AIR QUALITY MANAGEMENT CAPABILITY IN ASIAN CITIES

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ABSTRACT

Air pollution continues to pose a significant threat to the environment, quality of life and health of the urban population in Asia. Levels of air pollution in Asian cities regularly exceed World Health Organization recommended guidelines as well as national air quality standards. Many Asian cities have developed some form of air quality management (AQM) system to address the increasing levels of urban air pollution. However, the sophistication and completeness of the AQM system may not be adequate to effectively address the air pollution problem. An assessment of AQM capabilities of twenty-three cities in Asia was undertaken using the MARC AQM Capability Index questionnaire as part of a benchmarking exercise. Local authorities responsible for AQM in each city completed the questionnaire. The Index outlines four sets of indicators which represent the key components of AQM capability. The preliminary results from the assessment provide a comparative analysis of AQM capability among twenty-three Asian cities at different stages of economic development. The results from the AQM capability assessment were validated against city profiles, which were composed for each of the cities included in the benchmarking study. This paper identifies the key measures required to provide a comprehensive AQM and to improve urban air quality in the cities of Asia.

INTRODUCTION

Air pollution is increasingly posing a significant threat to the health, quality of life and environment of the urban population in Asia. Millions of people living in the largest cities in Asia are being exposed to some of the highest air pollutions levels in the world. Levels of air pollution in Asian cities regularly exceed World Health Organization (WHO) recommended guidelines and national air quality standards with fine particles (PM_{10}) being the main pollutant of concern.

The Air Pollution in the Megacities of Asia (APMA) project together with the Clean Air Initiative for Asian Cities (CAI-Asia) is undertaking a study on *Benchmarking Urban Air Quality Management in the Cities of Asia.* This a first attempt at undertaking a systematic assessment of the current status of air quality management (AQM) in Asian cities. It is intended to provide a benchmark from which future initiatives and progress in Asia can be assessed. It aims to allow the exchange of lessons learnt in dealing with urban air pollution issues in different countries at various stages of economic development. The study aims to gain an overview of the current capacity to manage air quality in different Asian cities. There are large differences in the developmental stage of the cities, based on this it is important that information presented in this paper are not interpreted as a ranking of cities in terms of air quality or AQM.

URBAN AIR POLLUTION IN ASIA

A useful framework to examine urban air pollution is Asia is the classic *Driving force – Pressure – State – Impact – Response* (DPSIR) framework. [1] As the wealth of a city and its citizens increases the driving forces (e.g. transport demand), pressures (e.g. emissions), state (e.g. air quality) and impacts (e.g. health, environmental and economic detriment) they face move from those that are located mainly in households and communities and impact on the city and urban region (e.g. emissions of particulates that affect urban air quality and have a direct impact on human health) to a global level (e.g. the delayed impact of tropospheric ozone on crops and forests and the emissions of greenhouse gases and global climate change). This results in responses (e.g. regulation, monitoring and enforcement) targeted at preventing and ameliorating the problems.

The Asia region has experienced a rapid growth in population and urbanization over the last decade, especially within South Asia. The percentage of the population living in cities is expected to substantially increase over the coming years. [2] The growth in population, urbanization and a strong economy has been accompanied by a rapid growth in motorization and a considerable increase in energy use The cumulative impact of these different driving forces have been experienced in countries such as India and the China – some of the most populous countries in Asia.

Technological improvements in fuel capacity, combustion technology and emission control technologies make it possible to considerably reduce the emissions per unit of fuel used. In those countries and cities in Asia where such technological improvements are widely adopted, the actual pressure on the environment resulting from the growth in the drivers of air pollution (i.e. population growth, urbanization, motorization and energy use) will be less intense than in countries and cities where regulatory pressure and private sector has not yet resulted in the wide scale adoption of low emission technologies.

