted by environmental regulatory agencies in many states and countries, including Australia.

Policies giving incentives to industries to reduce emissions are also needed. Industries should be encouraged to implement process changes in order to obtain ISO 14000 or 14001 certification. A number of companies, especially export-oriented ones, have already implemented changes and obtained the ISO environmental standard. Another new approach to speed up the reduction of emission is the emission-trading scheme. Experience of the trading scheme for SO_2 in the United States of America has shown that it has both environmental and economic benefits.

China has recently started a comprehensive reform of the pollution levy system covering all pollution sources including air, water, noise and waste (Bohm et al. 1998). The majority of pollution sources are the state-owned enterprises which have been propped up by the State for many years. The penalizing and treating of state-owned enterprises in the same way as other offending pollution sources are treated, shows the seriousness of the commitment of the government to reducing environmental damages, as well as to economic reform. The lessons of this reform should be very instructive.

G. Introduce transport planning to reduce traffic congestion

The present total road length is about 1,685 km (an average of 820 m of road per square kilometre) or about 4,000 km of traffic lanes. According to the city authority, to provide adequately for traffic flow, city vehicles require at least 9,200 km of traffic lanes. In recent years a number of initiatives have been taken, such as road widening and private build-operate-transfer schemes to reduce congestion and improve traffic flow. However, this has been out of necessity rather than the result of a careful or effective planning process.

Transport planning also involves the diversion of traffic in case of congestion, the management of traffic flows, effective traffic light coordination, and so forth. It is noted that the high level of nitrogen oxides and carbon monoxide pollution at many traffic sites is due mainly to traffic congestion. Unless there are policies to restrict the number of registered vehicles and to encourage other modes of transport, the building of new roads will not solve traffic congestion. The increasing number of vehicles would quickly make the return of congestion highly possible.

The traffic consists mainly of two-wheeled vehicles and almost no roads have clear lanes for different vehicle types, except at a few main roads in the city centre. One practical low-cost suggestion for improving traffic flows on some streets is to designate traffic lanes for different types of vehicle, giving priority to bus lanes. The city authority’s proposal is to allow pedestrian and public transport access (and deter other vehicles by charging a high fee) to some quarters in the city centre, as has been done in Singapore. This may not work, since the traffic congestion and high volume of traffic flows are mostly happening outside the city centre.

Traffic congestion is made worse by the numerous traffic accidents in the city. Since the economic reform of the late 1980s, the number of traffic accidents has increased rapidly. From 1990 to 1997, traffic accidents accounted for about 30,000 deaths and 94,000 injuries (Levine 1997). These figures are not surprising as there is no requirement for a motorcycle driver to have a driving licence, nor is there a minimum age limit unless the motorcycle engine capacity is 75 cc or above. In fact, most registered motorcycles in the city are of 50 cc capacity or below. Education on basic traffic rules, as well as regulations stating minimum requirements for driving a motorcycle would improve the situation.

Although heavy-duty trucks and commercial vehicles are restricted to the main arterial roads and are only allowed to travel at certain hours of the day, the inadequacy of alternative road access gives rise to numerous violations. This also provides fertile ground for corrupt practices. Priority should be given to new ring roads, bypassing the city altogether and linking the northern highways to the southern provinces.

H. Increase usage of public transport

At the moment, the provision of public transport, mainly buses, is low. The bus transport system meets less than 5 per cent of transport needs. Consequently, there is an increasing number of taxiing services involving cars, small private buses and even motorcycles. Moreover, with increasing members of tourists coming to the city the demand for convenient transport in the city is increasing. A scheme to expand bus services in many parts of the city, especially along high traffic routes, will ameliorate the traffic and pollution problems. Recent efforts by the city authority to introduce new buses to serve existing and new routes is encouraging, but the uptake of bus transport remains low.

