Economic and Social Commission for Asia and the Pacific

CITIES AND SUSTAINABLE DEVELOPMENT

LESSONS AND EXPERIENCES FROM ASIA AND THE PACIFIC

UNITED NATIONS

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CONTENTS

I. INTRODUCTION

Considering the density of Asia-Pacific cities both in terms of their size and population growth rates, their different trends in economic, social, political and environmental situation, it would be difficult to associate sustainable development with cities in general terms. Hence, much of what is needed to achieve overall sustainable development has to be formulated and implemented locally. It calls for innovative local strategies and techniques. For example, a local initiative to improve garbage collection and recycling will have beneficial effects for the environment of the local community. But if it is to spread to other areas within city limits, it requires encouragement of similar initiatives in other parts of the city. Thereafter, actively involving a wide range of city to city populace will enhance city governance and can be one of the best means of promoting city partnership for sustainable development.

Such is the objective of the Kitakyushu Initiative for a Clean Environment, i.e., improvement of the urban environment through local initiatives aimed at promoting effective implementation of UNESCAP's Regional Action Programme relating to environmental quality and human health. Established in 2000, the Kitakyushu Initiative's mechanism of implementation builds capacities of city governments to meet urban environmental challenges and improve the environment through information sharing, intercity cooperation as well as national government and donor community support. It encourages the conduct of pilot activities, collects and analyzes successful practices with the goal of replication of the practice as they relate to other cities which may then be able to benefit from the transfer of a particular technology or successfully adapt an on-going practice in one city to the local conditions of another.

Activities are promoted through the Kitakyushu Initiative Network, an open action-based network proposed as a primary mechanism to encourage local governments to promote actions outlined in the Kitakyushu Initiative. For this purpose, thematic seminars are held with the idea of encouraging the replication approach through discussions on the transferability and applicability of successful practices to other cities as well as the development and implementation of appropriate policies and detailed activities. Network meetings are regularly held to facilitate interaction between local governments and relevant stakeholders while national seminars are held to promote intercity cooperation in a country-specific context.

To be more specific, the reason why cities participate in the Kitakyushu Initiative is to learn from cities facing relatively similar problems under similar sociological conditions. They have the same constraints e.g., lack of resources, limited capacity of staff, which hinder city authorities from optimally managing their cities. To meet the needs of the Kitakyushu Initiative Network participants, there ought to be guidelines for transferring or replicating the best local practices compiled under the Kitakyushu Initiative. These guidelines could facilitate effective use of the best practices in solving urban environmental problems and provide practical advice to those engaged in peer-to-peer exchanges as well. A further step would be the establishment of a regional training centre where cities will be able to explore and share experiences with one another. The center could enhance capacity building for local governments on sustainable issues particularly on basic environmental services such as water supply, waste management and clean air. Pending establishment of the training center, experts from network participants could provide roving service to a network participant on a specific area of need. The

availability of expert advice could strengthen partnerships and collaboration between cities and create greater collective self-reliance while improving local capacity.

This publication is a compilation of city case studies highlighting the best practices of the Kitakyushu Initiative Network cities as presented at thematic seminars. The city studies are in a standardized format for easy comparison between cities with focus on the environmental issues and challenges faced, the implementation of the strategy to remedy the situation, lessons learned and prospects for replicability or possible transfer to other cities.

Take note that the best practices emanating from the case studies are those that are successful in a certain environment or surroundings. However well they work in a particular city, they may not necessarily be successfully transferred elsewhere for a number of reasons, among them, the existing enabling milieu in the city, political will, stakeholder commitment, capabilities of city officials and staff, financial constraints. It is foolhardy to expect to transfer a practice *in toto* from one city to another except in very few instances. Be that as it may, it is entirely possible that certain elements of the practice or defined aspects of a procedure may be transferred from one city to other. That is what one must aim for and failure to transfer a successful practice in one instance does not necessarily negate its usefulness in another situation. Cities must learn to evaluate their own current situation and attempt to transfer only those elements of a replicable procedure in a stepwise manner with appropriate monitoring to ensure that is has a fighting chance for success. At the same time, it is essential that capacity building take place side by side as technology alone will not ensure success unless applied effectively by trained individuals.

II. URBAN SOLID WASTE MANAGEMENT

An environmental consequence of the process of urbanization in Asia and the Pacific is the generation of large quantities of solid wastes brought about by rapid population growth and industrialization. As a matter of fact, UNESCAP's latest state of the environment report reveals the fact that urban residents in the region generate two to three times more solid wastes than their rural counterparts. Most serious is the uncontrolled waste dumping in rivers and streams rendering them biologically dead. Other wastes are dumped in open spaces in unsanitary ways posing danger to human health and life. Fortunately, governments are now aware of the problem brought about by uncontrolled disposal of wastes and many are embarking on a strategy of waste minimization and maximizing waste recycling. But although many cities are undertaking recycling initiatives, waste minimization is yet to be totally embraced. Aggravating the situation of wastes in cities are the marketing and packaging industries. Major impacts could be derived from waste minimization in these industries. Specifically, efforts are now on waste management through waste recycling and reuse.

Accordingly, the Kitakyushu Initiative for a Clean Environment suggests strengthening environmental management capability at the local level through, for example, initiatives of local authorities to solve environmental problems which have their roots in local activities. It means the ever increasing menace of urban wastes should be brought within the management capacity of local governments and communities. Noteworthy is the Kitakyushu Initiative to create a "resource recycling society" in which resources are more efficiently utilized through reuse and recycling.

Quite innovative are the following solid waste management case studies in Asian cities. Except for highly industrialized Fukuoka City which derives much of its wastes from industries, the rest of the studied Asian cities contend with household wastes and their proper disposal despite limited financial, technical and managerial resources. The significant features of their solid waste management systems are incorporated in Dhaka City's Waste Concern, a community-based organic waste recycling project; Nonthaburi City's Pilot Project which maximizes recycling and minimizes wastes; Kathmandu City's PSP (private sector participation) in overall waste management while handling monitoring and enforcement; Surabaya City's community fees system which includes waste transport fees and disposal charges for solid wastes; and Fukuoka City's Fukuoka Method or semi-aerobic landfill. A common thread running through all these community-based initiatives in solid waste management is strong, active and effective participation by local people.

Overall, the case studies proved that an efficient solid waste management service should be comprised of an appropriate mix of public, private and community involvement while focusing on simple management information systems that allow those involved to use a range of local service providers - sweepers, scavengers, pickets. Not to be ignored is the much needed income generation for the urban poor in small-scale waste recycling initiatives, a significant poverty alleviation effort.

The case studies have many transferable aspects appropriate to other cities of the region to address the critical issue of urban solid waste management.

A. Dhaka, Bangladesh
Community Based Initiatives in Controlling Solid Waste

1. Abstract

The city of Dhaka like any other city in the developing countries of Asia and the Pacific generates a large amount of waste, the management of which poses a big problem. Fortunately a large amount of this waste is organic and it is therefore possible to convert the bulk of it into compost. In 1995, a local NGO called Waste Concern initiated a small-scale, community-based organic waste recycling project for composting the municipal solid waste. Private initiatives have supported house-to-house collection of garbage in some residential areas, which have proved quite effective while waste separation at source has also been proving successful in some areas. Encouraged by the success of this project the model has been replicated in other parts of the city. This paper reviews the replicated models in terms of opportunities, constraints and future direction, which need to be undertaken in Dhaka city to exploit the full potential of community based initiatives for solid waste management.

2. Environmental Setting

Founded in 1608 as the seat of the Imperial Mughal Viceroys of Bengal, Dhaka, the capital of Bangladesh with an area of about 360 sq. km., has grown into busy city of about 10 million people. In recent years the population of Dhaka city has increased rapidly, with a growth rate of 3.72% per year. In Dhaka City Corporation (DCC) area 60% houses are of low income, 37% middle income and the remaining 3% constitutes high-income houses. The old part of Dhaka is more densely populated than the new part. About one million commuters also enter Dhaka city everyday for their livelihood. There are over 1,000 small and large industries including 149 tanneries in addition to about 500 clinics and hospitals in the Dhaka Metropolitan Area.

DCC'c expenditure on Solid Waste Management (SWM) is 52.87% more than its income. The per capita expenditure for SWM in Dhaka is very low (Tk. 53.00) compared to other Asian cities such as Bombay Tk.304.00, Manila Tk. 192.00 and Bangkok Tk. 84.00 (Enayetullah, 1994). DCC spent 15.42% of its total annual expenditure for SWM (Yousuf, 96). The solid waste management cost of DCC is Tk. 313.12 /cubic metre of which collection cost is Tk. 120.54 (32.75%), transportation cost is Tk. 150.09 (47.90%) and disposal cost is Tk. 60.60 (19.37%) per cubic meter (Salam, 2001).

3. Issues and Challenges

Current Status in Management of Solid Waste

(a) Formal Sector:

The Dhaka City Corporation (DCC) collects municipal wastes, which accumulate in DCC's bins or containers. About 7146 cleaners are employed for street sweeping and collection of waste found in places other than dustbins, road sides, open spaces, ditches etc. by hand trolley. They have 2,080 hand trolleys for primary collection of waste. DCC has 128 demountable container carrier trucks for the collection of accumulated waste in 414 containers

and 242 open trucks to collect waste from municipal bins at different locations. In some residential areas like Kalabagan, Dhanmondi, Banani, Gulshan, Baridhara, Uttara 'house to house' waste collection service has been organized through private initiative. Rickshaw vans are used for collection of waste from houses to municipal containers. 50% of the population use waste enclosures or bins, 20% of population use roads to dispose of waste, 20% of the population use drains to dispose of waste and the remaining 10% of the population, use open grounds to dispose of waste (MMI, 1992).

The total amount of solid waste generated each day in the DCC area is about 4500 - 5000 tons. According to a 1991 report by Mott Macdonald International Ltd., the entire waste stream of Dhaka city is made up of 46.8% domestic, 21.8% street sweepings, 19.2% commercial, 12.9% industrial and 0.5% clinical. In residential areas the solid waste is 58.7% domestic, 33.08% street sweeping, 7.9% commercial and 0.32% clinical (Salam, 2001). Analysis of the physical composition of domestic waste shows that the primary component is food waste comprising approximately 72.50%, with the rest being made up of polythene (13.70% - production of which is presently banned), paper and cardboard (5.63%), and plastic (3.31%). There is a variation of waste composition between downtown and residential areas of the new parts of Dhaka. Domestic waste generation rate for residential area is 0.60 kg per person a day (Salam, 2001).

(b) Informal Sector

At present the DCC has no waste treatment and recycling plant. An informal sector exists in resource recovery and recycling of solid waste in Dhaka City. The poor and socially disadvantaged people involved in extracting recyclable materials from waste from the streets, waste bins and dump sites total more than 87,000 in number. This informal sector accounts for almost 10% of total employed work force and is responsible for removing 26% of total generated waste in the DCC area (Sinha, 1993).

4. Implementation Strategy

Community initiatives, which include:

(1) Development of a small-scale community based organic waste recycling project to compost municipal solid waste;

(2) Encourage waste separation at source; and

(3) Involve public participation through CBO's to collect garbage on a house-to-house basis where garbage bins are not a feasible option.

Community Based Initiatives:

(a) Composting:

A large portion of organic matter (almost 80% of the waste) with the potential of being converted into an economic resource (compost/organic fertilizer) is totally unutilised by the informal sector.

To address this in 1995, a local NGO called Waste Concern, with the help of the UNDP and a local Lion's Club chapter initiated a small-scale, community-based organic waste recycling project for composting the municipal solid waste under the slogan "waste is not waste, waste is a resource". The project had three aims: (i) Capture value from the organic

portion of the city solid waste; (ii) Create job opportunities for the urban poor; and (iii) Create business opportunities for local entrepreneurs.

In January 1996 a local Lions Club (Dhaka North) donated a small piece of vacant land (1000 square metres) for the composting project. The composting plant initiated by Waste Concern is the first of its kind in Bangladesh. The primary goal is to explore the technical and commercial feasibility of labour-intensive aerobic composting. The technique is based on waste reduction and separation of compostables, recyclables, and other wastes. To this end source-separated organic wastes are collected door-to-door from the neighbouring community, vegetable markets and local hotels.

At present, one project manager and six persons (three female and three male) drawn from the informal labour sector are working in the project, two methods the Chinese (closed system - anaerobic) and the Indonesian (aerobic - with windrows). The Indonesian method, which did not develop a smell, was chosen for community level projects given then fact that it had the smallest odour problem. About 200 kg of compost is produced from one truck of collected solid waste. Three hundred households in Mirpur have been included under the composting project with modified rickshaw-vans being used by Waste Concern for the house-to-house collection system. A fee of Tk. 10/month is charged from each household. The collected domestic waste is separated and sorted in the composting planting site and processed into compost. Waste Concern is now trying to accelerate the decomposition process by using inoculums (compost digester).

(b) House-to-House Garbage Collection

Due to its narrow lanes and by-lanes DCC could not place waste bins in the residential area of Kalabagan, a densely populated area of Dhaka City to meet the needs of the community. The environment had deteriorated due to the emission of bad smells from the indiscriminately scattered decomposing wastes and also from waste in clogged drains. This unbearable situation drew the attention of one resident of the area Mr. Khurram who with a friend devised a mechanism to tackle the situation. In 1987, he purchased two old rickshaws and turned them into carriers. With local community participation these vans began collecting waste from house to house and disposing of them in community bins. The van-rickshaws were fitted with horns and 3 persons manned each one. The success of this operation led to the formation of a numbers of Community Based Organizations (CBOs) in different parts of Dhaka city. The experience of the Kalabagan CBO approach revealed that a house-to-house collection of domestic waste was very effective from the twin viewpoints of cost and environment (Mohit, 1995).

(c) Waste Separation at Source

In January 2002 Sheltech Consultants (Pvt) Ltd. started a pilot project to manage the solid waste related problems of the residential area of Dhanmondi with the assistance of the DCC. The main objectives of the project were to relieve residents of the area from the hazards of unmanaged garbage bins by providing door-to-door garbage collection in specially designed vans and disposing of the garbage so collected in municipal garbage containers together with drain and street cleaning. For operating the pilot project the total Dhanmondi residential area was divided into 9 blocks. 300 households in Blocks G and H were included under the initial operations.

Before intervention, the main identified problems of solid waste and disposal were: (a) Lack of awareness of waste disposal and environmental sanitation at household level; (b) Absence of awareness creation at community level; (c) Roadside bins were insufficient and often broken; (d) Scattering of waste from bins by animals and scavengers; and (e) Throwing of waste into drains which caused blockages and overflows into the streets.

Sheltech Consultants Pvt. Ltd (SCPL) has provided 2 garbage containers (Blue and Red) to every household for disposal of garbage separately, where blue and red container receives inorganic and organic waste respectively. Between 1am to 4 pm of the day the conservancy workers (Shebak) visited the households with their special designed vans to collect waste. This collected waste is disposed of at the central dumping sites of each block, where containers were kept under strong observation and monitoring of SCPL workers, so that scavengers did not scatter garbage while collecting inorganic materials from the dumping sites. Subsequently, the collected wastes are taken away by DCC transport to the central dumping sites on time (between 4pm – 6pm). SCPL collected revenue from every household at the end of the month and used it to cover the workers salaries.

5. Impacts

- Environmental pollution such as air, water and soil pollution has significantly reduced in the area;
- The project members (House-holds) no longer use the dustbins for disposing their daily wastes, which helps in reducing air pollution and the scattering of wastes in the neighbourhood;
- As the wastes (Organic and Inorganic) are separated in the houses and disposed in different containers it has became easier for the project authority to sell the inorganic materials to the retailers and re-cycle companies. On the other hand only the organic wastes are disposed in the secondary dumping sites, which is eventually carried away by DCC transport for possible composting;
- Secondary dumping sites are also monitored by the SCPL workers, which help reduce the scattering of waste outside the bins and on adjacent roads; and
- The project has helped to generate positive behavioural changes within the community.

6. Lessons

Dhaka City Corporation (DCC) functions on the basis of the "Dhaka Municipal Corporation Ordinance XL 1983". The ordinance has no specific clause or section for industrial hazardous or clinical waste storage, handling, collection, transportation and disposal either by DCC or privately. Necessary by-laws have not yet been introduced on “Standard” of refuse quality and details of punishment of any offence detected by DCC mobile court.

The main problems and limitations of the present solid waste management system of DCC are:

- **Lack of Institutional Arrangements**: The Conservancy Department of the Dhaka City Corporation has no scientific and engineering experience to implement the solid waste management planning approach. For instance the Conservancy Department has no solid waste management specialist (Engineering background). The present distribution of labor, transport in different areas is not based on demand data and the Conservancy Department does not maintain

any data base on the generation of waste or on transport and labor requirements. There are no standards for cleanliness. The Town Planning Department is yet to allocate any space for storage of waste bins and placing of containers. Placing dustbins on the road, near any house, creates social problems stemming from improper use, irregular cleaning, and road obstruction by collection vehicles in addition to bad smells, rodents and other vermin, flies all resulting in unhygienic conditions. At present the transport fleet of Dhaka City Corporation collects 43% of the waste in open trucks. The open truck collection system needs on average 3-5 hr for loading and unloading the waste to and from the trucks. Consequently, disposal by open trucks yield very low efficiencies.

- **Insufficient Financial Resources**: DCC normally spends14-17 percent of its budget on SWM. Municipalities in the developing countries spend 20 to 40 percent of municipal revenues (UNCHS, 1998).

- **Inefficiencies:** How to avoid inefficient management of existing manpower, equipment other resources, unscientific and inefficient collection practices, inefficient management of landfill.

- **Deficiencies:** Absence of appropriate by-laws and standards.

Composting: Realization of the full potential of this kind of project, however, can only be achieved if the government or municipal authorities provide the following types of support: - Land should be provided free of cost or at a nominal rate to the entrepreneurs interested to run the project.

Other Community Initiatives: During implementation of the Dhanmondhi project SCPL was made aware that a large number of residents are not aware of health hazards and solid waste related problems. Many households who do not use the project service dispose of their garbage in nearby open spaces. Also:

- The project authority could not expand the project satisfactorily due to lack of public awareness and motivation;
- No comprehensive awareness-building programme has been launched in the area by SCPL or DCC;
- Many households have refused to take the service, as they believe DCC should carry out such activities since they impose taxes on the dwellers;
- Hospital wastes are still disposed of in dustbins which lessen the effectiveness of achievements made by the project and contribute to the degradation of Dhanmondi`s environment; and
- DCC conservancy trucks do not show up on time, which also creates problem for the project authority.

Replication of an Innovative Initiative

Composting: After continuous demonstration of the project to the stakeholders of Bangladesh in 1998 under the Sustainable Environmental Management Program (SEMP) the Ministry of Environment and Forest with support from UNDP requested Waste Concern to replicate the model in 5 different communities of Dhaka City. Land was the biggest constraint

to initiate the model of community based composting plants in the city. Later on, after continuous advocacy and demonstration, the Dhaka City Corporation and Public Works Department were convinced and came into a partnership with Waste Concern by providing land for the composting plants. Waste Concern demonstrated further that the enrichment of compost with necessary nutrients could make it more attractive, affordable and effective to farmers. Small-scale compost plants can be located within the community provided appropriate scientific composting methods are followed. A decentralized compost plant can be commercially viable, as seen from the Mirpur experience. It has been found that women from the informal sector are interested to work in the composting plant, which is socially acceptable.

Initially, marketing of compost was a major problem. This problem was solved by involving private sector specialized fertilizer marketing companies (experienced and already having extensive networks all over Bangladesh) and enriching the nutrient content of the compost. The Press has played a positive role in disseminating project activities in Bangladesh. Apart from the media, Government has to formulate the necessary policies, which would be conducive to the marketing of compost. Based on the evidence gathered so far from the pilot project of Waste Concern, it appears that this type of micro-enterprise can be replicated elsewhere in Bangladesh as well as in other Asian Countries.

Other community Based Initiatives: House to house garbage collection has been replicated by CBO's in several parts of Dhaka city using Van-rickshaws. The waste separation at source though a relative newcomer is slowly gaining is also slowly gaining acceptance.

The success of a community-based programme depends largely on identifying and addressing community needs while the sustainability of the project hinges on involving the community in the cost-recovery/cost-sharing process. Community based projects must have demonstrable effects. NGOs can play an important role in initiating, demonstrating new concepts, providing technical know-how and providing training to others. The composting of organic waste coupled with the recycling of non-organic component by the informal sector should go a long way towards ameliorating the solid waste problems of the city.

7. Future Prospects

To overcome the existing problems Dhaka City is hoping to receive assistance to undertake the following:

- Institutional strengthening
- Capacity Building: Training for the Conservancy Department personnel to manage scientifically the solid waste management issues: While also supporting the following:
    (a) Gradual privatisation of solid waste management (collection, transportation and disposal);
    (b) Landfill design and management;
    (c) Formulation of policy for a community-based programme, local initiatives, NGO- small enterprise initiatives;
    (d) Waste reduction and recycling projects; and
    (e) Preparation of suitable legislation, (by-laws, rules, regulations).

- Exchange of information
- Public Awareness Programmes
- Assist sustainable solid waste management through generation of electricity, gas, fertilizer, ceramic products etc.

It is important to launch a long-term awareness building and campaigning programme in the area so that people get motivated about enhancing their own environmental conditions and participate in the pilot project willingly. Awareness building programmes can be launched in other areas of the city to motivate people about cleanliness and personal hygiene.

In May 2002, DCC selected 7 other Wards of the City to carry out similar kinds of solid waste management project like Dhanmondi area involving CBOs and local NGOs to which the city of Kitakyushu has agreed to extend its cooperation. Dhaka city is seeking the following: technical know-how for setting up a modified transfer station, financial support for public awareness and a motivation programme for the project.

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B. Nonthaburi, Thailand
Solid Waste Reduction

1. Abstract

The Nonthaburi Municipality in Central Thailand is one of Nonthaburi Province's nine municipalities, which is situated near Bangkok and lacks a solid waste disposal site, wastewater treatment and faces increasing amounts of waste generation. To address the problem of solid waste management Nonthaburi has adopted waste reduction through recycling, public awareness and community initiatives in recycling, composting, enforcement of user charges, capacity building. Under the Kitakyushu Initiative, Nonthaburi has embarked on a one-year pilot activity in two villages within the municipality, supported by UNESCAP to maximise recycling and minimise waste, promote community participation and promote public participation and local coordination with capacity-building. User fees are charged for solid waste with plastic bags given for recyclable materials. The collection staff and the community share in the income generated by the sale of recycled materials companies will buy to generate additional revenue. Transfer of the pilot initiative to other communities within the municipality is the overall objective.

2. Environmental Setting

(a) Nonthaburi City

Thailand is divided into four regions South, North, North-East and Central Thailand. Central Thailand includes 33 provinces, one of which is Nonthaburi. The province is located near Bangkok and covers an area of 622.3 km^2 with 839,029 habitants in the province. There are 37 local administrative organizations in the Nonthaburi province, 9 Municipalities, 1 Province Administrative Organization and 37 Tambon Administrative Organizations. One of the nine municipalities is Nonthaburi municipality, which besides being self-governed has its own judiciary. Established by a Royal Decree on February 14, 1953 it initially covered an area 2.5 km^2, which was subsequently expanded to 38.9 km^2. By 1988 the Nonthaburi municipality was located on the east side of the Chao Phraya River. The total population is 273,172 inhabitants in 91,702 households. Most of the available land is residential, agricultural or commercial. It is well known for many tropical fruits. The average per capita income is 11,713 baht per year. Income is mainly derived from the construction industry, service, banking insurance, real estate and agriculture. The average temperature is 29^oC. 95 % of the people are Buddhist. Nonthaburi city is 20 km. from Bangkok and it takes only 30 minutes by boat or by bus to commute to Bangkok.

(b) Current Status in Management of Solid Waste

Nonthaburi municipality is in a crisis of its own making as waste piles up together with untreated wastewater, whose unchecked spread is causing contamination, thus creating immediate and long-term problems. Presently, Nonthaburi produces 320 tons of solid waste a day and as this amount shows signs of rising it is becoming increasingly difficult to dispose of it in a regular manner. The capacities of existing sanitary landfills are almost exhausted and new dumpsites are difficult to establish due to stringent legislation as well as increasing public awareness about related health threats, chemical pollution of groundwater, and the unwise and

wasteful use of non-renewable resources. At present open dumping accompanied by burning is the most prevalent form of waste disposal in Nonthaburi. The potential to reuse waste materials has yet to be explored, only 3-5% of wastes are separated for recycling.

According to the Municipal Act 1953 and Public Health Act the responsibilities of the Nonthaburi municipality included keeping streets, pavements and public places tidy, disposing of refuse and waste, including infectious wastes, as well as wastewater treatment. The City's total expenditure on solid waste management in 2001 was 70,586,680 baht. (Operations and Maintenance = 50,018,680 baht, Equipment = 20,558,000 baht).

In the past the amount of waste generated was small and disposal took place near residences and even in canals or rivers where it decomposed without much problem. However, the amount of waste has increased steadily throughout the whole Kingdom of Thailand in the past decades. The Ministry of Science and Technology have estimated that the amount of waste generated per capita is approximately 0.8 -10 kg/day in Bangkok and also in Nonthaburi. As a result of population growth, the escalating amount of waste calls for improved management, especially, since it is quite common to find that waste is dumped on streets and other public areas. In addition, the composition of household garbage is changing with a rapid increase in the amounts of paper, plastic and metal leading to one of the most noticeable problems with solid waste today in that it tends to have a long residence time. Without proper disposal garbage tends to accumulate and fill up large areas, and as the waste remains untreated it will most likely result in a wide range of nuisances affecting people living in the immediate vicinity. The unpleasantness will include malodorous smell, which attracts insects and vermin, and besides this waste dispersion by small animals will also probably occur.

More than 130 sweepers collect refuse from streets and public places, 39 refuse trucks collect solid waste from households. Without a transfer station, waste has to be taken to the landfill directly, which is located 38 km from Nonthaburi municipality. In addition, refuse collection by boat is provided for the people who live along the Chao Phraya River.

The most serious problem in solid waste management is the lack of a waste disposal site and the increasing of the amount of waste. Furthermore, people do not separate waste. Presently, the capacity of waste collection is 292 tons/day although the city generated waste about 320 tons/day. Consequently about 10% of the waste is not collected because of the geography of the city and the narrow size of some roads.

3. Issues and Challenges

In 1997, Nonthaburi started a campaign to reduce waste by public relations and public awareness, which was moderately successful. The amount of waste has not increased significantly and the trend is that there was a reduction of waste by 5 – 10 %. The municipality has not been satisfied with this achievement and its goal has been to reduce solid waste 20 % by the year 2003. The strategy to achieve this goal is to emphasize public awareness and participation by training, seminars and the production of mass media material targeted at the people.

Towards this end in early 2001, Nonthaburi municipality requested the assistance of the Institute for Global Environmental Strategies (IGES), Japan and UNESCAP, in developing a

solid waste management strategy for Nonthaburi municipality. UNESCAP provided a budget of US$ 5,000 for the pilot project: "*Maximizing Recycling and Minimizing Waste at Phibulsongkram and Suan Klang Muang 3 Village, Nonthaburi, Thailand*".

The objectives of this project were as follows:

- to maximize recycling 20% and minimize waste 30% in pilot area;
- study appropriate models for handling waste and implement action in the community area;
- promote public participation and local coordination;
- advocate capacity building; and
- developed solid waste management in the Nonthaburi municipality.

4. Implementation Strategy

The Pilot Project, which maximizes recycling and minimizes waste at Phibulsongkram and Suan Klang Muang 3 villages is a case study in Nonthaburi. UNESCAP and the Institute for Global Environmental Strategies (IGES) supported this project after the first meeting of the Kitakyushu Initiative Network in 2001. At the end of the 1-year pilot study, the results appear most satisfactory, the first evaluation after 6 months indicated that the people had separated more than 20 % of the waste material. A second evaluation done after 12 months showed that this had risen to 37%; far exceeding the original expectations. This project should therefore be the model in reducing waste in Nonthaburi in the future.

The Project location is at Phibulsongkram and Suan Klang Muang 3 Villages in Nonthaburi municipality, Thailand. Normally, Nonthaburi municipality provides garbage truck collection to each village twice a week. The amount of solid waste form Phibulsongkram village is 1,000 kgs/day and 200 kg/day from Suan Klang Muang 3 village. These two villages are located in the central part of the city and most of its people are middle class and live in residential areas. They seek a secure village with a good environment. The population of the two villages is 1,280 persons.

The project was initiated in January 2002 following the plan of implementation of the project.

1. Initial Survey: A team of 10 staff members implementing the project initially surveyed the Phibulsongkram and Suan Klang Muang 3 villages with regard data on household numbers, populations, and amount of solid waste produced (**Table 1**).

Table 1
Households, Population and Solid Waste in the Two Villages

Village	Number of Households	Population (Persons)	Solid waste kg/day
Phibulsongkram	539	930	1,008
Suan Klang Muang 3	120	350	214
TOTAL	**659**	**1,280**	**1,222**

2. Community Participation: Meetings were held in both villages to apprise people about the problems and current situation of solid waste management including exchanging of ideas and selecting the appropriate model to reduce solid waste in their villages. This was accomplished with the co-operation and suggestions of the community committees and the participants. The project then proceeded with the following approaches:

- Make provision for meetings with the villagers to let them know about the purpose of the project;
- Make provision for getting a refuse collection truck twice a week for garbage and a recycling truck one a week for recyclable material;
- Distribute information on recycling and how to reduce solid waste to every household using mass media; and
- Provide plastic bags for recyclable materials and distribute a recycling bin to every household.

3. Waste Collection: The Nonthaburi municipality provided a garbage truck to collect garbage twice a week on specific days and also a recycling truck once a week. Each truck was weighed and the amount of garbage and recyclable materials recorded. The villagers separated recyclable material by themselves. The composition of the recyclable material was paper, glass, plastic, metal, and others. During the first half of the project 5% of recyclable materials could be recycled and 25% was waste. In the second half of the project the recyclable material 10% was recycled and 20% was waste. As shown in **Table 2** and **Table 3** in the first six months the income of Phibulsongkram village increased from 344 baht/month to 993 baht/month and the income of Suan Klang Muang 3 increased from 223 baht/month to 637 baht/month. In the last six months of the project the income of Phibulsongkram village increased from 993 baht/month to 1108 baht/month and the income of Suan Klang Muang 3 increased from 637 baht/month to 814 baht/month.

Table 2
Composition of Recyclable Materials and Income Generated at Phibulsongkram Village

Month	Composition of Recyclable Material (kg)					Total (kg)	Income (Baht)
	Paper	Glass	Plastic	Metal	Other		
November 2001	*365*	*373*	*230*	*92*	*575*	*1,635*	*344*
December 2001	*324*	*361*	*199*	*137*	*533*	*1,554*	*438*
January 2002	427	604	485	154	517	2,222	358
February 2002	381	664	473	141	571	2,196	428
March 2002	363	726	546	181	545	2,362	788
April 2002	475	921	713	236	786	3,160	866
May 2002	695	1,394	1,043	346	1,080	4,558	988
June 2002	866	1,294	779	192	1,016	4,147	993
July 2002	1,707	2,257	973	485	348	5,644	1,211
August 2002	1,580	2,430	820	480	339	5,589	1,086
September 2002	1,450	1,865	780	595	423	5,512	1,129
October 2002	1,940	2,710	1,020	610	493	6,773	1,083
November 2002	1,985	2,740	1,040	620	279	6,664	1,157
December 2002	1,670	1,890	1,120	725	529	5,896	1,108

November and December 2001 Values are Preparation and Collection Data

Table 3

Composition of Recyclable Materials and Income Generated
Suan Klang Muang 3 Village

Month	Composition of Recyclable Material (kg)					Total	Income
	Paper	Glass	Plastic	Metal	Other	(kg)	(Baht)
November 2001	*58*	*94*	*58*	*22*	*103*	*335*	*223*
December 2001	*59*	*88*	*56*	*15*	*93*	*311*	*260*
January 2002	91	147	110	18	139	507	390
February 2002	91	160	123	24	166	565	420
March 2002	109	218	151	32	219	729	521
April 2002	95	190	125	36	171	607	577
May 2002	160	164	125	41	182	672	584
June 2002	189	335	252	59	251	1,086	637
July 2002	495	705	235	160	133	1,710	766
August 2002	490	670	255	130	140	1,685	781
September 2002	450	535	270	125	94	1,474	754
October 2002	600	800	315	152	141	2,008	760
November 2002	585	770	330	220	117	1,959	779
December 2002	575	770	347	197	67	1,956	814

November and December 2001 Values are Preparation and Collection Data

As shown in **Table 4** the total quantity of solid waste from the two villages decreased from 958 kg/day to 700.6 kg/day during the 12-month period from January to December 2002. This represents a 27% reduction much greater than was originally envisaged. As shown in **Table 5** separated materials increased on average from 9.4% to 36.2% during the 12-month period, therefore the quantity of solid waste/capita/day decreased. As the recycling rate increased the quantity of solid waste for disposal was reduced.

Table 4
Amount of Solid Waste from Phibulsongkram and Suan Klang Muang 3 Villages

Month / Village	Weight of Solid Waste (kg/day)													
	Nov 01	Dec 01	Jan 02	Feb 02	Mar 02	Apr 02	May 02	June 02	July 02	Aug 02	Sep 02	Oct 02	Nov 02	Dec 02
Phibulsong-kram	1,008	996	819	776	962	897	968	680	539.9	538.8	568.9	709.3	701.3	594.3
Suan Klang Muang 3	214	215	139	173	204	150	115	151	109	106	92.3	122	105.6	106.3
Total	1,222	1,211	958	949	1,166	1,047	1,083	831	648.9	644.8	661.2	831.3	806.9	700.6
Solid waste/capita	0.95	0.94	0.75	0.74	0.91	0.82	0.84	0.65	0.51	0.503	0.57	0.69	0.63	0.58

November and December 2001 Values are Preparation and Collection Data

Table 5
Amount of Recyclable material from Phibulsongkram and Suan Klang Muang 3 Village

Month / Village	Weight of Recyclable Solid Waste (kg/day)													
	Nov 01	Dec 01	Jan 02	Feb 02	Mar 02	Apr 02	May 02	June 02	July 02	Aug 02	Sep 02	Oct 02	Nov 02	Dec 02
Phibulsongkram	54.5	50.1	74.0	78.4	76.2	105.0	147.0	138.0	182.1	180.3	177.8	216.5	222.1	190.2
Suan Klang Muang 3	11.2	10.1	16.3	20.2	23.5	20.2	21.7	36.2	55.2	54.4	49.1	64.7	65.3	63.1
Total	65.7	60.2	90.3	98.6	99.7	125.2	168.7	174.2	237.3	234.7	226.9	281.2	286.4	253.3
Avg. Recycled (%)	5.4	5.0	9.4	10.4	8.6	12.0	15.6	21.0	36.6	36.4	39.6	33.8	35.5	36.2

November and December 2001 Values are Preparation and Collection Data

4. Mass Media Production: Brochures containing information on how to reduce waste were printed and distributed to every household. A public comment board was set up for each village. In addition follow up and monitoring notes were left in some households.

		US $
• Recycling bin 660 bins	=	2,200
• Two Public Relations boards for comments	=	460
• Brochures 2 model	=	2,026
• Community meetings (2 times)	=	314
TOTAL	=	5,000

5. Impacts

The project progressed satisfactorily as seen in the first evaluation after 6 months and it exceeded expectations at the end of the 12-month project. The trend of increasing recyclable materials grew from 20% in the first six-month period to over 36% at the end of the 12-month period. Before the project began both Phibulsongkram and Suan Klang Muang 3 villages produced approximately 1222 kg/day of solid waste of which only 65.7 kg/day was recyclable material. The model of solid waste separation used in the pilot project was evaluated by committees and villagers, which included the public relations aspects of the project carried out by the committees and staff of Nonthaburi municipality. The villagers too joined and made contributions at the workshop of how to reduce solid waste from households. The recycling bins and plastic bags were distributed to every household in Phibulsongkram and Suan Klang Muang 3 villages. The villagers cooperated in reducing solid waste by separating the recyclable material before they put them in the bin. The garbage truck collected garbage twice a week (Tuesday and Friday) and the recyclable material pick up truck also collected on one of these days.

As a result of the pilot project the villagers themselves had solved the problem of solid waste management. Besides that, they were further encouraged by the income generated from recycling material increased from 748 baht/month in the first month (January 2002) of the project to 1630 baht/month at the end of 6 months to 1922 baht/month at the end of the project (December 2002), which helped towards improving the environment and their quality of life.

The outputs and the outcomes are as follows:

- The recyclable materials increased on average from 9% at the start (January 2002) to over 20% in 6 months to over 36% at the end (December 2002) of the project.

- The villagers changed their behaviour towards separation of recyclable material.
- Better cooperation between municipality and the villagers was seen
- Awareness was created about the importance of environmental conservation.

6. Lessons

After six months, the amount of recyclable materials had increased from 90.3 kg/day (in January) to 174.2 kg/day (June) to 253.3 kg/day (December). Still a lack of cooperation was observed among a few households. To counter this effective public relations and monitoring is very important to stimulate all persons to cooperate especially after the project has ended. Hence the key areas that should be addressed include:

(a) Public Awareness: As solid waste was reduced by 27% the initial goal was exceeded now even more reduction needs to be targeted so public awareness need to be raised through more information and public campaigns related to solid waste;

(b) Implementation and Enforcement Capacity: Nonthaburi Municipality is capable of implementing some environmental management activities such as monitoring waste generation and collecting waste. However, waste disposal and treatment activities are still rather weak. Enforcement and application of environmental regulation is generally low in Nonthaburi; and

(c) Capacity Building: Another weakness lies within the administration where untrained staff still manages the waste area. To deal with these and other problems suitable training programmes must be initiated.

7. Future Prospects

This type of pilot activity can be easily transferred to other cities provided there is political will to enhance community participation and introduce user charges. As in the case of Nonthaburi, the results of small-scale activities can be demonstrated to other communities to establish citywide activities.

Composting activities are also being carried out in conjunction with recycling activities. The commercialisation of composting will soon bring additional revenue for collection staff and communities. The expansion of these types of activities to other communities within the Municipality is also an overall objective for Nonthaburi.

C. Kathmandu, Nepal
Private Sector Participation in Solid Waste Management

1. Abstract

The Kathmandu Metropolitan City (KMC) has to manage approximately 212 tons of solid waste produced per day within limited financial, technical and managerial resources as well as having to face and overcome a number of other problems that hinder effective implementation. The strategy adopted by KMC in addressing this problem and reducing its financial burden was to encourage private sector participation (PSP) in overall waste management while handling monitoring and enforcement. Appropriate policies and laws for private sector participation were formulated initially. Since the initiative was experimental the strategy was to plan, implement and evaluate different approaches in a phased manner. To begin with door-to-door collection, street sweeping and waste transfers were introduced in two municipal wards without subsidies and charging fees from households. After one year the private sector was making a profit and willing to continue and expand their services. KMC has been able to reduce both its human resource and financial burden while receiving a significant approval rating on the effectiveness of the services being provided. Lessons learned included the necessity for careful planning and experimentation with different approaches, the need to build confidence among stakeholders, elimination of unnecessary political interventions and importance of transparency of the process. In future KMC hopes to involve the private sector in all other aspects of waste management, extending from efficient collection systems, scrap recovery, recycling, composting to sanitary landfills.

2. Environmental Setting

Kathmandu Valley, where Kathmandu Metropolitan City (KMC), is situated is between the latitudes 27^0 32' 13 and 27^0 49' 10" north and longitudes 85^0 11' 31" and 85^0 31' 38" east. It covers an area of about 667 km^2 and its mean elevation is about 1350m above sea level. The valley is bowl shaped with rivers draining towards the centre of the basin. The rivers merge into the Bagmati River, which drains out through the Chovar Gorge located at the southwest corner of the valley.

Kathmandu is the capital and commercial hub of Nepal. It is connected with other countries through only an International Airport and two major highways connect with India and China. Since it is the capital of the country all the embassies are concentrated in the Valley, and particularly in Kathmandu City. However, in recent years due to the development in transportation, major industries have moved into secondary cities.

The Kathmandu Valley consists of the historic cities of Kathmandu, Lalitpur (Patan), and Bhaktapur (Bhadgaun). In addition to these three cities, there are 110 Village District Committees (VDC) within the Valley. KMC is located in the Kathmandu District and covers an area of about 50.8 km^2.

Kathmandu Valley contains the prime city of the country comprising 24.1% of the national urban population and 70.4% of the valley's total urban population in 1991. KMC's population grew from 235,160 in 1981 to 421,258 in 1991, registering an annual growth rate of 6%. At present it is estimated that KMC's population is approximately 725,000. Kathmandu

is the largest city in Nepal with a population of approximately 725,000, the district that includes the cities of Lalitpur, Bhaktapur, Thimi, and Kirtipur, as well as several villages, has a population of 1.5 million.

