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3.11 Singapore

Situational Analysis

Singapore has one of the most rapidly growing economies of the 'Asian Tigers'. Located in South East Asia, between Malaysia and Indonesia, Singapore consists of one main island and 60 small islands about 137 kilometres north of the equator with a total land area of 647.5 square kilometres. With a resident population of 3.5 million, Singapore is not classified as a megacity. However, its air quality management and practices have been successful and may serve as a useful example of good practice for Asian megacities.

In Singapore, as in any highly urbanised city, emissions from motor vehicles are a significant source of air pollution. Currently, Singapore has about 560,000 motor vehicles and 130,000 motorcycles. In addition to this, an average of 30,000 Malaysian-registered motorcycles and 3,000 diesel-powered Malaysian-registered goods vehicles ply Singapore roads each day. 12 per cent of Singapore's land area is already taken up by roads and the Government wants to avoid further road expansion. Given the high aspiration amongst Singaporeans to own cars, the Government faces serious challenges in keeping Singapore's roads free-flowing. A number of measures have been introduced to improve public transport and avoid congestion on the existing road network.

Urban Air Quality Trends

Singapore uses a pollutant standards index (PSI) to report ambient air quality. The annual average levels of sulphur dioxide (SO_2) in Singapore have remained relatively constant in recent years. In 2000, the average level was $22 \mu\text{g}/\text{m}^3$ which was below the WHO guideline of $50 \mu\text{g}/\text{m}^3$. Concentrations of nitrogen oxides (NO_x) steadily increased through the latter part of the 1990s with some improvement in the year 2000 when the average level of nitrogen dioxide (NO_2) was $30 \mu\text{g}/\text{m}^3$, and below the WHO guideline of $40 \mu\text{g}/\text{m}^3$. In Singapore, particulate matter (PM) is of concern because of its impact on human health. Coarse particles

usually come from sources such as windblown dust, fugitive dust from paved and unpaved roads and industries, and dust from crushing and grinding operations. Fine particles are emitted from fuel combustion processes in motor vehicles, power stations and industrial facilities. Fine particles are also formed in the atmosphere when gases such as SO_2 , NO_x and volatile organic compounds (VOCs) are transformed by chemical reactions in the air. The 2000 average PM_{10} (particles with diameters ≤ 10 micrometres) level of $31 \mu\text{g}/\text{m}^3$ was within the US Environmental Protection Agency (USEPA) standard of $50 \mu\text{g}/\text{m}^3$. Carbon monoxide (CO), emitted mostly from mobile sources, had an ambient air 8-hourly average level, in 2000, of $0.9 \text{mg}/\text{m}^3$ which is well within the USEPA standard of $10 \text{mg}/\text{m}^3$. During 2000, the air quality for O_3 met the USEPA standard, which stipulates that the one-hour O_3 concentration should not exceed $235 \mu\text{g}/\text{m}^3$ on more than one occasion per year. Figure 3.11.1 shows Singapore's air quality from 1991-2000 as reported by the PSI and Figure 3.11.2 shows annual average ambient levels of SO_2 , NO_x and PM_{10} from 1995 to 2000.

Lead (Pb) levels in petrol had progressively been reduced since the 1980s and, in January 1991, unleaded petrol was introduced in Singapore. On 1 July 1998, leaded petrol was phased out. These measures have proven effective in reducing Pb concentration in the air. From roadside levels of as high as $1.4 \mu\text{g}/\text{m}^3$ in 1984, the Pb levels have been stable at around $0.1 \mu\text{g}/\text{m}^3$ since 1992 and remained at $0.1 \mu\text{g}/\text{m}^3$ in 2000 (ENV, 2001). The USEPA standard for three-monthly average Pb level is $1.5 \mu\text{g}/\text{m}^3$. The WHO guideline for annual average Pb levels is $0.5 \mu\text{g}/\text{m}^3$ and Singapore is currently below that value.