Low-sulphur diesel fuel should be introduced, not only for buses, but also for all trucks and heavy-duty vehicles. As particulates emitted from diesel fuel burning are highly toxic and contain many carcinogenic compounds, it may be appropriate to invest in running part of the bus fleet on compressed natural gases. This technology is now available although the cost is still about double that of diesel-fuel technology. Natural gas vehicle (NGV) bus fleets are running successfully in many cities of the world, such as Sydney, Caracas, Los Angeles and New

York. The Government of the United States of America has a policy of introducing NGVs in government fleets; the United States Postal Service has the world's largest NGV fleet. In 1998 the Government of Malaysia purchased 1,000 NGVs at the time of the Commonwealth Games, and these have now been redeployed as taxis. In Egypt the Government has speeded up plans to set up natural gas fuelling stations outside Cairo.

Another advantage of using NGV is that Viet Nam has abundant supplies of natural gas available from its offshore oil fields, which can be used at a much lower cost than diesel. NGV buses emit 60 per cent less nitrogen oxides, carbon monoxide and harmful particulate than diesel buses. In the long run, the benefits of NGVs outweigh their initial cost, given the lower health and environmental costs due to fewer adverse effects from air pollution.

Consideration should also be given to creating a light rail network in some sections of the city to complement the bus network. The city's transport and communications master plan specifies the future construction of three main railway lines. However, it is not clear whether a feasibility study has been conducted to determine the cost of the project and the time scale of its implementation. A light rail transit (LRT) system was implemented in Kuala Lumpur and is now running successfully. A second light rail system is being built, as well as a rail link to the new airport. Bangkok is also developing a mass transit system based on an elevated LRT system.

Lastly, human-powered, three-wheeled "cyclos" should not be completely banned in the city area, as happened recently. This form of transport is non-polluting and is many people's means of support. Rather than banning its use in the city centre, a limited number of cyclos should be allowed. Many people prefer this mode of transport. In Indonesia the pedicab is also very popular and still in use, although it is officially banned from the streets of Jakarta. The cyclo is popular with both local people and tourists, and contributes to the city's character.

I. Conduct airshed studies and an emission inventory for the city region

Airshed studies involve the detailed understanding of the transport mechanism of air due to meteorology and the emission inventory of both stationary and mobile sources. An airshed model can be made or adapted from well-known urban airshed models publicly available from organizations such as the United States EPA or the California Institute of Technology. The model can then be used as a tool to portray different scenarios resulting from different control strategies. This computer model can be an invaluable tool in the search for the best way to formulate an appropriate response to the air pollution problem. Particular emphasis should be placed on particles as well as gaseous pollutants.

If time and resources are problems in conducting a detail study, then at least an emission inventory of the amount of different pollutants emitted into the airshed from different sources (factories, domestic sources, cars, motorcycles, and so forth) during each month of the year could be conducted. This would at least provide an overview of the potential air quality problem for the urban area under consideration. The emission inventory might have to be updated (say, once in two years) depending on the rate of industrial and traffic growth in the area.

In addition, more studies on the effects of air pollution on people's health would help to ascertain the economic cost of air pollution. Studies could include the relationship between levels of particles, lead and volatile and reactive organic compounds with people's health. The many studies conducted before in other cities could be referred to in order to gauge the economic benefits of reducing these pollutants in ambient air.

J. Formulate an air quality management plan based on the airshed studies and the economic implications of various control strategies

Due to meteorological conditions and recirculation during the dry season, the highly concentrated new industrial parks in the north, north-east and south of the city can aggravate the air quality problem in the city. Using an the airshed study, a more effective air quality management plan, taking into account transport requirements and industrial development, could be formulated, avoiding serious degradation of the air environment of the city. For example, airshed simulation studies based on current emissions from mobile and stationary sources can predict the daily level of nitrogen oxides, ozone, sulphur dioxide or particles at various places in the city area. Different scenarios can be applied to see the effects of changing the emission input via urban redevelopment, industrial relocation and development, public transport routing, or reducing current motor vehicle emissions by, for example, 20 per cent.