Kathmandu Metropolitan City (KMC): The Mayor and deputy mayor are elected directly by the people every four-years. KMC consisted of 35 wards and each ward elects one-ward chairperson and four members every four years. The Mayor, deputy mayor, 35 ward chairpersons, and 140 members form the KMC Board. (s*ee* **Figure 1** *Organizational Structure).* Kathmandu Metropolitan City (KMC) consists of eleven departments including the Environment Department, which is the largest of all. This department is divided into three sections: Solid Waste Management Section, Mechanical Section, and Urban Environment Section. Overall KMC's Environment Department is responsible for managing the solid waste produced in Kathmandu.

Between 1980 and 1993, there existed a major project, funded by the German Government, which was responsible for waste management. KMC has 2,200 staff of which approximately 1400 are engaged in waste management.

Table 1
FINANCIAL CONSIDERATIONS OF SOLID WASTE MANAGEMENT IN KMC

Year	Total Expenditure	Expenditure on SWM	Income (Government)	Income Other (Intl. Donors)	Income (SWM services)
2000	Approx. US$ 6,500,000	Approx. US$ 2,000,000	Approx. US$ 3,100,000	Approx. US$ 3,400,000	Approx. US$ 72,000
2001	Approx. US$ 5,200,000	Approx. US$ 2,000,000	Approx. US$ 3,100,000	Approx. US$ 2,100,000	Approx. US$ 72,000

Solid Waste Management in Kathmandu: A study done in 2000 by the Kathmandu Valley Mapping Programme (KVMP) concluded that Kathmandu residents produce 1 litre (0.3 kg) of garbage per person per day and average loose density of garbage was found to be 0.225 ton/m^3. However, previous studies estimated that the density of garbage varies from 0.25 – 0.48 ton/m^3. In this study the density of garbage is estimated at 0.255 ton/m^3 for simplicity. This means that within Kathmandu City, the waste generation is about 650 m^3/day.

In addition to this, it is also estimated that 30% (approximately 300 m^3/day) of extra waste is generated by the daytime population, waste from neighboring cities, villages and commercial districts. Generally the waste production rate in cities of the developing world is about 0.5 kg per person per day. The neighboring city of Lalitpur generates approximately 130 m^3 of waste per day.

Kathmandu's waste is mainly organic in nature. Although the organic content may vary depending on the location of waste generation and the season, in general two thirds of the waste is organic. The rest of the waste consists of paper, plastic, glass, inert materials (dirt, bricks, stones etc.) and various other components. The **Table 2** presents the results of a recent waste characterization study.

Table 2 WASTE CHARACTERIZATION KMC (2000)

S. No.	Description	% Weight Basis
1	Organic	69.84
2	Paper	8.5
3	Rubber	0.54
4	Leather	0.12
5	Wood	0.73
6	Plastic	9.17
7	Bone	0.23
8	Textile	3.02
9	Ferrous Metal	0.87
10	Aluminium	0.05
11	Glass	2.5
12	Others	4.33
	Total	**100.00**

Source: KMC/KVMP 2000

3. Issues and Challenges

The main source of waste in Kathmandu is domestic waste. The city has only a few industries and most of the industries recycle their waste. The main industry is the carpet industry. The main source of hazardous waste is medical waste from hospitals and nursing homes. A recent study conducted by the Environment and Public Health Organization (ENPHO) estimated that there were 2347 beds in government and 1558 beds in private hospitals and nursing homes, which generate about 1189 kg of infectious waste per day. Most of the medical waste is discarded along with normal municipal waste.

KMC is in the process of establishing a medical waste management system for Kathmandu. KMC has completed a survey of current practice of waste management in 45 health care institutes and presented its results in a workshop. KMC has also recently drafted medical waste management guidelines and an Environmental Impact Assessment Study of the proposed medical waste management system is under way. In the near future, KMC wants to establish all the necessary infrastructure including a treatment plant, management plan, and to purchase collection vehicles, which will be contracted out to a private party to operate.

At present, due to lack of proper landfill site, KMC is dumping its collected waste at Bulkhu. KMC, along with the central government, is in the process of searching for a new landfill site. KMC currently collects approximately 600-650 m^3 of waste per day. Of this, a small portion is recycled, while most of the waste is landfilled.

Problems: The following are the major problems faced by KMC in SWM:

- Inefficient collection system-Multiple handling of Waste
- Attitude - *throw and forget*
- Daily collection (street Sweeping)
- Less willing to pay
- Political Intervention
- Inappropriate technology

- Inflexible system
- Inappropriate collection vehicles
- Inadequate trained manpower
- No appropriate laws and policies

Private Sector Participation (PSP): The main goal of KMC is to *establish an integrated solid waste management system, which is efficient, cost effective, and environmentally sound by the year 2002 with maximum involvement of local communities as well as the private sector.* To address the problems, KMC has been launching Private Sector Participation to achieve following outcomes:

- Efficient collection system
- Efficient transfer and scrap recovery
- Maximum recycling and composting
- Sanitary landfilling
- Special waste management
- Appropriate policy and law
- Public education and participation
- Professional management and monitoring

4. Implementation Strategy

KMC's Waste Management System: Each of the 35 wards in Kathmandu is assigned 20 to 30 sweepers. The sweepers sweep the streets and collect the garbage dumped by residents in certain locations. The garbage is loaded on to a tractor or tipper and brought to a transfer station. Garbage is also collected from 4 and 6 m^3 containers, which are placed in different locations and at major sources of waste. At the transfer station the garbage is unloaded on to a platform and some of the recyclable materials in the waste stream is removed. The rest of the garbage is put in compactors and sent to the landfill site.

Summary of Information - KMC's Waste Management System
(hh=households)

Average Waste Generation:	1.0 litre/per/day
Estimated population of KMC:	725,000
Estimated Waste Generation from KMC:	725 m^3/day
Street waste generation (assuming 10% of hh):	73 m^3/day
Commercial waste (assuming 10% of hh):	73 m^3/day
Waste from neighboring cities and village:	73 m^3/day
Total Waste Generation	944 m^3/day
Waste Collected by KMC:	650 m^3/day
Waste Collected (in ton):	200 ton/day
Collection Efficiency:	70%
Total No. SWM staff:	1400
Total No. SWM vehicles:	100
Actual Expenditure (2000):	14,000,000 NRs

Table 3 TOTAL EXPENDITURE BY KMC ON SOLID WASTE MANAGEMENT

SN:	Headings	Street Sweeping (Ward Level) Rs./Year	Street Sweeping (Central) Rs./Year	Collection Rs./Year	Transfer Station Rs./Year	Transport-ation Rs./Year	Landfill Site Rs./Year	Total Rs./Year
1	Salary	38,823,600	3,192,000	7,240,800	427,200	643,223	396,000	50,722,823
2	Allowances	10,459,780	857,600	1,884,040	112,160	164,966	102,600	13,581,146
3	Provident Fund	3,882,360	319,200	724,080	42,720	64,322	39,600	5,072,282
4	Overtime	12,811,788	1,053,360	2,812,152	163,008	82,820	160,056	17,083,184
5	Administrative Cost	1,319,551	108,443	652,583	223,298	267,246	94,289	2,665,409
6	Depreciation	1,000,800	57,000	4,967,382	354,880	1,523,848	1,129,880	9,033,789
7	Maintenance Cost	280,000	8,000	4,523,382	354,880	1,523,848	2,259,759	8,949,869
8	Interest			6,785,072	532,320	3,366,083	3,389,639	14,073,115
9	Fuel			3,692,224	705,024	2,190,118	2,410,560	8,997,926
10	Others (Materials)	6,720,000	4,272,000					10,992,000
	Total NRs.	75,297,879	9,867,603	33,281,714	2,915,490	9,826,474	9,982,382	141,171,542
	In US $	1,107,322	145,112	489,437	42,875	144,507	146,800	2,076,052
	% Total Expenditure	**53**	**7**	**24**	**2**	**7**	**7**	**100**

Private Sector Involvement: Involving the private sector in waste management (SWM) services usually results in an efficient and professional SWM system. The private sector is usually best at providing efficiency and technical expertise, while the public sector, which is directly responsible to the people, is best at doing the jobs of monitoring and enforcement. Therefore, a suitable combination of the best attributes that both the private and the public sectors have to offer will be necessary to provide and efficient waste management system.

Although efficiency and investment are two of the main causes that are often sited for involving the private sector, the bottom line is that the goal that KMC has set for itself cannot be achieved by KMC alone. Therefore, there is no option but to involve the private sector in SWM.

KMC, therefore, is committed to involve the private sector in SWM services to make it more efficient and cost-effective. However, because privatization of waste management is a new, often misunderstood and sometimes controversial process for Nepal, the privatization process has been carefully planned so as to maximize the use of KMC's existing manpower and equipment, and minimize risks and potentials for failures.

Effective private sector participation (PSP) in waste management requires:

1. Political commitment
2. Confidence of all stakeholders
3. Options suited to local conditions
4. Enabling environment
5. KMC capable to plan and monitor the process
6. Fair and transparent process

In the past, the few attempts made to involve the private sector had failed because the process was not well planned and not every body understood it. In 1996, an American company called Americore Environmental Services, and a Canadian firm, IER, had submitted unsolicited proposals for managing Kathmandu's waste. As solid waste management was a major problem in the city, the municipality readily signed letters of intent (LOI) with these companies, whereby the companies would manage all of Kathmandu's waste. However, the municipal sweepers immediately opposed the plan fearing loss of their jobs. As a result the project could not move ahead and KMC ended up hiring more sweepers to satisfy the sweeper community. In 1997 therefore, when KMC was formulating its new SWM strategy, the process of PSP was also planned accordingly and the pre-requisites for PSP mentioned above were first addressed.

KMC's Guiding Principles for SWM: KMC's strategy for waste management involved the following guiding principles:

***(a) Plan the process but don't wait for the perfect plan*:** In the PSP process, KMC first worked on preparing strategic plans and building the confidence of all stakeholders (KMC Board, KMC administration, KMC's sweepers, Private companies, and the General Public). While planning the process of PSP is important, it was also realized that KMC should not wait for the perfect plan because Nepal has had no prior experience of a municipality working with the private sector in waste management and there is a need to learn by doing. The plan therefore has room for trial and error and improvements as process moves ahead;

***(b) Phase wise implementation to build confidence*:** In order to build the confidence of all stakeholders, KMC is implementing PSP in phases, instead of giving all the entire responsibility to just one company. Incremental involvement of the private sector will allow both the private sector and KMC to slow down the learning the process thus enabling all parties to gain confidence; and

***(c) Try different approaches*:** There are several ways to involve the private sector in SWM such as contracting, franchise system and management contracts. KMC is in the process of trying these different processes and seeing which one best fits the conditions in Kathmandu.

The bottom line is that there is a need to be firm with the vision but flexible with the process. The vision is that by the year 2002, Kathmandu would have an efficient SWM system with maximum participation from the private sector. The process of achieving this would be by bolstering the confidence of all stakeholders as KMC tried different approaches to PSP in a phased manner and continuously built on the lessons learned from these experiences. The status of some of KMC's efforts to involve the private sector in waste management in outlined in the sections below.

West Sector Project: The city of Kathmandu has been divided into five sectors for the purpose of waste management. The West Sector is located west of the Bishnumati River and consists of recent expansions. The sector mainly consists of residential areas such as Kuleshwor, it is estimated that the sector has an approximately 12,000 households. The West Sector was chosen for introducing door-to-door collection for the following reasons:

In November 1998, KMC signed a five-year agreement with *SILT Environmental Services* to implement door-to-door waste collection in wards 13, 14, and 15. The main objectives of the project were as follows:

(i) introduce private sector participation in waste management to make the system more efficient;
(ii) initiate door-to-door collection of waste in order to avoid dumping of wastes on the streets;
(iii) introduce a source separated waste collection system to promote recycling;
(iv) introduce an alternate day waste collection system to reduce costs;
(v) encourage citizens to participate in Kathmandu's waste management system and pay for waste management services; and
(vi) generate revenue to recover part of the cost of waste collection.

SILT and KMC: SILT started its services in mid February 1999. This programme has been only partially successful because out of 12,000 potential members, only 4,000 have been getting the services and paying the fee. Problem faced by SILT is briefly described below:

- regular Street sweeping activity is conducted by KMC. So, people are not interested in paying because every morning streets are swept and cleaned by KMC staffs;
- there is not major financial benefit for KMC because it carried out regular cleaning activity; and
- inadequate technical knowledge in waste management (SILT).

Pilot Project Wards 1 and 24: Private Sector Participation (Door to door collection, Sweeping, and Transportation) In mid 2002, KMC announced that it was interested in contracting out waste management services (door-to-door collection, street sweeping, and waster transfer) of the Central Sector (Wards 1, 5, 11, 32, 33, and 34) to the private sector. The concept of contracting out six wards at one time has to be abandoned because of opposition by sweepers. After continuous negotiations with the sweepers' union, instead of awarding the contract for six wards to one private company, only two wards (Wards 1 and 24) were contracted out with the contracts awarded to two different companies. The following major steps were included in this PSP:

- After PSP, the sweepers were assured that there would be no layoffs.
- KMC's sweepers would be assigned to other locations or will utilized as gardeners.
- 30% of the total sweepers would remain in the same wards for tasks like cleaning of sewers, monitoring the private sector, and fixing streetlights.
- Private sector would not get any subsidies from KMC and the fee levied should be equal to or less than KMC's existing tariff rate.
- For six months, KMC would provide a vehicle to collect street waste but the private party would be responsible to transfer waste collected from door to door services.
- Technical and Management training would be provided to the private parties.
- Waste would be collected daily (not every other day) and waste separation will not be encouraged for the time being.

5. Impacts

After launching this programme, KMC closely monitored the progress made by the private sector. It has been one year now and KMC understands that these two private companies are making a profit and are willing to continue the services.

During the process KMC provided following services to the private sector:

- Technical and Management training was provided to both the private sector and NGOs who were involved in waste management services.
- Meetings were held to share views and difficulties among these groups.
- KMC constantly monitored and assisted in the planning process.
- KMC launched awareness programmes to the general public in these two wards to build confidence among the people.
- KMC became a mediator between ward representatives and the companies so as to build confidence among the stakeholders.
- KMC provided one vehicle to each company to collect waste (only from streets) for six months.
- KMC transferred 70% of its staff to new locations and are planning on providing gardening training.

6. Lessons

Problems that occurred during the implementation of the PSP programme and how they were handled is detailed in **Table 4** below.

Table 4 HOW IMPLEMENTATION PROBLEMS WERE ADDRESSED:

Problems	How Addressed
Opposition by sweepers	• Meetings were held among sweepers in the presence of ward representatives and assurances given that their jobs were secure and they would be relocated. • 30% of sincere sweepers were kept in the same ward as a reward. • Ward representatives were briefed on the importance of PSP and requested not to politicize the issue.
No confidence among private sector to start the programme in the beginning without KMC's financial assistance	• Private sector was briefed on financial cost benefits and the profits they could make if programme was carefully launched. • Assurances given to the private sector that KMC would contract out all its waste collection services, including door to door collection, street sweeping, and waste transportation activities to the private sector in future. • Private sector assured that they are here to stay and it is long term profit.
No confidence among Stakeholders	• Public meetings were held and assurances given that people will get better service and wards will be cleaner than before. • People and ward officials were assured that if they were not satisfied with the private sector's performance KMC will step in immediately. • Assurances given that the fee levied would be within, or below, the tariff rate set by KMC ($0.70/hh/mo). • General public was briefed regarding KMC's financial situation and that the fee they paid would be utilized to improve the environment of KMC.
Inadequate technical information and management skill in private sectors	• Technical and management training provided. • KMC's technical staff were made available all the times for them to discuss and share expertise as required.

The following outcomes were noted at the end of one year:

- The private companies were willing to continue the activities carried out by them.
- They showed interest in expanding their activities to other wards.
- Approximately 50% of people surveyed expressed the view that the service provided by the private sectors was better (and the ward is cleaner) than before.
- The membership increased approximately 40% as soon as KMC pulled all resources (waste collection vehicles) out from those wards.
- So far different private companies desiring to contract out new wards have filed ten applications in KMC.

The benefits that resulted to all sectors from the launching of this programme are listed in **Table 5** below.

Table 5 BENEFITS ACRUING TO ALL SECTORS

GENERAL PUBLIC	PRIVATE SECTOR	KMC
They are showing more concern than before because they paying a service fee.	Good profit	Better Katmandu
They feel proud because they are doing something for the environment.	Long term profit	Less management burden
The area is cleaner than before.	No major competition	Cost savings. KMC spends approximately US$25,000 for street sweeping and an additional US$7,000 for transportation annually per ward. So total cost saving is around US$22,000 / year/ward.
They do not have to worry about waste anymore.	Fairly small capital investments involved.	More efficient and effective services.
Door-to-door collection services.	Good relationship with local representatives and general public.	No waste in the streets.

One of the KMC's goals is to keep Kathmandu clean. This can only be achieved by involving the private sector and communities in solid waste management services. The PSP programme launched by KMC was partially successful and headed in the right direction but KMC must continuously build confidence among stakeholders.

After few years of PSP experiences, KMC believes PSP can be effective tool to provide efficient and cost effective waste management services to the general public. The following lessons were learned from the programme:

- Confidence must be placed in the PSP programme;
- Careful planning necessary and the need to try different approaches;
- Stakeholders must learn to have confidence in themselves;

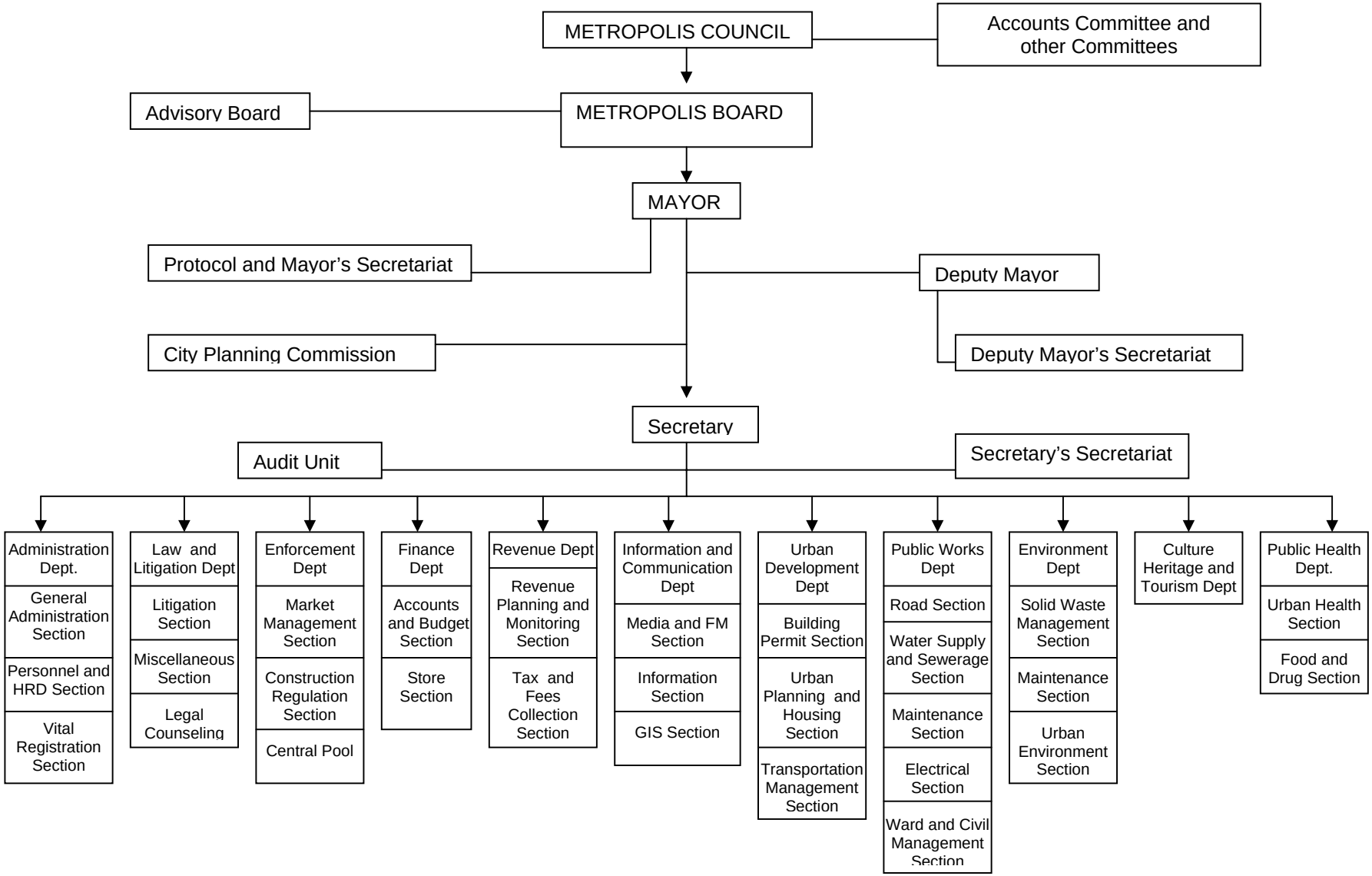
- Confidence must be built amongst stakeholders;
- Ensure that there is no political interference; and
- Transparency in the process is essential.

7. Future Prospects

The following recommendations are made for future success of the programme:

- Human Resources Development: KMC's staff has to be trained to oversee and become involved with the PSP programme;
- Technical and Management training should be provided to the private sector on a regular basis;
- KMC must regularly monitor the process, working system, effectiveness, and ensure their consent through satisfying the general public;
- KMC should make sure that there is always competition among the private sector so that it will be cost effectives and provide quality services to public;
- This is an ongoing process, mistakes will be made but it is important to continue the process;
- In future, KMC should change its role from providing services to the public to managing PSP programmes; and
- International Agencies can assist in the training of staff of KMC and the private sector.

Figure 1 KATHMANDU METROPOLITAN CITY – ORGANIZATIONAL STRUCTURE



D. Fukuoka, Japan
Municipal Solid Waste Management Master Plan (revised: June 1998)

1. Abstract

As a city within a developed country like Japan, Fukuoka City has shifted its approach to solid waste management from the conventional methods of incineration and land filling to promoting waste reduction and recycling methods. As land availability is a limiting factor in seeking final disposal sites, the City in collaboration with the Fukuoka University has developed a semi-aerobic landfill, known as the "Fukuoka Method" now adopted throughout Japan and recommended by the Ministry of Health and Welfare for final waste disposal. The system collects leachate in collection ponds through perforated pipes embedded in graded boulders at the base of the landfill site. Air is introduced into the landfill through the collecting pipes by natural ventilation. This takes place as a result of the heat generated from microbial decomposition of waste, which raises the temperature in the landfill. The temperature differential causes air (oxygen) to flow into the landfill via the leachate collection pipes, which accelerates the aerobic decomposition of waste. Among the advantages of the Fukuoka Method are its simplicity of construction, operation and cost effectiveness, increased waste decomposition rates, methane emission reduction, flexibility of selection and use of common, readily available materials and equipment, reduction of costs of secondary treatment of leachate, enhanced stabilization of waste, short turn around period for landfill to be returned to other uses, ease of future upgrading and improvement. The technology has already been successfully transferred to Malaysia, China and Iran. The method has excellent potential for applicability in other cities within the Kitakyushu Initiative Network.

2. Environmental Setting

Fukuoka City, Japan is located on the northern coast of the island of Kyushu, the third largest and southwestern most of the four main islands in the Japanese chain. Fukuoka City has an area of about 338 km^2. The city has the geographical advantage of being close to the Korean Peninsula and the Chinese Continent and has served as a gateway to important Asian continental cultures from olden times. In the fourth century B.C., the first rice cultivation in Japan began in this area. In 1889 Fukuoka City was born by the organization of a city administration. In 1989, the Asia-Pacific Expo was held to celebrate the First Centennial of the Fukuoka City Administration. The city is located in the centre of the crescent-shaped Fukuoka plain, facing the Genkai Sea on the north surrounded by mountain systems of Sefuri, Sangun, and Inunaki. The climate is rather mild with the annual mean temperature of about 17^oC and is characteristic of the climate of the Japan Sea. Fukuoka City's population consists of a rather young age group with a productive labour population of 72.6 percent in the age bracket of 15-64 years old (the national average was 69.4 percentage, according to the results of the national census taken in 1995.

It is claimed that the Fukuoka City's current citizens' lives are of a very high standard, and that this lifestyle of affluence and convenience inevitably leads to mass production, mass consumption and mass waste. These circumstances have gradually caused an increase in the amount of garbage, exceeding the capacity of current disposal plants. Fukuoka City has actively conducted a range of measures for reducing refuse volume and for promoting recycling. These measures include the collection of ferrous metal and aluminium at the Recycling Centre, supporting local group collections and instructing corporations in methods for reducing corporate

refuse, on top of its systematic improvement in disposal facilities. However, now that the incineration capacity of the disposal plants has now reached its limit due to the increase of combustible refuse, further steps for refuse reduction and recycling are immediately required. A prompt response to "the regulations for promoting separate collections and for recycling related to containers and packaging (Container and Packaging Recycling Act)" is also needed.

Under these circumstances, the Refuse Reduction Special Council was set up in November 1994 as a sectional council of the Fukuoka City Refuse Reduction and Recycle Council to oversee the measures that the city should conduct. In March 1996, the "Report on the Policy for Refuse Reduction and Process for Recycling Container and Packaging Waste" was prepared. With this report, taking into account the objectives of the Seventh Fukuoka City Master Plan, Environment Basic Regulations and Environment Master Plan, the city would seek to establish and ensure the sustenance of a resource recycling society, as well as a long-term and stable refuse disposal system. Citizens, corporations and administrations would work together to produce less refuse in the city and to establish a disposal system, which ensures the reuse and utilization of refuse.

Fukuoka City has developed as a hub city of Western Japan while completing and improving the city infrastructure. Together with its progress in urbanization, the refuse volume has also increased, especially that for combustible refuse such as scrap paper due to the emergence of the office-automation and information-oriented society and the use of disposable plastic containers. As shown in **Table 1** (below) over the 10 year period from 1986 to 1996, the refuse volume increased by 29 %, which is 175 thousand MT in quantity. For the yearly mean, the increase rate shows 3.4 % on average, which is three times larger than the growth rate of the population (1.0%). In the past several years, the growth rate has stabilised at 2% per year; however, it is still showing a tendency to increase, which necessitates work on reducing the refuse volume.

Table 1 TRENDS IN THE AMOUNT OF MUNICIPAL WASTE GENERATION

Year	Refuse Volume						Population	
	Domestic waste (MT)	Industrial waste (MT)	* Others (MT)	Refuse brought from outside the city (MT)	Total (MT)	Growth rate (%)	Population (x1000)	Growth rate (%)
1987	283,398	278,659	11,797	26,622	**600,476**	7.7	1,193	1.4
1988	295,006	287,901	8,661	28,915	**620,483**	3.3	1,208	1.2
1989	308,880	300,942	8,264	32,446	**650,532**	4.8	1,224	1.3
1990	315,590	313,398	7,921	33,584	**670,493**	3.1	1,237	1.1
1991	327,186	341,017	8,798	36,106	**713,107**	6.4	1,250	1.1
1992	330,697	335,989	7,920	37,638	**712,244**	-0.1	1,263	1.0
1993	347,011	336,656	7,789	39,455	**730,911**	2.6	1,271	0.6
1994	357,669	337,433	7,594	41,324	**744,020**	1.8	1,278	0.6
1995	359,996	347,681	7,458	43,489	**758,624**	2.0	1,285	0.5
1996	376,296	344,528	6,797	47,874	**775,495**	2.2	1,296	0.9

* *Others include the refuse from cleaning roads, streets and trash bins, piled refuse and refuse from skimming the rivers.*

Current Condition of Domestic Waste: Domestic refuse is collected on a regular basis by the city, except for the outlying islands, and brought to the municipal disposal plants. Glass bottles are collected at 100 key locations such as supermarkets within the city. The trial separate collection of glass bottles and PET bottles began in the designated districts in January 1997. The conventional two-way separate collection system (combustible refuse, and non-combustible with bulky refuse) shifted into the three-way separate collection system (combustible refuse, non-combustible and bulky refuse) in October 1997. The domestic refuse volume was about 376 thousand MT in 1996, which shows an increase of approx. 33% compared to that of 1987 and an increase of approx. 3.7% in the yearly mean (see **Table 2**). The composition of domestic combustible refuse (survey in 1995, see **Table 3**) is about 30% scrap paper, 13% plastic, 47% kitchen waste and 3.7% non-combustible refuse mixed together. Domestic non-combustible and bulky refuse (survey in 1994, see **Table 4)** consists of 39% non-combustible, and 28% bulky and 32.4% of the combustible refuse such as newspapers mixed together. The exhaustive separate disposal system should be further promoted together with educational activities on recycling.

Table 2 TRENDS IN DOMESTIC REFUSE COMPOSITION

Year	Combustible refuse (MT)	Non-combustible refuse and bulky refuse (MT)	Total (MT)	Growth rate from the previous year (%)
1987	219,481	63,917	**283,398**	7.8
1988	228,684	66,322	**295,006**	4.1
1989	236,858	72,022	**308,880**	4.7
1990	239,003	76,587	**315,590**	2.2
1991	243,527	83,659	**327,186**	3.7
1992	247,996	82,701	**330,697**	1.1
1993	252,495	94,516	**347,011**	4.9
1994	260,707	96,962	**357,669**	3.1
1995	270,352	89,644	**359,996**	0.7
1996	279,864	96,432	**376,296**	4.5

Remarks: The amount of non-combustible refuse and bulky refuse in 1996 included 367 MT of glass bottles, 3 MT of glass bottles collected at key locations and PET bottles collected through the trial separate collection project.

Table 3 DETAILED COMPOSITION OF DOMESTIC COMBUSTIBLE REFUSE

Category	Ratio (%)
Scrap paper	30.49
Plastic	13.41
Kitchen waste	47.34
Rags	2.23
Rubber and leather	0.15
Other combustible refuse	2.70
Noncombustible refuse	3.68
Total	**100.00**

(according to a fact-finding investigation in 1995)

Table 4 DETAILED COMPOSITION OF DOMESTIC NON-COMBUSTIBLE and BULKY REFUSE

Category	Ratio (%)
Bulky refuse	28.20
Noncombustible refuse	39.40
(Glass)	(21.60)
(Metal)	(12.27)
(Others)	(5.53)
Combustible refuse	32.40
Total	**100.00**

(according to a fact-finding investigation in 1994)

Current Condition of Industrial Refuse: Refuse resulting from business activities of corporations and retail stores (except for industrial waste) is collected by the general refuse collectors approved by the city mayor and brought to the municipal disposal plants. The remaining refuse is self-delivered by the corporations. Independent operators collect the refuse directly from city government offices. As seen in **Table 5**, corporate refuse was about 345 thousand MT in 1996, which was an increase of 24% and 66 thousand MT compared to 1987. This is an yearly increase of about 3.0 %, of which the major part is brought to the disposal plants as combustible refuse. The composition of corporate refuse (see **Table 6a**) is 44% scrap paper, 16% plastic, 30% kitchen waste and 5.4% non-combustible refuse mixed together. 24.2%

of recyclable refuse is also contained in corporate refuse (see **Table 6b**) and more detailed and thorough instructions are needed for separate disposal, refuse reduction and recycling.

Table 5 TRENDS IN CORPORATE REFUSE COMPOSITION

Year	Collection by the approved collectors and directly operated collectors (MT)	Self-delivered (MT)	Total (MT)	Increase and decrease from the previous year (%)
1987	140,367	138,292	**278,659**	8.4
1988	150,954	136,947	**287,901**	3.3
1989	161,200	139,742	**300,942**	4.5
1990	164,340	149,058	**313,398**	4.1
1991	170,061	170,956	**341,017**	8.8
1992	173,611	162,378	**335,989**	-1.5
1993	176,316	160,340	**336,656**	0.2
1994	181,724	155,709	**337,433**	0.2
1995	189,981	157,700	**347,681**	3.0
1996	197,963	146,565	**344,528**	-0.9

Table 6 COMPOSITION OF CORPORATE REFUSE

TABLE 6a

Category (Item)	Ratio (%)
Scrap paper	43.75
Plastic	15.85
Kitchen waste	29.68
Rags	2.05
Rubber and leather	1.57
Other combustible refuse	1.67
Non-combustible refuse	5.43
Total	**100.00**

TABLE 6b Recyclable materials among the items in TABLE 6a

Category	Ratio (%)
Newspapers and cardboard	20.48
PET bottles and trays	0.12
Glass bottles	0.45
Cans	2.93
Rags	0.23
Total	**24.21**

(According to a fact-finding investigation in 1995)

Current Condition of Refuse Disposal: Fukuoka City has proceeded with the systematic improvement of the final disposal plants for incineration and landfills in order to ensure a stable refuse disposal system. Handling and disposal of refuse should be conducted in a non-toxic, hygienic way so as to not interfere with the living environment, and a great deal of

effort is needed to reduce the final refuse volume. The outline of refuse disposal in Fukuoka City is as follows. Combustible refuse is incinerated at the disposal plants and disposed of in the landfill sites in order to enhance hygienic disposal as well as to reduce refuse volume and contents. The excess heat generated by incineration is utilized for power generation and hot-water supplies for the surrounding facilities. The city has also proceeded with the "Green Recycle Project" in which trimmed branches are used as a soil conditioner and scrap timber is sorted into valuable wood materials. Non-combustible and bulky refuse are crushed and sorted at the recycling centres into ferrous metal and aluminium. The combustible part is incinerated and the non-combustible refuse is disposed of in the landfill sites. Glass bottles collected at key locations, such as at supermarkets within the city, are transferred to collection merchants for recycling.

Current Condition of Refuse Incineration: Fukuoka City has endeavoured to maintain a system that fully disposes of (incinerates) combustible refuse which accounts for the majority of all refuse. In particular, the city has maintained its incineration structure (see **Table 7**) through efforts to cope with the rapid increase in refuse volume from the Showa 60's (a period of time from 1985 to 1988) such as the construction of the Tobu Second Plant in 1990 and the rebuilding of the Seibu Plant in 1992. In recent years, however, the volume of combustible refuse has exceeded the capacity of the incineration plants and the city's disposal issue is in a critical situation before the coastal incineration plant, which is scheduled for completion, is in operation. Under such circumstances, a carefully thought-out plan is necessary to ensure the effective disposal of refuse as well as to make efforts to reduce the refuse volume.

Table 7 LIST OF INCINERATION PLANTS

Incineration Plant	Capacity	Yearly Disposal Capacity		Remarks
		1996	2001	
Tobu Plant	600 t/day	510 t/ day	480 t/ day	Opened in 1976
Tobu Second Plant	200 t/day	170 t/ day	160 t/ day	Opened in 1990
Nanbu Plant	600 t/ day	510 t/ day	480 t/ day	Opened in 1981
Seibu Plant	750 t/ day	630 t/day	600 t/ day	Opened in 1992
Coastal Plant (schedule)	(900 t/day)	-	580 t/ day	Scheduled to open at the end of 2000
Total	**2,150 t/day**	**1,820 t/day**	**2,300 t/day**	

Remarks: The yearly disposal capacity is calculated reflecting a halting of incinerators for regular maintenance. The working ratio will be changed from 85% to 80 % after 2001 (when the coastal plant will be opened).

Current Condition of Refuse Crushing and Separation: Recycling Centres for crushing and separating non-combustible refuse and bulky refuse (see **Table 8**) are situated at the Seibu Clean Park and the Tobu Clean Park to reduce the refuse volume dumped in the landfill sites, as well to collect ferrous metal and aluminium. The volumes of non-combustible refuse and bulky refuse shows an increase probably due to issues related to collection at key locations (where combustible refuse mixed together with corporate refuse is brought in). A review of the collection of domestic refuse since December 1997 indicates that reducing refuse volume should be promoted.

Table 8 LIST OF CRUSHING AND SEPARATING PLANTS

Plant Location	Capacity	Yearly Disposal Capacity	Remarks
Tobu Recycling Centre	250 t/ day	125 t/ day	Opened in 1986
Seibu Recycling Centre	200 t/ day	120 t/ day	Opened in 1994
Total	**450 t/ day**	**245 t/ day**	

Remarks: Yearly disposal capacity is the value recorded after 1998.

Current Condition of Landfill Disposal: Acquisition of final disposal sites for landfill is the biggest issue with respect to refuse disposal and Fukuoka City has put a great deal of effort into this (see **Table 9**). As the Tobu (Fushitani) landfill site located in Hisayama-machi in the Eastern district and the Imazu landfill site in the Western district will reach their full capacity soon, the Seibu (Nakata) site has been reopened as a landfill site and has been utilized since 1996. Since acquisition of final disposal sites will likely be more difficult in the future, we have to seek ways to use the existing final disposal sites for the longest period of time possible through the promotion of refuse reduction and recycling.

Table 9 LIST OF FINAL DISPOSAL SITES

Site	Land Area	Capacity	Remarks
Tobu (Fushitani) Landfill Site	Approx. 644,000 m^2	Approx. 3.40 million MT	Opened in 1988
Seibu (Imazu) Landfill Site	Approx. 758,000 m^2	Approx. 1.64 million MT	Opened in 1975
Seibu (Nakata) Landfill Site	Approx. 380,000 m^2	Approx. 2.38 million MT	Opened in 1996

Current Condition of Refuse Reduction and Recycling: To cope with the issues of constantly increasing refuse, Fukuoka City has formulated a range of policies to promote refuse reduction and recycling while improving the disposal facilities and structures. Since refuse is deeply connected with the citizens' lives and business activities, the "*Reducing Refuse Volume and Recycling Promotion Committee*" has been organized in cooperation with citizens, corporations and administrative entities to work on the issues together.

***1) Reducing Domestic Refuse and Recycling*:** Fukuoka City has been engaged in a variety of refuse reduction and recycling promotional projects. Two examples are rewarding achievements for local group collections conducted by the children's societies, and subsidizing systems for purchasing compost. The city is also promoting the "Recycle Dream Market" in which unused furniture and other items are provided to citizens, promoting the "Karl Mark Stores" which provide simple wrapping, and promoting the "Clean Recycle Project" in which each ward office collects empty cans and other items. As supplemental collection projects of local groups, a scrap paper collection at key locations project and a regular collection project have also gone forward. Citizens' consciousness has also been raised about reducing refuse and recycling through a range of activities. One example is establishing the “Recycle Plaza”, which is a place for information on recycling and activities. The City hosts “Refuse Reduction Fairs” and organizes field trips to disposal plants and recycling-related facilities. Further, the “empty cans pressing car (kanpaku taisho)” is taken to elementary schools and other facilities, and a

leaflet entitled "Garbage and Us" as one of the educational materials provided to the social studies classes of 4th grade students.

Citizens' awareness about environmental issues has recently been raised and it is crucial to encourage them to carry out concrete actions and to further enhance the reduction of refuse and recycling. There is a problem with excess scrap paper as unused and old magazines are not collected due to the sluggish prices existing throughout the nation. Because the amount of collected scrap paper far exceeds the low demand for recycled paper, an effective solution is needed to ensure stable scrap paper recycling.

***2) Reducing Corporate Refuse and Recycling*:** In order to reduce corporate refuse, corporations with business buildings larger than the specified size (a total floor space of 3,000 m^2) are obligated to prepare a refuse reduction report and appoint a refuse reduction promotion manager. In addition, government authorities will inspect the inside of the buildings in order to give guidance on reducing refuse and recycling. Reducing refuse from the city government offices is also enhanced through controlling the usage of paper, promoting the usage of recycled paper and separating the disposal of scrap paper from other items. Since the volume of corporate refuse disposed of is the same as that of domestic refuse, reinforced and comprehensive guidance should be provided to further promote corporate refuse reduction and recycling. In addition, a system offering a great incentive to move to refuse reduction and recycling (since recycling is more reasonable and economical than disposing paper as refuse) should be established.

Prediction of Future Refuse Volume (Based on the past records: Estimated refuse volumes have been calculated based on records of refuse volume for the past ten years and the estimated population changes described in the 7th Fukuoka City Basic Plan. As an estimate of future refuse volume (see **Table 10**), domestic refuse will increase from 376,000 MT in 1996 to 515,000 MT in 2010, corporate refuse from 345,000 MT to 506,000 MT, and the total amount from 775,000 MT to 1,104,000 MT, which is an increase of 42%.