Emission source data in Asia is often fragmented and incomplete. The absence of reliable emission inventories, incomplete activity data and location specific emission factors for area, point and mobile sources of pollution explain the lack of detailed estimates of emissions at the local, national and regional level in Asia. However, if carbon dioxide (CO_2) is taken as a proxy for emissions of other criteria pollutants, it becomes clear that overall emissions will increase substantially in the future. [3]

The state of air quality in Asian cities is becoming increasingly well documented due to improvements in air quality monitoring. Yet, there are still considerable differences in the number and type of pollutants measured, coverage of monitoring stations and the monitoring methodology. These cautionary remarks explain why the annual average values presented in Figure 1 for individual pollutants at the city level should not be interpreted as a ranking of air quality by city. In general, PM_{10} is the main pollutant of concern in Asia. However, in cities with large and growing vehicle fleets there is increasing concern over levels of nitrogen dioxide (NO_2) and ozone (O_3). Limited information exists on levels of air toxics and trace metals in the atmosphere in Asian cities, however, where measurements have been undertaken, it is apparent that substantial problems exist. [4]

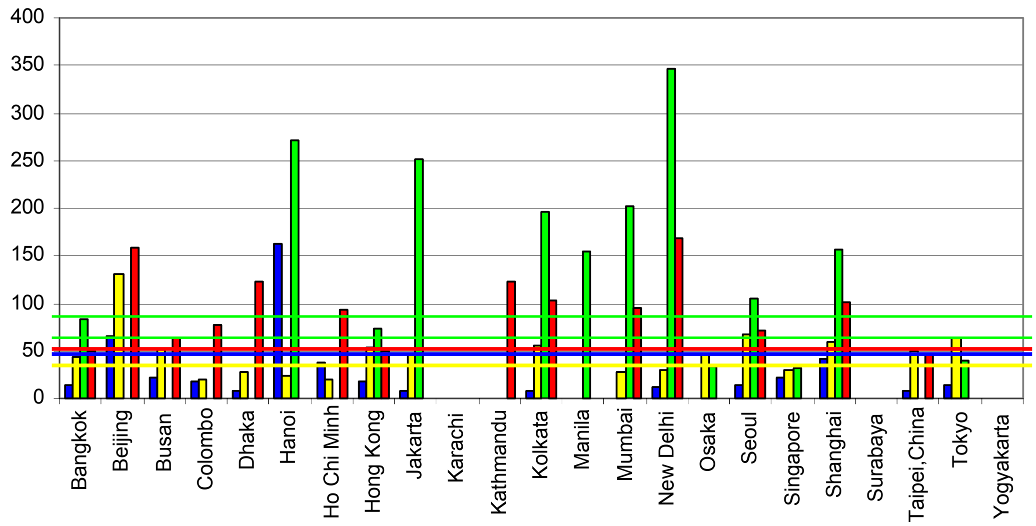

Figure 1. Average Annual Air Quality Levels for 2000 – 2003 in Selected Asian Cities

■ = PM_{10} Limit = 50 µg/m^3 (USEPA, 1997) [5]
■ = SPM Limit = 60-90 µg/m^3 (WHO, 1979) [6]
■ = NO_2 Limit = 40 µg/m^3 (WHO, 2000) [7]
■ = SO_2 Limit = 50 µg/m^3 (WHO, 2000) [7]

Notes: Busan (2000-2002); Dhaka (2002-2003); Hanoi (2000-2002); Jakarta (2000-2001); Kathmandu (2003); Manila – PM10 (2002-2003); Mumbai (2000-2001); New Delhi (2000-2002); Osaka (2000-2001); Seoul (2000-2002), SPM (2000-2001); Tokyo (2000-2001)

The WHO has ranked ambient air pollution as the seventh leading cause of premature deaths. [8] The Global Burden of Disease study estimates that 487,000 persons die prematurely each year due to exposure to ambient air pollution. In addition, millions of people are affected by respiratory diseases, which are either caused or aggravated by exposure to ambient air pollution. Air pollution results in a substantial economic cost. Typically the annual cost of air pollution in a megacity ranges from US$ 100 to 300 million per year. [9] There is emerging evidence that the poor are affected disproportionately by ambient air pollution due to greater exposures, weaker biological defence mechanisms against air pollution and more limited abilities to seek medical assistance once affected by air pollution. [10, 11, 12]

In conclusion, the drivers of air pollution are increasing and although the pressure on air quality is not increasing in a direct ratio due to technological improvements, there is substantial evidence on the state of air quality and the impact of pollution, which confirms the seriousness of air pollution as a developmental problem with costs to individuals and households as well as society as a whole.