Air Quality Monitoring

Singapore attributes its effective air quality management programme, in part, to regular monitoring and

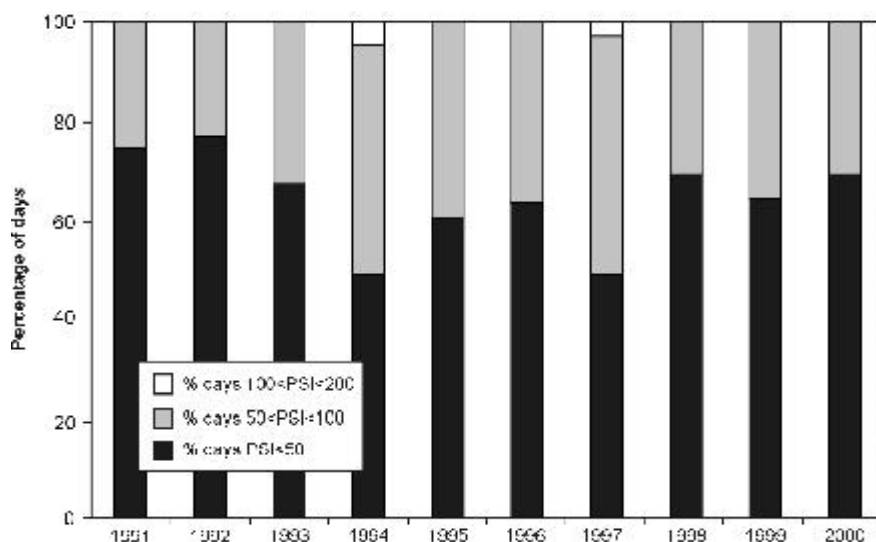


Figure 3.11.1 Singapore's air quality as reported by the PSI from 1991 to 2000 (Source: ENV, 2001)

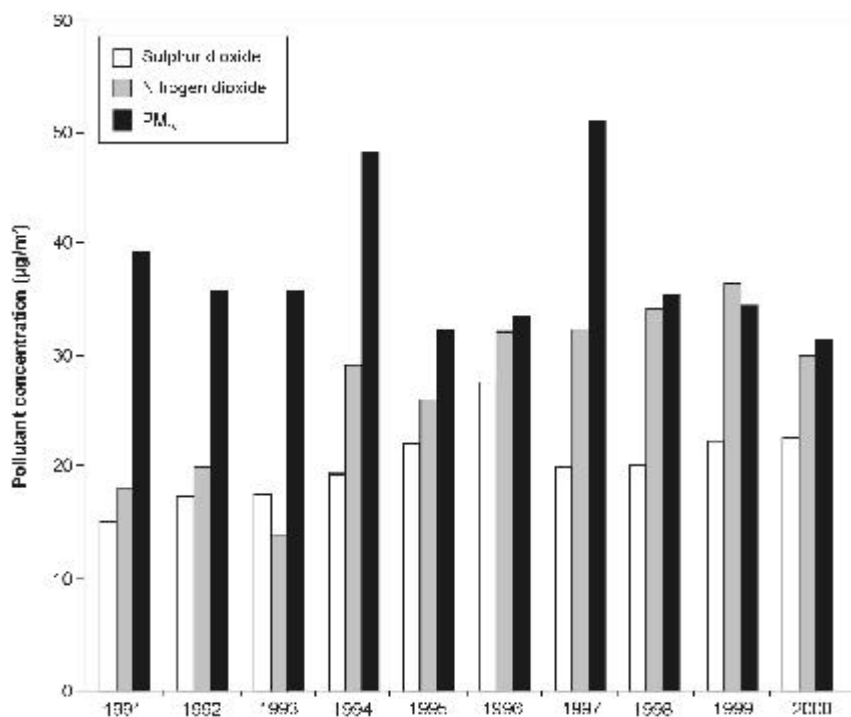


Figure 3.11.2 Annual average levels of ambient air pollution in Singapore, 1995-2000. (Source: ENV, 2001)

assessment of the quality of ambient air. The results have helped in the development and review of pollution control measures.

The ambient air quality in Singapore is routinely monitored by the Strategic Planning and Research Department (SPRD) through the Telemetric Air Quality Monitoring and Management System (TAQMMS) by the Singapore Ministry of the Environment (ENV). The system comprises 18 remote air monitoring stations

linked to a Central Control System via dial-up telephone lines and provides an efficient means of obtaining air quality data.

Fifteen of the monitoring stations monitor ambient air quality and three stations measure roadside air quality. The automatic analysers and equipment at the stations measure the concentrations of major pollutants such as SO_2 , NO_x , CO , O_3 , hydrocarbons (HC) and respirable suspended particles (PM_{10}).

Impacts of Air Pollution

There have been no major studies conducted in Singapore on the health impacts of ambient air pollutants. However, the Singaporean government considers the health risks to be serious and bases its policies on general health impact data for ambient air quality.

The Singapore Government has commissioned a study on indoor air quality. In 2000, ENV continued to investigate complaints of building-associated illnesses in air-conditioned buildings. Using a standardized protocol established in 1995, complaints are investigated via interviews with the occupants of the building and its management. The protocol also requires inspection of the building and air-conditioning system, environmental survey of the office premises and, if necessary, recommendations for the monitoring of indoor air quality.