Table 10 ESTIMATE OF REFUSE VOLUMES BASED ON PAST RECORDS

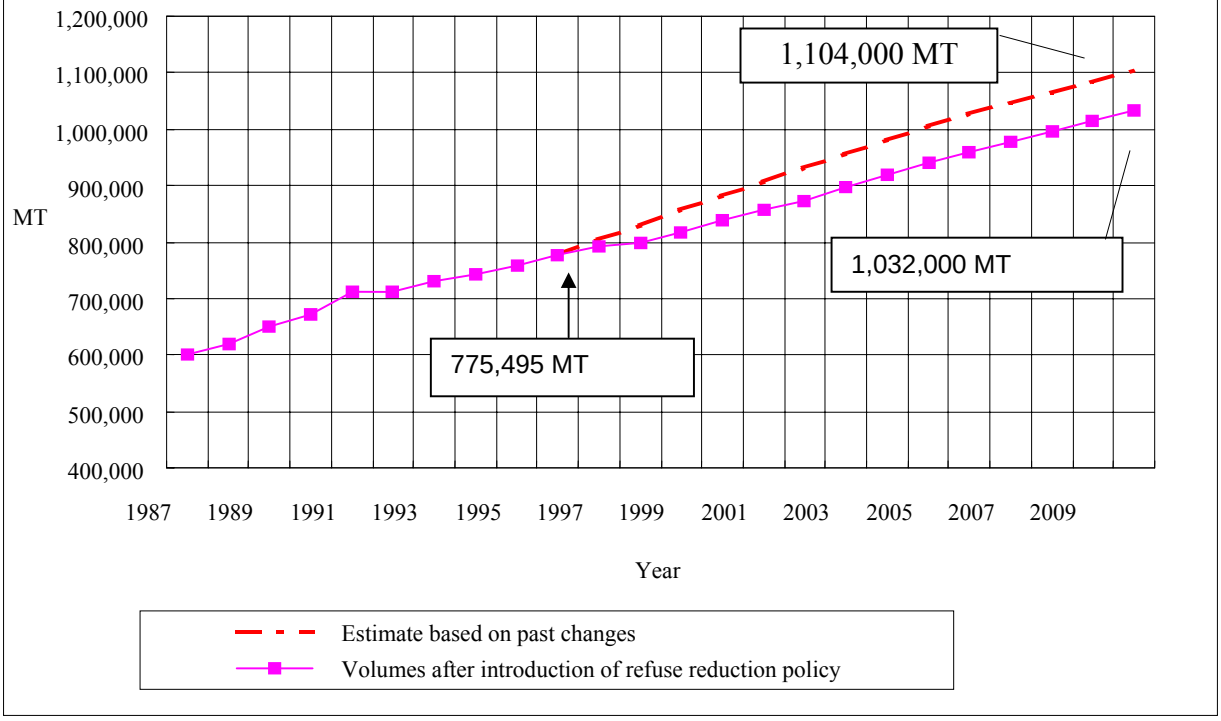
Category	Domestic refuse	Corporate refuse	Others	Refuse brought from outside the city	Total	Population
1996	376,296 MT (100)	344,528 MT (100)	6,797 MT (100)	47,874 MT (100)	775,495 MT (100)	1.296 million (100)
2010	515,000 MT **(137)**	506,000 MT **(147)**	7,000 MT **(103)**	76,000 MT **(159)**	1,104,000 MT **(142)**	1.467 million **(113)**

Remarks: The value enclosed in brackets is an index number as compared with 1996 figures = (100).

Trends in Refuse Volume: Future refuse disposal volumes are calculated deducting an estimated reduction amount brought about by the introduction of refuse reduction policies, such as the three-way separated collection system introduced in December 1997, from an estimated refuse volume based on the past changes (see **Graph 1**). The estimated refuse volume in the milestone year (the year 2010) is approx. 473,000 MT of domestic refuse and 476,000 MT of corporate refuse, making a total of 1,032,000 MT of refuse (see **Table 12**). Since improvements

in refuse disposal facilities and structures will be designed and carried out according to the changes in the refuse disposal volume, we must manage the progress of each project effectively, as well as further promote the future reduction of refuse volume and recycling.

Graph 1 Changes in Refuse Disposal Volumes



Leading Organizers of Refuse Disposal: The main organizers of refuse disposal in the milestone year are as shown in **Table 11**; however, other measures such as voluntary collections by corporations will be promoted to reduce refuse and to encourage recycling.

Table 11 REFUSE DISPOSALS ORGANIZERS

Category	Collection and Transport	Intermediate Handlers	Final Disposal
Domestic refuse	City	City	City
Corporate refuse	Approved collectors or disposal agents	Approved disposal agents or the city	Approved disposal agents or the city

3. Issues and Challenges

The garbage disposal problem has been considered to be one of the environmental issues in the preservation of limited natural resources. A shift from the conventional disposal approach of burning and land filling the refuse to the new circulation-oriented concept of reducing the refuse volume and promoting recycling while utilizing the excess heat generated from incineration is a priority consideration.

Municipal Solid Waste Management Master Plan: The City's goal is to control the generation of Municipal Solid Waste and promote recycling. It is hoped that the social structure can be changed to harmonize with the natural environment, emphasizing the conservation of natural resources while creating a city which produces less refuse. The intention is to accomplish this by raising citizens' consciousness and shifting their lifestyle so that actively promoting refuse reduction and recycling with the involvement of the citizens and corporations can preserve the natural environment. It is planned to promote citizens' consciousness raising through education on environmental issues. From the viewpoint of refuse reduction and the promotion of recycling, the City must carry out research and review the establishment of refuse disposal fees which can be effective as an economic incentive. In addition it is planned to:

- Establish refuse disposal systems which ensure thorough reuse and recycling;
- Change the current refuse disposal system to a recycle-oriented system;
- Review the collection of refuse and improve the recycling-related facilities;
- Systematically improve facilities and structures to establish an appropriate stable and long-term disposal system; and
- Establish a refuse disposal system, which can ensure thorough reuse and recycling through a variety of approaches such as collecting recyclable materials at disposal plants and actively proceeding with the utilization of excess heat.

Conforming to the Seventh Fukuoka City Basic Plan, the year 2010 is designated as the target (or milestone) year. **Table 12** gives the estimated volumes of refuse in 2010 as compared with 1996.

Table 12 ESTIMATE OF THE VOLUME OF REFUSE IN THE TARGET (MILESTONE) YEAR

Category	YEAR 1996 (MT)	YEAR 2010 (MT)	Remarks
Domestic Refuse	376,296	473,000	The future refuse disposal volume is calculated by deducting the estimated reduction amount brought about by the introduction of refuse reduction policies, such as the three-way separated collection system begun in December 1997, from the estimated refuse volume based on past records.
Corporate Refuse	344,528	476,000	
Others	6,797	7,000	
Sub-total for Refuse within the City	727,621	956,000	
Refuse Brought from Outside the City	47,874	76,000	
Total	**775,495**	**1,032,000**	

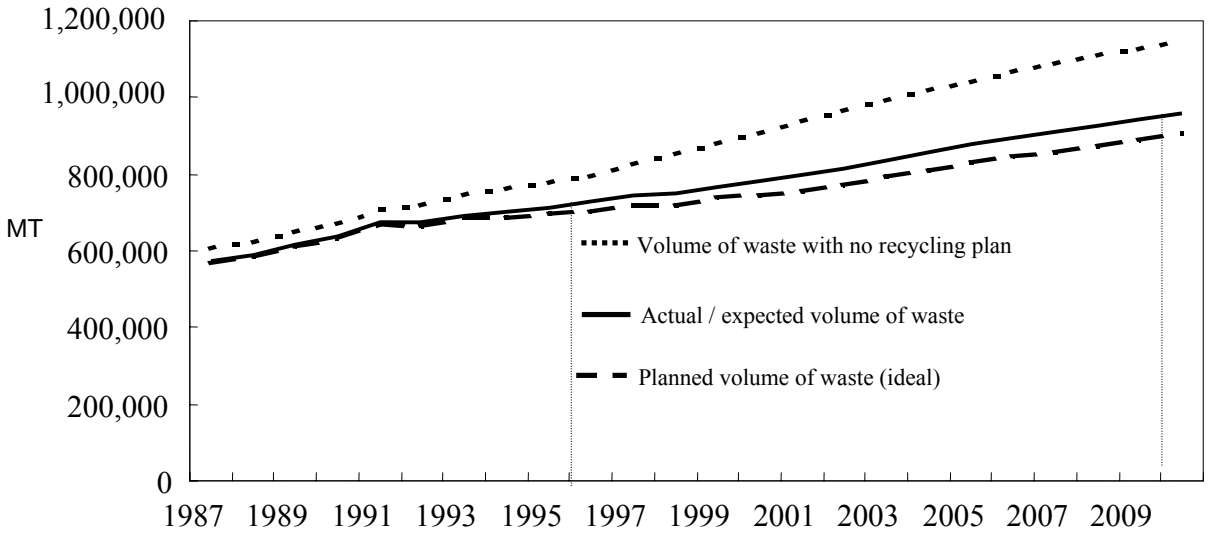
4. Implementation Strategy

The Master Plan for the management of Fukuoka City's solid waste was designed after a review by the Fukuoka City Solid Waste Disposal Facility Construction Research Committee, Special Council in order to ensure a closer linkage with the future improvement and construction of waste disposal facilities.

This Master Plan is the mid- and long-term plan for refuse disposal for the coming 10 to 15 years (including disposal by the city and out-sourced entities). Designed in April 1993, the "Fukuoka City Municipal Solid Waste Management Master Plan" was revised taking into consideration various changes such as the prevailing social situation.

The Control of Refuse Generation and a Recycling Plan: The percentage of reduced or recycled volume out of the estimated volume of refuse production (see **Table 13**) within the city (the sum of the volume of refuse to be disposed of and the reduced volume) will be increased (see **Graph 2**), to 21% in 2010 from 11.2% in 1996. The contributions of the major projects, whose targets would result in the reduced and recycled amounts for 1996 and the estimated amounts for 2010, are shown in **Table 14**.

Graph 2 Volume of Reduction and Recycling
(Excluding waste outside of City)



Year

	1996	2010
Estimated Volume of Refuse	791,832 MT	1,145,000 MT
Vol. Reduced and Recycled	88,687 MT	241,000 MT
Reduction and Recycled Ratio	11.20%	21%

Table 13 REFUSE REDUCTION FOR 1996 AND 2010

YEAR	Estimated Amount of Refuse	Reduced and Recycled Amount	Reduction and Recycled Ratio
1996	791,832 MT	88,687 MT	11.2%
2010	1,145,000 MT	241,000 MT	21.0%

Remarks: The estimated volume of 791,832 MT of refuse for 1996 = the sum of the 727,621 MT from refuse collected within the city, the 25,042 MT from local group collections, the 35,000 MT from reduced corporate refuse achieved by guidance, the 2,989 MT from kitchen waste reduction realized by subsidizing compost, the 170 MT from refuse reduction achieved through Curl Mark Stores, the 190 MT from clean recycled materials, the 751 MT from scrap paper collected at city government offices, and the 69 MT from the recycle dream market. The estimated volume of refuse in 2010 is calculated based on the past record and the future estimated population.

Table 14 TARGETS OF MAJOR PROJECTS

Major Projects to Reduce and Recycle Waste	1996 (MT)	2010 (MT)
Promotion of local mass collections	25,042	50,000
Instructions on reducing corporate refuse	35,000	62,000
Reduction in the volume of bulky refuse	-	36,000
Separate collections of glass bottles and PET bottles	-	16,000
Collection of ferrous metal and aluminium at the Recycling Centres	18,605	21,000
Green recycling	4,768	14,000
Reduction by other approaches	5,272	42,000
Total	88,687	241,000

Methods for Controlling the Generation of Refuse and Encouraging Recycling: The Master Plan proposes ten methods for controlling refuse generation. These are:

***1) Education and Understanding about the Environment*:** The plan proposes to develop educational structures and subjects on the environment to deepen our understanding of what an environmentally-friendly lifestyle is, including the reduction of refuse volume and what local actions can be taken. The plan proposes to:

- Encourage corporations to utilize recycled materials;
- Develop long-term durable products;
- Establish a maintenance and repair support system;
- Make durable containers and wrapping for general use; and
- Promote simple wrapping.

The plan also will attempt to raise citizens' consciousness about reducing the volume of refuse, such as by:

- Not bringing home items that will be thrown away by carrying a shopping bag (avoiding plastic shopping bags);
- Refusing decorative wrapping;
- Cooperating with the separate collection and mass collection systems;
- Using recycled products; and
- Taking good care of their goods.

***2) Refuse Reduction and Recycling Committee*:** Citizens, corporations and administrative bodies should cooperate with each other to work on refuse problems through the promotion of the use of recycled products by an "appointment system" and through the presentation of a detailed "environmentally-friendly" lifestyle.

***3) Research of Effective Refuse Disposal Fees System*:** In the viewpoint of promotion of refuse reduction and recycling, the effective refuse disposal fees system including introduction of "paid specified garbage bags" will be continuously reviewed and researched considering changes in citizens' consciousness and conditions of other cities.

***4) Promote Mass Collections*:** As for the award system for local group collections, the City intends to rethink the system itself and raise the reward values according to the collected amount. The City will promote recycling activities in which citizens can easily participate, such as key station collections and regular collections of scrap paper, and encourage citizens and corporations to increase the use of recycled paper. The City will also support the resource collection industry, which is the basis of scrap paper collection, by forming an organization and building a stable recycling route. In addition, the City will establish group collection routes for items such as milk cartons.

***5) Promote Collections at Retail Stores*:** Voluntary collections of some items such as milk cartons, plastic trays and plastic shopping bags by corporations should be further promoted. The collection boxes for glass bottles placed in supermarkets will be used for point collections of other items such as plastic trays when separate collections of glass bottles and PET bottles are fully introduced.

***6) Promote the Recycling of Usable Furniture*:** The Recycle Plaza in which recyclable furniture is displayed will be appropriately arranged according to the demands of the citizens. The swapping sessions of unused items for freshmen will also be promoted at universities.

***7) Diffusion of Compost*:** The support for a domestic kitchen waste disposal system will be considered as well as the subsidization of the purchase of compost on the basis of the conditions of technical development.

***8) Guidance on Reducing Waste from Business Establishments and on Recycling*:** Provide strict direction to corporations occupying an area smaller than 3,000 m^2, which produce a great deal of scrap paper. In addition, refuse brought to the municipal disposal facilities should be strictly monitored and managed by giving instructions on the reuse of recyclable materials and

by refusing the non-disposable items. Promote the wide use of specified garbage bags for corporate combustible and non-combustible refuse. Promote the recycling of paper by scrap paper collections and the recycling of confidential papers. Develop the green recycling system (utilizing trimmed branches and scrap timber). Decompose a large amount of kitchen waste now disposed of in public facilities. Consider the introduction of a refuse disposal fee system to enhance the incentive to reduce refuse.

***9) Separate Collections of Domestic Refuse*:** Several new systems will be adopted such as the introduction of "reserved and paid" collections of bulky refuse, the usage of specified garbage bags (three-way separate collections) and separate collections of glass bottles and PET bottles (four-way separate collections) in 2000.

***10) Promote Collection and Recycling Initiated by Manufacturers*:** Voluntary collections by manufacturers of a range of items such as button-shaped batteries, Nickel/Cadmium batteries, LP gas canisters and fire extinguishers will be further promoted, as well as collections of unused electric appliances and personal computers.

Collection and Transport Plans: The plan proposes four targets for collection and transport.

***1) Efficient Collection and Transport System*:** Instructions should be given to the contracted collectors and approved general refuse carriers to ensure a more efficient collection and transport system. The introduction of low-pollution vehicles for collections and deliveries should be considered.

2) A Fully Improved Collection and Transport System Supporting Separate Collections: Provide a collection and transport system that supports four-way separate collections (combustible, non-combustible, bulky, glass bottles and PET bottles).

***3) Guidance on Appropriate Refuse Disposal*:** Provide more strict instructions and education to citizens about the separate disposal of refuse, group collection and point collection. Corporations will be monitored more strictly and instructed in refuse reduction and recycling as well as in appropriate separate disposal.

***4) Cost-saving*:** Endeavour to save costs by carefully reviewing and planning the working system and equipment for collections and deliveries.

Collection and Transport Districts: The collection and transport districts cover all of Fukuoka City.

Methods for Collection and Transport:

1) Domestic Refuse

- Combustible refuse (specified garbage bags, house-to-house collections twice a week at night since December 1997);

- Non-combustible refuse (specified garbage bags, house-to-house collections once a month at night since December 1997);
- Bulky refuse (house-to-house collections during the daytime since December 1997. Handling fees and applications are required); and
- Glass bottles and PET bottles (house-to-house collections once a month at night after 2000).

2) Business Waste

- Carried by the general refuse collection contractors or the corporations which produced the refuse;
- Reusable and recyclable materials should be removed; and
- Combustible refuse, non-combustible refuse, trimmed branches and scrap timber should be sorted and separated before bringing them to the disposal plants.

3) Other Refuse

- In order to recycle the refuse disposed of in the parks and along the roads, separate trash bins will be provided.

Intermediate Processing Plans: Refuse disposal facilities for intermediate processing are essential to hygienically dispose of and treat refuse, and to ensure smooth maintenance of the city infrastructure. The City intends to improve the incineration plants, which contribute to the reduction of refuse content and non-toxic disposal, as well as the recycling-related facilities which support the collection of recyclable items and refuse reduction. The disposal plants will function not only as incineration facilities, but will also utilize the excess heat generated from burning the refuse to supply electricity, hot water and air conditioning to the surrounding facilities. With the purposes of promoting the co-existence of human-beings and the natural environment, and the building of a recycle-oriented society while preserving the global environment, the Clean Park situated around the disposal plant will play an important role as a community centre where citizens can have free access to the natural environment. A mutually cooperative relationship with adjacent autonomous governments will be further enhanced.

1) Targets for Intermediate Processing

- Promote refuse reduction and recycling by offering and improving on recycling-related facilities, including one for glass-bottle and PET-bottle sorting and storage;
- Reduce the combustible refuse volume by providing a wide range of intermediate processing for combustible refuse;
- Maintain an incineration system which can handle all the combustible refuse volume;
- Develop steps for controlling the production of dioxins;
- Promote the collection of ferrous metal and aluminium;
- Save energy by utilizing the excess heat from the incineration plants; and
- Save costs by carefully reviewing and planning personnel management and equipment.

2) Intermediate Processing Methods

(a) Combustible Refuse: The plan provides diversified processing methods and promotes the reduction of refuse volume through recycling trimmed branches and scrap timber. All of the combustible refuse will be handled at the disposal plants. Investigate new potential refuse disposal technologies such as highly efficient "refuse" power generation, and develop gas-firing processing to reuse incineration ash and decomposition processing for kitchen wastes produced by large corporations and facilities.

(b) Non-combustible and Bulky Refuse: The refuse will be sorted into combustible, non-combustible, ferrous metal and aluminium materials after crushing at the crushing and sorting plant. The combustible refuse will be incinerated, the non-combustible refuse will be land filled, and the ferrous metal and aluminium will be recycled.

(c) Glass Bottles and PET Bottles: Glass bottles are sorted according to colour and PET bottles are compressed at the sorting facility after removing any foreign objects. The City will review and plan how to support the recycling of scrap plastic such as trays based on the Wrapping and Container Recycling Act which will be introduced in 2000, as well as a new recycling method for glass.

3) Outline of Plans to Improve Intermediate Processing Facilities

(a) Rinkai Plant: To be completed at the end of 2000, a new coastal plant is now under construction at the landfill site at Hakozaki Futo 4-chome, Higashi Ward (capacity: 900 MT/day). The plant will be equipped with a Recycle Plaza in which reusable furniture will be displayed. A leisure facility for citizens utilizing the excess heat will be provided.

(b) Tobu Plant: Since it opened in 1976, the Tobu Plant has been used for a long period of time and is to be rebuilt on an adjacent site at the end of 2004. The capacity of the newly rebuilt plant will be 900 MT/day to cope with the rapid increase in combustible refuse.

(c) Nanbu Plant: Since its opening in 1981, the Nanbu Plant has also been used for a long period of time and is to be rebuilt after a lapse of 25 years. The capacity of the newly rebuilt plant will be set in accordance with changes in the amount of combustible refuse available for disposal.

(d) Tobu Second Plant: This facility has been built to handle a sharp increase in the amount of refuse on an emergency basis, and will be abolished when the new Nanbu plant begins operation because of the inefficiency of management between it and the Tobu Plant.

(e) Recycling-Related Facilities: Facilities for sorting and providing transit and storage of glass and PET bottles will be completed (scheduled to open in 2000) in both the eastern and western districts with a capacity of 40 MT/day. The utilization of private facilities will be considered for sorting and storage for containers other than

glass bottles and PET bottles, as well for the recycling of trimmed branches and scrap timber in the western district.

Final Disposal Plan: The Final Disposal Plan intends to:

- Promote the reduction of content and weight of refuse and minimize the final disposal amount by introducing the intermediate processing of refuse;
- Strictly monitor and manage the refuse brought to the landfill sites;
- Restrict delivery of reusable and recyclable refuse; and
- Appropriately, manage landfill sites and sewage treatment facilities.

This plan will be carried out by selecting the optimum landfill method as well as exuded waste water prevention measures, and taking countermeasures to prevent the scattering and out-flowing of refuse and offensive odours.

THE FUKUOKA METHOD: Is one such method used successfully in Fukuoka namely the Development and Practice of Solid Waste Landfill Technology: Semi-Aerobic Landfill. (The description below is derived from material presented during a power point presentation at the 1st Kitakyushu Initiative Thematic Workshop in Kitakyushu City, Japan as well as material from the ICLEI website (http://www.iclei.org/mia98-99/fukuoka.htm).

In the late 1960s to the early 1970s, a dramatic increase in economic development in Japan brought with it an increase in waste materials. Many cities were not equipped to handle an increase in waste materials. Dumping wastes directly onto landfill sites that were constructed on low-level ground was a common approach to disposing solid wastes in urban areas. The sudden increase in waste resulted in air pollution and production of combustible gases, ground water and river contamination as well as damage to agricultural products due to toxic leachate, in addition, the foul odours attracted vermin such as flies and rats. Complaints from residents living nearby soon followed.

In an attempt to establish a relationship with residents living near the landfill site and to improve urban public health, Fukuoka City initiated a waste management research project. Supported by the Ministry of Health and Welfare and working with the University of Fukoka, the project involved classification of landfill structures. Fukuoka City, Habitat Fukuoka Office and Fukuoka University helped finance the overall development budget of US$1,291,000. Professor Masataka Hanashima of Fukuoka University proposed five types of landfill structure based on their microbial makeup. This was the genesis of the semi-aerobic landfill. Exhaustive tests at two local landfill sites (Hisayama and Shinkamata) were undertaken before the first semi-aerobic landfill was completed in Fukuoka in 1975. In 1979, the semi-aerobic landfill approach, known as the "Fukuoka Method," was adopted in the Final Waste Disposal Guidelines issued by the Ministry of Health and Welfare. Its salient features are its low cost, low technology and the fact that it causes less pollution.

Municipal Solid Waste disposal sites should ideally have the following criteria:
(1) Adequate storage capacity;
(2) Possess some form of environmental pollution control;

(3) Promote decomposition/stabilization of the waste;
(4) Promote leachate self-purification; and
(5) Have gas ventilation.

The site also reduced leachate generation, and sped up its production. A leachate collection and draining unit (collecting pipe) consisting of Cobble stones and a perforated pipe, are installed in the bottom of the landfill, which is waterproofed to speedily discharge the leachate out of the system to prevent retention in the waste layer. This serves to prevent the leachate from permeating the landfill foundation, and to as much as possible, purify the leachate at the collecting stage. The latter can be achieved by introducing air into the landfill through the collecting pipe by natural ventilation, thus helping to accelerate the aerobic decomposition of waste (**Figure 1**). The leachate collection pit can either be external or internal and the collected leachate is finally treated biologically.

With the semi-aerobic landfill method, heat generated from the microbial decomposition of waste raises the temperature in the landfill. The heat convection brought about by the temperature difference between the inside and the outside causes air (oxygen) to flow into the landfill via the collecting pipe. Installation and maintenance are also simple. The Biochemical Oxygen Demand (BOD) of leachate shows little variation in conventional landfills even after one year of operation, but landfills using the semi-aerobic landfill design have shown verified results of BOD dropping to about 1/1,000 in the same period of time. These factors reduce the expenses associated with managing wastewater from the landfill sites. As well, lower construction and maintenance expenses contributed to the economic benefits from the project.

1) ***Outline of Conditioning of Final Disposal Sites***

(a) Tobu (Fushitani) Landfill Site: Since opening in 1988, this site has been used longer than its forecasted period because of the reduction in the content and weight of the refuse. The landfill period will be discussed with the respective organizations and according to the progress of the landfill, the site will be systematically conditioned.

(b) Seibu Landfill Site: Seibu (Nakata) landfill site was scheduled to be used for 20 years from its opening in 1996, and will be systematically conditioned according to the progress of the landfill. Imazu landfill site will be arranged and conditioned based on the site utilization plans when the landfill is completed.

(c) Other Sites: Continuous acquisition of final disposal sites is the biggest issue for waste disposal, and will likely be more difficult in the future. Careful consideration and planning should be given to the acquisition of the next landfill site.

2) Land Utilization Plans for Completed Landfill Sites

After landfills are completely full, the final disposal sites should be effectively used in the long-term after comprehensive consideration of the demands of local communities and administration bodies. The final success of a landfill is its ultimate closure and reversion to being site having a functional land use such as sports parks, green areas, promenades, etc wherein the site can be used by the residents of the area in a safe and productive manner.

5. Impacts

The **Fukuoka Method** of developing a semi-aerobic landfill works to preserve and protect the environment, while at the same time aiming to establish a practical landfill method that is both economically practical and socially acceptable. The semi-aerobic landfill structure that maximizes the decomposition and cleaning effects provided by microbial activity existing within waste layers. A comparison of semi-aerobic landfill sites with conventional anaerobic sites revealed that semi-aerobic landfill structures promote the decomposition of organic waste, and yield lower levels of methane, hydrogen sulphide and other harmful gases. The comparison also showed that semi-aerobic landfill sites reduced methane gas generation by 59 percent when compared with conventional sites. This contributes to the prevention of global warming by suppressing greenhouse gas emissions.

Technology Transfer: The City will promote, as a key contribution the transfer of waste disposal technologies to the Asian-Pacific region in cooperation with universities and private sectors, and will consider the technical transfer of and training in landfill technology.

6. Lessons

FUKOKA METHOD: From the mid 1960s to the mid 1970s, many cities in Japan were in the same situation as Fukuoka City and several adopted the semi-aerobic landfill method, which has been endorsed by the Ministry of Health and Welfare. Organization and financial support were key factors in successfully initiating the project. The project depended on the collaboration between Fukuoka City and the local university.

The city found that it was difficult to assure that specialized knowledge and experiences were passed on to new team members as staff left the project.

7. Future Prospects

Refuse is deeply connected with citizens' lives and also with business activities such as manufacturing. The solution to garbage issues requires the promotion of recycling and the restriction of refuse production as much as possible at each stage from production, distribution, consumption and disposal, through fair assignment of responsibilities between citizens, corporations and administrative bodies. We need to establish a system that enables our limited resources to be effectively recycled. To promote the Basic Plan, not only the efforts of the city government, but also the voluntary involvement of citizens and corporations in refuse reduction and recycling is needed. To achieve these objectives, Fukuoka City intends to secure the cooperation and understanding between the citizens and corporations by accurately promoting conditions of proper refuse disposal and by actively providing promotional materials and information. In addition, various matters will be discussed in the "Refuse Reduction and Recycling Promotion Committee" organized by the citizens, corporations and administrative bodies to reflect all their opinions in the making of policy. After understanding and analysing the various approaches to refuse reduction and recycling, together with their progress the City will review all policies and organizational structures as the situation demands to aggressively carry out the Master Plan.

FUKOKA METHOD: Cities in Malaysia, Indonesia, the Philippines, China and Brazil also use this technology. Presently, training courses and workshops are being held throughout the Asia-Pacific Region.

Figure 1: Installation of leachate collection pipes, gas collection pipes and gas ventilation system. Fukuoka University proposed and helped implement a low-cost semi-aerobic design in Malaysia using locally available materials, such as concrete pipe, bamboo, and used steel drums.

E. Surabaya, Indonesia
Solid Waste Management

1. Abstract

Although it had won awards from UNCED and UNEP in the early 1990's Surabaya City's environmental quality deteriorated later in the decade. In an effort to improve Surabaya's environmental quality waste management experts from Surabaya and Kitakyushu are together working on a model that is environmentally sound, manageable by a city in the developing world and sustainable. Building on the elements of the 5R principle of waste management (Reduce, Reuse, Recover, Revalue and Recycle) an alternative waste management system that involved greater community participation has been evolved. The strategy is to empower local communities to solve their own problems by being responsible for waste management in their neighbourhood with support from local government and professionals. User fees are charged from households based on collective decisions and arrangements made to collect and transport solid waste to transfer stations. For practical reasons fees for transport and disposal charges for solid waste are embedded with other "community fees" such as water bills or at the sub-district level. The scheme has an improved role even for the informal sector (scavengers or waste pickers) in recycling waste and reducing the load of waste that needs to be disposed. The institutional framework including rules and regulations need to be instituted if private sector participation in waste management is to be encouraged.

2. Environmental Setting

Surabaya is the second largest city in Indonesia. Its area is about 326 km^2 of largely coastal and lowland area. The altitude varies from 3 to 10 m above sea level. Surabaya has about 2.8 million permanent residents in addition about 300,000 people commute every day to Surabaya from surrounding areas. Surabaya is a tropical city and the temperature is almost constant throughout the year, varying from 25^{o}C during the night to 34°C during the day. The average humidity ranges from 65% to 85 %. The rainy season starts from October to April, and the dry season from May to September. During the rainy season some lowland areas get flooded, the condition becomes worse when garbage clogs the drainage channels.

Surabaya is divided into 31 districts and 163 sub-districts. Each sub-district consists of several neighbourhood units. The neighbourhood unit is a community organization, which consists of about 200 to 300 families, and is a forum in which the residents can share their ideas on improving and support their living conditions. Financial support for the neighbourhood organizations comes from its members each of whom contributes money for neighbourhood activities, including collection of garbage from each household.

Solid Waste Generation: The total volume of solid waste generated by the whole city each day is about 7,600 m^3 (or kL), which is equivalent to about 1,630 tons per day. For calculation purposes, the City uses the standard of 3.2 litres (L) per person per day. Total garbage generation includes both residential and commercial areas and most of the waste is disposed in a landfill site, which is semi-sanitary. Some of the garbage is disposed of by

individual in empty lands or even thrown into surface waters. **Table 1** shows waste generated by source.

Table 1 Waste Generated by Source (tons/day) in 1993

Source	Amount	Percentage (%)
Domestic	1,108	68
Market	258	16
Commercial and Industries	177	11
Street and Open Spaces	83	5
Total	**1,626**	**100 %**

Source: Cleansing Department of Surabaya.

Waste Composition: According to a JICA survey carried-out in 1992, organic wastes dominate the physical composition of garbage generated in Surabaya. The detailed composition is presented in the **Table 2** with the 1992 JICA study used as a reference. Another study, completed in December 2002, was carried out with the assistance of the city of Kitakyushu, Japan to analyse garbage composition in Surabaya.

Table 2 Average Physical Composition (%) of Waste (Wet basis)

Classification	Rainy Season	Dry Season
Paper	13.54	4.37
Textile	1.85	2.03
Organics	52.93	55.59
Wood / Grass	19.15	15.72
Plastic	7.70	7.51
Leather / Rubber	0.45	0.03
- Metal (Ferrous)	0.82	0.74
- Metal (Non Ferrous)	0.08	0.16
- Glass	1.12	0.68
- Stone ceramic	1.61	4.46
- Bones	0.62	0.74
- Others	0.13	0.07
Total	**100**	**100**

Source: JICA Study (1992)

3. Issues and Challenges

Solid waste management consists of three main components: collection, transportation and disposal systems. The collection system collects garbage from the waste generation sources. The city-cleansing department manages transportation of garbage from transfer stations to disposal sites. The third component is final disposal, which consists of a semi-sanitary landfill, mini incinerators, incinerator (out of operation) and composting. There are problems however at each stage starting with storage of garbage in houses prior to collection.

4. Implementation Strategy

Solid Waste Management: Household Storage: In residential areas, each individual equips their house with a household garbage storage unit. Generally, the storage unit can be a plastic or metal bin or the household storage can be a fixed brick-box, which is placed in front of the house. The capacity of the storage unit varies from 70 - 120 litres. Most of the household storage units are open systems, meaning that the stored material is exposed to the air. So, flies, rats and other vermin can easily get at the garbage stored. Generally, households put their garbage into the storage unit and it stays there till it is collected on another day.

Collection: Neighbourhood organizations, known as ***Rukun Warga (RW)*** manage the collection of garbage in residential areas. The neighbourhood organization collects a fee from each household to finance the garbage collection. The RW is instituted on a voluntary basis and its members elected by the community. In terms of administration, the RW is not part of the city government. Each neighborhood organization is an independent unit for managing the collection of garbage and is a self-financed organization. These neighbourhood units organize the community into providing handcarts, and to pay the collector's wage. The responsibility of the RW is to collect the garbage from the household unit and then bring the garbage to the transfer stations.

Generally, the household storage unit is fixed-box open system. Garbage is collected using a bamboo basket to take out the garbage from the storage unit and put it into the handcart. Consequently, garbage is exposed to the air and some of it falls out of the handcart and gets dispersed. The condition is therefore unhealthy for the collectors and degrades the environment. In addition after garbage is deposited in household storage units, often stir up the garbage in order to find out materials they need and cause dispersion of the garbage.

Collection of garbage from commercial and institutional areas is undertaken by the City Cleansing Department. The market management carries out collection of garbage from traditional markets. Collection from industrial areas and large sized waste is managed by the sources (generators). In certain areas the private sector has become involved in solid waste management in Surabaya, particularly for collection and transportation of garbage from commercial areas. The involvement of the private sector is mainly on a contract basis for a fixed period.

Transfer Station: After garbage is collected, it is first taken to a transfer station before it is finally delivered to the disposal sites. There are two types of transfer facilities for waste

disposal. These are (1) Transfer Stations, with land (about 200 - 300 m^2), in residential areas - two persons supervise this type of transfer station; and (2) Container Platforms, with land (about 60 - 100 m^2), in residential and market areas. The transfer stations are equipped with container(s). A transfer station can contain one or two containers depending on the service area of the transfer station. The collectors from the community neighbourhoods put the garbage collected into the containers in the transfer station. Regularly, a truck will take the container to the disposal site.

Transportation: The Cleansing Department under the City of Surabaya is responsible for hauling the wastes to the final disposal sites. The transportation system involves the use of containers and dump trucks of varying volumes. The trucks take the garbage filled containers from the transfer stations to the disposal site. One disposal site is located in the west part of Surabaya about 35 kilometres from the centre of the city. Another disposal site is situated in the east part of the city about 7 kilometres from the centre of the city.

Disposal: There are three types of waste disposal in Surabaya, they are sanitary landfills, composting and mini incinerator. There are two sites for disposal landfill in Surabaya, in the eastern and western part of the city respectively. The Keputih landfill site in the east has a total area of 40.5 hectares while the Benowo landfill site in the west has a total area of 16 hectares.

The Keputih landfill has been operating since 1982; according to the design it is supposed to be a sanitary landfill, however, it is operated mostly as a dumping ground because the garbage is not covered regularly with soil. The Keputih landfill is located in a swamp and flat area; ground water is high and there is no available soil deposit nearby to cover the garbage. For covering purposes, soil must be brought from outside Surabaya, which is very far away from the landfill area. When initially designed the Keputih landfill was far from residential areas in the middle of a swamp and fishpond. During the design period, the area around the landfill site was not considered to be potential residential areas. However, presently many houses have been constructed in areas adjacent to the landfill

Waste Scavengers: Scavengers have been part of solid waste disposal in Surabaya for a long time. The scavengers take materials that can be used and recycled from the solid waste. They are a presence in almost all aspects of solid waste management. From the time that solid waste is deposited in household storage units which scavengers rifle through looking for materials they can use all the way up until the final disposal site, scavengers are present looking for materials they can recycle. Accordingly, scavengers offer some advantages in solid waste management, namely by contributing to waste reduction.

Financial Aspects: As part of city management, solid waste management in Surabaya is also part of the city's financial obligations. As explained above, solid waste management consists of collection, transportation and disposal. Collection of domestic waste is carried out by community neighbourhood organizations (RW's). The RW's charge their members a "collection fee". For practical reasons, the collection fee for solid waste is combined with other "community fees" which may consist of security and environmental improvement. In this way the community only pays a single time for all community fees levied in their residential area. The community fee varies from IDR 10,000 to IDR 30,000 (about US$ 1.1 – US$ 3.2) a month. The

amount of community fee charged depends on the living conditions of the residential area and is decided amongst community members.

In addition to collection fees, the citizens of Surabaya have to pay the transportation and disposal costs of solid waste. The amounts charged for transportation and disposal costs depend on the dimensions (land area) of the residential plot. Payment for disposal and transportation can be done in one of two different ways:

(1) Households connected to the city water supply system pay their solid waste fees through their water supply bills. Thus the water supply bill includes the solid waste fee. The water supply company then delivers the payment to the account of the City on a monthly basis. This method was adopted based on the assumption that the efficiency of payment will be high as people are more eager to pay water supply bills. Predictably the willingness of people to pay a separate bill for solid waste fees is very low. Furthermore, the water supply company is a semi-autonomous company, which is owned by the City government. Solid waste revenue is thus based on the number of water supply connections, which is about 280,000 connections out of about 600,000 properties in Surabaya. Solid waste fees for transportation and disposal generally vary from between IDR 6,000 – IDR 14,000 (US$ 0,55 – US$ 1.5).

(2) People who are not connected to the water supply system pay solid waste transportation and disposal costs through direct payment to the City sub-district office. The number of people, who are not connected to the water supply system, is larger than the number connected. However, solid waste revenue from properties without water supply connections is far below that received from properties connected to the water supply system.

5. Impacts

Collection: As mentioned before, in residential areas, and collection of street waste is undertaken by the community (RW's) while, cleansing and collection of street waste of most from most commercial areas is carried out by private companies on a contractual basis. For commercial areas, street sweepers are responsible for keeping public streets and facilities clean, including city yards and terminals.

Transfer Station: Most of the transfer stations have a single platform level. Collectors from the community neighbourhood organisations use bamboo basket to take out the garbage manually from their carts and then put the garbage into the container. This is an unnecessary waste of time, in addition the garbage is again exposed to air and mixing of garbage takes place. Generally, the condition of the transfer station is poor.

Transportation: Since traffic is very heavy in the city, travel time to the disposal site is very long; consequently the frequency of vehicles travelling to the West disposal site is only about twice per day.

Disposal: Due to poor operation, the landfill produces noxious odours. Sometimes, the landfill catches on fire, particularly during the dry season. The smoke rising from the landfill disturbs people and affects the environment. People complained about the operation of the

landfill. Finally civic action resulted in area residents blocking access to the landfill site in October 2001, so that vehicles could not deliver garbage to the disposal site. During this time when the Keputih (East) landfill was non-operational the Benowo (West) landfill was under construction. As a result for more than two weeks, there was no waste disposal in Surabaya, and the garbage was spread out on the streets of the entire city. After two weeks, the west landfill site (Benowo), though under construction, was forced to open early and has been functioning since then continuously.

Waste Scavengers: According to the research carried out by the Institute of Technology in Surabaya, scavengers reduce waste volumes by almost 30%. This number represents a large reduction taking the city as a whole the spin off advantages include reduced transportation costs and final disposal costs for solid waste. Problems associated with scavengers hinge on the way they take materials from solid waste. Since there is no source separation of waste, in order to take recyclable materials it scavengers stir and mix the waste, exposing it to the open air. Rotting materials end up mixing with paper and other materials producing odours and attracting vermin such as rats, flies and other insects. The way scavengers take materials from waste is very unhealthy both for the scavengers and other people. Therefore, the scavenger activities pollute air and the environment.

Financial Aspects: The total income of city receives from solid waste fee (from properties both connected and not connected to the water supply system) is about IDR 15 billion (about US$ 1.6 million) a year. However, for the year of 2002, expenses of the city for transportation and disposal were about IDR 60 billion (about US$ 6.6 million). The city of Surabaya thus has to provide a big subsidy for solid waste management, as the US$ 6.6 million spent has to serve about 3 million people. This translates into an average annual cost for solid waste management of about US$ 2.2 for each person. In comparison for the year of 2002, the total budget of the city of Surabaya was IDR 980 billion (about US$ 110 million).