AIR QUALITY MANAGEMENT CAPABILITY

Methodology

The Strategic Framework on Air Quality Management developed by APMA and CAI-Asia is a high-level approach that is flexible and adaptable to the needs of different countries and cities. [13] The Strategic Framework identifies seven main components of a comprehensive AQM:

1. Air quality Policies
2. Air Quality Governance
3. Emissions
4. Air Quality Modelling
5. Air Quality Monitoring
6. Health, Environmental and Economic Risk Assessments
7. Financing of AQM

Capabilities for each component of an AQM system are an essential requirement for achieving a sustainable urban environment for those cities experiencing air quality problems. [14] Each category of capability is equally important in developing appropriate and cost-effective AQM strategies.

An assessment of AQM capabilities enables the identification of the strengths and weaknesses of a city's current capabilities. In order to provide an assessment of AQM capability in Asian cities, it is necessary to develop indicators to assess each component of capability. Each component indicator can be then grouped in an index of AQM capability. The index provides a useful tool to identify deficiencies and to allow comparisons between cities at different stages of economic development.

The 1996 MARC/UNEP/WHO study of AQM in twenty major cities throughout the world developed a methodology to assess AQM capabilities in the form of a questionnaire survey. The AQM capability questionnaire survey was also conducted in sixty-four major cities of Europe. [15] Four sets of indicators (indices) representing the key components of AQM capability were used:

1. **Air quality measurement capacity index:** assesses the ambient air monitoring taking place in a city and the accuracy, precision and representativeness of the data collected.
2. **Data assessment and availability index:** assesses how air quality data is processed to their value and to provide information in a decision-making relevant format. It also assesses the extent to which there is access to air quality information and data through different media.
3. **Emission estimates index:** assesses emission inventories, and their scope, undertaken to determine the extent to which decision-relevant information is available on the sources of pollution in the city.
4. **Management enabling capabilities index:** assesses the administrative and legislative framework through which emission control strategies are introduced and implemented to manage air quality.

Each of the four component indexes consists of a number of indicators, which are designed to determine a city's capacity with respect to a particular element of management capability.

As part of the benchmarking exercise, an assessment of AQM of twenty-three Asian cities was undertaken using the methodology developed in the MARC/UNEP/WHO study. The original questionnaire was revised taking into consideration technological developments and the situation unique to Asia. A number of city authorities in Asia were requested to complete the questionnaire survey covering the key component indicators.

Each question was allocated a score. The total number of points available for each component index is 25. The more questions answered positively the greater the management capability of that city.

The responses to the questionnaire survey from city officials and other key informants were reviewed and validated by the study team. Use was made of the city profiles which were also composed for each of the cities included in the study and which contained a description of the AQM systems. Clarifications were undertaken by email, telephone or face-to-face meetings to obtain additional information.

Table 1 presents five bands of AQM capabilities according to scores obtained from the questionnaire survey. Each component index has also been combined to provide an overall assessment of the AQM capability. Each of the four indexes have a maximum score of 25 indicator points; by adding these together an overall assessment of capability is obtained with a maximum score of 100. The same five bands used for the component index are used for the overall capability index. [14]

Table 1: Scorings for the component and overall capability indices

Effectiveness of capability	Component index score	Overall capability index score
Minimal	0–5	0–20
Limited	6–10	21–40
Moderate	11–15	41–60
Good	16–20	61–80
Excellent	21–25	81–100

Source: [14]

The index score obtained from the questionnaire provides a useful tool for assessing AQM capability. It provides an indication of the AQM capabilities of Asian cities and identifies which cities could further develop their capacities it also allows a comparison with the AQM capabilities of other cities at similar and different levels of development. It provides quantitative information which can be used to examine the relationship between different components of management capability.

RESULTS

Table 2 presents the results of the questionnaire survey for the four AQM capability indices.