Levels of pollutants have exceeded national standards at many locations in the city. It is important to identify which pollutants should be targeted for a reduction in their emission levels and to study various control strategies and their economic implications. If particles PM_{10} and $PM_{2.5}$ levels are to be reduced as a policy priority, methods to estimate the health and economic benefits of particle level reduction are available (Ostro 1992 and 1998). The cost of implementation is dependent on the plan, which can be chosen from the best scenario of the simulation study. Costs can be short term, whereas benefits are always long term. Alternatively, if NO_2 is targeted, emissions from motorcycles, which currently contribute, about 70 per cent of total emissions, could be reduced by a plan such as phasing out the old fleet by incentive schemes, limiting total fleet growth and providing more public transport. Currently, the economic benefits of NO_2 reduction are hard to quantify, as the studies looking at its effects on health are not yet as comprehensive as those relating to particles.

CONCLUSION

The air pollution problem in Ho Chi Minh City is rapidly becoming as serious as other larger cities in the region. Levels of sulphur dioxide and lead are low compared to other cities, but they are increasing. Levels of particles, nitrogen oxides and carbon monoxide are similar to, or higher than, those of a number of other cities, such as Bangkok, Tokyo and Manila.

To address the problem of increasing degradation of air quality in many cities in the Asian region, many governments are now actively pursuing plans to contain the problem. For example, the Government of the Philippines has taken initiatives to meet this challenge, one of which was to call for and organize a meeting in 1995 on sustainable development within Asia-Pacific Economic Cooperation countries. The aim of the meeting was to establish a collaborative framework for protecting the environment. A number of initiatives have also recently been taken to contain the air quality problem in Ho Chi Minh City, but a more focused and integrated plan, using the experience gained by other cities that have suffered serious degradations in air quality in the past, is vital to prevent the situation of air pollution in the city from getting worse and becoming harder to contain in the future.

Annex

AIR QUALITY STANDARDS OF SELECTED COUNTRIES AND OF WHO

Pollutant	*Country*	*Annual average*	*Daily average*	*Daily maximum*	*Hourly average*	*3-month average*	*8-hour average*
Total suspended particulates (mg/m^3)	China	0.3	1.0				
	India	0.2					
	Indonesia		0.26				
	Thailand	0.1	0.33				
	Philippines		0.15		0.25		
	Viet Nam		0.2		0.3		
	Japan		0.1	0.2			
	United States	0.075		0.26			
	Australia (NSW)	0.09					
	WHO	0.06-0.09	0.15-0.23				
Particulate matter<10 μm (mg/m^3)	United States	0.05	0.15				
	Australia (NSW)	0.05	0.15				
	European Union		0.07				
	WHO		0.07				

Annex *(continued)*

Pollutant	*Country*	*Annual average*	*Daily average*	*Daily maximum*	*Hourly average*	*3-month average*	*8-hour average*
			0.3				
Sulphur dioxide	Philippines		0.37	0.85			
(mg/m^3)	Viet Nam		0.3		0.5		
	Japan		0.11	0.26			
	United States	0.08		0.365			
	Australia (NSW)	0.06			0.7		
	WHO	0.03	0.09		0.35		
	China	0.12	0.1-0.15	0.15			
	India	0.08	0.0925				
	Indonesia		0.0093				
	Philippines				0.19		
Nitrogen dioxides	Thailand				0.32		
(mg/m^3)	Viet Nam		0.1		0.4		
	Japan		0.04-0.06				
	United States	0.1					
	Australia (NSW)	0.1			0.32		
	WHO		0.16		0.19-0.32		

Annex *(continued)*

Pollutant	*Country*	*Annual average*	*Daily average*	*Daily maximum*	*Hourly average*	*3-month average*	*8-hour average*
	WHO		0.065		0.15-0.2		
Lead (mg/m^3)	Indonesia		6.0				
	Thailand		0.01(7)				
	Viet Nam		0.005				
	European Union	0.002					
	United States					0.0015	
	Australia (NSW)					0.0015	
	WHO	0.0005-0.001					
Carbon monoxide (mg/m^3)	India	2					
	Indonesia						22.6
	Viet Nam				40.0		10.0
	Australia (NSW)				30.0		10.0
	United States				40.0		10.0
	WHO				30.0		10.0

Source: Compiled from different sources.

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