6. Lessons

Public Participation: The key element in public participation is the involvement of the community in the decision and implementation process, such as for instance the opportunity for the community, particularly the city residents, to be involved in the various phases of programmes such as planning, implementation, operation and maintenance. In the solid waste collection system, the community took the responsibility of managing their own neighbourhoods including paying the salary of garbage collectors and street sweeper's, providing garbage bins and containers, purchasing of carts, etc. Participation becomes a total and continuous process of knowing, doing and learning by all involved parties. Everybody is equal in sharing both responsibility and rewards. The street sweepers, neighbourhood community, university students and staff, waste collectors also have the same rights. They are acknowledged as an integrated part of solid waste and environmental management system. All of them have a part in Surabaya's waste management system.

Partnerships: There are at least two segments of the public that contribute to the management of solid waste. The first (internal) segment whose sub-components consist of waste generators, community, scavengers, non-government organizations and others. The second

(external) segment is comprised of tourists, outsiders, research institutions, people, organizations, non-government organizations, universities and institutions outside Surabaya who have direct and/or indirect impacts on the solid waste management in Surabaya.

The people outside of Surabaya can make great contributions to the improvement of solid waste management in Surabaya. A great deal of knowledge can be obtained from the experiences of others outside Surabaya. Research institutions, non-governmental organizations – both national and international can provide transfer of know-how to the management of Surabaya. Best practices in other cities can also be adopted to improve the solid waste management in Surabaya. Approaches and experiences from other cities may help to bring about a better understanding of solid waste management. Problems in one city can be a good example for analysis to develop procedures and technologies to solve similar problem in another. Although solutions pertaining to one city may not be suitable for direct implementation in another, the approach to the problem may be amenable for adoption and implementation in other cities.

Partnership can also serve as alternative route to expand the capacity of solid waste management. The partnership between the cities of Surabaya and Kitakyushu is a good example of the improvement of capacity in Surabaya. Through the partnership, experiences in Kitakyushu can be adopted in Surabaya to improve solid waste management. International forums serve as venues to share experiences with other cities that may provide information to widen the horizons and ideas of city managers. Partnership can be improved and increased to develop a network within cities. Through the network exchanges in new technologies and information can be carried out. Assistance from city partners can therefore be a catalyst to speed-up the improvement of solid waste management.

7. Future Prospects

There are number of issues and problems should be further improved in Surabaya. Some of them are listed below: they to be considered as future action plans.

(a) Reduction of garbage through introduction of the strategy based on the 4R approach: Reduction, Reuse, Recovery, and Recycle. The existing reduction system, which is mainly carried out by scavengers should be improved, so, it can be made healthier and attempt to avoid unnecessary consequences such as pollution of the environment. The scavengers need to be organized and regulated in order to prevent inappropriate types of waste reduction. At the same time other methods in the 4R approach should be adopted.

(b) A continuous public campaign has to be carried out to improve understanding and promote adoption of new approaches to management and new technologies in solid waste management. The community needs to be informed and regularly updated about any actions that are introduced in the city to improve solid waste management. At a certain level, the community involvement as a partner in development will promote self-propagating development of the community itself.

(c) Since technology keeps changing and improving, the solid waste management has to utilise the latest technology available. New methods and procedures can help to improve the efficiency of solid waste management.

(d) Institutional improvement is an important part that needs to be addressed in Surabaya. As a developing country, institutional aspects - particularly laws and regulations - have to be improved. To support institutional development human resources need to be improved as well.

(e) As mentioned before there is a big gap between income and expenses in solid waste management in Surabaya. Expenses are subsidized from other sources such as tax and other city revenues. The financial mechanism in solid waste needs to be restructured to achieve a balanced financial condition.

(f) Involvement of private investors needs to be promoted. The involvement of the private sector in Surabaya is still very limited. Perhaps, the reason for the limited private sector participation is due to insufficient laws and regulations, since most private sector organizations want to be secure when they invest their capital in solid waste management. Therefore, the environment for investment should be improved so that the private sector would be encouraged and eager to enter into solid waste management in Surabaya.

(g) Improvement of partnerships with other institutions and cities is very important to expand the horizons of the city and the solid waste managers. City sharing, twinning cities, and other forms of partnerships are necessary to exchange experiences amongst cities. Seminars and workshops are also venues that can be used to improve capacity of the city.

III. URBAN WATER SUPPLY AND WASTEWATER TREATMENT THROUGH PUBLIC PRIVATE PARTNERSHIPS

Partnerships between and among different actors (local people, business and commercial enterprises, local government, community organizations) are needed to achieve sustainable development. This is particularly true in projects with lead roles for local residents whose individual impact may be small but whose collective impact is significant. Participatory in nature, partnerships develop mechanisms to bring out the priorities and needs of local people imbuing them, in the process, with self-confidence.

Policy guidance of the Kitakyushu Initiative for Clean Environment highlights enhancement of partnerships and promotion of public-private sector investment in the environment. Among others, it calls for dialogue and consultation between local authorities, citizens and private enterprise as well as investment to improve the environment through, for example, the sewerage system.

Towards that end, improvement in water quality and management of wastes are action areas in the Kitakyushu Initiative. Their indicators include number of voluntary pollution reduction initiatives as well as number of local industries which have adopted cleaner production approaches and actions.

Inadequate urban water supply and wastewater treatment are two of the consequences of the low priorities and limited funds assigned to these sectors in cities across the developing world. In the case studies presented four Asian cities embarked on public-private partnerships to solve, or at least minimize, the problem. Partnership came in different forms - technical support, self-help, subsidies, joint venture, all geared at easing a situation which, in reality, although primarily government responsibility also requires people's action for resolution.

Partnership in the featured case studies is single-purpose and project-oriented between the public and private sectors. Briefly, in Macao, the private sector company Water Macao has exclusively operated the water supply system for years but instead of deteriorating, water was adjudged continuously improving with the company investing a sizeable amount for the modernization of its equipment and facilities for water treatment. Self-help, on the other hand, whereby the government provides the machineries and technical know-how while the residents provide the financing for new water connections is the approach in Yangon.

Public-private participation is likewise the strategy in Ho Chi Minh City's Clean Water Project in six cities. With the central government providing technical support and the local authorities supervising the project, local people provided the needed funds as well as labour to complete the project. Weihai City's sewage treatment plant (second phase), on the other hand, will be set up through joint venture on a "build-operate-transfer" (BOT) scheme. The use of mechanisms which feature public-private partnership such as BOT for new projects is a realization that the government cannot cover everything that is encompassed by environmental protection and there are instances when market mechanisms inherent in a market economy ought to be utilized.

If public-private partnership proved feasible in the areas of water supply and wastewater treatment, such initiatives could also build capacities to meet other urban environmental challenges.

A. Yangon, Myanmar
Public Private Partnerships for Water Supply

1. Abstract

Yangon, (formerly Rangoon) is governed and run by the Yangon City Development Committee (YCDC), which has wide-ranging powers, which include the authorisation of territorial limits, operation of city development with its own funds obtained through the assessment and levy of taxes, leasing of its lands for development and the ability to take loans and grants from the Government or foreign donors on its own cognisance. Its chairman functions as the Mayor of Yangon, which is a Senior Minister's post directly responsible to the Head of State. The primary duties of the YCDC include street lighting, water supply, garbage disposal and maintenance of public property. The present Water and Sanitation Department of the YCDC is charged with supplying potable water to the more than 5 million residents of Yangon from 4 main reservoirs and over 200 tube wells. Income received from supplying of water has to be augmented from other sources to cover construction and maintenance of the water supply infrastructure. YCDC has engaged the services of local residents in a public private partnership through a "self help" programme where YCDC provides the equipment, machinery and engineers while the residents provide the financing to enhance the water supply and provide new water connections. Similarly the business community has stepped in and is working with the YCDC, especially in new industrial zones, through the public-private partnership of the "self help" programme to meet the targets for water supply. In addition, Yangon has an ambitious Master Plan to search for new sources of water in the future and improve the existing water supply system.

2. Environmental Setting

Yangon, the capital of Myanmar, formerly knows as Rangoon is a city with history of more than three thousand years and site of the world-famous Shwedagon Pagoda. The city covers about 610 square kilometres has about 5 million inhabitants and lies on a dagger-shaped peninsula at the confluence of Yangon River, Pazundaung Creek and Sago River in the central part of Yangon Division. The topography of the city comprises slightly undulating and hilly land in the centre of the city and low flat land on the fringes. Drainage channels, which generally originate in the highest parts run in all directions and finally drain into the Yangon and Bago Rivers. The climate of Yangon is marked by three distinct seasons, namely the rainy season from June to September, winter lasting from October to February and summer from March to May. The lowest temperature is about 25^{o}C and the highest 35^{o}C. Because of close proximity to the sea, the weather is generally cool and mild. But it can be very hot in summer. The average annual rainfall is around 100 inches which adequately meets the demand of water supply to the citizens, from 4 main reservoirs located about 40 miles to the north of the city.

Current Status: The present city authority, Yangon City Development Committee, which was formed under the provisions of Yangon City Development Law of 14 May 1990, is an independent body with wide powers and authority. The Chairman of Yangon City Development Committee, concurrently the Mayor of Yangon, holds the position of a Senior Minister and is responsible directly to the Head of State. Assisting the Chairman is a Vice-Chairman (Vice-

Mayor), Secretary, Joint-Secretary, and 3 Committee Members who function virtually as a Cabinet, performing all relevant duties and functions, stipulated in the Rangoon Municipality Act of 1922, which is still valid, and Yangon City Development Law of 14 May 1990. Since the time of Yangon Corporation, which was established after the promulgation of Rangoon Municipal Act of 1922, which is still in force, Yangon's water supply has all along been one of the principal functions of successive municipal organizations. The primary duties of the City Committee, such as street lighting, water supply, garbage disposal, maintenance of parks and gardens, markets, slaughter houses remain unchanged. Additional powers vested in the Committee by virtue of Yangon City Development Law authorize territorial limits of the city, to operate city development works independently with its own funds, to assess and levy its own taxes, to utilize the funds currency derived from the lease of its own lands and premises for development works and to take loans and grants from the Government or from foreign organizations on its own responsibility.

The Water and Sanitation Department, which is responsible for supply of clean and potable water to more than 5 million citizens of Yangon was formerly known as the Water and Sewage Department. Headed by senior engineer as Director-General, the engineers and staff of this department have been working with their own resources to provide not less than 90MGD of safe water to the city from 4 main reservoirs (Hlawga, Gyobyu, Phugyi, and Ngamoyeik) and over 200 tube walls lying in various parts of the city.

The income from former municipal organizations entirely depended on property tax, made up of water-tax, conservancy tax, and general tax. The income from property tax amounts to a small fraction of the annual budget, the principal source of income being from the condominiums, hotels, markets, and golf courses belong to YCDC and from vehicle tax. The Committee's income for current fiscal year 2002-2003 is estimated at Kyats 15 billion out of which the income from Water and Sanitation is estimated at Kyats (Ks) 600 million.

YCDC is an entirely independent body, which has to find its own resources for all development works and services. By virtue of the Yangon City Development Law of 14 May 1990, YCDC is authorized to levy its own taxes, to draw its own budget and to utilize its own funds, independently on its own. Bills for collection of water charges prepared by the staff of the Water and Sanitation Department are distributed to and collected on behalf of the Water and Sanitation Department by Executive officers in charge of each of 33 townships. The present rate of water charges for domestic use is Ks 120 per month (unmetered) for and Ks 30 per 1000 gallons (metered) for each household. For commercial/industrial use, the charge is Ks 135 per 1000 gallons.

3. Issues and Challenges

The income from water supply sector falls far below the level of expenditure involved in construction and maintenance of reservoirs main pipe lines, boosters, treatment plants and water connections. However, in all city development works relating to environmental protection, the Committee subsidizing these works from funds received from other sources.

The challenge was to get residents and the business community involved financially in expanding and augmenting the water supply system with technical assistance being provided by YCDC.

4. Implementation Strategy

Previously, people living in suburban townships like Thingangyun and Insein had to depend mainly of artesian wells and ponds for water. With the advance of time increasing widening spectrum of water connections has emerged within the city limits. A popular programme, called self-help under which YCDC has to provide required equipment, machinery and engineers and the local residents provide financing, has contributed significantly to Yangon's water supply. This plan involved the digging of tube wells and piped connections.

Resident Involvement: To illustrate a recent operation of this programme, residents from ward No.3 of Hlaing township, which lies in the north western part of City and a little distance from YCDC's main pipe line, formed a water committee, composed of leading residents and engineers/staff of Water and Sanitation Department. After working out the details of expenditure and equipment, machinery and manpower required, the water committee petitioned the Mayor of Yangon for permission to undertake a new water connection in their area. This resulted in the laying of 6", 4", and 3" pipe with total cumulative length of 22,000', costing approximately Ks. 50 million, collected from local residents. This programme enabled 180 households to enjoy adequate supply of potable water.

Industry Involvement: Another example of public private partnership in the water supply sector relates to energetic efforts being made by factory owners in the city's new industrial zones. The emergence of private enterprises after the introduction of market-oriented economy in the 1990s created a tremendous pressure on YCDC's resources. Construction of industrial zones in new suburban towns, such as Hlaingtharyar, Shwepyithar and Dagon (South) was implemented with great speed. To meet the target for water supply YCDC had to depend on the business community who agreed to participate in financing the projects under "self-help" programme. To date several projects are under way fro water connection from YCDC's main pipe to industrial zones with the use of 12', 6", 4" PVC pipes, the total length of which amounts to 46,000'. Total expenditure will be approximately Ks. 700 million, to be borne safely by local business community. 450 factories will be able to enjoy fresh and potable water, after completion of these projects.

5. Impacts

In this age of globalization, all nations and cities have had some form of impact on their social, economic, political, and cultural sectors, as a result of the IT revolution. Thus in attempting to meet the challenges of an aware and growing population and increasing pressure on infrastructure the city authorities and planners have become conscious of the need to employ innovative approaches in city governance. In the context of maintaining the status of a sustainable city, synergistic efforts in terms of public private partnership have become an essential element. In the water supply sector, as well as in other sectors of environmental protection, the community is now beginning to perceive how the citizens of Yangon as well as

the business community can have a participatory role in the financing and management of Yangon's water supply.

6. Lessons

Investments for improvement of Yangon's water supply, either from local or foreign resources will not be forth-coming, at least in the near future, due to heavy volume of expenditures involved and slow, inadequate returns. To increase the water charges so that the total income from water supply will be commensurate with capital and current expenditure is a matter of national policy.

Under Article 9 (c) Chapter IV of the city of Yangon Development Law, YCDC has the power to prescribe, revise, assess and collect duties and taxes relating to development works in accordance with the existing laws. The Chairman of Yangon City Development Committee, who is concurrently the Mayor of Yangon has direct access to the Head of State. Acting under the guidance of the Head of State, YCDC always takes special care not to increase the tax burden befalling the citizens of Yangon. The scenario in the foreseeable future is for YCDC to expand its efforts for inviting foreign investors in Yangon's water supply with a certain scheme under which the investment, cost plus a certain percentage can be recovered say be exporting the country's staple products like rice and timber.

7. Future Prospects

Privatisation programmes launched by the central government have gained momentum. But they are not likely to include infrastructure sectors, which are closely associated with national security, such as telecommunication, energy and water supply.

Therefore the ongoing attempts to augment the city's water supply by digging tube wells on the basis of self-help will continue to be a main feature of public-private partnership.

YCDC is faced with the urgent problem of financing a project for connection of a pipeline from newly constructed reservoir, called Ngamoyeik to Yangon. Foreign assistance to the amount of USD 30 million is being expected from an international organization or a friendly foreign country.

The City Committee is, however, conscious of the urgent necessity to look for new sources of water supply and to improve the existing supply system. Arrangements are being made to draw up a Master Plan for Yangon's water supply and to establish priorities. Under this project, which envisages a long-term plan from 2002 to 2020, Yangon's water supply will eventually reach the mark of 400MGD. The plan calls for improving water supply from existing reservoirs as well as harnessing water from fresh sources such as Hlaing river and the Lagunbyin reservoir.

B. Ho Chi Minh City, Viet Nam
Implementation of the National Strategy on Clean Water Supply and Sanitary Improvement for a Rural Area

1. Abstract

With a population of 5.3 million living in the 22 districts that make up Ho Chi Minh City (HCMC), formerly known as Saigon, 32% of the population live in 4 outer districts and 5 suburban districts having rural characteristics with only a few residents having proper toilets and a large number lacking clean water supply. Surface water is becoming polluted by untreated or poorly treated city wastewater including industrial effluents as well as animal wastes, fertilizer and pesticides in the rural areas causing concomitant health problems. Cleaning the environment of the suburban areas is being undertaken in pilot projects with the Department of Agriculture together with the Department of Science, Technology and Environment (DOSTE) providing technical support, while local authorities supervise implementation of the programme. Implementation of the programme included loan appraisal and disbursement to households, resident participation in public projects, training, workshops and necessary manpower under the guidance of experts. The projects included the building of tanks for treatment of animal wastes, biogas facilities, upgrading of toilets, solid waste management, awareness workshops on environmental protection, sanitary lifestyles and agrochemical use. Almost 80% of the cost of the pilot projects came from the contributions of the local people with only 20% coming from the City budget. Many households were able to access long term loans from the City's interest free Fund for Poverty Alleviation. Apart from the financial and technical assistance the residents were also given the basic awareness to protect the environment, improve their health and improve productivity. In another PPP temporary relief was afforded a region in need of enhanced clean water supply by building water tanks, which are filled by a utilities service company, which levies a fee on the users.

2. Environmental Setting

One of the three biggest municipalities in Vietnam with very rapid economic growth, Ho Chi Minh City (HCMC) takes pride in being the industrial, commercial, scientific and services centre of the Southern region, contributing up to 37% of the national GDP annually. However, among the 22 districts of the City, 4 are outer districts and 5 are suburban districts (with the rural characteristics of farming and fishing land). These occupy 78.97% of the total area (1657.7 km^2 out of 2,093.7 km^2 that constitute the whole City). There are approximately 1.7 million people living in these districts, accounting for 32% of the City population.

The suburban farming land is earmarked for rapid urban development, where inner city dwellers will gradually move out together with the relocation of industries to the City periphery. In practice, uncontrolled growth has taken place as urbanization has drawn rural people to the vicinity and other provinces.

Current Status: The latest statistical figures indicate less than 90% of HCMC people use clean water, the situation is worse for the rural districts, where clean water is hard to access, especially in the two coastal districts of Nha Be and Can Gio. Of the 600,000 m^3 of the City wastewater being discharged daily, 10% is from industries, which is either not treated or is not

treated to acceptable standards. Therefore, surface waters - especially those water bodies that are down stream of these discharges are polluted.

At present only a small fraction of rural households, have proper toilets. The outer and suburban districts are locations where a large number of livestock are being raised, and animal waste disposal is another problem. All of these factors daily pose ever increasing adverse impacts on the air, the surface water and shallow ground water in these rural areas.

Clean water supply to the distant districts is very limited. People have to pay a considerable amount for drinking /cooking water. Alternatively, they have to make do with rainwater or water from rivers or canals, with very (sometimes no) primary treatment. This causes health problems - especially in women and children who are most vulnerable – together with a reduction in productivity and increase in the costs for health care.

3. Issues and Challenges

Clean water and a sanitary, healthy environment is a basic need in everyone's daily life but has become a pressing issue in all the rural areas of Vietnam where 75% of the Country's population live. Agriculture is the main component of Vietnam's national economy but people living in the countryside are generally poor and are increasingly disadvantaged when compared with urban inhabitants both in terms of economic growth and quality of life.

At present, 70% of the rural population use water of sub-hygienic standard and half the rural households do not have proper toilets. Water-borne diseases are common and the highest proportions of those frequently affected are among the rural inhabitants. The need for a supply of clean water for domestic use and sanitary improvement is a persistent and popular demand.

In this context, the government of Vietnam in August 2000 made the decision to approve the "*National Strategy on Clean Water Supply and Sanitary Improvement for the Rural Areas*". The Strategy defined very concrete objectives to be realised by the year 2020 (85% of the rural inhabitants to have access to clean water, 70% households to have proper toilets, all kindergarten, schools, clinics and markets to have proper toilets and suitable animal waste disposal, etc.) and set forth the basic principles and key measures for implementation including the promotion of public-private partnerships, establishment of credit and subsidy systems, capacity building for application of suitable technology and increasing administration effectiveness and efficiency. All line Ministries and People's Committees at provincial and City levels are responsible for enforcement of the decision and implementation of the Strategy hence the activities in Ho Chi Minh City.

At the outset, the objectives were identified as:

(i) Gradually improve the living and working environment of the rural inhabitants;
(ii) Advocate and raise people's awareness on a hygienic lifestyle and on health issues related to actions for the environment; and
(iii) Assist the people to protect their health, prevent disease infections, and increase local productivity.

4. Implementation Strategy

Public Private Partnerships (PPP) in Implementation of 6 Pilot Projects in HCMC Suburban Districts

In response to the National Strategy objectives Ho Chi Minh City has implemented Pilot projects in 6 villages (wards) of 6 suburban districts entitled "*Clean Water and Sanitary Environment for Rural Areas*" over a period of five months. All these sites share the typical characteristics of rural or semi-urbanized areas. The main sources of water are either from wells (dug or drilled) or rainwater stored in rudimentary earthenware drums. Farming practices are mainly traditional, on a small family scale and with low yield. Pollution of surface water, air and soil is apparent, arising from improper use of fertilizers and insecticides; poor farming practices with no barns for cattle and livestock, together with no treatment of human or animal wastes

The Department of Agriculture and Rural Development together with DOSTE provided technical support while the local authorities supervised the implementation of the program. The local Women's Union took charge of loan appraisal and disbursement to needed households. The Youth Union and the Farmers' Association promoted people's participation in public projects. Functional agencies such as the Centre for Preventive Health Care, the Clean Water Centre, etc. were responsible for the training and workshops. The workmen were drawn from the households themselves and worked under the expert guidance of the relevant agencies.

The total cost of the pilot program in these six locations was VND 2,693,693,080. Of this only VND 566,802,080 came from the City's budge. The main source of funding was from the contribution of the local people, which accounted to VND 2,126,890,000 (approximately 80%). It is worth noting that many households were able to get access to the City's Fund for Poverty Alleviation, which was interest free and had long-term instalment payment. As they took part in the Project, both as beneficiaries and contributors, the households used part of these loans to cover the direct expenses.

(Table 1 summarizes the total workload carried out in the Pilot Project)

Description of activities:

(1) Building underground tanks for animal waste treatment.
(2) Installing biogas facilities.
(3) Upgrading existing toilets.
(4) Setting waste bins and stations for solid waste collection and treatment.
(5) Field application of guidelines on proper use of agrochemicals to protect plants and trees.
(6) Public awareness raising workshop on environmental protection and sanitary lifestyles.
(7) Workshop on chemicals and chemicals use.

Table 1 EXPENSES AND WORKLOAD CARRIED OUT IN THE PILOT PROJECT ON 6 RURAL SITES

Locality	**Projects/Activities**							**Expenses (VND) (1 USD = 15,300 VND)**		
	(1) units	(2) units	(3) units	(4) unit	(5) acres	(6) course	(7) course	Total	From City budget	From people's contribution
Ward:Nhon Duc District: Nha Be	50	50	200			6	2	325,570,000	73,320,000	252,250,000
Vinh Loc B, Binh Chanh	30	30	350	2	1	9	2	480,708,560	99,928,560	380,780,000
An Loi Dong District 2	30	30	420			10	2	533,608,000	99,958,000	433,650,000
Tan Thong Hoi Cu Chi	30	100	250	4	0.5	8	1	416,889,520	97,709,520	319,180,000
Tan Xuan Hoc Mon	150		200	20	0.5	7	1	378,922,000	96,072,000	282,850,000
TamThon Hiep Can Gio		10	480			10	1	557,994,000	99,814,000	458,180,000
Total	290	240	1,910	26	2	50	9	**2,693,693,080**	**566,802,080**	**2,126,890,000**

PPP for Clean Water Supply in an Outer District

District Nha Be with the population of 64,143 in 1635 households, is one of the most critical areas in Ho Chi Minh City in terms of water need for daily activities. Located in low-lying land downstream, with brackish tidal water, the surface water in Nha Be canals and rivers is saline and heavily polluted as well. Water supply pipelines have not reached the area due to high investment costs as a result of the necessity for pipes to cross a number of water bodies as well as the under-developed transport infrastructure of this remote area. Although the topology is not suitable for drilling for underground water 741 wells have been established but are still inadequate to supply user needs. Most households must pay considerable amounts to get clean water distributed by trucks. Even so, it is a real scarcity, particularly in the dry months.

In 2001, the City decided to choose a temporary solution to meet the pressing needs of the people while pending sufficient investment into water pipeline connections. The Project was to construct 30 water tanks (of two types: each of 5 or 10 m^3 capacity) strategically positioned near public places like kindergartens, primary schools, local health care stations, etc., in the most remote wards of the District. Twelve water supply stations were also installed.

A Utilities Service Company was established and operated like a firm that had a concessionary management contract with the local government. This Company invested in acquiring its own water trucks (2 trucks with a 9 m^3 capacity and 3 trucks of 5 m^3 capacity) to carry water from the nearest stations to fill the tanks, and thus ensured continuous supply of water to meet the demand. In return, the Company was able to set the price of water that allowed viability and sustainability of the scheme.

5. Impacts

As a result of the Pilot Projects the following were achieved:

290	Underground tanks for animal waste treatment were built.
240	Biogas facilities have been installed
1,910	Existing toilets were upgraded
26	Waste bins / stations for solid waste collection and treatment were set up
2	Acres of field applications followed guidelines on proper use of agrochemicals
50	Public awareness raising workshops on environmental protection and sanitary lifestyles were held
9	Workshops on agro-chemical use were held

6. Lessons

Beside the households, which received financial and technical assistance to build sanitary improvement projects, people of the whole ward in these sites were exposed to

basic knowledge of hygienic ways of life and, environmentally friendly farming practices. This has helped much to increase public awareness in protecting the environment and their own health, further reduce epidemic diseases and improve local productivity.

There has been concern in terms of equity with the argument that the poor people in the remote place had to pay so high for clean water, compared to inner city inhabitants. However, various forms of financial assistance were implemented along the line of the City's overall Poverty Reduction Strategy, whose beneficiaries are actually these very people.

On the other hand, this water price serves as a helpful public awareness tool for the City people in general since it was probably the first time that the real cost of water had been accounted for (note that currently water price through pipelines is still heavily subsidized). People came to realise that clean water is no longer free or abundant. In addition, it is clear that people are willing to pay VND 18,000 per m^3 of clean water, and use it economically, rather than face health risks.

7. Future Prospects

The Pilot Projects which included the building of tanks for treatment of animal wastes, biogas facilities, upgrading of toilets, solid waste management, awareness workshops on environmental protection, sanitary lifestyles and agrochemical use involving local residents in the financing, execution and managing of projects with technical assistance from the relevant government authorities is one that could be replicated elsewhere provided that concessionary funds are available for the residents to utilise.

The scheme of installing water tanks by the government, contracting out supply trucks to a company, and charging users to cover part of the financing of the water supply may not be the best mechanism in the long run. But for now, it has helped alleviate the need that rural people have at least in terms of drinking /cooking water. In fact, 20 more tanks will be added soon and the scheme is being considered for dissemination to other sites in the rural districts with similar situation

The "*National Strategy on Clean Water Supply and Sanitary Improvement for the Rural Areas*" is a focused national program with far reaching objectives and large-scale activities. Ho Chi Minh City is not among the 15 cities and provinces selected to carry out pilot projects in the present Action Plan of the National Strategy, which extends up to the year 2005. However, several programmes have been conducted in line with the Strategy in response to the urgent needs of the City inhabitants in the rural districts. The paper covers just two small programmes, which have been implemented. A full evaluation of the results is yet to be done so that further lessons could be drawn for possible replication in the remaining parts of the City.

C. Macao, China
Public Private Partnership for Urban Water Supply in Macao, China

1. Abstract

With a population of 437,000 the historical city of Macao which once had a rich cross-cultural heritage is now a tourist city visited by over 10,000,000 tourists a year. The Civic and Municipal Affairs Bureau (IACM) handles the environmental protection, green zone preservation, municipal waste management, cultural events, food inspection, animal and plant quarantine as well as urban water supply, Since the 1930's water supply has been privatised and since the mid 1980's it has been run by Macao Water which just renewed its contract in 1999 for another 15 years. The IACM monitors water quality through its laboratory. Throughout the years they have been associated the Government's PPP with Macao Water, which has successfully met demand, treatment and storage capacity growths, replaced 85% of the existing pipelines, extended the existing network by 280% and improved water quality till it now meets Government standards. The project is on a BOT basis with Macao Water having invested over US $ 80 million in modernising its operations. Based on its charges for water the Company has seen its after tax profits increase by over 400% in 2001 when compared with its profit in 1985.

2. Environmental Setting

Macao, including the Macao peninsula and islands of Taipa and Coloane, is a city located at the Delta of Pearl River adjacent to Zhuhai city covers 23.5 km^2, has a, with a population of 437,000 and is about 60 kilometres from Hong Kong. After 442 years of Portuguese rule Macao became a Special Administration Region of China on December 20, 1999.

Macao is a historical city where oriental and occidental culture crossed and merged for over 400 years. Macao now is a tourist city; old culture residuals and buildings, special food and exciting entertainment activities attracting more than 10 millions tourists visit Macao every year.

Current Status: The Civic and Municipal Affairs Bureau (IACM in short hereafter) is the government department in charge of most municipal and civic affairs including environmental protection, green zone preservation, municipal waste manipulation, local cultural activities organization, food hygiene inspection, animal and plant quarantine and also urban water supply monitoring

3. Issues and Challenges

To give the residents of Macao a safe reliable water supply system with effective quality controls that expands as required.

4. Implementation Strategy

The Urban water supply was privatised in the 1930's. From the mid 1980's the private sector company *Macao Water* has run the water supply system. *Macao Water*'s activities are prescribed by a 15 years exclusive contract, which is its second contract with the government, and started from 1999. The monitoring of *Macao Water*'s compliance with the contract is divided into two areas. In the public administration area, a government representative is commissioned to the company by the Secretary for Transport and Public Works to monitor the compliance of the exclusive contract and affairs related to public administration. In the municipal management area, it is done according to the administrative statutes of the Macao Special Administration Region.

The Civic and Municipal Affairs Bureau is a committee to monitor the water quality of the urban water supply and related technical matters. *Macao Water* reports to the President of IACM monthly on the status of the local water catchments, the condition of local reservoirs, the quantity of raw water acquired from adjacent areas, the quantity of water produced and consumed, the number of new water meters installed etc. The Laboratory of IACM is the technical department that monitors the quality of water. *Macao Water* sends reports to the IACM Laboratory monthly. The reports include analytical reports and other technical parameters. The IACM Laboratory, together with the laboratory of *Macao Water*, collect about 2000 water samples per year from urban water system and analyze them individually for over 50 different parameters to ensure the quality of the water meets with the requirements laid in the administrative statutes.

5. Impacts

The public-private partnership between Macao government and the company has lasted for 17 years (15 years in the first contract from 1985 and 2 years into the second contract). The result of the compliance of the exclusive contract can be observed by the follow facts:

- The maximum demand grown from 77,000 m^3/day (1985) to 178,000 m^3/day (2001).
- The treatment capacity has grown from 85,000 m^3/day (1985) to 225,000 m^3/day (2001).
- Storage capacity has grown from 17,000 m^3 (1985) to 63,000 m^3 (2001).
- 85% of the existing pipelines (1982) have been replaced.
- Total pipelines length growths from 127km (1985) to 356 km (2001).
- The quality of water is continuously improving and now meets with the criteria set by the Macao government.
- The company invested a total of over MOP 666 millions (1 USD = 8 MOP).
- The project is on a BOT basis.
- The charge of 1 m^3 is MOP 4.39 (2001).
- The net profit after tax of the company has grown from MOP 10 million (1985) to 49 million (2000) and 44 million (2001).

6. Lessons

The Public-Private Partnership between the Macao Government and *Macao Water* has so far proved very successful. From the mid 1980's water quality has continuously been improving. Due to its holding of the exclusive contract, *Macao Water* has had the incentive to invested a large amount of its own resources to modernize the equipment and facilities in water treatment, to modernize the laboratory facilities for better water quality control, to replace the city piping network and install an up to date computerised remote control system to control the overall city water supply system.

7. Future Prospects

It would appear that Macao Water would continue to receive the exclusive contract when this contract expires provided it continues to give the service it is providing at present. All these results have lead to very positive response from the public. It therefore can be concluded that in Macao's water supply system the Public-Private Partnership (albeit a tightly controlled one) is a good way to solve municipal problems.

D. Weihai, China
Using Market Mechanisms to Establish a Sewage Treatment System

1. Abstract

Located on a peninsula and dependent on the protection of its marine and inland waters (as aquatic farms form its core industry), the city attaches great importance to environmental protection. It has therefore spent considerable sums on establishing sewage treatment plants, which treat 60% of the sewage produced before it is released into ocean outfalls. The cost of treatment, which was initially borne by the Government, is now partially recovered by sewage treatment fees charged by the local authority. Initially, only industrial enterprises were charged but now even the residents are charged a subsidised amount to defray some of the expenses of treatment. The local government charges water supply fees, which augment the subsidised fees collected for sewage treatment. The opening up of all environmental infrastructure to market mechanisms such as BOT and TOT was an initial step. The building of a modern medical solid waste incinerator in 2001 on government allocated land by a private contractor who collected treatment fees from hospitals was a first step and helped towards alleviating the air pollution experienced through ad hoc incineration in hospitals using outmoded equipment. Subsequently, the Wendeng sewage treatment plant reached an agreement with a tannery to establish a joint venture to construct the second phase of the sewage treatment plant on a BOT basis. The government, joint venture, public and other stakeholders will determine the treatment fee and collection method.

2. Environmental Setting

Weihai covers an area of 5,436 square kilometres with a population of 2.47 million. The city proper has an area of 731 square kilometres with a population of 520,000. Weihai is a fledging city, located at the eastern tip of the Shandong Peninsula, at 12°34′ north latitude and is surrounded by sea on three sides and faces the Liaoning Peninsula to the north and the Korean Peninsula and Japanese Archipelago to the east. Weihai has jurisdiction over three county-level cities of Rongcheng, Wendeng, Rushan and one district of Huancui. The central urban area covers 44 km^2, with a population of 300,000. Weihai government has attached great importance to environmental protection. It holds to the sustainable development concept of "never sacrifice the environment for economic development". As a result Weihai has successfully achieved "Win-Win" results for both economic development and environment protection

Weihai was inhabited as far back as 7,000 years ago. In 1398, the Ming Dynasty stationed troops in Weihai, which was called Weihaiwei. In 1898, Weihai was leased by Britain but was returned in October 1930 to China and the Weihaiwei Administrative Division was set up. In 1945, Weihaiwei City was set up which was renamed Weihai City after the establishment of the People Republic of China. In June1987, the State Council approved Weihai City as the prefectural city.

Current Status In the last 15 years, the GDP of Weihai has increased by 18.2% on average, and it reached 62.7 billion yuan RMB in 2001 with an average per capita income of US$ 3,069. Weihai was classified as one of the top 50 cities having comprehensive economic power, and is one of the top 40 cities with the best investment environment in China. The developed urban area of Weihai has enlarged 2.4 times, its urban population has increased 5.6 times and its economic inventory was boosted 17.3 times. Concurrently, its urban environment quality indices are at the forefront in China and have made Weihai the first "State Sanitary City", the first in the group of "State Garden City", "China Excellent Tourist City", "China's Model City on Environmental Protection" and was twice assessed as the Best Practice for Improving Human Settlements by the UN. Now, all three cities under its jurisdiction have received awards for model cities and Weihai is fast becoming foremost in the group "China's Model City on Environmental Protection".

In recent years, rapid economic reforms in China have resulted in market mechanisms not only spreading within the industrial sector but also affecting urban infrastructure development. The first breakthrough was a medical solid waste incinerator project at the end of 2001. Before this project became a reality medical solid waste was incinerated by each hospital individually. Due to the use of outdated technology and proximity to residents, the resulting air pollution resulted in numerous complaints. Following a number of discussions, the government decided to allocate a piece of land, invest 0.5 million Yuan RMB for the equipment, issued a regulation to enable the collection of a disposal fee from hospitals amounting to 2 Yuan RMB per bed per day and let a company run the incinerator. As a consequence the medical solid waste problem was solved and the government do not need to invest any more but let the company develop on its own to meet the increased demand. In all likelihood this was a first for China. In 2000, the Shandong Provincial Government issued a regulation, allowing all cities to appropriately increase their water supply fees, enabling them to collect and accumulate money for further development, and also encouraged the public to value the resource by using water efficiently. Cities were also allowed to levy sewage treatment fees, initially equalling 1/3 the water supply fee, and gradually rising until the sewage treatment plants can be self-supporting. The government considered the sewage treatment plant as an enterprise, using market mechanisms for their administration.

3. Issues and Challenges

Shandong Peninsula suffers from water shortage. The annual precipitation in Weihai is only 700mm and no external water supply is available. Weihai has a coastline of 985 km and aquatic farms are its core industry. The water quality along the coastline directly affects the quality and quantity of the aquatic products. Preservation of its rare water resources and protection of the ocean waters is the tough task and primary concern of the Weihai government. The government has attempted to use market economy forces to build and run sewage treatment plants designed to protect the city's precious water resources.

4. Implementation Strategy

In 1982, the Weihai government realized that using central treatment methods for sewage was the best way to deal with water pollution, both from environmental and economic aspects. Weihai has, since then, invested 262 million yuan RMB and established 6 sewage treatment plants with a combined total capacity of 215,000 T/d. The extent of sewage treatment is 60%. Except in houses that are not served by sewage collection pipes, most of the sewage is properly treated before discharge into natural water bodies. As a consequence even though the population, GDP and developed urban areas in Weihai have increased rapidly, the water quality still meets national standards.

Name	Capacity (T/d)	Total Investment (million yuan RMB)	Treatment Method	Start Date of Operation
No.1 Sewage Treatment Plant	15,000	12	Secondly treatment method	1985
No.2 Sewage Treatment Plant	80,000	120	Ocean outfall	1997
No.3 Sewage Treatment Plant	10,000	40	OBAl oxidation channel	2000
Rongcheng Sewage Treatment Plant	50,000	20	Wetland	1997
Wendeng Sewage Treatment Plant	40,000	50	OBAL oxidation channel	1999
Rushan Sewage Treatment Plant	20,000	20	Oxidation channel	2001
Total	**215,000**	**262**		

An ongoing project is the second phase of the Wendeng sewage treatment plant. Wendeng City is under the administration of the Weihai municipal government. The urban population is approximately 200,000. In 2000, a sewage treatment plant was constructed incorporating secondary treatment methodology. Plant capacity was 40,000 tons per day and total investment was 50 million yuan RMB.

Along with rapid industrial and urban development, the volume of discharged wastewater increased very rapidly causing the treatment plant to work at full capacity. Often it was over loaded and consequently the treated water did not meet national discharge standards. People living downstream of the river jointly protested the pollution of their farming and drinking water source. The plant needed to construct a second phase.

Within the urban area there was a tannery which was a limited liability company with 1000 workers and a processing capacity of more than 3 million pieces of pig's hide annually and its financial status was strong. In 2001, the company's profit and tax profile was 40 million yuan RMB, which was the highest in the Chinese hide industry. But it was a significant source of water pollution discharging 4000 tons of wastewater per day. The concentration of pollutants was also high, COD: 2500mg/L, BOD: 1000mg/L and Suspended Solids: 1500mg/L. In 1998, the company had invested 10 million yuan RMB and constructed a secondary treatment plant, but residents in the area complained bitterly of the heavy odour and noise due to its proximity to their residences. As a result the treatment plant couldn't run properly and the tannery needed to construct a treatment plant elsewhere.

Through negotiation, the local government, the sewage treatment plant and the tannery reached a general agreement: (1) The sewage treatment plant and the tannery would establish a joint venture to construct the second phase of the sewage treatment plant; (2) The total investment of the second phase of the sewage treatment plant was about 40 million yuan RMB. The sewage treatment plant purchased the new land as its part of the investment. The tannery was responsible for the construction and equipment investment; (3) Taking into account the cost plus a reasonable profit, the government, the joint venture, the public and other stake holders jointly established a treatment fee level and a collection method; and (4) After 15 years the joint venture would transfer ownership of the second phase of the treatment plant to the sewage treatment plant.