Air quality measurement capacity index

An increasing number of cities in Asia now monitor air quality on a regular basis. However, there is still a significant portion of the urban population in Asia living in cities where air quality is not monitored regularly. The use of continuous monitoring stations with an emphasis on monitoring regular criteria pollutants such as carbon monoxide (CO), sulphur dioxide (SO_2) and nitrogen oxides (NO_x) are becoming more widely used. Fewer cities monitor lead and O_3, although over the last few years there has been an increase in the monitoring of O_3. While total suspended particulate (TSP) has been monitored for some time, PM_{10} is less widely monitored and very few cities monitor $PM_{2.5}$ on a regular basis. Quality assurance and quality control procedures are often underdeveloped although where they do exist they tend not to be well documented. The costs for the establishment of air quality monitoring systems in several of the cities in the study were borne by development agencies. The sustainability of several of these systems may, therefore, be questionable.

Table 2: AQM capability in different Asian Cities

City	Air quality measurement capacity index	Data assessment and availability index	Emission estimates index	Management enabling capabilities index
Bangkok	●●●●●	●●●●●	●●●●●	●●●●
Beijing	●●●●●	●●●●●	●●●●	●●●●●
Busan	●●●●●	●●●●	●●●●●	●●●●
Colombo	●	●	●	●●●
Dhaka	●●	●●	●	●●●
Hanoi	●●●	●●	●●	●●●●
Ho Chi Minh	●●●●●	●●●●	●●●	●●●●
Hong Kong	●●●●●	●●●●●	●●●●●	●●●●●
Jakarta	●●●	●●●●	●●●●	●●●●
Karachi	●●	●●	●	●●●
Kathmandu	●	●●	●●●	●●●●
Kolkata	●●●	●●●●	●	●●●●●
Manila	●●	●●	●●●●	●●●●
Mumbai	●●●	●●●	●●●	●●●●
New Delhi	●●●●●	●●●●	●●●	●●●●●
Osaka	●●●●●	●●●●	●●●●●	●●●●●
Seoul	●●●●●	●●●●●	●●●●●	●●●●●
Shanghai	●●●●●	●●●●●	●●●●	●●●●●
Singapore	●●●●●	●●●●●	●●●●●	●●●●●
Surabaya	●	●●	●●●	●●●●
Taipei, China	●●●●●	●●●●●	●●●●●	●●●●●
Tokyo	●●●●●	●●●●●	●●●●●	●●●●●
Yogyakarta	●	●●	●●●	●●●●

Legend:

Minimal ● Limited ●● Moderate ●●●
Good ●●●● Excellent ●●●●●

Data assessment and availability index

Most of the cities conducting air quality monitoring undertake simple analyses. More complex modelling of trends is rare and can only be found in cities with well-developed air quality monitoring network and management systems. Information on air quality is often made available in an aggregated format in the form of an Air Quality Index (API). The raw data are usually not available, which hampers the efforts of academic and research organizations to undertake their own analysis of air quality. Where air pollution indices are being used daily or weekly updates are often published on information boards, television, in newspapers and increasingly on the internet (see Table 3). APIs were intended to communicate air quality and potential health hazards to the public, providing warnings of serious health risks at higher levels of air pollutant concentrations and suggesting possible action. However, APIs in Asia are mostly used to communicate air quality levels in general, without their corresponding recommendations on what special measures should be taken by vulnerable groups.

Table 3: Air Quality Monitoring Data available online

City	Country	Website
Bangkok	Thailand	http://pcd.go.th/AirQuality/bangkok/
Beijing	China	http://www.bjepb.gov.cn/
Busan	Republic of South Korea	http://www.bihe.re.kr
Dhaka	Bangladesh	http://www.doe-bd.org/aqmp/
Ho Chi Minh	China	http://www.doste.hochiminhcity.gov.vn/
Hong Kong	China SAR	http://www.epd-asg.gov.hk/eindex.php
Kathmandu	Nepal	http://www.mope.gov.np/pollution.html
Kolkata	India	http://www.wbpcb.gov.in/html/airquality.php
Manila	Philippines	http://www.emb.gov.ph/
Mumbai	India	http://mpcb.mah.nic.in/envtdata/airtraficjunc.php
New Delhi	India	http://envfor.nic.in/cpcb/
Singapore	Singapore	http://www.nea.gov.sg/psi/
Shanghai	China	http://www.sepb.gov.cn/english/index.asp
Tokyo	Japan	http://www2.kankyo.metro.tokyo.jp/kansi/portal.htm