Enforcement and Control Strategies

In Singapore, air pollution is regulated under the Environmental Pollution Control Act (EPCA 1999) and its subsidiary Regulations. The Environmental Pollution Control (Air Impurities) Regulations 2000 stipulate emission standards for air pollutants. ENV assesses and evaluates the hazard and pollution impact of the proposed industries to ensure that they do not pose unmanageable pollution, health and safety hazards. An industrial facility is allowed to be built only if it is sited in an appropriate industrial estate and can comply with pollution control requirements. In January 1997, ENV introduced a scheme that requires industries to conduct

source emission tests. This is to ensure that industries monitor their exhaust emissions regularly and take remedial measures, where necessary, to comply with the air emission standards. ENV conducts regular inspections of stationary sources of pollution to ensure that pollution control equipment is maintained and operated properly as well as conducting source tests on gaseous emissions, fuel analyses and smoke observations of chimneys. ENV has also published the Code of Practice on Pollution Control which contains information on air pollution control requirements and emission standards.

A wide range of measures are being taken in Singapore to control air pollution from motor vehicles, including :

- Adoption of stringent engine emission standards;
- Adoption of fuel quality standards;
- Periodic mandatory inspection of vehicle emissions by vehicle inspection centres; and
- Enforcement against smoky vehicles by the Pollution Control Department.

With continuing growth of the vehicle population in Singapore, total emissions from vehicles will need to be controlled through stringent emission standards for new vehicles. ENV has, therefore, tightened the emission standards in tandem with advances in vehicle technology. From 1 January 2001, the emission standards were further tightened and vehicles registered for use in Singapore are required to comply with Euro II standards (see Table 3.11.1).

To encourage Singaporeans to leave their cars at home the Government is constantly introducing initiatives to make the public transport system more efficient and user friendly, through multi-modal transport operations. Car ownership is discouraged

Table 3.11.1 Singaporean Vehicle Emission Standards

Type of Vehicle	Emission Standard	Implementation
Petrol vehicle	All new petrol vehicles are required to comply with the EC Directive 96/69/EEC.	1 January 2001
Diesel vehicle	All new diesel passenger cars are required to comply with the EC Directive 96/69/EEC.	1 January 2001
	All new light commercial vehicles, 3.5 tonnes or below, are required to comply with the EC Directive 96/69/EC.	1 January 2001
	All new heavy duty vehicles, exceeding 3.5 tonnes, are required to comply with the EC Directive 91/542/EEC Stage II.	1 January 2001
Motorcycle & scooter	All new motorcycles and scooters are required to comply with the United States Code of Federal Regulations (US 40 CFR 86.410-80) emission standards.	1 October 1991

through high import duties, registration fees and the requirement to purchase a Certificate of Entitlement (COE), the combined effect of which increases the basic cost of a new car by around 200 per cent. Electronic Road Pricing (ERP) was introduced in September 1998 as a further measure to combat traffic congestion on certain roads and expressways at specific times of the day. The Land Transport Authority (LTA) was established as a Government Statutory Board in September 1995, bringing together all sectors of land transport into one entity. Singapore Mass Rapid Transit (SMRT) was incorporated in August 1987 to operate and maintain the existing MRT system under a licence from the LTA, the owner, builder and regulator of the system. Traditionally, the Government has funded all capital expenditure programmes in the form of advances and grants. These cover the cost of road and rapid transit system infrastructure and construction expenses, as well as the cost of the first set of operating assets for the rapid transit system. In 2000, they turned to the market for the first time to successfully raise S\$300 million through a Singapore dollar bond issue, a process which

is expected to be repeated in the future.

Conclusions

The ambient air quality in Singapore is generally good and during 2000, the levels of air pollutants were within the WHO long-term goals and the USEPA standards. For stationary emission sources, this has been achieved by enforcing strict air pollutant emission standards, making sure new industries comply with pollution control requirements and regular inspections. For mobile emission sources, a wide range of measures to control air pollution have been put in place, including stringent emission standards and fuel quality standards, mandatory inspection of vehicle emissions and enforcement against smoky vehicles. From 1 January 2001, all vehicles, newly registered for use in Singapore, were required to comply with Euro II standards. Furthermore, car ownership is discouraged using a variety of financial disincentives combined with the constant introduction of initiatives to make the public transport system more efficient and user friendly.