In helping Weihai establish this new public-private partnership for urban wastewater treatment, the setting up of the Weihai sewage treatment system, specifically the second phase of the Wendeng sewage treatment plant, was approved by UNESCAP/IGES as a pilot project

5. Impacts

In September 2002, the National Planning Ministry, the National Construction Ministry, and the National Environmental Protection Administration jointly issued a regulation opening all environmental infrastructure to the market. To meet the increased demand for environmental protection any private company or foreigners can now invest in sewage treatment plant and solid waste treatment facility construction.

The Weihai government used market mechanisms to develop environmental infrastructure systems since 2000. The financing of the sewage treatment system in Weihai was just like the economic system reform in China, which experienced a change from planned economy to market economy, but it took place a little bit earlier. The mayor of Weihai publicly invited private and foreign companies to invest in this field. New projects could use BOT (build, operate, transfer) and existing projects use TOT (transfer, operate, transfer) mechanisms, with a choice or either monopoly, or joint ownership. As a result many foreign and private companies came to Weihai to take advantage of this opportunity and some were successful.

6. Lessons

The total investment for the sewage treatment system in Weihai was 262 million yuan RMB, that equalled 0.46% of GDP of 2000 while the running cost of the system was 50 million yuan RMB annually which equalled 1.3% of the local government revenue of 2000. It is a heavy burden for the local government support the running cost.

In 1982, when Weihai began to build its first sewage treatment plant it also was the first sewage treatment plant in the Shandong Province. At the time very few sewage treatment plants existed in the whole of China. The nation was also considering the reform of its centrally planned economic system, but no concrete action was being taken. Almost all the enterprises were owned by the government, and produced only what the government let them, all expenses were met from government coffers, including the workers' salaries. All profits, if indeed there were any, were handed over to the government. In the case of the sewage treatment plant the entire investment came from government revenue. In 1985, when Weihai's first sewage treatment plant began to operate, the running costs were also met from government revenue.

In 1992 when the Weihai government began to construct the second sewage treatment plant economic reform in China was underway. Many foreign investors came to China, joint ventures or foreign owned companies sprang up everywhere and private companies become an important part of the economy. The Weihai government, which originally was of the opinion that it could not let foreigners or private companies take all the profits away initially, expected the environmental problems to be handled by the local government and expected that it would pay for the environmental pollution that was taking place. During this time with a fast growing economy, urban area and population the necessary infrastructure construction needed a lot of money, which the government could not support. The local government therefore asked the provincial government to permit them to collect some sewage treatment plant construction fee from the enterprises. In 1995, the Shandong provincial government gave its permission to Weihai and according to the daily wastewater discharge volume of the enterprises, collected 700 yuan RMB per ton. This is the first time that permission had been given for this type of fee in Shandong Province although the fees collected could only cover about 40% of the actual investment.

In 1994, the Weihai government realising that the running cost of the sewage treatment system was a big burden and that it was not reasonable for the government to take on total responsibility, issued a regulation enabling the collection of some sewage treatment fees in the order of 0.15 yuan RMB per ton from the enterprises but did not collect fees from residents. This covered only about 1/4 of the actual costs incurred, but it was a start.

In 2000, Weihai government revised its regulation for sewage treatment fee collection, raised the fee to 0.40 yuan RMB per ton for enterprises, and expanded it to include residents who paid 0.20 yuan RMB per ton. This is also the first time it had been done in the Shandong Province. In Weihai, the running cost of sewage treatment is

around 0.70 yuan RMB and the government still has to heavily subsidise the enterprise to keep the sewage treatment system running.

7. Future Prospects

Using the market mechanisms and although a new public-private partnership has been established for urban wastewater treatment; Weihai still faces some challenges namely:

(1) Conceptual Changes: The former perception in China was that the while the economy was dependent on the market environmental protection was the responsibility of the government. Lately, the government has come to realize that it can't cover everything involved in environmental protection and in some areas it must utilise market mechanisms. This change in perception has taken more than ten years after China made the transition to a market economy. It will therefore not be easy for the general public and private enterprises to change their ingrained conceptions especially as this change would involve costing them more money even as it reduces government spending. What is needed is increased environmental awareness educating the average citizen that everyone must take responsibility to overcome pollution.

(2) Legal Aspects: In normal economic activities, China has laws that protect the investors' rights and interests. But in the case of BOT and TOT, China has not formulated proper laws for the protection of investors for although a private company or plant signs the contract the authority really resides in the local government. In the event of any conflict, private or foreign investors are at a definite disadvantage when facing down a government. This is why many investors, although they may be interested in this field, show little concrete action.

(3) Technical Problems: Because using market mechanisms to establish sewage treatment systems is a new subject there is little by way of successful experiences. Many technical problems need to be solved, such as the actual percentage of registered capital the investor should have, the proper time to transfer after operations begin, the maximum extent of profit the investors could expect, how the operation should be supervised, etc. The situation needs to be studied more carefully so that the information and experience that ensues can be advantageously exchanged.

IV. URBAN AIR QUALITY MANAGEMENT

In spite of increasing environmental awareness, air pollution levels are still high in the cities of Asia. Trends indicate that nine of the world's major cities located in Asia have the highest levels of total suspended particulates (TSP) in the air. In fact, levels of TSP are two to three times higher than those recommended by WHO. At least six cities with the highest levels of sulphur dioxide (SO_2) are also located in the region. City transport systems are the major source of air pollution, often responsible for 70-80 per cent of local air pollution. However, in cities of developing industrialized countries like China which depend on coal as a major source of energy, industry is a key factor. Measures originally in place to curb air pollution follow the command-and-control approach involving direct regulation along with monitoring and enforcement systems which rely on application of regulatory instruments e.g., standards, permits and licenses. However, increased use of motor vehicles as well as expansion of industrial activities have led to more deterioration of air quality exposing the urban population to more health risks.

The Kitakyushu Initiative for Clean Environment calls for improvement in air quality to meet WHO standards or local standards when they exist. It also encourages private sector investment for pollution control in conformity with the "Polluter Pays Principle."

Nine Asian cities conducted case studies under the Kitakyushu Initiative with the objective of sharing their recent practices and experiences in air pollution control with other cities. The Asian cities are located in countries under different stages of economic development - developed, developing industrialized country and countries in economic transition. Whereas before emergence of preventive strategies for pollution control, control measures were confined to vehicular emission checks and inspections and end-of-pipe treatment for industries to meet environmental standards, the range of pollution control-related practices presently in use range from total ban on leaded petrol and phasing in of unleaded gasoline, retrofitting of particulate removal devices especially on old heavy diesel vehicles, to limiting use of old vehicles in the city, designation of pollution free roads, increasing use of public transport, expanding underground transport system, promoting car free days, upgrading and widening of streets as well as more use of media including radio and TV channels for public information on pollution levels. Current practices to reduce industrial pollution, on the other hand, range from relocation of high pollution industries and restraint on new constructions, encouraging clean energy like wind, tidal and solar energy by levying a compensation fee on coal use, central heating system from plants fitted with pollution control devices, to support measures such as a low-interest fund for pollution mitigation available to industries, and even measurement of mercury and lead in blood of persons living in areas close to the pollution source. In addition, the case studies detail new initiatives like Green Fleets (Bangkok), Blue Sky Programme (Surabaya), Action Plan with a management action plan to ensure implementation is on track (Tehran).

Indeed, the case studies provide ample choice of preventive and remedial actions and innovative ways of curbing air pollution which could be replicated in the cities of Asia and the Pacific. Take note, however, that the practices and experiences in the case studies did not eliminate the need for standards, environmental monitoring, enforcement and other forms of government participation. Recent measures described in the case studies supplement direct regulation.

A. Bangkok, Thailand
Bangkok Air Pollution - Situation Management

1. Abstract

Heavy traffic and rapid increase in motor vehicle numbers, aggravated by poor maintenance, have resulted in air pollution being Bangkok's most serious environmental problem and this has lead to over 1 million citizens suffering from air pollution related illnesses in the metropolis. The Bangkok Metropolitan Administration (BMA) in 1999 instituted a number of measures designed to reduce air pollution. These have included, among others, the setting up of vehicular emission checkpoints, mobile inspections, designated pollution free roads, public display of air quality data from monitoring stations, engine inspection and tune up services, public relations campaigns, enforcement of covering sheets in construction sites and haulage trucks, controlling road dust, improvement of fuel quality, private sector supported devices designed to reduce black exhaust and improve engine performance, reducing vehicle emission in municipal fleets through initiatives like the "Green Fleets" Programme, increasing the green area in Bangkok, pursuing a rigorous energy conservation policy, upgrading the motorcycle fleet, controlling public transport bus emissions and testing use of alternative fuels like diesel and bio-diesel mixtures. There have been mixed results with some measures being more successful than others. But on the whole there have been demonstrable success in improving air quality especially PM-10 levels. Other Programmes being implemented and under consideration include the World Bank funded "Bangkok Air Quality Management Project", the EU funded "Asia Urbs" Programme, the Environment Protection Volunteer Project and a Cooperative Programme to check up and tune up engines to save energy.

2. Environmental Setting

Bangkok, the capital of Thailand is situated on the low flat plain of Chao Phraya River, which extends to the Gulf of Thailand. Its latitude is 13^{o} 45' North, and longitude is 100^{o} 28' East. The total area of Bangkok is 1,568.737 km^2. divided into 50 districts. Bangkok has a monsoon type of climate, that can be classified as: rainy (May - October), cool (November - January) and hot (February - April). The average annual temperature ranges from 29.2 °C to 33.3 °C. The relative humidity is high throughout the year. The provision of well-developed infrastructure has enabled Bangkok to develop into the focal centre for economic, culture and administrative activities. Thus, Bangkok is regarded as the growth flagship of the Central Region and the whole country.

As of 2002, the city had an estimated population of 5.7 million. These estimates however can be conservative as people from nearby provinces also flock to the city for work during daytime. As the city is also the hub of economic activity for the country, most industries are located in Bangkok. Economic statistics of 2000 showed that Bangkok has 21,026 registered factories that are mostly small and medium scale enterprises (SME's) with a capital investment of 261,428 million baht and employ more than 600,000 persons.

To diffuse the concentration of factories in the city, the Bangkok Comprehensive Plan defined special zones for industrial estates at Lat Krabang and Bangchan. The total number of factories in the two Industrial Estates is 221. The plan aims to promote the development of non-polluting and nuisance-free industries to improve the urban environment. New industries and factories have also been shifted outside Bangkok to Sarnut Prakan and Pathum Thani. As Environmental Management Systems (EMS) certification (ISO 14001) has gained popularity, many companies are now venturing to be EMS certified. Records show that a total of 288 companies were certified under ISO 14001 in 1999.

Bangkok City has been undergoing rapid urbanization and industrialization since 1960. The increasing population along with the development of infrastructure such as road networks coupled to real estate development, increasing land value, and a developing economy, has resulted in the expansion of the city into the surrounding areas. The rapid rise in population has caused community numbers to increase. The Bangkok Metropolitan Administration (BMA) has defined 5 categories of communities; these are slum, suburb, real estates, urban and housing communities. The number of canals in Bangkok was 1,395 in 2001 of which 339 are under the jurisdiction of the Department of Drainage and Sewerage and 1,056 are the responsibility of the District Offices. In 2000, the Public Works Department reported that there were 4,076 kilometres of road in Bangkok, with has total area of 58.45 km^2.

Current Status of Air Pollution: The number of motor vehicles has increased significantly in Bangkok, leading to traffic congestion and deterioration in environmental quality. One of the most severe environmental concerns facing the city is air pollution. It affects the quality of life of the over 10 million inhabitants of the Bangkok Metropolis, including their work productivity. The deterioration of Bangkok's urban air quality has also adversely affected tourism, and this has resulted in both direct and indirect economic losses.

Air pollution problems in Bangkok are attributed to heavy traffic congestion and a rapid increase in the number of motor vehicles. The problem is aggravated by the lack of sufficient and effective maintenance of vehicles. It is estimated that the number of motor vehicles in Bangkok accounts for roughly one - third of the total number of vehicles in the country. In 2001, approximately 4.5 million cars were registered in Bangkok, in addition to 1.8 million motorcycles. Roughly 95% of the registered motorcycles have two stroke engines and thus are the main contributors to white smoke and particulates. Further, air pollution has also become a serious contributor to health problems in Bangkok for over a decade, especially among the poor who are more exposed to the pollution. Concentration of particulates of less than 10 micron (PM_{10}) and carbon monoxide (CO) in the atmosphere have been found to exceed acceptable standards, while the concentrations of oxides of nitrogen (NO_X), hydrocarbons (HC) and ozone (O_3) has been increasing. It has been found that over 1 million citizens of the Bangkok Metropolis have suffered from air pollution related illnesses.

3. Issues and Challenges

Health Effect from Air pollution: As with other cities around the world, airborne particulate matter cause serious health impacts in Bangkok. Fine Particulate Matter, especially PM_{10}, poses a direct threat to human health as the particles penetrate deeply into lung tissue and convey toxic substances. Diesel emissions mostly contain carbon dust and organic carbon compounds. Small particulates also result from the chemical reaction of sulphur dioxide gas (formed from sulphur in fuel during combustion), which oxidizes into sulphuric acid, and reacts with ammonia to form ammonium sulphate, which is abundant in Bangkok's air (Chula Unisearch, 2000). These particles, and the highly reactive chemicals that can be absorbed onto the particles, are known to be causal agents of respiratory, neurological, and carcinogenic health disorders. Dust from brake pads is a major cause of lung cancer. At its current level, PM_{10} concentrations in Bangkok can cause as many as 4,000 to 5,500 premature deaths each year in the metropolitan area. The Sanitary Division, Ministry of Health, has studied the effect of pollution on health in people of various areas, with the following results:

(1) A study of the effect of particulates on the respiratory system shows both immediate and chronic symptoms in students aged between 7 - 12 years from 6 BMA affiliated schools located in the areas with high particulate levels (119.57$\mu g/m^3$) and moderate particulate levels (54.75 μ/m^3) between September 1996 - August 1997. The results showed that students in schools located in the areas with high and moderate particle levels (size smaller than 10 micron) were affected more than those in schools located in low particulate level areas.

(2) The major source of air pollution in Bangkok is undeniably from the increasing number of vehicles, which has resulted to increased traffic congestion problems. Consequently, more people are exposed to dangerous gases and smoke from incomplete combustion in engines, which are detrimental to human health.

Similarly, in a separate research carried out by Dr. Sawang Sanghiranwattana it was noted that there is decreasing lung capacity of Traffic Policemen in Bangkok. Out of 174 policemen studied, 30 were been found to have restricted lung capacity, 11 had airway obstructions, and 3 had severe airway obstructions. There were 44 policemen with abnormal pulmonary function. From a Health Department survey of congested areas at Pradipat Police Station, the air was found to have dust particles exceeding the standards, increasing from 3 percent in 1993 to 4 percent in 1994 and to 16 percent in 1995.

The adverse health impacts of airborne fine particulate matter (PM_{10}) exact very high costs from the community in terms of premature deaths, hospitalisation and other health care and lost productivity. Numerous studies have attempted to estimate the health costs of PM_{10} emissions, on a cost per ton basis, with figures ranging from US$ 20,000 per ton (for hospital costs only) through to over US$ 500,000 per ton for (total community costs) in some high-income countries.

The results also suggest that there are likely to be substantial benefits, in terms of improved public health, productivity, and quality of life, from reducing particulate matter in Bangkok. It was estimated that the annual cost to the Bangkok area population in terms of reduced health costs and quality of life improvements that would be achieved by a 20 $\mu g/m^3$ reduction in annual average PM_{10} concentrations is likely to be between 65 and 175 billion baht (based on 1995 prices and U.S. to baht exchange rate of 1 to 25).

The Bangkok Metropolitan Administration (BMA) has been aware of the need to tackle the air pollution problems for several years. Such a need includes efforts to reduce the particulate matter of less than 10 micron (PM_{10}) and other pollutants from motor vehicle sources.

4. Implementation Strategy

Air Pollution Management by the Bangkok Metropolitan Administration (BMA): The BMA has declared the year 1999 as the year for mitigating air pollution through the initial implementation of 13 measures for the reduction of air pollution problems. An additional 7 measures were made later. Several public and private agencies were involved in the implementation process, which include the Traffic Police Division of Royal Thai Police, Pollution Control Department, the Department of Land Transport, Bangkok Mass Transit Authority, and Petroleum Authority of Thailand. The campaign focused on building of awareness and public participation through all forms of public relation activities between January 1-February 28, 1999. The implemented measures for reducing air pollution in Bangkok are the following:

1) Setting up check-points for vehicles that emit black smoke;
2) Organization of the Mobile Inspection Units in cooperation with the Traffic Police Division of the Royal Thai Police to inspect vehicles and check for violations of permitted emission levels;
3) Establishment of Motorcycle Units at the checkpoints to arrest detected violators;
4) Initiation of pollution free roads, which promotes the decongestion of routes during peak traffic hours;
5) Public Air Quality Reporting;
6) Provision of free vehicle inspection and tune-up services that are set up in gasoline service stations;
7) Raising awareness through public relations campaign on air pollution;
8) Enforcing the use of covering sheets at construction sites and hauling trucks;
9) Controlling road dust through the improvement of road shoulders;
10) Inspections on motorcycle emissions;
11) Improvement of Fuel Quality**,** which is to be implemented over a ten-year period and includes measures for fuel quality inspections and proper disposal of used oil;
12) Promotion of Special Engine Devices, which are aimed at reducing the emission of black exhaust smoke and enhance engine performance;

13) Promotion of Green Fleets Programme in order to reduce vehicle emissions from municipal fleets;
14) Investment in increasing the Green Area in Bangkok;
15) Promotion of the Energy Conservation Policy as issued by the BMA through an executive order;
16) Upgrading of the motorcycle fleet with the aim of reducing air pollution in Bangkok through reduction of emission, improving fuel efficiency and ensuring effective combustion of motorcycle engines;
17) Reduction of emissions from buses carried out in collaboration with Bangkok Metropolitan Transport Authority) BMTA on Public bus transport; and
18) BMTA vehicles to explore alternative fuel mixtures: such as mixtures of Bio-Diesel and Diesel to be used by public bus transport.

Other Initiatives to Improve Air Quality: Other initiatives for improving air quality in Bangkok are described below:

(a) Bangkok Air Quality Management Project - With financial assistance form the World Bank under the *"Bangkok Air Quality Management Project"*, the BMA with assistance from the consultants Parsons International Limited (Parsons) have developed a Bangkok Air Quality Management Plan (BAQMP), which provides the framework for implementing a comprehensive air quality management programme for the city.

The BAQMP developed as an outcome of previous air pollution abatement studies for Bangkok identified strategic objectives crucial to improving Bangkok's air quality: (i) Designing practical methods to address the PM_{10} problem in the next 3 to 5 years; (ii) Developing a phased approach that would identify medium to longer-term measures to combat air pollution; (iii) Prioritizing, designing, and conducting studies to improve available knowledge of the next series of pollutants to be targeted after PM_{10}; and (iv) Increasing awareness and local knowledge on the issue.

The BAQMP focuses on the first of the above objectives, while initiating actions to address the other three. Priority project actions are directed to cost-effectively reduce particulate emissions from buses, trucks, two-stroke motorcycles and automobiles; control the re-suspension of road and construction dust; and control other significant pollution point sources.

The BAQMP also recommended the following components for the programme:

Component 1: ***Transportation Source Control:*** This component proposes the following measures to be implemented:

- Encouragement of more effective and frequent maintenance of diesel and motorcycle engines, through public education programmes backed up by mandatory periodic and random emissions testing.

- Incentives to replace or re-manufacture existing vehicles or engines to comply with more stringent emission standards, especially high-mileage vehicle groups such as buses and urban trucks.
- Programmes or incentives to fit devices that remove particulates from the exhaust stream (e.g. particulate traps or exhaust catalysts).
- Introduction of cleaner diesel fuels, especially through the removal of particulate-producing sulphur from the fuel.
- Encouragement of the substitution of diesel with other fuel types, for example: compressed or liquefied natural gas (CNG or LNG), liquefied petroleum gas (LPG), or introduce fuel systems that blend one of the above alternative fuels with traditional diesel, with the mixture burned in an otherwise unmodified diesel engine.

Component 2: ***Transport Management*****:** Transport management has two main subcomponents namely:

Bus Sub-Programme: The principle aim of the Bus Sub-Programme is to implement a public transport improvement programme that will integrate mass transit services as quickly as possible for Bangkok. The key elements of this programme include, among others, (i) implement bus and other passenger transfer facility plans for selected Bangkok Mass Transit System (BTS) and Metropolitan Rapid Transit Authority (MRTA) stations to provide convenient and safe transfers; (ii) implement extensive full-time exclusive bus lanes/bus ways in the major travel corridors that feed into the current and upcoming mass transit stations; (iii) introduce "Trunk Bus Line" services that operate entirely or almost entirely on the major corridor bus lanes/bus ways; (iv) implement a localized bus lane network in the Central Area of Bangkok that is served by the BTS and MRTA mass transfer lines; and (v) conduct a study on institutional reforms for public transport operations and management.

Traffic Sub-Programme: This subcomponent will implement institutional reforms and traffic operations training for Police agencies which have the following activities: (i) Continuation of the Area Traffic Control (ATC) System; (ii) Traffic Police Training; and (iii) The Traffic Operations and Control Institutional Reforms.

Component 3: ***Road Dust and Other Sources Control***

1) Road Dust: The initiative by BMA to privatize road-cleaning operations showed successful results in reducing road dust effectively compared with the activity being undertaken by BMA by itself. Because of this success, BMA will be expanding the role of private companies in road cleaning, eventually contracting all road-cleaning operations. BMA's role would then become that of supervising and monitoring the road cleaning operations conducted by the private contractors.

2) Crematorium: The BAQMP proposes that the crematorium retrofit/ installation programme to be implemented on a phased basis to cover development and

finalization of design requirements to procurement and installation of retrofitted crematorium.

Component 4: ***Air Quality Monitoring:*** This component will seek the enhancement of the current air quality monitoring programmes through standardization of data collection and improving quality assurance program for air quality monitoring.

Component 5: ***Capacity Building***: The component aims to strengthen the capacity of BMA in managing air quality within the City of Bangkok which include among others, the establishment of an air quality management unit within BMA organization; providing adequate staff training; imposing an air pollution abatement effort as a City's agenda; and establishing an on-going performance evaluation programme to monitor the effectiveness of the proposed implementation plan

(b) Improving Management and Supporting Guidelines in Air Quality in Metropolitan Cities (Asia-Urbs Programme) - Automobiles and motorcycles remain the key source of air pollution in Bangkok along with emissions from industry. The results from recent monitoring data collected in Bangkok showed that the average concentrations of most of the pollutants monitored exceeded the national standards. While ambient lead levels have dropped sharply since the phase-out of leaded gasoline, the annual mean total suspended particles (TSP) averaged 480 $\mu g/m^3$ from 1988 to 1997, exceeding the annual average standard of 330 $\mu g/m^3$, while the TSP in non-traffic dominated sites was 100 $\mu g/m^3$. Particulates smaller than 10 microns remain above the standard level of 120 $\mu g/m^3$. In 1998 the daily standard for PM_{10} was exceeded by 12 percent at the monitoring stations. The major sources for this are industrial boilers (29 percent) motor vehicles (23 percent) and re-entrained dust from roads (33 percent).

This Programme is supported by the European Union (EU) and has the aim of improving air quality management and supporting guidelines towards a more sustainable urban environment in the metropolitan area. This will be achieved through developing and enhancing local air quality management including the promotion of awareness among stakeholders. The main activities envisaged include developing options for improving air quality in the long-term; developing information dissemination strategies and materials relating to air pollution and risk assessments; establishing stakeholder information to assist in the exchange of air quality information; implementing action in relation to risk estimates and precautionary approaches, producing local management and supporting guidelines and public awareness materials and preparing training modules and new procedures for BMA personnel.

(c) Environment Protection Volunteer Project - The BMA has set up an Environment Protection Volunteer (EPV) Project, which seeks to promote cooperation and foster exchange of experiences on environmental preservation between the BMA, academic institutions, and communities.

The activities of the project include: (i) arranging meetings to encourage brainstorming among the Environment Protection Volunteers; (ii) train Environment

Protection Volunteers to act as key person that will educate the people within the community covering the 50 district areas; and (iii) preparation of a manual for the Environment Protection Volunteers and pamphlets about EPV. This project has now produced the EPV Newsletter as a medium for the public to learn about the activities in the project.

(d) Check up and Tune up the Engine to Save Energy – This Project is being done as a cooperative effort of the Ministry of Energy, BMA, the PTT Public Company Limited and the Car Manufacturers and involves the setting up of vehicle tune-up services to save energy and reduce emissions. The activities include an information dissemination campaign setting up stations to tune up engines for free at 3 landmark sites in Bangkok inclusive of a free oil change while giving recommendations on taking care of vehicles to save energy and reduce emissions. The projects is to be launched on 15 February 2003 and will be implemented for 3 months.

5. Impacts

Air Pollution Management by BMA: The following highlights the impacts and effects of the Air Pollution Management programme implemented by the BMA:

1) Checkpoints for vehicles emitting black smoke have been set up in 50 areas in Bangkok. Between March 1, 1999 and November 2002: 532,457 vehicles were inspected by BMA with 254,132 vehicles found to have emissions that exceed the standards.

2) Between March 1, 1999 and November 2002, 6 mobile inspection units, organized with the cooperation with the Traffic Police Division of Royal Thai Police, inspected 238,700 vehicles and found 124,546 to have violated the permitted emission levels. Mobile inspection units, organized with the Department of Land Transport, between April 1999 and August 2002 inspected 17,599 vehicles and issued bans on 1,017 vehicles that exceeded the standard emission levels.

3) The first phase of the campaign for pollution free roads was implemented on Silom, Rachapralop and Paholyothin Roads. The campaign was later extended to Arjanarong, Ramkamhang, Rama 9, Si Paya and Phetburi Road. Now, this measure has been extended by obtaining the cooperation of car users to avoid using roads with high pollution potential near schools and commercial areas especially during rush hour which includes allowing BMTA to frame policy to enable clean buses to run in the inner area of Bangkok.

4) Air quality from 17 air quality measuring stations are being reported to the public on display boards of the Pollution Control Department at 4 locations, which are: (a) Wireless Intersection (Lumpini Park), (b) Lum Sumlee Intersection, (c) Lard Proa Intersection and (d) Taksin intersection. The BMA has one permanent air and noise monitoring station and one mobile monitoring unit. The data from this monitoring supports environmental planning and surveillance programmes. BMA has plans to provide more stations for air pollution monitoring especially PM_{10} on the roadside.

5) Free vehicle inspection and tune-up services were provided by service stations of the Mechanical Maintenance Division (MMD), BMA. Moreover, there are four vehicle inspection service centres under MMD. These vehicle inspection service centres are at Bang Kapi, Rat Burana, Phasi Charoen and Prawet and provide inspection and recommendation services.

6) Boards and documents were prepared for campaigning on air pollution and its effects. Topics included how to reduce air pollution through media such as TV, VDO, pamphlets, manuals, leaflets etc. In addition the BMA together with related agencies prepared the "Bangkok - State of the Environment 2001" Report supported by UNEP that was targeted at administrators and the general public and aimed at promoting correct understanding and awareness of environmental problems including air pollution in Bangkok. It also collaborated in the preparation of the "Thailand Environment Monitor 2002 (Air Quality)" which is a report detailing the state of air pollution, public perception of its effects and the challenges for air pollution management.

7) Inspection and strict enforcement of the use of covering sheets at construction sites was initiated by the Working Group on Inspection of Building and Infrastructure Construction and implemented by the district offices. The district offices also implemented inspection and strict enforcement of the use of covering sheets by trucks.

8) The Improvement of road shoulders and controlling of road dust was implemented by district offices and the Department of Public Cleansing, BMA, which also cleaned roads by sweeping, vacuuming, and washing. Road cleaning, implemented in 50 districts, was the most cost-effective measure in controlling dust especially on narrow roads.

9) Inspection of White Smoke from Motorcycles was implemented since 2 August 1999. The inspection has experienced considerable difficulties due to the cumbersome measuring methodology that required at least 15 consecutive accelerations. The Pollution Control Department has therefore made adjustments to the inspection methodology and opted for measuring carbon monoxide and hydrocarbon emissions.

10) The BMA launched the "Car Free Road" project by closing Silom Road every Sunday. The National Energy Policy Office (NEPO) reported that as a result of closing Silom Road, people reduced the use of private cars by using the BTS service instead. The reduction in road use correspondingly has reduced air pollution problems to more than 50% including CO; from 3.9 - 5 PPM/hour to 0.9 – 2.4 PPM/hour and particulate matter 10 microns in diameter and smaller from 95.1 μg/hour to 56.0 μg/hour. A poll carried out on people joining this campaign found that 85% agreed with this campaign and 81% thought that this project helped to save energy, 86% thought that it can reduce air pollution, 79% thought that it was a tourism promotion and 87% thought that it should be held every Sunday - continuously.

11) The Office of National Energy Policy formulated a 10 - year policy on improvement of fuel quality. Commencing in 1993, implementation of the policy

includes study on collection of used engine oil for disposal and eradication of counterfeit fuel. Inspection of fuel quality has been regularly conducted or carried out upon request by the Fuel Division, Department of Trade Registration.

12) The following four special devices for engines from the private sector were tested:

(a) ***Power Jet*** is a device to reduce the emission of black exhaust. It is installed next to the exhaust pipe. It aims to compress the exhaust gases produced within the combustion chamber in order to ignite and burn the fuel more efficiently (achieve complete combustion) Price: The power jet is approximately 5,000 baht. Vehicles of all sizes and engine capacity can make use of it.

(b) ***Device for Preheating Fuel*** is a device designed to heat fuel by using hot water taken from the radiator tank of a vehicle, before it enters the injection pump. The aim is to increase the temperature of the fuel, which is mixed with air in the combustion chamber, and achieve more complete combustion with less waste gases. Price approximately 2,000 baht only requirement is that it has to be installed in a pick - up truck with a capacity not in excess of 3,000 c.c. (or other kinds of vehicles depending on their size).

(c) ***Magnetic Device*** is supposed to rearrange the molecules of the fuel as it is injected into the combustion chamber, to cause it to mix more thoroughly with air and burn more completely. It is installed on the pipe leading to the injection pump. Price: approximately 6,000 baht (on a pick - up truck).

(d) ***Catalytic Converter*****:** This device is located in the exhaust system of a motor vehicle, contains a catalyst for converting pollutant gases into less harmful ones. It consists of an exhaust pipe containing ceramic cells coated with rhodium and other elements. This absorbs heat from the exhaust and raises the temperature up to $300^{o}C$, promoting oxidation of hydrocarbons into carbon dioxide and water, thus reducing black exhaust and air pollution. Price: approximately 8,000 - 25,000 baht, depending on the size of the vehicle. (on a pick - up truck).

13) A seven – step process describes how to "green" a fleet by choosing from a list of strategies and methods that include: travel reduction, clean, more efficient vehicles and/or fuel purchases and preventive vehicle maintenance. The seven steps are:

(1) Determine the Basis for an Ordinance or Executive Order.
(2) Establish the best policy tool to implement a Green Fleet Programme.
(3) Establish a Green Fleet Executive Committee (Car Pool Committee, Engine Inspection and Maintenance Committee, Public Relation and Campaigning Committee).
(4) Appoint a Green Fleet Director.
(5) Establish a protocol for conducting a fleet inventory of the BMA.

(6) Outline the Green Fleet strategies that will be employed by Bangkok Metropolitan Administration (BMA).
(7) Define Technical or Confusing Terms within the Policy.

Assistance in implementing these steps was obtained from the United States Environment Protection Agency (USEPA), including developing a pilot project, providing institutional support and incentives, and developing projects to assist the general public. From a range of potential activities for the BMA, several have already been implemented, and examples are:

(a) Providing buses for transporting BMA staff;
(b) Encouraging staff and general public to use mass transit;
(c) Car pooling for BMA employees;
(d) Setting up standards for vehicle purchase (developing engine specifications for lower emissions;
(e) Changing engines on BMA vehicles to lower emission engines and promoting cleaner and more efficient motorcycles and other vehicles;
(f) Enforcement of existing regulations;
(g) Changing behaviour and using cars only when necessary;
(h) Promoting public awareness of air pollution and vehicle issues;
(i) Installing equipment such as catalytic converter to reduce air pollution;
(j) Promoting the GIS map to cheek the best way and efficient routing of vehicles to save time and energy for travel; and
(k) Use the same car for District in the same area to send the document by using GIS map.

BMA has expanded the implementation of the Green Fleet Project to cover private and government vehicles as well as motorcycle. For government vehicles, training of officials will be provided to follow these steps: training on automotive mechanics as well as checking by check list before start the engine and maintenance, bringing the vehicles for inspection periodically as specified in the vehicle maintenance manual, and maintaining the engine to be in good condition and free -from pollution.

14) The BMA administrators have placed high priority on this project in order to expand and increase the green areas within the Bangkok Metropolis. This includes encouraging and supporting various sectors, both governmental and non-governmental organizations, to become involved and grow trees on various vacant plots of land by leasing them. The aim is to reduce air pollution by using the air purifying effects of trees. A successful project of this type is the area under King Rama III Bridge in Bang Khor Lam District. Moreover, various organizations have cooperated including such companies as Bayer Thai Company Limited, area stakeholders and the general public. At present, there are 1,180 parks in Bangkok with an area of approximately 12.6 km^2. (average: approximately 2.2 m^2/person). Bangkok has approximately 4,578,678 trees. The target up to 2005 is to provide green areas on the average approximating 2.5 m^2/person and increasing the number of trees by 450,000 to 1 million trees in total. At present, the BMA had launched a pilot project on Dinso Road growing trees along the

roadside, which also acts as a living green wall to mitigate the effects from vehicle emissions.

15) The Energy Conservation Policy recommended the following activities: (i) regular maintenance of fleet vehicles as recommended by the vehicle manual; (ii) switching off the engine while parked; (iii) minimizing use of vehicles and promoting telecommunication use instead wherever possible; (iv) establishing more efficient routing of vehicles by introducing a GIS map; and (v) promoting carpooling between BMA offices.

16) Motorcycle Fleet Upgrade to Reduce Air Pollution in Bangkok has been initiated by the BMA with the World Bank, Motorcycle Manufacturers, Petroleum Product Producers, Thailand Motor Vehicle Industry Association and relevant agencies signing a memorandum of understanding (MOU) for cooperation on abatement of air pollution from motorcycles. Under the MOU, activities have been organized to improve environmentally sound performance of motorcycles including reduction of emission, fuel efficiency and effective combustion. In addition the BMA has set up such activities like (a) Motorcycle Clinics – designed to reduce the air pollution from the fleet of in-use motorcycles and increase public awareness on air pollution from motorcycles; (b) Organizing meetings with related agencies such as BMA, PCD, LCD, Traffic Police, World Bank, Government Savings Bank (GSB), Education Institutes, NGOs, Kenan Institute Asia, Thai Industrial Standards institute (TISI) and Thailand Automotive Institute etc. The objective is to get the support, increase cooperation and exchange ideas about the Bangkok Motorcycle Upgrade Project; and (c) Organizing a seminar for manufacturers of motorcycles, parts manufacturers, dealers, motorcycle users and related agencies in Bangkok. The objective was to impart and exchange knowledge about inspection and maintenance of motorcycles, including brainstorming on how to solve the air pollution from motorcycles.

17) In an effort to reduce emissions from public buses the Bangkok Metropolitan Administration has submitted a formal letter to BMTA (Bangkok Mass Transit Authority) requesting their cooperation to improve and amend the terms of concession given to private companies in operating mass transportation to prevent the use of old vehicles. BMA has suggested that BMTA add an appropriate addendum to the terms of concession for operation of bus lines by private companies to (a) ensure that the private company receiving the concession hire an entrepreneur to ensure proper maintenance of vehicles to prevent pollution problems (b) include a warning that any mass transit vehicle receiving two inspection notices for the black-smoke violations, will be suspended for six months. In addition should such a vehicle after it returns to operation get the third notice; the company will be prohibited from using the vehicle permanently.

18) The Ethanol Bio-Diesel Alternative Energy Institute Foundation of Thailand, the Bangkok Metropolitan Administration, the Bangkok Mass Transit Authority, the Petroleum Authority of Thailand, the Office of National Energy Policy, the Office of Natural Resources and Environmental Policy and Planning, the Ministry of Natural Resource and Environment and the Raja-Bio Diesel Company Limited initiated a joint-project on transforming vegetable oil into fuel. This is one of the research choices in

finding energy alternatives. In Thailand, there are various types of vegetable oil, which can be used as raw material for Bio-Diesel production. From a previous study, it is discovered that Bio-Diesel fuel can be effectively used as a diesel alternative that is environment friendly. Based on the study, the emissions have smaller amounts of pollutant than the normal diesel fuel. In addition, it was discovered that Bio-Diesel could be used as a chemical additive to enhance the lubricating properties of low sulphur diesel. The objectives were to: (a) test the use of fuel mixtures of Bio-Diesel and diesel in the Bangkok Mass transit Authority (BMTA)'s vehicles; (b) study and collect data on the environmental impacts of Using Bio-Diesel fuel; (c) publicize and create public awareness and understanding on the use of Bio-Diesel; and (d) support the agricultural industry.

6. Lessons

The BMA has long recognized the necessity for continuous reduction of air pollution in our metropolis to mitigate its impacts on public health. The improvement in air quality in Bangkok has been included by the national government in the policy and protection of public health formulated in accordance to the 7th National Economic and Social Development Plan (1992-1996). The policy recommended clear measures for management and improvement of the air quality including an increase in number of roads, traffic improvement, development of public transport systems, reduction of lead in gasoline and improvement of fuel quality. Although some measures, such as the use of unleaded gasoline nationwide in 1999, have been very successful, other measures particularly those under the responsibility of several agencies have not been as effective due to lack of harmonization of efforts and insufficient coordination. In the 9th National Economic and Social Development Plan (2002-2006) support was provided for continuous implementation of capacity building for environmental improvement. However, such support was found to be still insufficient especially in the face of the economic crisis that plagued the country at that time.

Problems in Managing Air Quality in Bangkok The problems in implementing the management of air quality in Bangkok are mostly due to worsening air pollution problems and the economic crisis, which limits allocation of public funding. These problems and constraints can be listed as follows:

Problems facing the Public Sector:

(1) Local agencies, especially the Bangkok Metropolitan Administration, do not have full authority in managing air quality;
(2) Limited public funding which adversely affects both improvement of public buses and capacity building among officials;
(3) Implementation of policies not backed by infrastructure such as the promotion of natural gas consumption while there are still insufficient service stations dispensing it is a problem;
(4) Public relations of governmental agencies lack independence and continuity; and

(5) Inefficient public transport systems are incapable of fulfilling public needs.

Problems facing the Private Sector and General Public:

(1) Limited funding for improvement of private buses;
(2) Private inspection stations are unable to meet acceptable standards due to limited funding and inadequate labour force coupled with ineffective inspection; and
(3) Lack of awareness of how to participate in solving air pollution problems.

7. Future Prospects

The 6th Bangkok Development Plan (2002-2006) and BKK Agenda 21 share the same objectives with those of the 9th National Economic and Social Development plan regarding regulation of urban growth and development, improvement of the quality of life and the environment, and provision of sufficient social services for the less fortunate.

All BMA tasks are being implemented under Bangkok Agenda 21 CONTENT namely:

1. The strategy for a more SUSTAINABLE BANGKOK - a better place to live.
2. Leading URBAN ECONOMY towards sustainability.
3. Using URBAN PLANNING to improve quality of life in Bangkok.
4. REORGANIZING TRAFFIC AND TRANSPORT to raise quality of air and neighbourhoods.
5. INVESTING IN GREEN URBAN AREAS.
6. USING URBAN PUBLIC SERVICES to make Bangkok A CLEAN CITY.
7. Focus on GOOD GOVERNANCE in BMA to meet the challenges of the future.
8. Easy access to INFORMATION in BMA.
9. HUMAN RESOURCES as a strategic tool in SOCIAL and ECONOMIC DEVELOPMENT.
10. INVOLVING the CITIZENS in the development of A BETTER BANGKOK.

The 6th Bangkok Development Plan (2002-2006), the Work Plan for Prevention and Solution of Air and Noise Pollution includes:

1. Control and reduce emission of particulate matter from sources to the standard levels;
2. Monitor air pollution quality covering the Bangkok areas;
3. Promote to use the clean technology by adapting BMA vehicles to use low emission engines;
4. Raise public awareness on air pollution problems including its impacts and promote public participation;
5. Promote Mass transit instead of private car use; and

6. Cooperate with the Land Transport Department (LTD) to inspect and penalise offending owners.

There are many challenges in solving the air pollution problem in Bangkok. Among them are:

1. Tackling the unfinished agenda in Bangkok. Particulate matter remains to be a major public health threat in Bangkok, with concentration levels exceeding permissible standards. There are several million gross polluters among the very old diesel vehicles that are continually rebuilt or older two - stroke motorcycles. Addressing this problem can be accomplished by implementing a rigid Inspection and Maintenance (I/M) Programme, joining hands to introduce incentive schemes for users to replace their two-stroke motorcycles with four-stroke machines and controlling road dust;
2. Improving air quality management;
3. Improving public transport and traffic management;
4. Strengthening institutional effectiveness;
5. Improved Inter-Agency Coordination; and
6. Broadening Public participation.