Emission estimates index

Of all the four indices, the emission estimates index is the weakest. Accurate emission estimates and source apportionment studies, based on the data collected in air quality monitoring, are the foundation for sound AQM programmes in Asia. If the results from air quality monitoring indicate that ambient air quality standards are not being met, in many cases control measures are being formulated and implemented. However, it is uncertain whether the targeted activity is responsible for the non-compliance with the standards. The capacity to conduct an emission inventory in Asia is poorly developed and no standard methodology is in place. The limited capacity that exists is often situated outside the regulatory agencies in academic institutes or with consultancy firms. This further hampers a consistent application of the emission inventory as an essential supportive management tool.

Management enabling capabilities index

Almost all of the cities covered in the study have adopted air quality standards at the national level , which generally comply with WHO ambient air quality guidelines. In addition, a number of cities have been able to adopt more stringent air quality standards through local ordinances. Standards have also been developed for mobile and stationary sources. However emission standards for mobile sources, especially new vehicles, have received more attention than stationary sources. Standards for area sources are generally absent. Although the legislation in several countries allows for special measures to be taken in the case of non-compliance, this is rarely undertaken. This is mainly due to a delay in obtaining the analysed results of air quality monitoring, the absence of appropriate institutional structures, underdeveloped organisational capacity and the lack of political will to restrict or restrain economic activity. The majority of cities that have adopted emission standards have also adopted a system of fines and penalties for non-compliance but enforcement of standards is generally weak, for the same reasons as the non-implementation of ambient air quality standards.

OVERALL ASSESSMENT OF AIR QUALITY MANAGEMENT CAPABILITIES

To arrive at the overall assessment of the AQM for the twenty-three cities covered in the study, the combined results of the four indices were taken into consideration in combination with the city profiles composed for each of the cities. Cities were grouped in different stages of AQM capability (see Table 4).

It is clear from an analysis of the development path of AQM in Asian cities that the improvement of AQM capacity is a process without any real short cuts. While it may be possible for some cities to 'leap frog' certain elements of AQM (e.g. adopting stricter fuel standards and emission standards earlier) and reduce emission levels, this does not mean that the city skip an entire stage of its AQM development.

Based on the results of the benchmarking study, there appears to be a correlation between gross domestic product (GDP) and the capability of the cities to manage their air quality. Increases in GDP make it possible to increase domestic funding of AQM systems, strengthening the capacity of regulatory agencies and reducing the dependence on external donor funding. Donor assistance plays a critical role especially for those cities at Stages 1–3. Insufficient information is available to determine the importance of donor assistance in assisting cities to move to a higher stage. Other factors of importance include awareness of the impact of air pollution and political will to allocate resources to AQM; institutional continuity within regulating agencies; the overall performance; and effectiveness of bureaucratic structures.

The capacity to manage air quality is also determined by the presence of local institutions other than the regulatory agencies, which were the direct focus of this study. Capacity can also be found in academic or other research organisations as well as local consultancy firms. In general, the more advanced the AQM capacity within a city the larger the number of additional organisations and the more structured the linkages between regulatory agencies and other bodies. It is apparent that even in cities with mature or excellent capacity these additional organisations play a substantive role, especially in the area of conducting specialized studies to assist regulatory agencies to achieve more reliable emission estimates