The plan for BMA to tackle air pollution in Bangkok includes the following:

- Setting up checkpoints to detect vehicles that emit black smoke in cooperation with the traffic police and the Land Transport Department (LTD);
- Air Quality Monitoring in Bangkok;
- Set up Engine Inspection and Tune-up Services Stations;
- Public Relation Campaign to raise awareness in air pollution;
- Improvement of road shoulders and controlling road dust;
- Inspection of white smoke from motorcycles;
- Increasing green areas in Bangkok;
- Improvement the Green Fleet Programme supported by USEPA and Kenan Institute;
- Cooperate with the Ministry of Energy, PTT Public Company Limited and the Car Manufacturers to set up tune-up services to save energy and reduce emissions at landmark areas in Bangkok by launching a 3 month project on 15 February 2003;
- Promote studies on air pollution effects by educational institutes;
- Prepare the Bangkok State of the Environment Report 2003 supported by UNEP;
- Improve Management and Supporting Guidelines for Air Pollution Control in Bangkok in co-operation with the cities of Athens and Bristol in Greece and the U.K. respectively;
- Implement the Environment Protection Volunteer Project;
- Implement other projects to promote reduction in air pollution.

B. Hong Kong, China
Urban Air Quality Management in Hong Kong, China

1. Abstract

With roads among the most heavily used in the world, with almost 300 vehicles per kilometre of available road, high density of built-up areas and diesel vehicles accounting for 70% of all vehicle kilometres travelled per year Hong Kong has a fair share of air pollution problems. But Hong Kong faces two major air pollution issues, namely street level pollution with Particulate matter and oxides of nitrogen being the main concerns as well as regional air pollution from vehicles, industry and power plants in Hong Kong and the Pearl River Delta. Annual losses due to air pollution related health costs have been estimated as $3.8 billion. Fourteen (14) fixed stations routinely monitor seven parameters, which serve as benchmark targets as well as contributing towards the development of an Air Pollution Index (API), which informs the public on the prevailing air quality. A wide range of measures have been introduced in Hong Kong to control air pollution from vehicles as well as industries and power plants including phasing in unleaded gasoline, a total ban on leaded petrol since 1999, catalytic converters, retrofitting of particulate removal devices especially on old heavy diesel vehicles, ban on high sulphur fuels, vehicle inspections, stringent standards on diesel cars since 1998, new taxis using LPG by 2001, motor cycle vehicular standards strictly enforced etc. Hong Kong and Guangdong Provincial government have reached a consensus to implement long-term air quality measures. Hong Kong is well on track to achieve its stated goals by 2005.

2. Environmental Setting

The Hong Kong Special Administrative Region (HKSAR) occupies an area of approximately 50 kilometres (km) from North to South by 60 km from East to West on the Southeastern coast of the Asian mainland. The land area of slightly less than 1,100 km^2 is made up of two main islands and one rhomboidal shaped piece of land that adjoins the mainland of China. This is surrounded by open water on three sides. 17% of all Hong Kong's land has been developed for residential, commercial, industrial or other "built-up" uses and is where most of Hong Kong's man-made emissions to the atmosphere would originate. Currently, it has a population over 6.8 million people.

Hong Kong's roads are among the most heavily used in the world, with over 580,000 vehicles on 1,940 km of roads. The extremely high density of built up areas and the unusually high reliance on diesel vehicles in Hong Kong are unique - 30% of Hong Kong's vehicles have diesel engines, compared with 19% in Japan, 17% in Singapore and 10% in the UK. Diesel vehicles account for 70% of all vehicle km travelled each year.

Air pollution problems in the HKSAR are similar to those encountered in most comparable urban areas elsewhere in the world. However, the air pollution of yesterday is not the same as that of today or tomorrow. Pollution from industry and power plants used to be the main concerns in the 1970s and 1980s. Then vehicle pollution came to the

forefront in the 1990s. Regional air pollution has become the most recent worry. Many programmes have been put in place to control these problems. Indeed, identifying solutions has been the easy part. Getting everybody to agree on solutions is where the SAR Government has faced the greatest challenges. Hong Kong has had some success in achieving consensus and reducing pollution, but significant work still needs to be done to ensure clean, healthy air.

Urban Air Pollution in Hong Kong: Hong Kong is confronted with two air pollution issues:

(a) Street-level Air Pollution – Concentrations of the two major air pollutants, namely Respirable Suspended Particulates (RSP) and Nitrogen Oxides (NO_x), at roadside are high. The problem is caused by a combination of factors including high population density, high-rise buildings that hinder circulation of air at street level, and a high concentration of vehicles, particularly diesel vehicles on urban roadsides. The hilly topography also adds to the effect of the many high-rise buildings in the urban centres, restricting the flow of air and inhibiting dispersion of air pollution.

(b) Regional air pollution – Emissions from vehicles, industry and power plants in Hong Kong and the Pearl River Delta (PRD) Region all contribute to a regional air pollution problem, commonly seen as smog in the ambient air. The deterioration in visibility, which is a sign of photochemical smog, is a common phenomenon in many neighbouring cities in Guangdong, the Chinese province to the north of Hong Kong. The influence of regional air pollution is most noticeable when the prevailing wind is from the Northwest to the Northeast. This is more common in the winter months.

Air pollution is a threat to the health of every citizen. A study completed in 1998 on acute hospital admissions linked to air pollution estimated that the annual cost in medical expenses and loss of productivity could be around US$3.8 billion. Air pollution is a threat to Hong Kong's economy. Poor visibility and a reputation for poor air quality are a disincentive to tourism and to companies establishing or maintaining their operations in Hong Kong. Poor air quality also undermines the quality of life for every resident of Hong Kong.

Measuring Air Pollution: Concentrations of up to seven air pollutants are routinely monitored at 14 fixed stations (**Annex A**). Air Quality Objectives for seven major components of air pollution have been established for Hong Kong (**Annex B**). They serve as a benchmark for the quality of air needed to protect public health and also as measurable targets to be achieved in the fight against air pollution. The Air Pollution Index transforms the many different measurements into a single number to give the public a simple indicator of how good or bad air quality is.

Two air pollution indices are issued in Hong Kong - the General Air Pollution Index and the Roadside Air Pollution Index. The former represents the quality of air, which most people will experience at home, in school or at work. The latter represents the quality of air in busy streets.

3. Issues and Challenges

Current Trends in Air Pollution: The following trends have been observed with respect to air quality and emissions:

- Lead, sulphur dioxide and carbon monoxide are at low levels, well within Hong Kong's Air Quality Objectives;
- Annual averaged concentrations of RSP remain high although slight improvement has been observed in 1997 and 1998. It worsened a little in 1999 and is still the biggest concern in terms of health impacts;
- There is a slow but steady rising trend of nitrogen dioxide concentrations. These now reach the limit of the 24-hourly maximum levels under Hong Kong's Air Quality Objectives;
- Concentrations of ozone are steadily increasing. Average concentrations have increased by 50% since 1991. **Figure 1** shows the trends in visibility impairment during the period 1991 to 2001; and
- Emissions from industrial power generations have fallen by 58% for sulphur dioxide and 45% for nitrogen oxides, and need to be further reduced to reduce Hong Kong's contribution to regional air problems.

4. Implementation Strategy

Action Taken to Reduce Air Pollution: The Air Pollution Control Ordinance (APCO) provides a statutory framework for stipulating the anti-pollution requirements for air pollution sources. It enables the making of subsidiary regulations to deal with specific air pollution problems, such as dark smoke from chimneys, dust from construction sites, open burning, emissions standards for vehicle engines, volatile vapour from petrol filling stations and dry-cleaning machines. It also empowers the Authority to issue legal notices to air pollution sources to demand remedial actions. A wide range of measures which had been introduced in Hong Kong to control air pollution are briefly described in **Annex C**, together with the effects that they have.

Control of Emissions from Industries and Power Plants: Major industrial emission sources including power plants have been placed under licensing control of the APCO since 1987 and high sulphur fuels have been banned since 1990. Hong Kongs's Environment Protection Department (EPD) requires that these sources use the best practicable means to minimise emissions.

Power plants in Hong Kong are required to adopt the best practicable means to reduce their air pollutant emissions through a licensing system under the APCO. Coal-fired power plants constructed after 1 January 1991 have been required to install electrostatic precipitators to minimize dust particles; flue gas desulphurisation units to minimize the SO_2 emission; and low NO_x burners to minimize NO_x emissions. Also all new power plants have to use natural gas together with low NO_x technology.

Control of Motor Vehicle Emissions: In the 1999 Policy Address, the SAR Government announced a comprehensive programme of measures targeted at diesel vehicles, which are the dominant source of RSP and NO_2 at the street level. The strategy includes the following key elements:

- Converting the 18,000 strong taxi fleet to liquefied petroleum gas (LPG) and the 6,000 light bus fleet to LPG or electric vehicles with concession of fuel duty;
- Requiring another 50,000 older light diesel vehicles to be fitted with particulate traps;
- Requiring 30,000 older heavy diesel vehicles to be fitted with diesel catalysts;
- Introducing EURO III standards for new diesel vehicles as soon as the standards are in place in Europe in 2001; and
- Stepping up enforcement action against smoky vehicles and enhancing the vehicle inspection programme.

Substantial resources are allocated for implementing these measures. These include HK$1.4 billion (US$1 = HK$7.8) set aside as grants to owners of vehicles switching over to LPG, to installation of particulate traps and fitting of diesel catalysts. The concessions on duty for LPG will result in $700 million revenue foregone every year when all taxis have switched to LPG. Land premium is waived to support the installation of LPG filling stations. Upon full implementation of these measures, by 2005, EPD expects that the total emissions of particulates and nitrogen oxides from vehicles will be reduced by 80% and 30% respectively from prevent levels.

Improving Regional Air Quality: To address the regional air pollution in the Pearl River Delta (PRD), Hong Kong needs to first reduce its total emissions from industry, power generation and motor vehicles so as to lessen Hong Kong's contribution to the regional problem. In an effort to encourage the Guangdong Provincial Government to take similar steps, a joint study was conducted in 1999 with the Guangdong authorities to identify the extent and nature of air pollution problems in the entire Pearl River Delta Region with a view to developing suitable strategies and measures to reduce emissions to solve the air pollution problems in the region.

In April 2002, the HKSAR Government and the Guangdong Provincial Government reached a consensus to implement long-term air quality improvement measures. The two Governments have agreed to aim to reduce by 2010, on a best endeavour basis, the regional emissions of SO_2, NO_x, RSP and volatile organic compounds (VOC) by 40%, 20%, 55% and 55% respectively. The two governments have set up an expert group to take forward the recommendations in the study report. The work of the expert group includes assessment of changes to regional air quality and the effectiveness of the additional improvement measures to be implemented.

6. Impacts

Industrial Emissions: As a result of the control measures implemented, SO_2 concentrations in industrial areas have fallen by up to 80%. Combined with the reduction in industrial activities, total industrial SO_2 emissions fell from 46,616 tonnes in 1989 to 7,045 tonnes in 2000.

Power Plant Emissions: As a result of the above measures, the SO_2 emissions from power plants fell from 131,600 tonnes in 1991 to 56,803 tonnes in 2000, and NO_x emissions dropped from 149,400 tonnes in 1991 to 43,627 tonnes in 2000.

Vehicular Emissions: Upon full implementation of the comprehensive programme to reduce motor vehicle emissions, the emission of particulates and NO_x from motor vehicles will be reduced by 80% and 30% respectively by the end of 2005. Up to now, we have reduced 58% of the particulate and 26% of the NO_x emissions from motor vehicles.

Hong Kong is well on track to achieve the anticipated improvements by end-2005. Over 90% of the 18,000 taxis have switched from diesel to cleaner LPG since a government grant for the switch was made available in 2000. 6,000 public and private light buses are also being funded with grants under a similar programme introduced in August 2002. They have the option of switching to either LPG or electric vehicles.

Pollution from the remaining diesel vehicles on the road is also being controlled. New diesel vehicles have to meet the latest European emission standards, which are the strictest in the world. Vehicles imported before standards started being tightened in 1995 have to be fitted with particulate removal devices – subsidized by a government grant. About 80% of the 24,000 old light diesel vehicles have been fitted with such devices since 2000, and heavier diesels started being fitted at the end of 2002.

Alongside these measures, ultra-low sulphur diesel (ULSD) has become the only diesel fuel available in Hong Kong - the only city in Asia to mandate the use of this cleaner diesel. Vehicles that still exceed accepted smoke standards can be hauled in for testing and fined.

Together, these measures have improved air quality significantly, especially at street level. Roadside readings of RSPs have fallen by 19 per cent since 1999. Nitrogen oxides, which affect health and contribute to smog, have dropped by 16 per cent. The number of smoky vehicles has also been reduced by 70%. Moreover, further improvements are expected as the impacts of the motor vehicle emissions programme are felt over the next few years.

The fitting of particulate removal devices on old heavy diesel vehicles, for example, will start having an impact in 2003. As with light diesel vehicles, the government is offering a grant to vehicle owners to fit the devices. The heavy diesels will be retrofitted in phases, first the 30,000 vehicles driven mainly in Hong Kong,

second the 10,000 vehicles that travel across the border, and third the 4,000 long-idle vehicles (such as concrete mixers). Legislation will eventually make the devices mandatory.

6. Lessons Learnt

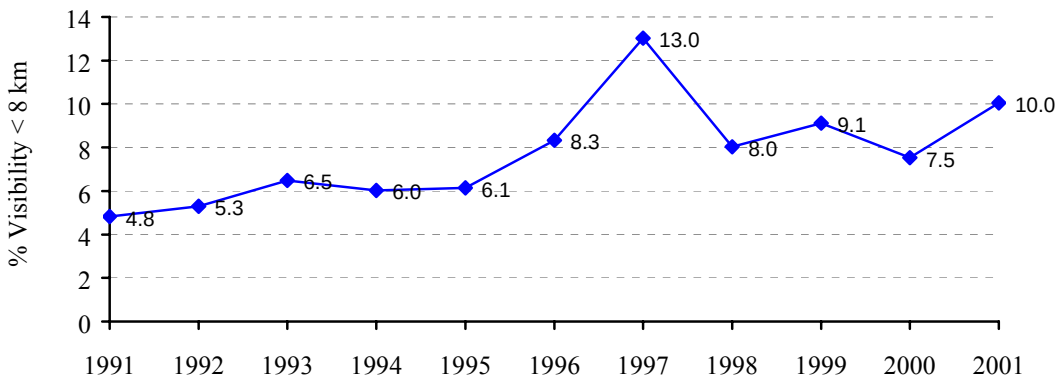
Hong Kong's exhaustive motor vehicle programme is succeeding because it has involved extensive consultations with the trade - and, of course, government grants to help cushion the costs. Roadside air pollution is improving, but controlling vehicle emissions alone will not improve the cloudy views. Hong Kong must continue to reduce its other sources of air pollution and work with its counterparts around the region to ensure lasting impacts.

7. Future Prospects

The HKSAR Government will continue to implement various programme to reduce emissions from motor vehicles. Among other initiatives it will:

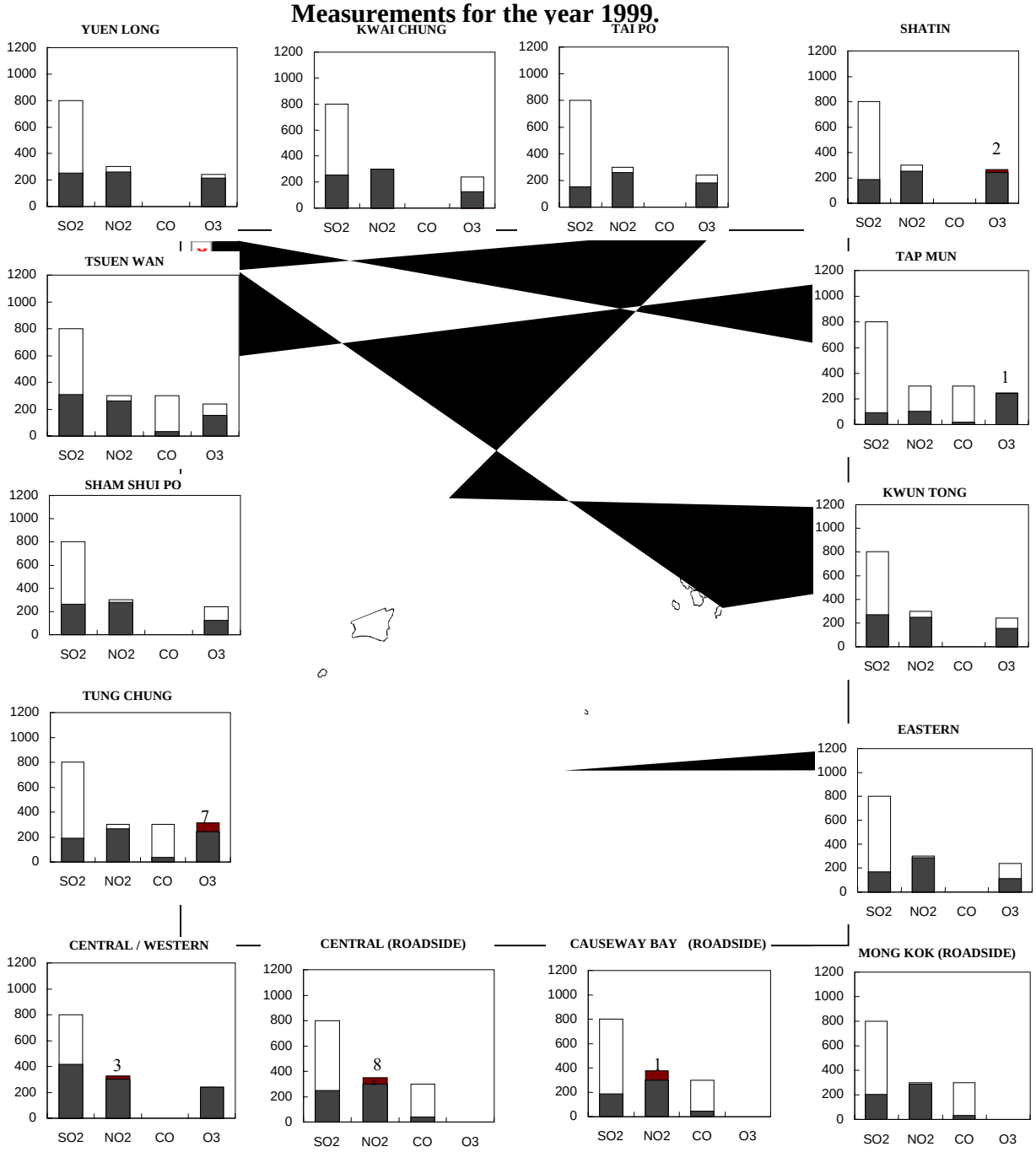
- Continue to explore ways to encourage the use of cleaner vehicles and fuels and technologies that can help reduce air pollution;
- Assist owners of pre-Euro heavy vehicles to install pollution removal devices;
- Prepare a plan to reduce petrol vapour emission at petrol filling stations during vehicle refuelling;
- Work with the Guangdong authorities to develop plans and measures to improve air quality in the Pearl River Delta Region; and
- Adjust the transport development strategies to encourage the use of more sustainable modes of transport. One measure is to rely on railways as the backbone of Hong Kong’s transport system. Hong Kong’s railways now account for more than 30% of daily domestic passenger travel. More railways will be built and the Government will invest over $100 billion on railway development in the next 5 years.

Figure 1: Trend of Visibility Impairment (1991-2000 & 2001Jan-Oct)



Note: Y-axis values calculated from dividing the no. of hours of Visibility < 8 km and RH is less than or equal to 80% (<=80%) by the total hours when RH<=80%

ANNEX A: Air Quality Monitoring Stations in Hong Kong and Air Quality Measurements for the year 1999.



KEY:

AQO not complied | AQO complied

Air Quality Objective

NOTES:

1) Figures shown are the maximum hourly concentration. (No. of violations of Air Quality Objective (AQO) limit value shown above each column.)

2) All concentrations are in micrograms per cubic metre except CO which is in hundred micrograms per cubic metre.

3) Maximum hourly pollutant concentrations are in light red.

4) Non-compliance of hourly AQO value shown in dark red. (Not more than 3 times per year is allowed.)

Figure AIR QUALITY MONITORING NETWORK. MAXIMUM HOURLY POLLUTION CONCENTRATIONS AND OBJECTIVES IN 2000.

ANNEX B:
Hong Kong Air Quality Objectives

Pollutants	Concentration (micrograms/cubic metre)				
	Averaging Time[1]				
	1-hour[2]	8-hour[3]	24-hour[3]	3-month	1-year
Sulphur Dioxide (SO_2)	800		350		80
Total Suspended Particulates			260		80
Respirable Suspended Particulates			180		55
Nitrogen Dioxide (NO_2)	300		150		80
Carbon Monoxide (CO)	30,000	10,000			
Ozone (O_3)	240				
Lead (Pb)				1.5	

1. AQOs provide the targets for protecting the public from adverse health effects of air pollution. They are based on scientific analysis of the relationship between air pollution concentrations, and the associated adverse effects of the polluted air. As air pollutants may cause acute health effects for short periods of exposures or chronic effects for longer periods, AQOs are set for 1-hour, 8-hour, 24-hour, 3-month or 1-year periods, according to whether there are corresponding effects for any particular exposure periods.
2. Not to be exceeded more than three times per year.
3. Not to be exceeded more than once per year.

Calculation of APIs from Air Quality Objectives (AQOs) Levels

API	Corresponding Air Quality Objective Levels
25	Air pollution is low - at half the Annual AQO, or at a quarter of the 1-hour or 24-hour AQO level
50	Air pollution is medium - at the Annual AQO, or at half the 1-hour or 24-hour AQO level
100	Air pollution is high - at the 1-hour or 24-hour AQO level
200	Air pollution is very high - at 2 times the 1-hour or 24-hour AQO level
500	Air pollution is severe - at 3-12 times the 1-hour or 24-hour AQO level

ANNEX C: Programme already in place to control air pollution

Objectives	Measures Taken	Effects
Reduce emissions from industries	Ban on high sulphur fuels since 1990	SO_2 concentrations fell by up to 80% in industrial areas. Combined with reduction in industrial activity, total industrial SO_2 emissions fell from 46,616 tonnes in 1989 (before the ban) to 16,688 tonnes in 1997
	Licensing control of major polluting sources since 1987	Overall, up to 55% of the emissions from industries have been reduced from 1987 to 1997
Reduce emissions from power generation	Natural gas for power generation and coal units built after 1991 installed with flue gas desulphurisation system	SO_2 emissions fell from 131,600 tonnes in 1991 to 52,659 tonnes in 1997
	Units built after 1991 fitted with latest low-NO_x technology and old units retrofitted with low-NO_x burners	NO_x emissions fell from 149,400 tonnes in 1991 to 55,723 tonnes in 1997 Also helps reduce Ozone formation
Reduce dust emissions from construction activities	Construction dust regulation introduced in 1997	Dust emitted from individual construction activities reduced by up to 80%
Reduce emissions from petrol vehicles	Unleaded petrol phased in since 1991. Complete ban on leaded petrol since 1 April 1999	No leaded petrol. Virtually eliminates lead emissions from vehicles
	3-way catalytic converters and trade in incentives for old private cars	More than 75% of petrol vehicles now have catalytic converters For vehicles complying with new standards: NO_x and Hydrocarbons reduced by 90% Carbon monoxide reduced by 90%
	New vehicles to install controls on evaporative emissions which is planned to take effect in July 1999	Reduces 90% of VOC emissions from individual vehicles
Reduce emissions from diesel fleet	Fuel sulphur standards: Pre-1995: 0.5% 1995: 0.2% 1997: 0.05%	SO_2 from individual vehicles reduced by 90%
	Engine standards: Euro I standards adopted in 1995 Euro II standards adopted by stages since 1997	For vehicles complying with latest standards: RSP reduced by 80% NO_x reduced by 20%

	Inspection and enforcement programme Smoky vehicle control programme in place since 1998 Step up smoke testing procedures for annual roadworthiness inspection since late 1997 Police using portable smoke meters for enforcement against smoky vehicle from early 1999	Smoky vehicle reports reduced by 30% from 1993 to 1998
	Stringent standards for diesel private cars introduced in 1998	No new diesel private cars have been registered
	All new taxis to use LPG starting end 2000	Will eliminate RSP emission from individual diesel taxis and reduce overall RSP emission from vehicle fleet by up to 30%
Reduce Volatile Organic Compounds (VOC) emissions	Oil depots installed floating roof oil tanks since 1993	VOC emissions from oil depots reduced by over 90%
	Vapour recovery system at petrol filling stations since April 1999	VOC emissions from petrol filling stations reduced by over 30%
Reduce emissions from motorcycles	All new motorcycles to meet stringent emission standards planned for October 1999	Reduce 50% of VOC emissions from individual motorcycles

C. Shanghai, China
Retrospection and Perspective of Air Pollution Control in Shanghai

1. Abstract

Shanghai as one of the biggest cities and the economic ocuse of China has a large population and intensive economic activity. Air pollution in Shanghai today is mainly caused by coal combustion (the main energy source for the industrial sector) and vehicle exhaust. The main pollutant of concern, especially to health, is PM_{10}. Many existing laws, regulations and standards at both state and local levels addressing air quality are already in place. In the past pollution reduction strategies ocused on improving combustion and dust removal, now with mixed pollution problems more integrated strategies are being explored. The Shanghai Environmental Protection Bureau (SEPB) has developed implementation programmes and support systems to put into practice these strategies. This is coupled with public information dissemination and response to public complaints. Further steps are planned for the period 2003 – 2005 with the objectives of freezing coal consumption despite growth in energy consumption, reduce sulphur dioxide emissions by 20% and attaining WHO guideline values for major air pollutants. These would be achieved through improvement of legislation and standards; pertinent studies on integrated strategies, enhancing Implementing capacity, the development of economic/market-based policies, improvement of stakeholder communications and coordination. The main measures would be implemented through programmes for emission control from point and mobile sources.

2. Environmental Setting

Shanghai is an important economic and shipping centre and a famous historic city. From the 1990s' the implementation of social and economic plans changed Shanghai significantly. With a sustained and rapid growth of the municipal economy, the expansion of the urban area doubled and redoubled together with a gradual increase in the urban population. In the coming 20 years, Shanghai will be progressively constructed transforming itself into a modern international metropolis, one that would be an international economic, financial, trading and shipping centre.

The Municipal of Shanghai covers an area of 6340.5 km^2 and is located in the middle of China's coastline, in front of the Yangtze Delta and is connected with the Jiangsu and Zhejiang Provinces.

According to the fifth population registration in 2000, the total population in Shanghai is 16.4 million, including about a 3.87 million floating population.

In 2001, GDP of the whole city was RMB 495.115 billion (US$ 60.2 billion). GDP per capita was about US$ 4,000. The different sectors comprise primary industries (1.8%), secondary industries (48%) and tertiary industries comprising the rest (50.2%).

Organizational Structure of Local Government in Environment Management:

(1) The municipal and district/county governments are responsible for the environmental quality within their respective jurisdictions. Governments specify environmental protection targets for their tenure and formulate implementation programmes, on the basis of their environmental protection plans;

(2) Municipal level--Shanghai Environment Protection Bureau (SEPB) conducts unified supervision and management of city wide environmental protection; and

(3) District/county level-D/C EPBs conduct unified supervision and management of environmental protection within their respective jurisdiction and subject to the operational leadership of SEPB.

Total Investment on Environmental Protection:

The total investment of environmental protection in 2001 was RMB15.29 billion (US$1.86 billion), which is 3.09% of total GDP, including investment from different sectors in infrastructure construction, regional rehabilitation, pollution elimination and capacity building.

Air Quality Situation:

The air pollution in Shanghai is mainly caused by coal-combustion and vehicle exhaust. The main pollutant is inhalable particulate matter.

In 2001, the annual average concentration of PM_{10} in downtown was 0.100mg/m^3, and the annual average concentrations of NO_X and SO_2 were 0.044 mg/m^3 and 0.024 mg/m^3.

The total volume of coal combustion was 44.68 million tons and the emission load of SO_2, particulates from coal-burning and dust from industrial sources were 472.6 thousand tons, 135.2 thousand tons and 18.2 thousand tons. The total vehicle population in 2001 was 1,208,000.

Existing Legislations, Regulations and Standards:

(1) Laws and Regulations

State Level	Local Level
• Environmental Protection Law • Air Pollution Prevention and Control Law	• Procedure of Shanghai Municipal on the Implementation of Air Pollution Prevention and Control Law

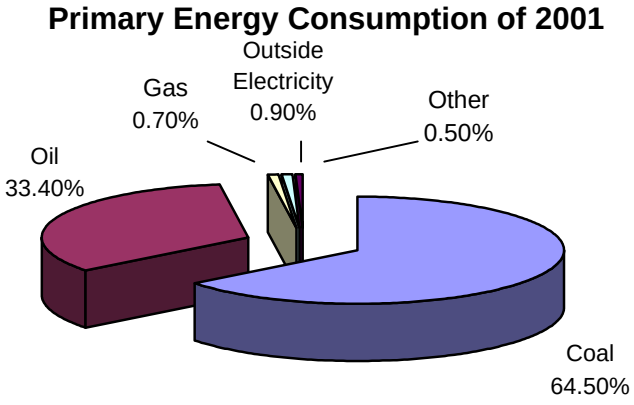
(2) Standards

State Level	Local Level
• National Ambient Air Quality Standard • Integrated Emission Standard of Air Pollution • Odor Pollutants Emission Standard • Specific standards for some source categories (boilers, cement mills, industrial kilns and oven, incinerators, vehicles)	• Limitation of Sulphur Ratio in Fuel

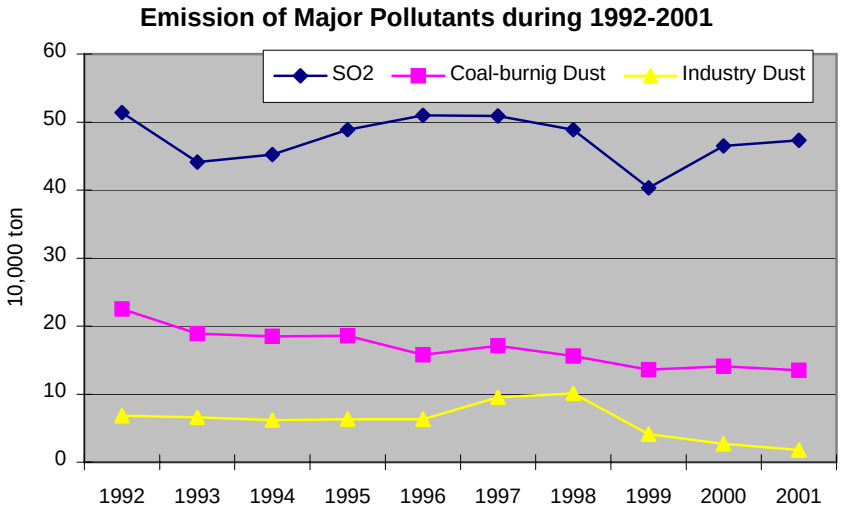
3. Issues and Challenges

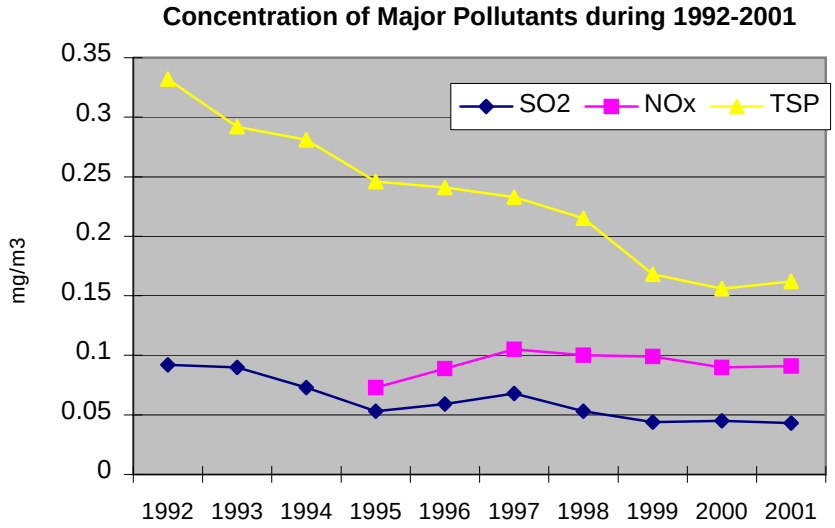
Evolution of Main Issues on Air Quality:

Energy Consumption and Structure: Historically, Shanghai has always been one of the biggest industrial centres in China since the early 20th century. The major energy source for industry and other sectors was coal. With economic development, the energy structure in Shanghai changed considerably. The primary pattern of energy consumption in 2001 was: 64.5% - coal, 33.4% - oil, 0.70% - natural gas and 0.9% - electricity obtained outside Shanghai.



Air Quality and Emission Load of Main Pollutants: From 1960's to 1990's, the air pollution was caused by coal burning and the highest concentration of SO_2 and TSP reached 0.17 mg/m^3 and 0.332 mg/m^3 respectively. In the years 1992-2001 although the economy grew very fast with an average rate of more than 10% per year, the emission load of main pollutants decreased.





4. Implementation Strategy

(a) Evolution of Pollution Control Strategies

1960's - 1990's: In middle of the last century, the main measure of eliminating pollutants caused by coal combustion was improving the combustion and dust-removing technology—focusing on kiln and boiler renovation and reconstruction.

1990's - present: To solve the mixed pollution problems, a series of more integrated strategies have been introduced and implemented:

(1) Adjusting general layout of the city;
(2) Adjusting and optimizing industrial structure;
(3) Regulating and optimizing energy structure (industrial, non-industrial and vehicle);
(4) Pollution control in industrial zones; and
(5) Vehicle exhaust control (non-leaded petrol and Euro-I standard).

(b) Implementation Programmes and Support Systems

Implementation Programmes: In order to implement the air pollution control strategies, since the 1990s SEPB has developed programmes and systems to eliminate the main pollutants in the whole city area.

(1) Standard meeting programme
Emission sources covering more than 90% emission load must meet the national and local emission standards.

(2) Clean energy programme
Most of coal-burning boilers and kilns in down town were removed or replaced with cleaner fuel. From 1995-2001, about more than 6000 boilers and kilns were retrofitted.

(3) Vehicle exhaust control programmes
120,000 using cars were asked to install exhaust control equipment and about 37,000 taxis were asked to install bi-fuel system (LPG and petrol). Leaded petrol has been forbidden since 1997. New cars' emission standard that is equal to Euro I has been implemented since 1999.

(4) Top cap control programme and permit system
Top cap policy has been introduced to control some major pollutants (SO_2 and dust). Owners and operators of major sources must apply emission permit for emitting major pollutants, like SO_2, and must cut the emission volume to meet the allowance.

***Support Systems*:**

(1) Monitoring and Inspection Systems
There are 42 monitoring stations of ambient air quality (including 21 automatic monitoring stations) in the whole city, which locate in down town, suburb, and industrial zones. The emission situations of 189 major sources are checked regularly through compliance monitoring.

(2) Economic Policies

By collecting pollution fee from enterprises whose emission exceed the emission standards, municipal government sets up a compensation mechanism for pollution control projects, in order to encourage factories owners and operators installed pollution control equipment and renovated their facilities.

(3) Information declaration and public involvement

SEPB declares daily ambient air quality to public, and publishes the annual environmental bulletin. Complaining and solving mechanism is set up to settle the arguments between the owners or operators of facilities and the neighbourhoods.

5. Impacts

In the years beginning with the 1990's economic development resulted in energy restructuring and more efforts in air pollution control. As a consequence the ambient air quality improved considerably.

Compared with the peak value of the last decade, in 2001 the emission load of SO_2 reduced by 41,000 tons, while the emission load of dust from coal burning reduced by 94,000 tons and industrial dust reduced by 77,000 tons.

As a result, the concentration of SO_2 in the ambient air was reduced by 53%, and TSP was reduced by 51%. In 2001, more than 80% of the days reached class II of API indices. But, the city is facing an increasing level of mixed pollution caused by both coal combustion and vehicle exhaust, NO_X concentration in the downtown area have increased by 10% in the last 7 years.

6. Lessons

Shanghai has moved from improving combustion and dust-removing technology, popular during the 1960's to the 1990's and the main measure of eliminating pollutants caused by coal combustion in the last century towards more integrated strategies to solve mixed pollution problems from the 1990's onwards.

7. Future Prospects

Perspective for Air Pollution Control in Shanghai - 2003-2005

(a) Objectives

- By 2005, zero increase of coal consumption along with the growth of energy consumption;
- By 2005, 20% reduction of SO_2 emission (based on 2000 levels); and
- By 2005, concentration of major pollutants will reach or close to WHO guidance

(b) Main Focus

(i) Improvements to Legislation and Standards System

- Technical-based emission standards for different industrial facilities
- Euro II standard for new vehicles in March, 2003

(ii) Studies on Integrated Strategies

- Major source/Area source/Mobile source
- Normal pollutants/Toxic pollutants
- Local issues/Regional issues
- Development of emission inventories

(iii) Enhancement of Implementing Capacity

- Inspection and auditing
- Monitoring and assessment

(iv) *Development of Economic/Market-based Policies*

- Compensation for clean energy
- Exemption of emission discharge fee for vehicles meeting Euro-II standard
- Emission trade pilot project

(v) Improvement of Communication and Coordination

- Within governmental sectors
- Between all stakeholders

(c) Main Measures for 2003-2005

(i) *Emission Control Programme for Point Sources*

- Desulphurization Projects in Power Plants: To meet the requirements of SO_2 top cap control target and mitigating the regional acid rain problem, desulphurization facilities for 2 X 300MW power units will be operated by 2005.
- Continuous Emission Monitoring: CEM systems for power plants and large boilers will be installed in power plants in next 3 years.
- Clean Fuel Replacement for Low Point Sources: About 400 km^2 non coal-burning area have been planned, where more than 1500 medium-and-small size boilers will be retrofitted with clean fuel by the end of 2005.

(ii) *Emission Control Program for Mobile Sources*

- New Emission Standard for New Vehicles: New emission standards that are equal to Euro II will be implemented by March 2003. The implementation scheme of stricter standards is also under consideration.
- Inspection and Maintenance (I/M) System for Vehicle Use: In order to accelerate the phasing-out process of old vehicles with poor emission standards, SEPB formulated a framework for an I/M system in Shanghai

which is under development. By 2005, the I/M system will be implemented in the whole city.

Since Shanghai is a metropolis with large population and highly intensive economic activities, its economic development schedule has been compressed in the last 20 years; consequently the evolution of environmental issues has also been compressed to a relatively short period. Shanghai is presently facing air pollution issues caused by development, like emissions from power plants, industrial facilities and construction activities. Emerging gradually and adding to this are issues stemming from older problems caused by poor coal burning facilities, like black smoke in suburban areas as well as problems caused by modernization, like ozone and photochemical fog in the downtown areas. Shanghai hopes to work with other major cities through the Kitakyushu Initiative Network on these issues.

In the past twenty years, Shanghai has realized sustained rapid development of both society and economy, as well as the improvement of environmental protection. And in the coming twenty years, this trend will be extended and reinforced bringing Shanghai's citizens much more wealth and health. Fostering innovation, rewarding excellence and learning from other cities, in order to reach the goal of a 'better life', is something Shanghai hopes to channel its best efforts. The 2010 EXPO slogan '*Better City, Better Life*' is something that Shanghai promises to give her citizens.