Table 4: Stages of air quality management development *

Stage	Cities
STAGE 5 - Excellent Capacity AQM is a routine activity. Well-established indigenous institutional capacity exists. Air quality levels are typically stable and below WHO guideline values as well as the national ambient air quality standards. Comprehensive control strategies are in place with a strong emphasis on air pollution prevention. Air quality standards and emission standards enforced on a regular basis.	Hong Kong, Osaka, Seoul, Singapore, Tokyo, Taipei
STAGE 4 - Mature Capacity AQM is increasingly comprehensive and well structured. External donor involvement limited to specialized areas. Regular AQM activities funded from local resources. Continuous air quality monitoring. Air quality levels improving and approaching WHO guideline values as well as national ambient air quality standards. Emphasis on development of medium-term strategies for key sources of pollution. Emerging emphasis on prevention of pollution. Enforcement of standards becoming standard practice.	Bangkok, Beijing, Busan, New Delhi, Shanghai
STAGE 3 - Evolving Capacity A systematic approach to AQM is being implemented often with extensive external donor support. Air quality monitoring increasingly through continuous monitoring. Sustainability of institutional capacity not ensured from local resources. Air pollution levels high but stable. A reduction in pollutant levels for certain pollutants as a consequence of pollution control measures. A more structured approach to enforcement is emerging.	Ho Chi Minh, Jakarta, Kathmandu, Kolkata, Manila, Mumbai
STAGE 2 - Basic Capacity Initial legislation, standards and control measures exist. Air quality regulators heavily dependent on external donor support and local specialized institutions. Air pollution levels high and still increasing. Air quality monitoring limited to few stations, often manual monitoring. Enforcement of air quality regulations often very weak.	Dhaka, Hanoi, Surabaya, Yogyakarta
STAGE 1 - Minimal Capacity Cities unable to establish basic AQM capacity. Rising pollution levels common. No comprehensive air quality legislation and standards in place. Limited and *ad hoc* approach to air quality monitoring and pollution control.	Colombo, Karachi

Note: * This table includes only the cities in the benchmarking study – Stage II

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The scope of the benchmarking study did not extend to a comprehensive historical analysis of the development of AQM capacity and earlier studies. Nevertheless, it is possible to characterize the development of AQM capability of cities included in the study in four main categories:

1. **Gradual but steady increase in AQM capability** – typically these are the cities in Stages 4 and 5.
2. **Early starters in AQM but stagnation in AQM capability** - due to loss of political momentum and associated funding progress in developing AQM capability has slowed down e.g. Manila, Jakarta and some Indian cities.
3. **Late starters but relatively fast progress in AQM capability** – this category is exemplified by the Chinese cities included in the study. Strong political commitment, partly resulting from the staging of large international events such as the Olympics in Beijing in 2008 and the World Expo in Shanghai in 2010 have accelerated the development of AQM systems.

CONCLUSION

Benchmarking AQM in Asian cities highlights the overall AQM capacity between different cities and countries. The completion of the AQM questionnaire survey by national and local authorities in Asia was a form of 'self-assessment'. The results of this study were therefore significantly influenced by the validation of questionnaire results by the study team making use of information collated as part of the city profiles. The validation of results for cities with a less developed AQM capability generally resulted in a larger reduction of the initial scores than for the cities with a well-developed capacity. Future studies would need to address further the independent assessment of the information obtained from the city authorities. The questionnaire survey used to assess future AQM capability will need to be adapted to include new priorities in AQM. For example, the original 1996 questionnaire gives relatively little attention to the monitoring and management of PM_{10} and $PM_{2.5}$, which are now of wide concern to national and local authorities.

Based on the collation and validation of information obtained from the questionnaire survey and city profile, the study has demonstrated that AQM capacity varies widely in Asian cities. Some cities in Asia have well-established AQM systems; others have only an intermediate capacity while several have a very limited capacity. Cities with high levels of economic activity and well developed AQM systems tend to have better air quality than those with poorly developed AQM systems. This result provides a strong rationale to increase funding for AQM and strengthen the capacity to manage air quality.

The benchmarking exercise has also identified common weaknesses in AQM that are shared by all cities. Emission data are generally weak. For AQM in cities across Asia to advance, more emphasis needs to be given to the development of standard methodologies for conducting emission inventories and source apportionment studies. The capacities within regulatory agencies to conduct such studies need to be increased. This should lead to emission inventory studies that should be undertaken on a regular basis using internationally accepted methodology and ensuring results are freely and widely available. The benchmarking study has also indicated other general weaknesses such as quality assurance and quality control procedures for air quality monitoring and the general weakness in enforcing ambient air quality and emission standards.

The identification of the stage of development in terms of AQM capability can assist cities in setting priorities and developing strategies for strengthening their AQM capability. Cities with a relative low score need to focus on establishing or strengthening continuous air quality monitoring system and implementing basic control strategies. Cities with higher scores should focus on improving emission data. In the development of air pollution control strategies, they should aim to integrate local air pollution measures with transboundary air pollution and greenhouse gas abatement. All cities will need to ensure that their AQM systems not only manage traditional criteria pollutants such as CO, NO_x and sulphur dioxide (SO_2) but also new pollutants of concern, which include O_3, PM_{10} and $PM_{2..5}$.

Although other global studies of AQM have included Asian cities [14, 16], the benchmarking study is the first of its kind to provide a systematic and comparative analysis of cities in Asia. It provides a baseline against which future studies can be assessed. Periodic benchmarking of AQM enables historical patterns to be distinguished. Taking a historical perspective, the relatively strong increase in AQM capability in China becomes apparent. By monitoring the progress made in developing AQM capabilities, learning from past experience and identifying future priorities, national and local authorities can be assisted in achieving a more sustainable urban environment and a better quality of life for the millions of people living in Asian cities.

REFERENCES

[1] EEA. 1999. Environment in the European Union, at the turn of the Century. European Environment Agency, Copenhagen, Denmark.

[2] see http://www.undp.org/hdr2003)

[3] Marland, G., T.A. Boden, and R.J. Andres. 2003. Global, Regional, and National CO_2 Emissions. In Trends: A Compendium of Data on Global Change . Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A. Available: http://cdiac.ornl.gov/trends/emis/tre_fea.htm

[4] CEN, 2004. Concentration of Toxic PAH in Kathmandu's Air is Three Times Higher Than EU Norms. Clean Energy News: 10 February 2004.

[5] USEPA. 1997. National Ambient Air Quality Standards. Available: http://epa.gov/air/criteria.html#2

[6] WHO 1979. Sulfur oxides and suspended particulate matter. Environmental Health Criteria No. 8. World Health Organization, Geneva.

[7] WHO 2000. Guidelines for Air Quality. WHO/SDE/OEH/00.02. World Health Organization, Geneva. Internet address: http://www.who.int/peh/

[8] WHO. 2002. The World Health Report 2002. Reducing risks, promoting healthy life. World Health Organization, Geneva. http://www.who.int/whr/2002/en/

[9] ADB. 2003. Reducing Vehicle Emissions in Asia. Asian Development Bank. Manila

[10] Martins MCH, Fatigati FL, Ve´spoli TC, Martins LC, Pereira LA, Martins MA, Saldiva PH, Braga AL. 2004. Influence of socioeconomic conditions on air pollution adverse health effects in elderly people: an analysis of six regions in Sao Paulo, Brazil. Journal of Epidemiology and Community Health 2004; 58:41–46 Comments in: J Epidemiol Community Health 2004;58:2-3; and 3-5

[11] Gouveia N, Fletcher T. 2004. Time series analysis of air pollution and mortality: effects by cause, age and socioeconomic status Journal of Epidemiology and Community Health 2000;54:750–755. Available: http://jech.bmjjournals.com/cgi/content/full/54/10/750

[12] Stern, RE. 2003. Hong Kong Haze: Air Pollution as a Social Class Issue. Asian Survey; Sep/Oct2003, Vol. 43 Issue 5, p780, 21p

[13] APMA/CAI-Asia. 2004. A Strategic Framework for Air Quality Management in Asia. Available: http://www.cleanairnet.org/caiasia/1412/article-58180.html

[14] MARC/UNEP/WHO, 1996. GEMS/AIR Air Quality Management and Assessment Capabilities in 20 Major Cities. Monitoring and Assessment Research Center, London, United Nations Environment Programme and the World Health Organization.

[15] EEA. 1998. Europe's Environment: The Second Assessment. European Environmental Agency, Copenhagen, Denmark. Available: http://reports.eea.eu.int/92-828-3351-8/en/toc.html

[16] WHO/UNEP. 1992. Urban Air Pollution in Mega-cities of the World, World Health Organisation/United Nations Environment Programme, Blackwell, Oxford