D. Tehran, Islamic Republic of Iran
Air Quality Management in Tehran

1. Abstract

Urban Air pollution in Tehran is among the world's worst and is increasingly due to the rapid increase in population and development of industry. The Municipality of Tehran (MOT) deals with the city's air pollution control through 5 organisations under its control while the Department of Environment (DOE) is responsible for controlling air pollution in Iran. The DOE since 1995 has a Parliament approved Clean Air Act while the Municipal Act only relates to stationary sources. Mobile sources are responsible for 71% of the air pollution in Tehran. Petrol powered light duty vehicles (LDV) and trucks (LDT) are the major sources of air pollution as at present all public transport uses low-sulphur diesel and taxis use LPG fuel. A number of studies including a Master Plan to reduce air pollution control have been done in Tehran. The MOT's main actions have been to encourage increased use of public transport, conversion of public transport to use initially low sulphur fuels then move towards CNG fuel, vehicular inspections, increasing intelligent traffic signals, install parking meters and maintain restricted vehicular travel area in the city centre and simplify passenger line changes through a common ticketing system, educate people about health consequences of air pollution and enforce existing laws, establish a radio channel for traffic information and public awareness and operate and expand the underground transport system. The Action Plan, which was derived from the Master Plan, has a 10-year implementation timeframe starting 2000. As it is somewhat behind schedule due to financial, procedural and official constraints. A management action plan is being formulated to ensure implementation is on track.

2. Environmental Setting

Tehran is one of a few capitals of the world, which is not located around a river or even close to the sea. Mountains surround the city from North to the East. **Figure 1** shows the map of Tehran; the city is divided into 21 districts. The total area of the city is about 700 km^2. There are four distinct seasons, with the annual mean rainfall at about 230 mm. The annual mean temperature is 17°C. The highest temperature is 39°C in summer and - 6°C in winter (Asadollah-Fardi, 2001). There is no rain for about 6 months of the year.

Tehran is a political, industrial and economic centre. Air pollution in Tehran is increasing due to rapid increase in population and development of industry. Twenty years ago, about 98.7% of the population of the city lived in the Municipality of Tehran (MOT) area but in recent years it has decreased to 67% and about 33% of the population has moved to the suburbs. It was predicted that the population of the MOT and the suburb would increase to 9 million and 14.2 million respectively by 2002 (JICA, 1997). The growth of the population in the MOT over a period of hundred and ten years is shown in **Figure 2**. The strongest growth, proportionately, was experienced during the period from the end of World War II until 1966 with an annual growth of over 6 percent.

The strongest growth was experienced during the period from mid 1960s to the end of 1970. During this period the growth was over 200,000 persons per annum (SWECO, MTC, 1997)

The MOT is under the supervision of the city council whose members are voted into office by general election. The Mayor of Tehran is appointed by approval of the members of the city council. A summary of the organisational structure of the MOT is shown in **Table 1**. This includes an organisation and four companies with duties relating to Air Pollution Control, directly or indirectly, and within the different branches of the MOT. These are as follows: Air Quality Control Company (AQCC), Tehran Vehicle Technical Inspection Bureau (TVTIB), Tehran Traffic Control Company (TTCC), Tehran Traffic and Transportation Organisation (TTTO) and Relocation and Systemising of Urban Industrial and Trade Occupation Company (RSUITOC).

According to Environmental Act (1973) and Clean Air Act (1995) the Department of Environment (the DOE) is responsible for controlling Air Pollution in Iran. A part of the organisational structure of the DOE relating to air pollution control is shown in **Table 2** (for a complete chart, refer to Asadollah-Fardi 2000 and 2001). The AQCC (owned by the MOT) carry out planning, research, public awareness as well as type approval and conformity of production of new motorbikes. Tehran Provincial Directorate (TPD) and Office of Air Pollution of the DOE in Tehran carry out planning, executing, industrial inspection, enforcement, co-ordination, monitoring as well as type approval, and conformity of production of vehicles engine factories.

According to data collected by the AQCC and the DOE, Tehran is one of the worst cities in the world in terms of air pollution. Between the two types of emission sources, mobile sources are much worse than stationary sources. The Japan International Co-operation Agency (JICA) predicted that about 71% of the air pollution in Tehran is produced from mobile emission sources. However, the increase of urbanisation in Tehran will increase energy consumption, which will increase air pollution relating to stationary emission in future (JICA 1995).

Table 3 shows the amount of energy consumption in the Greater Tehran Area (GTA) and Iran. In future the numbers reported for two items (natural gas and fuel oil) may change due to the increase in the implementation of gas pipelines in Tehran and other cities. Since 1995 the AQCC and the DOE have monitored some parameters relating to air pollution continuously. **Figure 3** shows the locations of air pollution monitoring stations in Tehran. **Figures 4 and 5** show daily variation of SO_2, NO_2, CO, and PM_{10} for 2002. The total budget for Air pollution reduction from March 2002 to March 2003 is about 5.4 million dollars that include the budget of the office executing the integrated master plan programme, the office of Air Pollution, the AQCC and Energy Conservation Organisation and the TPD.

Laws, Regulations, Standards: In 1955, the Municipality Act passed by Parliament included one item in Section 55 of the law, which related to air pollution control (stationary sources). According to Environmental Law (1973) the DOE was

established. As mentioned before the DOE is responsible for prevention of air pollution from both stationary and non-stationary sources. The Clean Air Act was passed by Parliament in 1995. This legislation consists of six Chapters and 36 Sections and classifies the air pollution sources into the following three groups: (1) Motor vehicles; (2) Factories, workshops and power plants; and (3) Business, domestic and miscellaneous sources.

Table 4 shows principal system for Air Pollution Control with brief information relating to legislation, regulations, and standards in Iran. **Table 5** illustrates Ambient Air Quality Standard in Iran. **Table 6** shows the standards for Light Duty Vehicles (LDV) and Light Duty Truck (LDT). For detailed information about stationary Emission standard refer to the DOE 2000. According to Clean Air Act (1995) the Cabinet approved following regulations: All importers and producers of 4 stroke engine motorbikes must comply ECE-40-01 standard for 2004, the timetable for implementation for this item to be decided upon by the DOE. The DOE will review this standard every three years in consultation with of the Ministry of Oil (the MOO) and the Ministry of Industry (the MOI).

3. Issues and Challenges

Major Sources of Air Pollution in Transportation: The numbers of the Light Duty Vehicles (LDV) and Light Duty Trucks (LDT) in Tehran, which use petrol is about 2.0 million. These vehicles are major sources of air pollution. The number of the LDV's that are involved with public transport is very high. Two measurable parameters of air pollution emitted by these types of vehicles are carbon monoxide (CO) and hydrocarbons ($HC_{(NMHC)}$.) Considering CO in **Figures 4 and 5** for Bazaar and Fatemi stations, it is clear that the amount of CO during two seasons is higher than the standard level.

Buses and minibuses which use high sulphur gas-oil, had problems relating to the amounts of SO_2 they released. At present all public buses and minibuses use low sulphur gas-oil and taxies use Liquid Petroleum Gas (LPG) fuel.

Table 7 shows numbers of registered vehicles classified by car type and age. Up to 1996 all vehicles mentioned before used leaded petrol and high sulphur gas-oil but now leaded petrol has been prohibited and has been replaced by unleaded petrol.

Major Issues of Concern in the Transportation Sector of the MOT is as follows:

- Increasing the capacity of public transport (Bus, Minibus, Taxi and Underground);
- Persuading people to use public transport;
- Changing fuel of public buses, minibuses from low gas-oil to the Compressed Natural Gas (CNG) fuel;
- Inspection of all vehicles regularly each year;
- Increasing numbers of Intelligent Traffic Signals (ITS);
- Installation of parking meters on the road side in the city center; and

- Providing a common ticket system for public transport to simplify line changes for passengers.

Relatively speaking there are sufficient numbers of acceptable laws, regulations and standards. However, their effectiveness is limited, as they are not properly implemented. Executing some sections of laws and regulations needs a budget, suitable interaction between the MOT, the MOO, the DOE, the MOI, traffic police, radio and television organisations, a powerful management system to enforce authority ensuring people comply with the laws and enough equipment and expertise. Compliance of public in relating to existing laws is not enough, people need to be educated and be aware about laws and impacts of air pollution on human health.

There are only 6 lines of electric buses in three axes south of Tehran, which carry about 150,000 passengers per day. Two hundred public buses use CNG fuel and about 30,000 taxis use LPG fuel. **Table 8** shows the situation of public versus private transportation in the MOT. Two lines of underground transport system with a length of 30 km are already in operation and one of 36 km under construction.

4. Implementation Strategy

In December 1997 JICA finalised a study on Air Pollution Control in Tehran entitled "*The Study on an Integrated Master Plan for Air Pollution Control in the Greater Tehran Area*". Also the AQCC, on behalf of the MOT and three Swedish firms SWECO, SMHI (the Swedish Meteorological and Hydrological institute), and Motor Test Centre (MTC) in Joint Venture (JV) studied Air quality in Tehran. The title of this study was "*Tehran Transport Emissions Reductions Project*". The main report of this study was published in September 1997.

In 2000, according to Section 35 of the Clean Air Act (1995), the Cabinet of Iran, after consideration of some of the important conclusions and suggestions found in the above-mentioned studies approved an integrated Master Plan of Air Pollution Control in Tehran. It consisted of 3 chapters and 8 sections (DOE 2000). The summary of the Master Plan is shown in **Table 9**. The timetable for implementing this Action Plan was ten years, commencing in 2000. To date, 3 years of the Action Plan have past and despite the efforts of the ministries and the organisations relating to the master plan regulation, the results of implementation during this period has not been entirely acceptable. In the three years only 15% of the master plan has been implemented, which is fifty percent behind schedule.

There are reasons for the lack of reasonable progress in the implementation of the master plan for the reduction of air pollution, which are as follows:

(1) Weakness in Executing Legislation, Regulations and Standards: A reason for ineffectiveness of the law is the shortage of tools and equipment to carry out the law. For example the TVTIB needs six centres to inspect motor vehicle but to date, all the centres are not completed. Section 5 of the Clean Air Act (1995) states that any motor vehicle

without an inspection sticker must be stopped by the traffic police; but unfortunately there is no appropriate co-operation and interaction between these two centres. Even if there is a good co-operation there will still be no satisfactory results because. (a) a high percentage of existing Motor vehicles are old and it is difficult to bring them to levels, which will meet with existing standards; and (b) some of the car factories still produce cars with fuel emissions that do not meet acceptable standards. Therefore for proper application of the law all the Ministries and the Organisations must carry out their duties as determined by legislation and regulations.

(2) The related Ministries and Organisations are too busy to concentrate adequately on the decisions regarding air pollution.

(3) Certain ministries (e.g. the MOI) may not perceive reduction of air pollution in Tehran as a first priority but rather consider industrial development and increasing quantities of production as more important than air pollution control.

(4) Decision-making in reducing the air pollution is made without having enough specialised and scientific back up.

(5) There are not enough contributions and interactions between the relevant ministries and organisations responsible for implementing the air pollution reduction plan.

(6) Lack of an efficient, specialised and well-equipped supervising body and a system for supervising the performance of the ministries and organisations responsible for executing the solutions for reduction of air pollution.

A new JICA study relating to air pollution reduction entitled "*The Study on Strengthening and Improving Air Quality Management in the Greater Tehran Area*" carried out since September 2002 will be finalised in January 2005. The objective of the study is to formulate an effective Management Action Plan for developing the environmental management system in accordance with ISO 14001 principles. The Management Action Plan (MAP) will be formulated taking in to account the following points.

- The Management Action Plan will consist of continuous activities for achieving an environmental target by respective stakeholders related to air quality improvement; and
- The present Action Plan will be examined carefully and some parts of the present Action Plan will be incorporated in the Management Action Plan (PADECO Co, 2002).

5. Impacts

Some Efforts of Local and National Governments in Combating Air Pollution are as follows:

- Removing lead additives from petrol;
- Achieving production of some types of vehicles to meet emission standards;
- Establishing a restricted area in centre of the city;
- Installation of about 170 intelligent traffic signal (ITS) on important cross roads;
- Establishing, the TTTO, the TVTIB, the AQCC and TTCC;
- Establishing a radio channel for traffic information and public awareness;
- Changing fuel of buses and minibuses of public transport to low sulphur fuel;
- Changing fuel of all taxis from petrol to LPG; and
- Changing fuel of 200 buses to CNG fuel and by the end of 2003 adding 1200 new CNG fueled buses.

6. Lessons

It is clear that the national government and the MOT have expended a considerable amount of effort to reduce air pollution. Some of the efforts mentioned before included passing laws, regulations, standards, establishing related organisations and companies, studies carried out with the help of international agencies, approval of a master plan and implementation of some parts of the master plan. However implementing the master plan has not been entirely satisfactory. The following weakness may still exist:

- Lack of a powerful managing system that can enforce related authorities to implement their duties according to the action plan;
- Shortage of a budget to substitute new cars for the existing old cars which emit pollutants every day;
- First priority of the MOI is quantity and quality development of industry and reaching their productions with emission standards as a second priority;
- The DOE do not have enough expertise in dealing with inspections of industries, type approval and conformity of production of vehicles;
- Lack of close interaction between the related authorities charged with implementing their duties relating to the action plan;
- Absence of a suitable and wide spread programme for public awareness and education on impacts of air pollution on health; and
- No approved programme, which allows participation of Tehran citizens, NGOs, Universities and Enterprises for the reduction of air pollution.

If the above weaknesses are removed then the Action Plan for Tehran is suitable for other big cities in Iran such as Esfehan City.

Public and Government awareness relating to the issues involved and cooperative interactions between relevant ministries and organizations are two important lessons, which were learned from successful experiences. A lack of powerful management,

shortage of essential equipment, expertise and budget constraints together with the financial impacts of implementing the standards (Inspection and Maintenance) to the people who own cars are reasons for the failures in implementing the action plan.

7. Future Prospects

If the management of the MOT decide to carry out parts of the Action Plan, as required of them there are two possible scenarios as follows:

(a) Using their own resources:

It is necessary to consider the Action Plan as a first priority but it will take a long time to complete all the related projects (directly and indirectly). These include completion of 8 lines of underground, changing the fuel source of public buses and minibuses to CNG fuel, completion of Intelligent Traffic Signal (ITS) installation, creating many parking spaces in the centre of city and construction of inspection maintenance systems. The total annual budget of the MOT, which is about 750 million dollars, is not sufficient for these purposes.

(b) Sharing resources:

It is been suggested that the MOT with the participation of domestic private sectors, international investment sectors, and international loans, could carry out the projects in a reasonable time.

The author suggests following as areas of possible collaboration between the MOT and the Kitakyushu Initiative Network:

- Retrofitting existing Paykan's cars carburetor;
- Reduction in existing motor cycle emissions;
- Development of CNG fuel vehicle (for the LDV and LDT);
- Technical co-operation in vehicle emission standard promotion; and
- Inspection and maintenance programme management.

8. References

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ACRONYMS USED

$\mu g/m^3$	Micro-gramme per cubic metre
AQCC	Air Quality Control Company
CO	Carbon Monoxide
CNG	Compressed Natural Gas
DOE	Department of Environment
GTA	Great Tehran Area
$HC_{(NMHC)}$	Hydro Carbon
ITS	Intelligent Traffic Signals
JICA	Japan International Co-operation Agency
JV	Joint Venture
LDV	Light Duty Vehicles
LDT	Light Duty Truck
LNG	Liquid Natural Gas
LPG	Liquid Petroleum Gas
MOI	Ministry of Industrial
MOO	Ministry of Oil
MOT	Municipality of Tehran
MTC	Motor Test Centre
NO	Nitrogen Monoxide
NO_2	Nitrogen Dioxide
NO_X	Oxides of Nitrogen
O_3	Ozone
PM_{10}	Particulate Matter - less than 10 μ m of particle size
PPB	Part Per Billion
PPM	Parts Per Million, normally referred to as "PPM"
RSUITOC	Relocation and Systemising of Urban Industrial and Trade Occupation Company
Rw	A automobile which is ready to drive without any load (objects, persons) with full of fuel and necessary tool plus 100 kg
SO_2	Sulphur Dioxide
SPM	Suspended Particulate Matter
SMHI	The Swedish Meteorological and Hydrological institute
TPD	Tehran Provincial Directorate
TVTIB	Tehran Vehicle Technical Inspection Bureau
TTCC	Tehran Traffic Control Company
TTTO	Tehran Traffic and Transportation Organisation
WHO	World Health Organisation

Figure 1 Map of 21 districts of the Municipality of Tehran (the MOT)

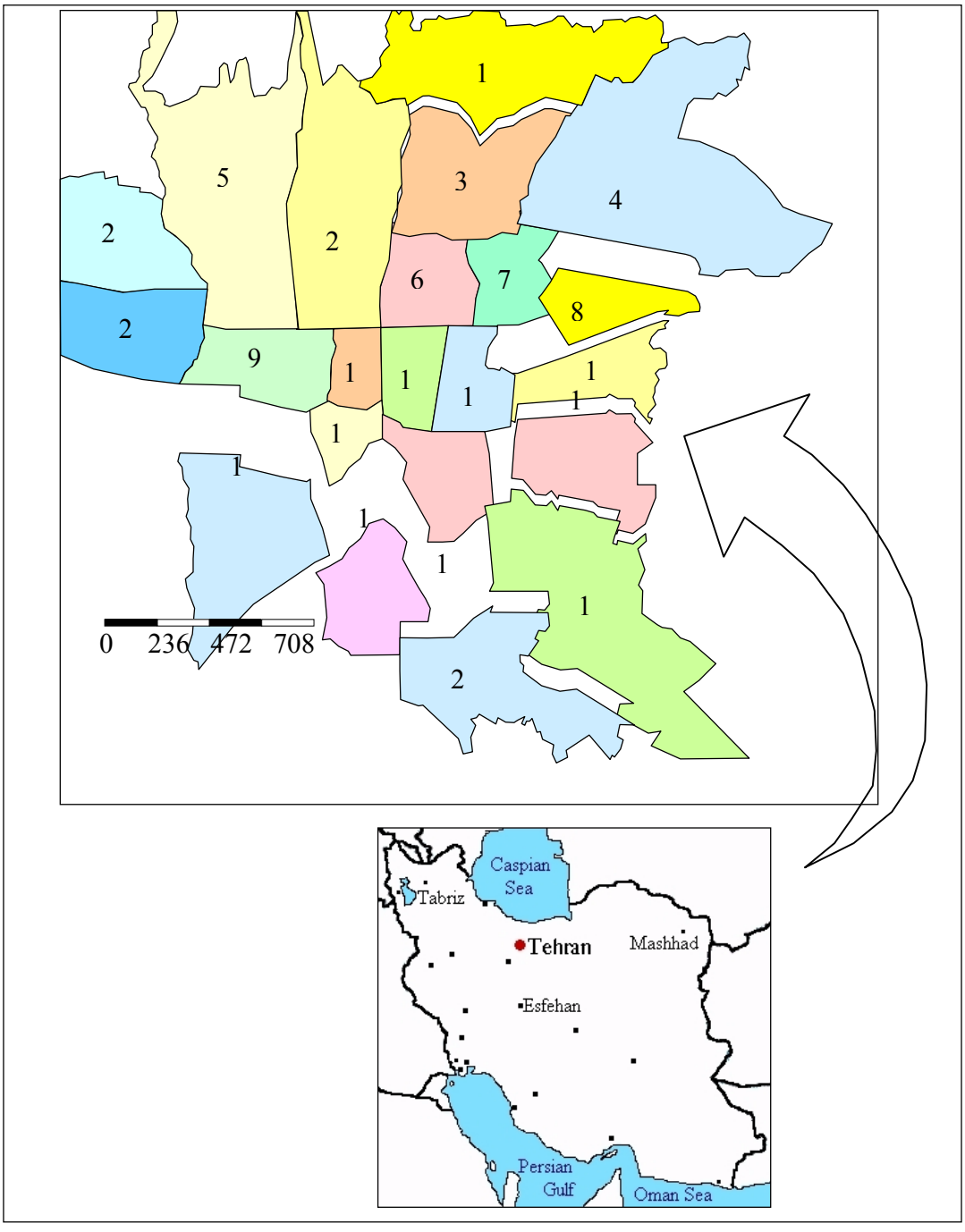


Figure 2 Population in Tehran Municipality 1891- 2001.

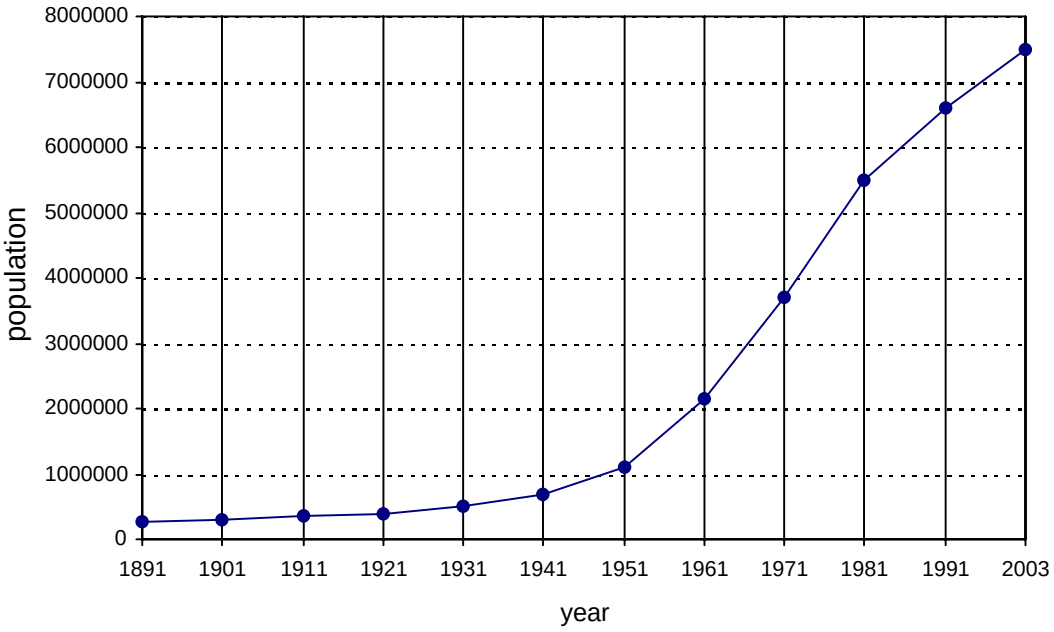
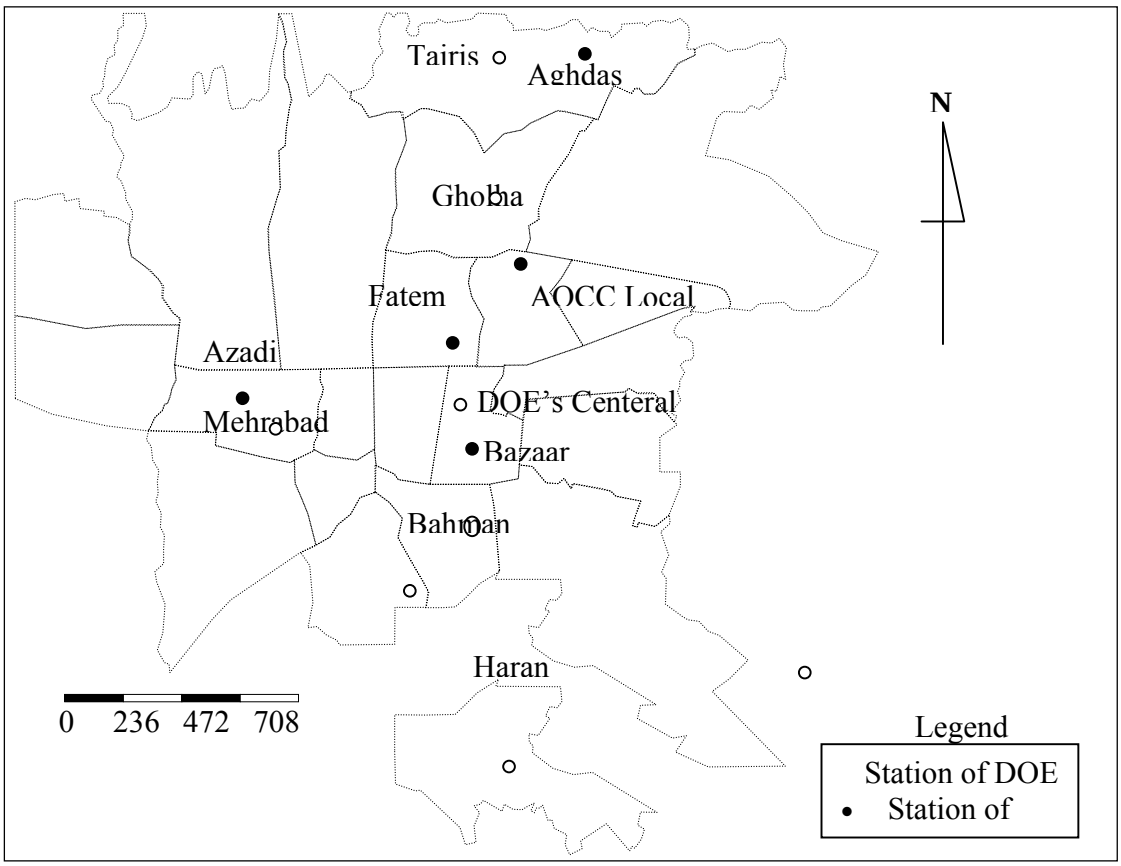


Figure 3 Locations of Air Pollution Monitoring (Continuous and Real Time) Stations in Tehran (the DOE and the AQCC) (Asadollah-Fardi, 2001)



Figures 4 and 5 – Daily Variations of SO_2, NO_2 CO and PM_{10} for 2002

Figure 4 variations of Air Pollution parameters during 2002 for Fatemi station

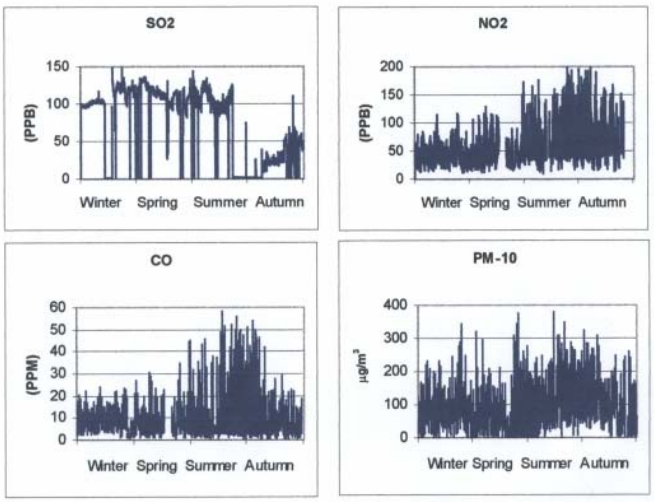
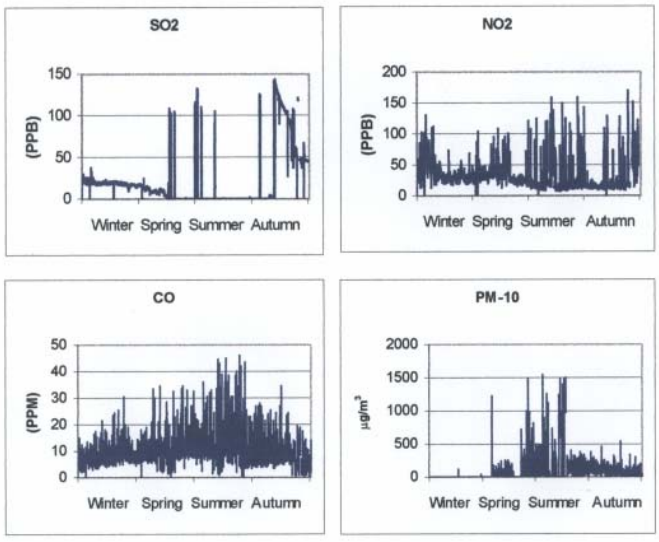


Figure 5 variations of Air Pollution parameters during 2002 for Bazar station



8

Table 1 Part of the Constitutional Chart Representing the MOT in Iran

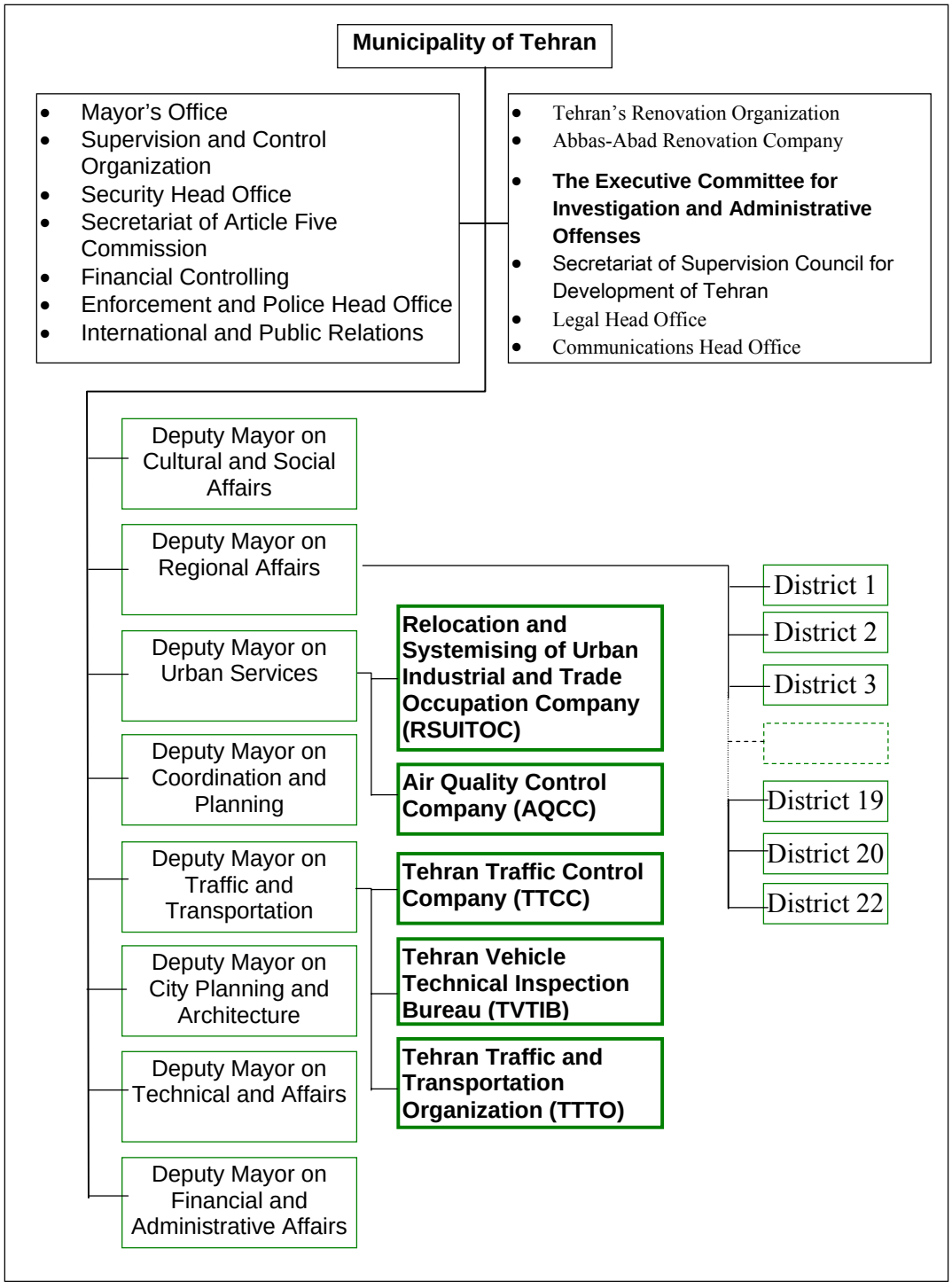


Table 2 Part of the Constitutional Chart Representing the Air-Pollution Research Section in Iran

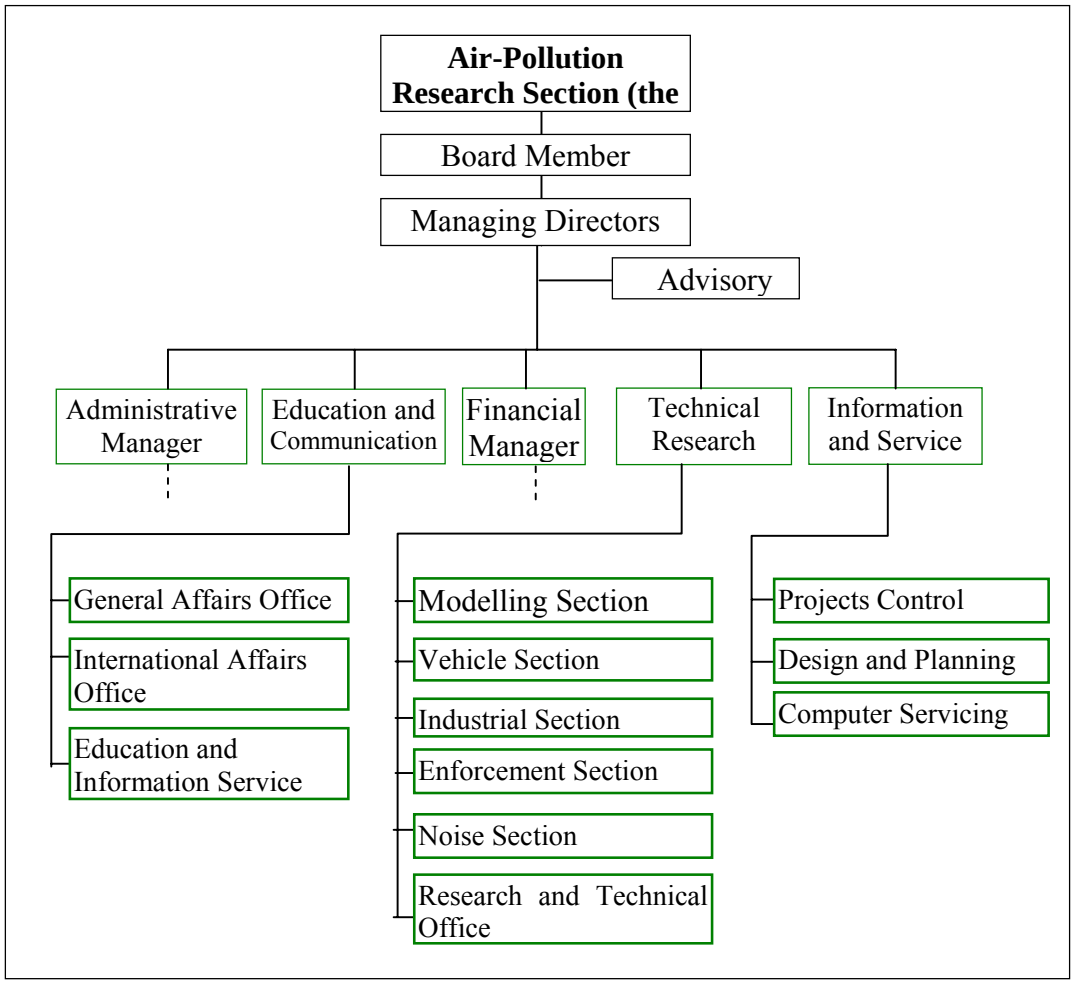


Table 3 Amounts of Energy Consumption in Greater Tehran Area (GTA) and Iran (1997)

Type of Energy (%)			Consumption by Sector (%)		
Item	**GTA**	**Total Iran**	**Item**	**GTA**	**Total Iran**
Electricity	8.5	5.5	**Manufacturing**	46.6	23.7
Liquid Natural Gas (LNG)/ Liquid Petroleum Gas (LPG)	40.8	36.7	**Commercial and Household**	32.6	26.7
Fuel oil	43.9	51.7	**Transport**	11.4	17.9
Others	6.8	6.1	**Energy Conversion**	9.4	21.3
			Others		10.4
(Total)	**100.0**	**100.0**	**(Total)**	**100.0**	**100.0**

Table 4 - Principal System for Control of Air Pollution (including some detailed information)

Principal Act	The Relevant Ministries	Enforcement Authorities	Number of Chapters and Sections Relating to Air Pollution Control	Regulation Relating to the Legislation of Air Pollution Control	Number of Chapters and Sections
Municipality Act 1955	Interior Ministry	Municipality	1	-	3
Environmental Act 1973	The President of Iran	The DOE	-	-	14
Oil Act (1987)	The MOO	-	1	-	-
The second Development Plan of Economy, Social and Cultural of the Country Act (1994)	The President of Iran	The DOE	1	Regulation relating to Section 4(B) (1994)	-
				Regulation relating to Section 4(B) (1998)	- 10
				Regulation relating to Section 4(B) (1999) [1)]	- 4
Clean Air Act 1995	The President of Iran	The DOE	6 36	Clean Air regulation in accordance with section 35 (2000)	3 10
				Regulation relating to Section 7 (1998) [2)]	-
				Regulation relating to Section 8 and 11 (1999) [3)]	-
				Regulation relating to Section 15 (2000) [4)]	-
				Regulation relating to Section 11 (2000) [5)]	
The Third Development Plan of Economy, Social and Cultural of the Country Act (2000)	The President of Iran	The DOE	1	Regulation relating to section 104 (2001)	- 17

Note:

[1)] The Prohibition of imports and production of buses and minibuses, which do not meet the Iranian standards

[2)] Executive directive for emergency situation of Air Pollution

[3)] Emission standards for the LDV and the LDT

[4)] Emission standards for factories and industrial workshops

[5)] Emission standards for motorbikes

Table 5 Ambient Air Quality Standards in Iran

Air Pollutant	Duration for Evaluation	Air Quality Standard 1	Air Quality Standard 2
CO	Max conc. 8 hours average	9ppm	9ppm
SO_2	24 hours average	0.14ppm	0.1ppm
$HC_{(NMHC)}$	3 hours average, (6 a.m.-9 a.m.)	0.24ppm	0.24ppm
(NO_2)	annual average	0.05ppm	0.05ppm
SPM*	24 hours average	260μg/m3	150μg/m3

Note: Air Quality Standard 1 and 2 applied to the proper area according the local
* *Suspended Particulate Matter*

Table 6 Emission Standards for Light Duty Vehicles (LDV) and Light Duty Truck (LDT) (DOE 2000)

Reference (rw)*	Mass (kg)	Carbon Monoxide (CO) (gr./test)	HC-NO_X (gr./test)
rw < 1020		58	19
1020 < rw ≤ 1250		67	20.5
1250 < rw ≤ 1470		76	22
1470 < rw ≤ 1700		84	23.5
1700 < rw ≤ 1930		93	25
1930 < rw ≤ 2150		101	26.5
2150 < rw		110	28

* Reference weight (rw) is defined as follows:
A automobile which is ready to drive without any load (objects, persons) with full fuel and necessary tools plus 100 kg

All importers and domestic producers (the LDV and the LDT) of gasoline used must comply with European standard (ECE-15.04) or equivalent (83.351/ECE) for producing or importing.

Provision: if domestic car factories cannot comply with the above mentioned standard. They have a deadline until 1999 according to a plan, which will be confirmed by the MOO and the DOE, to conform their production to the standard, otherwise production of vehicles would be forbidden in 2000.

Table 7 Numbers of Registered Vehicles (Classified by Car Type and Age)

	Passenger Car	**Van**	**Mini-Bus**	**Bus**	**Mini-Truck**	**Truck**	**Total**
1967-1971	83,970	25,992	2,743	5,676	1,823	13,514	133,721
1972-1976	225,020	76,109	5,010	2,920	1,230	12,768	323,057
1977-1981	199,269	52,286	4,643	2,947	219	13,758	273,122
1982-1986	98,979	33,627	1,450	1,586	57	10,880	146,579
1987-1991	46,487	13,068	3,893	852	50	6,945	71,295
1991	4,375	----	3,265	1,330	150	5,422	14,542
1992	230,398	15,056	3,786	1,331	552	32,704	283,827
1993	73,168	----	----	----	----	----	73,168
1994	56,877	----	----	----	----	----	56,877

Table 8 Public vs. Private Transportation in the MOT

PUBLIC TRANSPORT			PRIVATE TRANSPORT		NUMBER OF PASSENGERS
Type of Vehicles	**Number**	**Type of Fuel**	**Number**	**Type of Fuel**	
Bus	5500	Low sulphur gas-oil and CNG	700	Low sulphur gas-oil	4,000,000
Mini Bus	----	- ---	4500	″	2,500,000
Taxi	----	----	30000	LPG	2,000,000
Passenger Car	----	----	50000	Unleaded Petrol	
Metro	----	Electricity			630,000

Table 9 Master Plan for Regulation and Reduction of Air Pollution in Tehran

Section	Type of Programme	Budget	Time Table	Responsible Ministry or Organisation
1	To establish six (6) Vehicle Technical Inspection Centres	1.65 million dollars	Early 2001	(the MOT)
2	To change gas-oil fuel for all public buses to gas fuel	The MOO must prepare necessary Budget	-	(the MOO)
3	To install enough numbers of parking meters in the city centre	7.74 million dollars	-	The MOT
4	To install ITS Controls, especially at cross-roads	3 million dollars	By 2001	
5	(1) Replacing the paykan's carburettor cars with the age of less than ten years with fixed Nozzle carburettor (2) Use of catalyst in gas fuel used in taxis and changing the fuel system to run only on LPG (3) To install catalyst for motorbikes	-	By 2005	The MOT
6	(1) To provide at least 70% of unleaded petrol for consumption in Tehran and also to provide low sulphur gas-oil for public buses in Tehran (2) To present and implement an Executive programme consisting of time tables and necessary resources to produce unleaded petrol and gasoline with acceptable standards	-	mid 2000	The MOO
7	Considering distribution of unleaded petrol all over the country, if the MOO produces enough unleaded petrol and are able to distribute it properly, then the MOI must comply with ECER-83 standard for domestic LDV production, also imported cars must comply with the mentioned standard	-	2002	The MOI
8	In order to continue studying other methods for Air Pollution and also to guarantee executing this regulation property, the committees that were appointed by the Cabinet have to continue their duties. Also for public awareness and participation of people towards contributing to carrying out this regulation, a committee under the provision of the DOE with memberships of the MOT, the MOO, Interior Ministry, the MOI, representatives of Radio and Television, Deputy police relating to Traffic Control must be established.			The DOE

E. Surabaya, Indonesia
Ambient Air Quality Management in Surabaya

1. Abstract

Air pollution in Surabaya city comes from both stationary (industry, power generation, fireplaces) and mobile (transportation) sources. The dominant pollution source (65-70%) comes from the transport sector as a result of Surabaya's development, which has caused increased vehicular traffic within the city. The city with the help of its citizens is trying to reduce air pollution by improving public transport within the city. One such initiative taken is the Blue Sky Programme (PLB) whose activities past, present and future include ambient air quality monitoring along high density roads, monitoring of industries and offering guidance and monitoring to new industries, measurement of mercury and lead in blood of persons (including police) living close to sources of air pollution, promoting car free days, testing vehicular emissions, collect and evaluate air pollution data, development of a model for air quality distribution pattern in the city, campaign for using CNG in motor vehicles. Ambient air quality monitoring of 5 key parameters has shown that in Jan-Jun 2002 dust was the dominant parameter. Efforts have been made to reduce air pollution from both mobile and stationary sources through government coordination and private sector support.

2. Environmental Setting

Surabaya is the second largest city in Indonesia. Its area is about 326 km^2 of largely coastal and lowland area. The altitude varies from 3 to 10 m above sea level. Surabaya is a tropical city and the temperature is almost constant throughout the year, varying from 25^oC during the night to 34°C during the day. The average humidity ranges from 65% to 85 %. The rainy season starts from October to April, and the dry season from May to September.

Surabaya has about 2.8 million permanent residents in addition about 300,000 people commute every day to Surabaya from surrounding areas. Mainly private vehicles dominate transportation. According to a study carried out a few years ago, the composition of the transportation fleet in Surabaya was 35% public transport and 65% private transport. Nowadays, the percentage of private cars is even higher due to the increase on vehicles. Average velocity at the centre of the city is about 15-20 km/h due to the high volume of traffic.

The city of Surabaya is trying to improve the transport service within the city, so that air pollution due to vehicle emissions can be reduced. To improve the transport situation, the city is promoting air quality and transportation improvements by involving its citizens. One of the most important environmental problems as the consequence of the development is air pollution. Since air is required as a resource for life, the quality of air has to be managed wisely with constant improvements. With the growth in activities, the emission of pollutants into the air after is more severe. Having experienced an economic crisis, Indonesia could face a growing environmental problem because of the lack of attention paid to controlling pollution sources especially from the industrial sector, which affects environment quality.

Normal condition, every pollutant that is emitted into the air will be ultimately neutralized by nature itself (Self Purification). But on the other hand different environments have different carrying capacities. When pollution exceeds the carrying capacity of the

environment, it will result in the contamination of air. There are many factors that influence the level of air contamination in a given area, for example topographic issues, meteorological issues, the sources of emissions, the population and energy use among others.

Air pollution in Surabaya comes from various sources, namely:

1) (a) Air Pollution from Non Mobile Sources: Pollutants the from the refining industry (fuels for consumption): food and beverage industry, wood refining, chemical, minerals, non metal industry, textiles, metal refining. Average pollutant levels from these activities are given in **Table 1**: dust (5,204.66 ton/year), SO_2 (0 ton/year), NO_x (19.825 ton/year), HC (236.72 ton/year), CO (255.20 ton/year), others (0.015 ton/year) [data 2000]

Table 1. Air Pollution from the Refining Industry

Parameter	Dust ton/year	SO_2 ton/yr	NO_X ton/yr	HC ton/yr	CO ton/yr	Others ton/yr
1. Food	4,442.42	0.00	0.00	0.00	0.00	0.015
2. Beverage	0.02	0.00	0.00	0.00	0.00	0.00
3. Wood (and other forest products)	42,47	0.00	19.82	0.00	0.00	0.00
4. Chemical	29.59	0.00	0.00	236.72	0.00	0.00
5. Mineral non metal	0.00	0.00	0.00	0.00	0.00	0.00
6. Metal	31.68	0.00	0.00	0.00	255.20	0.00
7. Metal Refining	0.00	0.00	0.00	0.00	0.00	0.00
8. Textile	658.50	0.00	0.00	0.00	0.00	0.00
	5,204.66	0.00	19.82	236.72	255.20	0.015

Source: Environment Quality Scale Surabaya, Book III

(b) Air Pollution from Non Mobile Sources (fuel consumption): [data 2000] These Pollutants come from electric power, fireplaces commercial/industrial, and domestic fireplaces (coal, fuel, natural gas/LPG/wood): dust (0 ton/year), SO_2 (0.37 ton/year), NO_2 (4.9 ton/year), HC (0.17 ton/year), CO (0.79 ton/year), others (121.1 ton/year).

2) Air pollution from Mobile Sources (fuel consumption): [data 2000] Dust (3.35 ton/year), SO_2 (0.26 ton/year), NO_X (46.2 ton/year), HC (28.45 ton/year), CO (9.5 ton/year), others (0.8 ton/year).

As of 2002 growth in Surabaya has been rapid due to both physical and non-physical reasons stemming from the multi-dimensional nature of the city. The growth in the industrial sector alone is enough to have implications and impacts on all environment sectors in Surabaya. City growth besides increasing the mobility of residents and goods, also causes progressive traffic jams where traffic density is high enough (current ratio of flow: capacities is 0.8 – 1.6). The total length of road in the city of Surabaya is approximately 2,035.95 km [2000 data], and the amount of passenger vehicles, wagon cars, motorbike have reached approx. 909,131 [2000 data] and tends to increase each successive year. This results in increasing air contamination from both mobile as well as non-mobile sources (industry). According to a previous study, the dominant air pollution source in

metropolises - including the city of Surabaya - is from transportation (mobile source) that contributes to 65 – 75 % of the pollutants.

To identify and control the quality of ambient air, regular measurement is needed together with the enforcement of the ambient air quality standards. The ambient air quality standard is specified as the maximum concentration of ambient air quality that could prevent the occurrence of air pollution, and it is revised every 5 years. The ambient air quality standard of Surabaya is set exclusively for the ambient air in Surabaya City, while the ambient air quality standard for the East Java Province is set by the Governor with the consideration of the national ambient air quality standard. The ambient air quality standards are set based on the research on the databases of the primary sources of air pollution, meteorology conditions and geographic position. If during a period the ambient air quality of Surabaya is greater than that of the National ambient air quality standard, the Governor will proclaim that the ambient air quality of the city is poor.

3. Issues and Challenges

The problems of air pollution faced by the city of Surabaya include:

- The imbalance in the ratio between the increasing capacities of joint roads as compared with the increasing amounts of vehicles every year.
- The gas emission measurement of every vehicle in 100 vehicles which uses gasoline and diesel fuel in the year 2002, showed that the number of vehicles with the emission rates higher than the emission quality standards is as follows:
  - Personal vehicles using gasoline: 19 % (CO), 11 % (HC.
  - Public vehicles using gasoline: 16.5 % (CO), 214 % (HC).
  - Personal vehicles using diesel: 49.5 % smoke.
  - Public vehicles using diesel: 44 % smoke
- There are insufficient urban forest/green belt areas when compared to the city area and its population.
- There were no community development programmes in ambient air quality management or for that matter reward and punishment programmes.

4. Implementation Strategy

Urban activities connected with housing, transportation, commercial, industrial, solid waste management and other related activities have the potential to alter air quality in urban areas. Air pollution from existing sources are transmitted to the atmosphere and spread according to wind direction. To overcome air pollution in urban areas, the real steps that need to be taken involve ambient air quality management. The air quality management programme of the Surabaya Government is conducted through the cooperation of several departments, institutions, the community and NGOs. The ***Blue Sky Program*****me** was created as a response to the increasing population as well as transportation and industrial growth in urban areas with a view to addressing the problems of deterioration of air quality and community health, especially in Surabaya.

The Blue Sky Programme (PLB): Surabaya's air pollution control programme for non-mobile and mobile sources.

(a) Goals: Creating a mechanism to control air pollution effectively.

- Controlling air pollution to ambient standards
- Creating the ambient air quality needed for the health of human beings and others.
- Creating environmental awareness among the residents

(b) Targets:

- Decreasing air pollution from non-mobile and mobile sources;
- Establishing an operational system for ISPU/PSI monitoring (Air Pollution Standard Index) in Surabaya and an integrated AQMS (Air Quality Monitoring System);
- Developing coordination and partnerships in creating the targeted ambient air quality in Surabaya; and
- Increasing environmental awareness among the community and indicating their role in air pollution control in Surabaya.

(c) Regulatory Provisions: State Constitution, Governmental Regulations, Environment Ministry Regulations, Government Decrees.

(d) Implementation:

Year 1996 – 2000:

- Ambient air quality monitoring along the high-density roads, with dust as the dominant result of measurement.
- Introduction of Taxis running on natural gas fuel (BBG) since 1997, with their own filling station.
- Conducting guidance and monitoring programmes for industries with air pollution potential.
- Founding the KPPLH Team (the Commission for Operation and Controlling the Environment Pollution) in 1999 to monitor industries with air pollution potential.

Year 2001:

- Measurement of Hg (mercury) and Pb (lead) concentrations in blood, especially those resident close to the source of pollution.
- Measurement of ambient air quality and noise in relation to transportation and industrial sectors.
- Measurement of the air quality of emissions from industrial sector.
- Monitoring of ambient air quality using automatic instrumentation continuously integrated with the Monitoring Centre in the Ministers Office of Environment in Jakarta carried out every day.
- Car Free Day (CFD) in several streets in the heart of the city to promote utilization of public transport and environmental awareness of the people. Daylong from 06.00 to 18:00 hours all vehicles were forbidden to enter the car free day zone. During the day, a lot of activities were carried out to support the car free day. Citizens got together for the activities such as aerobic exercise, fun bike riding, fun rickshaw (“becak”) races, skateboard races, photo and poster exhibitions/displays, food bazaars, live music shows, drawing contests for children. All events were themed around environmental awareness improvement. Each activity promoted messages of environmental awareness to the audience and to the participants. The car free day was successfully implemented. As part of the system to improve the environmental quality, car free day is not a stand-alone activity, it needs follow-up action plans in order to achieve its objectives. Action programmes on urban transportation and environmental protection are being carried out by the city. Surabaya is determined to do all the actions necessary to achieve good environmental quality.

Year 2002

- Measurement of gas emissions from motor vehicles.
- Effective regulation to enable testing of public and private vehicles; (Regulation for the Emission Test of Public and Private Transport).
- Execution of Blue Sky Programme Campaign using an elementary school with one activity involving distribution of masks to motorcyclists, public transport (bus) users, plantation workers along with the NGO "Tunas Hijau".
- Car Free Day declared in several streets in the heart of the city.
- Data derived from ambient air quality monitoring results in Surabaya by a group of research students yielded the following results:

(a) A study on the influence of SO_2 and NO_X emissions on the rainwater in Surabaya, yielded results which indicated that the southern part of the city is the area at greatest risk from acid rain.
Stipulation of priorities for programme activities with regard to ambient air quality in Surabaya using the Analytical Hierarchy Process (AHP) approach.
(b) Development of an information system for monitoring air pollution in Surabaya.
(c) Study was done on the CO/Hg concentrations of the Traffic Police blood in the Metropolis of Surabaya 2002.
(d) An evaluation was carried out on the data of the record keeping and reporting systems for the Air Pollution Standard Index in Surabaya.
(e) A literature study was carried out on Air Quality Monitoring Systems.

Year 2003

- A mathematical model of the air quality distribution pattern in Surabaya was carried out.
- A compilation was carried out of the role inspection played on effects on personal car passengers.
- A campaign to encourage use of CNG fuel for motor vehicles was executed by the Government of Surabaya (100 government vehicles) since year 2002/2003.
- Car Free Day declared in several streets in the heart of the city.

To achieve the targets in the Blue Sky Programme above, it was considered necessary to monitor ambient air quality continuously. The results would then be used by the municipal government to frame control regulations in order to create conditions of suitable quality to sustain public health. The implementation of this programme was aided by a soft loan from the Government of Austria through Indonesia's Environmental Impact Management Agency (BAPEDAL) for the installation of equipment in Surabaya together with another 10 big cities in Indonesia to develop a network to monitor ambient air quality. The monitoring equipment is installed in 5 different places in Surabaya, and 1 RAQMC Room (Regional Air Quality Monitoring Centre) including 1 Room for Operations and Maintenance. Five key ambient air quality parameters are measured in Surabaya namely: PM_{10}, SO_2, O_3, NO_2, CO and also meteorological conditions (temperature, humidity, global radiation, wind direction and wind speed). The information represented by an air quality index (ISPU/PSI) is publicized each day on public data display boards at 15:00 hours, on the internet (http://www.surabaya.go.id), over the radio and in the newspapers. The scoring

system and the interpretation of the ISPU/PSI could be seen in **Table 2**, and the corresponding Action Plan is elaborated in **Table 3**.

5. Impacts

Result of Measurement of Ambient Air Quality Monitoring 2001 (March – December): The Ambient Air Quality Monitoring Station equipment was installed in November 2000, but starting operating in March 2001. The Air Pollution Standard Index (PSI/ ISPU) Category in Surabaya for 2001 was therefore reported only after this date.

From January - December 2002: The ISPU/PSI category in Surabaya showed that dust is a dominant parameter.

The ISPU/PSI values during the years **2001 and 2002** are indicated in **Table 4** below, from the values it can be concluded that the most dominant category is "Moderate" the dominant parameters were PM10 (dust), the next was O_3 (ozone).

Table 4: ISPU/PSI values in 2001 and 2002

ISPU/PSI	Days in 2001	Days in 2002
Good	27	40
Moderate	272	314
Unhealthy	7	11
Very Unhealthy	0	0
Dangerous	0	0

The results showed that in 2001 (March-December), there were 7 unhealthy days; while in 2002 (January-December) there were 11 unhealthy days, showing that degradation of ambient air quality had taken place. In addition, the parameters SO_2, NO_2 and CO at all stations showed a tendency of increasing in the morning. The PM_{10} had a tendency to increase at around midnight and in the morning, while O_3 concentration increased from morning until evening.

The increased concentrations in the morning are correlated to the increase in the number of vehicles as monitoring was done by ambient air quality monitoring stations. During the night, condensation occurred in the air so that the dispersed pollutants precipitated, as was reflected in the results obtained from the ambient air quality monitoring stations.

The data indicates that air quality in Surabaya tends to decrease gradually. This necessitates that the city undertake air pollution control.

6. Lessons

From what has been observed a number of measures have been taken or are anticipated in an effort to reduce air pollution in Surabaya.

Reduction of Air Pollution from Mobile Sources: were implemented through a number of measures including:

- Substitution of vehicle fuel from BBM to BBG (CNG) for governor of Surabaya;
- Test the use of CNG for public transport in Surabaya City;
- Develop regulations for public transport management;
- Limit age of vehicles given permission to operate;
- Operation of traffic lights together with an Area Traffic Control System (ATCS);
- Traffic management and engineering;
- Develop a traffic demand management plan;
- Develop a mass public transport development plan;
- Evaluate the quality of the public transport service plan;
- Develop an integrated land, air and sea transport mode plan;
- Development of non-motorised vehicle and pedestrian facility plan;
- Develop an mobile public vehicle emission testing plan;
- Development of plan to regulate public workshops (that examine motor vehicles);
- Gain social acceptance for the usage of BBG (CNG) as an alternative fuel for public transport, personal and government vehicles;
- Enforce vehicle owners to comply gas emission quality standards;
- Encourage plantations of urban forests, green gardens, green bands by government, private sector and civil society at large; and
- Development regulations for the inspection and maintenance (I&M) of private vehicles to ensure that they comply with emission quality standards in 2003.

Reduction of air pollution from non-mobile sources: were also implemented through a number of measures including:

- Regulation of potential air polluters
- Monitoring programmes to ensure goals are met
- Carrying out Initial monitoring
- Signing a letter agreeing to reduce pollution
- Ensuring the adequacy of the framework of air quality control and operation:
  - The framework is adequate.
  - The framework is not adequate.
- If the framework is adequate, determine the status of the air quality monitoring programme:
  - The air quality-monitoring programme is adequate.
  - If the air quality-monitoring programme is not adequate guidance and routine monitoring and application of law enforcement should follow it.
- If the structure is not adequate, determine the status of the air quality monitoring programme:
  - The air quality-monitoring programme is adequate.
  - If the air quality-monitoring programme is not adequate guidance and routine monitoring and application of law enforcement should follow it.

7. Future Prospects

In the final analysis proper air quality management will result in good ambient air and should be supported by all stakeholders in Surabaya (Government: by coordination in every relevant institution, implementation, regulation; Private sector and Society: which must use public transportation to a greater extent; encourage and carry out green plantations, etc). This will ensure an air quality supportive of a better life in the years to come, and must be achieved because only through responsible stewardship can the present generation be responsible custodians of the environment and must ensure a healthy future for the coming generations.

8. References

1) Code Number 23 Year 1997 about Environment Management.

2) BAPEDAL, (1999), Regulation of Republic Indonesia Government, Number 41 Year 1999 about Air Pollution Control.

3) De Nevers, Noel, (1995) Water Pollution Control Engineering, McGraw Hill, Inc, Singapore

4) Nathanson, Jerry A. (2000) Basic Environmental Technology " Water Supply, Waste Management Pollution Control and", Third Edition, 2000

5) Peavy,H.S.; Rowe,D.R, Tchobanoglous, G.,1985, Environmental Engineering, McGraw Hill Inc, Singapore.

Table 2: Air Quality Categories according to KEP-107/KABAPEDAL/11/1997 with its Potential Effects

Category	ISPU/PSI Index	Effects	CO	NO_2	O_3	SO_2	PM_{10}
Good	**0-50**	Level of air quality which does not have an effect on human or animal health and does not affect plants, buildings and aesthetic quality	No effect	Little effect	Damage to some plant species especially in combination with SO_2 (4 hour test)	Damage to some plant species especially in combination with O_3 (4 hour test)	No effect
Moderate	**51-100**	The limit to the air quality which does not damage human or animal health or animal and does not affect sensitive plants and aesthetic quality	Chemical changes in blood but not obviously detectable	Smell	Damages some plant species	Damages some plant species	Indicates degradation [at] the approachable distance
Unhealthy	**101-199**	Level of air quality which can harm human and/or sensitive animal health or can damage plants and affect aesthetics	Heart patients and smokers at Risk of cardiovascular disease	Smell loss of colour perception, risk for asthma patients	Loss of ability to exercise and affects bone mass	Smell; Increasing in crop damage	Indicates presence of dirt. Approachable distance decreases
Very Unhealthy	**200-299**	Level of air quality, which is able to harm the health of a large segment of the exposed population.	Increasing risk, to smokers and heart patients to cardio-vascular disease. Some experience weakness	Increasing disease experienced by bronchitis and asthma patients	Chronic lung patients at risk of disease respiratory effects during light exercise	Increasing risk of disease experienced by bronchitis and asthma patients	Increasing risk of disease experienced by bronchitis and asthma patients
Dangerous	**300 or more**	Level of air quality, which is dangerous to health and can seriously harm all populations exposed.	dangerous levels for all populations which are exposed				

Table 3. Air Quality Index Values and Corresponding Action Plan	
ISPU/PSI Levels	**Action Plan**
100-200	**Precautionary Actions** Steps taken by the relevant government officials to limit certain activities, as well as certain industrial activities
200-300	**Action Alert** Immediately limit activities involving combustion, thereby lessening large emission potentials Limit transportation activities as well as industry and other sources of possible pollution
300-400	**Further Actions** Government decision to prohibit activities involving combustion, use of factory furnaces, reduction of operational activities at certain factory facilities and request public to limit usage of private and public transport, and other activities, which would trigger increased pollution concentrations. Government decides on limited evacuation of sick people, old persons and children, recommends use of masks and alerts the Emergency Task Force
More than 400	**Emergency Measures** Governmental decision to stop most or all industrial and commercial activity, usage curtailed on all personal vehicle and other activities, which trigger increased pollution concentrations. Government carries out total evacuation in a stepwise fashion with usage of masks. The Emergency Task Force is directed to control pollution with the help of the necessary technical equipment

AIR QUALITY IN SURABAYA
JUNE – OCTOBER 1999

No.	Date	Location	SO_2	CO	NO_X	PKP	Dust	Pb	H_2S	NH_3	HC	Temp	Noise	Adv.
1	16.06.1999	Air Quality at cross section Demak- Dupak	0.0167	6.40	0.0107	0.0025	0.460	0.0024	0.0000	0.0025	0.21	32	77.9-81.3	**Air Quality standard**
2	16.06.1999	Air Quality in front of Plasa Jembatan Merah	0.0142	1.32	0.0145	0.0014	0.173	0.0018	0.0000	0.0014	0.06	32	73.3-84.2	**which is allowed**
3	16.06.1999	Air Quality at cross section Tunjungan-Gentengkali	0.0268	2.33	0.0188	0.0003	0.253	0.0022	0.0000	0.0003	0.16	34	71.7-74.0	**Regional Law Governor**
4	16.06.1999	Air Quality at cross sect.Prof Mostopo-Dharmawgs	0.0161	1.60	0.0128	0.0014	0.360	0.0012	0.0000	0.0014	0.04	32	74.9-77.0	**129/1996**
5	16.06.1999	Air Quality at cross section Gubeng-Pemuda	0.0174	1.42	0.0015	0.0012	0.293	0.0011	0.0000	0.0137	0.08	30	70.4-76.2	
6	16.06.1999	Air Quality at Bratang Terminal	0.0161	5.80	0.0143	0.0009	0.473	0.0017	0.0000	0.0009	0.30	34	72.3-75.4	**SO_2 = 0.1 ppm**
7	16.06.1999	Air Quality at cross section SIER Rungkut	0.0268	2.55	0.0161	0.0013	0.160	0.0014	0.0000	0.0003	0.33	33.5	71.6-75.6	**CO = 20.0 ppm**
8	16.06.1999	Air Quality at Purabaya Terminal	0.0104	4.67	0.0176	0.0100	0.453	0.0025	0.0000	0.0005	0.56	32	68.7-75.3	**NO_X = 0.05 ppm**
9	16.06.1999	Air Quality at Mayangkara fly over	0.0155	7.15	0.0104	0.0006	0.627	0.0031	0.0000	0.0066	0.44	30	77.3-81.4	**PKP = 0.10 ppm**
10	16.06.1999	Air Quality at Joyoboyo Terminal	0.0167	2.06	0.0071	0.0015	0.373	0.0028	0.0000	0.0066	0.11	33	77.5-80.6	**Dust = 0.260 mg/m^3**
														Pb = 0.06 mg/m^3
1	26.07.1999	Air Quality at cross section Demak- Dupak	0.0186	7.41	0.0123	0.0027	1.000	0.0028	0.0001	0.0028	0.13	30	76.9-79.8	**H_2S = 0.03 ppm**
2	26.07.1999	Air Quality in front of Plasa Jembatan Merah	0.0157	2.80	0.0135	0.0018	0.247	0.0019	0.0000	0.0015	0.06	31	68.3-72.1	**NH_3 = 2.0 ppm**
3	26.07.1999	Air Quality at cross section Tunjungan-Gentengkali	0.0136	1.66	0.0147	0.0022	0.293	0.0024	0.0000	0.0014	0.02	33	72.3-77.0	**HC = 0.24 ppm**
4	26.07.1999	Air Quality at cross sect.Prof Mostopo-Dharmawgs	0.0159	3.38	0.0168	0.0051	0.240	0.0024	0.0000	0.0012	0.04	32	72.5-76.8	
5	26.07.1999	Air Quality at cross section Gubeng-Pemuda	0.0193	1.27	0.0123	0.0042	0.307	0.0015	0.0000	0.0083	0.03	32	72.7-77.6	
6	26.07.1999	Air Quality at Bratang Terminal	0.0172	3.22	0.0153	0.0011	0.320	0.0019	0.0000	0.0012	0.06	32	67.6-72.9	**Law Health Minister**
7	26.07.1999	Air Quality at cross section SIER Rungkut	0.0271	4.01	0.0183	0.0098	0.133	0.0016	0.0000	0.0010	0.08	31	69.4-74.0	**718/1987**
8	26.07.1999	Air Quality at Purabaya Terminal	0.0162	6.84	0.0192	0.0000	0.320	0.0028	0.0000	0.0012	0.11	31	72.2-77.7	**Zona D = 60-70 dBA**
9	26.07.1999	Air Quality at Mayangkara fly Over	0.0178	9.30	0.0123	0.0012	0.227	0.0034	0.0000	0.0015	0.20	29	74.1-79.5	
10	26.07.1999	Air Quality at Joyoboyo Teminal	0.0183	2.47	0.0105	0.0012	0.207	0.0031	0.0000	0.0068	0.08	30	67.4-72.3	
1	11.08.1999	Air Quality at cross section Demak- Dupak	0.0236	8.90	0.0122	0.0029	0.960	0.0031	0.0009	0.0036	0.16	31	75.6-83.7	
2	11.08.1999	Air Quality in front of Jembatan Merah Plaza	0.0162	3.42	0.0134	0.0018	0.313	0.0019	0.0000	0.0023	0.08	33	70.2-75.8	
3	11.08.1999	Air Quality at cross section Tunjungan-Gentengkali	0.0165	3.63	0.0175	0.0041	0.293	0.0028	0.0000	0.0023	0.06	35	75.8-81.3	
4	11.08.1999	Air Quality at cross sect.Prof Mostopo-Dharmawgs	0.0142	1.72	0.0158	0.0025	0.273	0.0017	0.0001	0.0018	0.07	32	73.2-76.7	
5	11.08.1999	Air Quality at cross section Gubeng-Pemuda	0.0178	1.93	0.0196	0.0006	0.320	0.0018	0.0000	0.0007	0.17	34	70.5-74.7	
6	11.08.1999	Air Quality at Bratang Terminal	0.0185	3.28	0.0163	0.0010	0.827	0.0019	0.0000	0.0015	0.07	34.5	70.1-74.6	
7	11.08.1999	Air Quality at cross section Rungkut SIER	0.0286	4.12	0.0193	0.0048	0.287	0.0019	0.0004	0.0025	0.05	34	70.6-75.7	
8	11.08.1999	Air Quality at Purabaya Terminal	0.0184	6.88	0.0120	0.0012	0.707	0.0029	0.0004	0.0015	0.11	34	80.0-80.6	
9	11.08.1999	Air Quality at Mayangkara fly over	0.0199	10.32	0.0186	0.0013	0.500	0.0036	0.0001	0.0018	0.25	30	74.6-79.4	
10	11.08.1999	Air Quality at Joyoboyo Teminal	0.0189	2.58	0.0125	0.0009	0.300	0.0032	0.0005	0.0070	0.08	30	78.9-81.8	

Continuous

No.	Date	Location	SO_2	CO	NO_X	PKP	Dust	Pb	H_2S	NH_3	HC	Temp	Noise	Adv.
1	15.09.1999	Air Quality at cross section Demak- Dupak	0.0212	7.68	0.0145	0.0019	0.813	0.0029	0.0009	0.0041	0.17	32	73.5-78.2	
2	15.09.1999	Air Quality in front of Jembatan Merah Plaza	0.0148	3.11	0.0123	0.0014	0.426	0.0015	0.0000	0.0019	0.07	33	66.4-74.7	
3	15.09.1999	Air Quality at cross section Tunjungan-Gentengkali	0.0152	3.43	0.0169	0.0021	0.305	0.0025	0.0002	0.0031	0.05	33	70.9-74.7	
4	15.09.1999	Air Quality at cross sect.Prof Mostopo-Dharmawgs	0.0136	1.76	0.0161	0.0029	0.258	0.0021	0.0001	0.0020	0.06	34	70.4-76.4	
5	15.09.1999	Air Quality at cross section Gubeng-Pemuda	0.0152	2.16	0.0187	0.0010	0.354	0.0020	0.0000	0.0012	0.15	30	70.8-76.7	
6	15.09.1999	Air Quality at Terminal Bratang	0.0186	4.15	0.0183	0.0010	0.718	0.0018	0.0002	0.0024	0.11	29	68.2-76.2	
7	15.09.1999	Air Quality at cross section Rungkut SIER	0.0222	3.51	0.0173	0.0035	0.279	0.0015	0.0000	0.0019	0.07	30.5	65.4-75.6	
8	15.09.1999	Air Quality at Purabaya Terminal	0.0200	7.59	0.0189	0.0045	0.816	0.0031	0.0015	0.0014	0.14	31	72.2-77.6	
9	15.09.1999	Air Quality at Mayangkara fly over	0.0251	11.78	0.0216	0.0019	0.614	0.0039	0.0004	0.0049	0.26	32.5	73.6-84.2	
10	15.09.1999	Air Quality at Joyoboyo Terminal	0.0193	4.12	0.0159	0.0012	0.355	0.0031	0.0004	0.0063	0.11	33	66.1-75.6	
1	06.10.1999	Air Quality at cross section Demak- Dupak	0.0218	6.51	0.0136	0.0015	0.553	0.0027	0.0008	0.0090	0.19	32	73.6-78.2	
2	06.10.1999	Air Quality in front of Jembatan Merah Plaza	0.0145	3.12	0.0127	0.0011	0.480	0.0017	0.0000	0.0217	0.05	33	66.4-73.7	
3	06.10.1999	Air Quality at cross section Tunjungan-Gentengkali	0.0143	3.40	0.0126	0.0016	0.333	0.0023	0.0004	0.0054	0.08	33	70.9-74.7	
4	06.10.1999	Air Quality at cross sect.Prof Mostopo-Dharmawgs	0.0138	1.07	0.0131	0.0021	0.213	0.0019	0.0001	0.0012	0.08	34	70.4-76.4	
5	06.10.1999	Air Quality at cross section Gubeng-Pemuda	0.0169	2.58	0.0193	0.0008	0.373	0.0022	0.0000	0.0016	0.17	33	70.8-76.7	
6	06.10.1999	Air Quality at Bratang Terminal	0.0188	4.74	0.0125	0.0010	0.660	0.0021	0.0002	0.0032	0.13	29	68.2-76.2	
7	06.10.1999	Air Quality at cross section Rungkut SIER	0.0269	2.68	0.0124	0.0005	0.193	0.0016	0.0009	0.0054	0.05	30.5	65.4-75.6	
8	06.10.1999	Air Quality at Purabaya Terminal	0.0236	8.42	0.0223	0.0018	0.873	0.0030	0.0000	0.0074	0.16	31	72.2-77.6	
9	06.10.1999	Air Quality at Mayangkara fly over	0.0228	12.58	0.0225	0.0021	0.740	0.0041	0.0006	0.0077	0.25	32.5	73.6-84.2	
10	06.10.1999	Air Quality at Joyoboyo Terminal	0.0218	6.51	0.0231	0.0024	0.467	0.0030	0.0006	0.0153	0.10	33	66.1-75.6	

Ambient Air Quality in Surabaya
2001

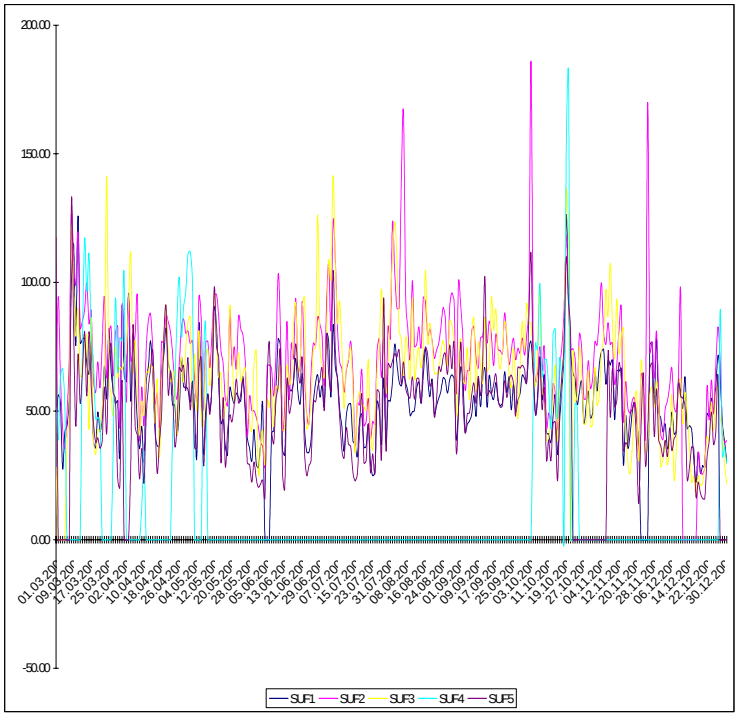


Figure 1. Measurements of PM_{10} for Year 2001

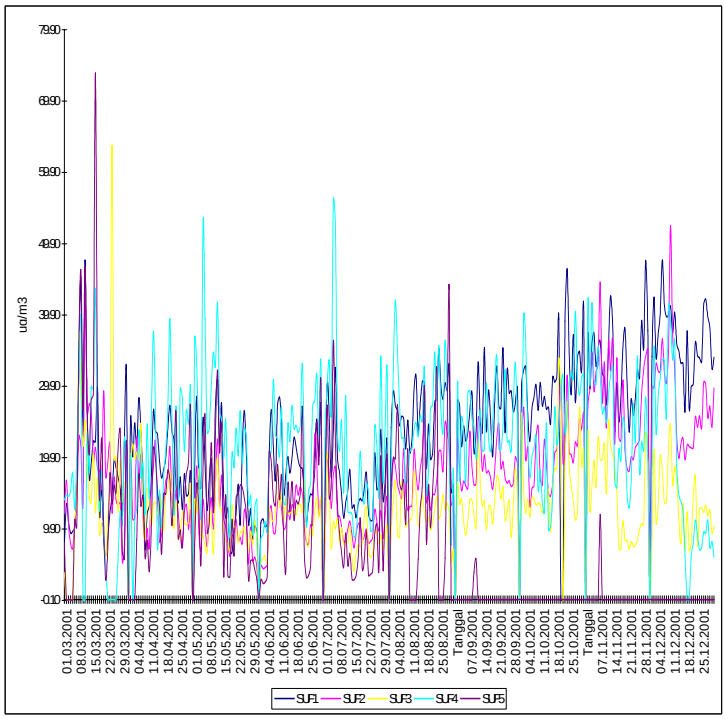


Figure 2. Measurements of SO_2 for Year 2001

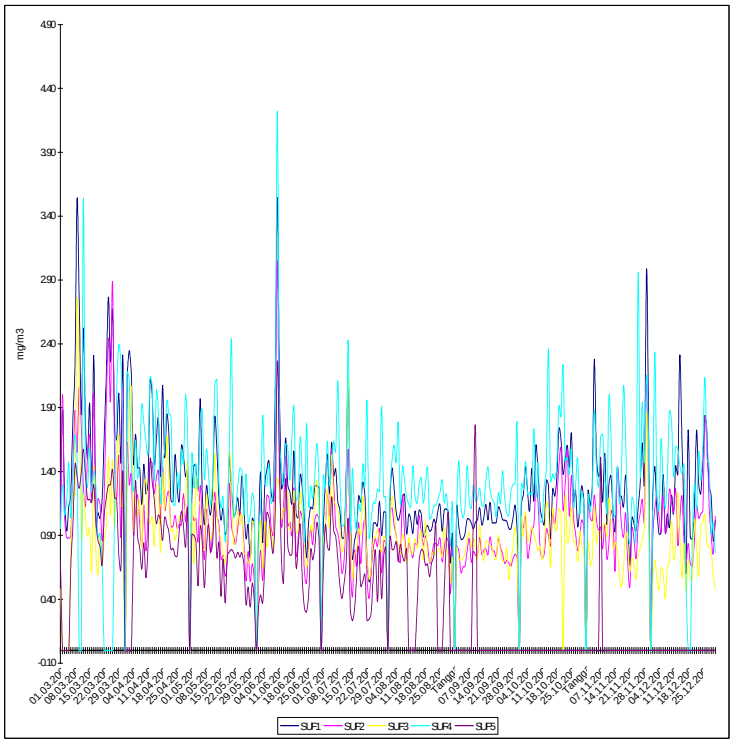


Figure 3 Measurements of CO for Year 2001

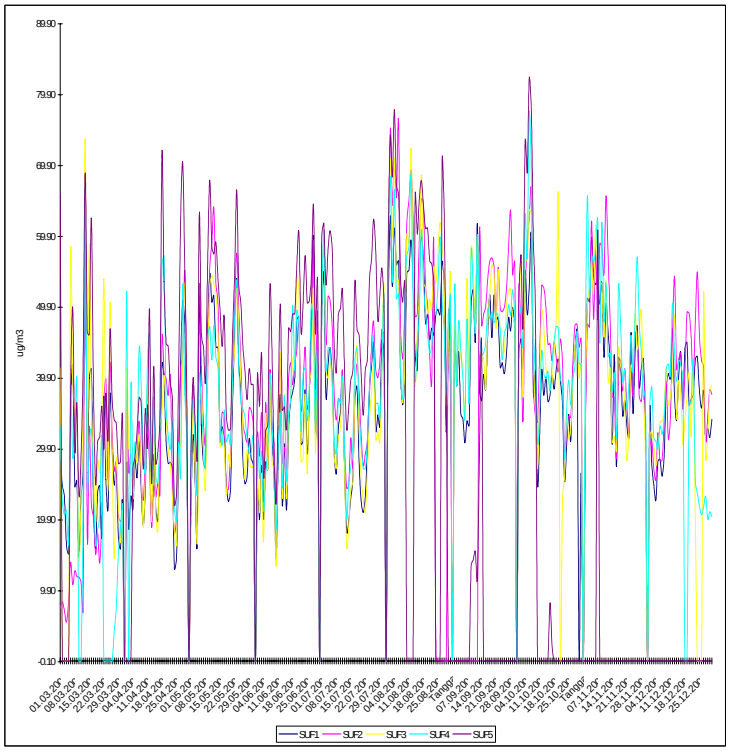


Figure 4. Measurements of O_3 for Year 2001

Continued

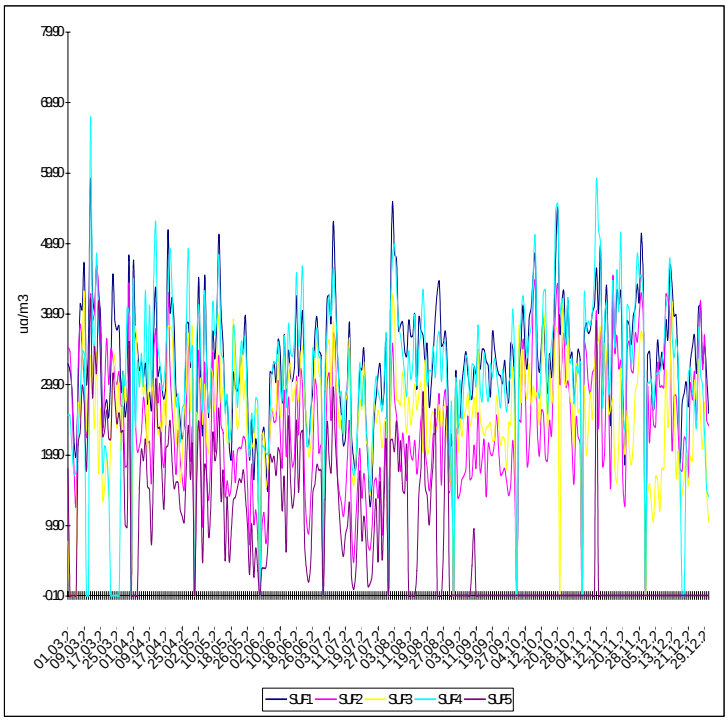


Figure 5. Measurements of NO_2 for Year 2001

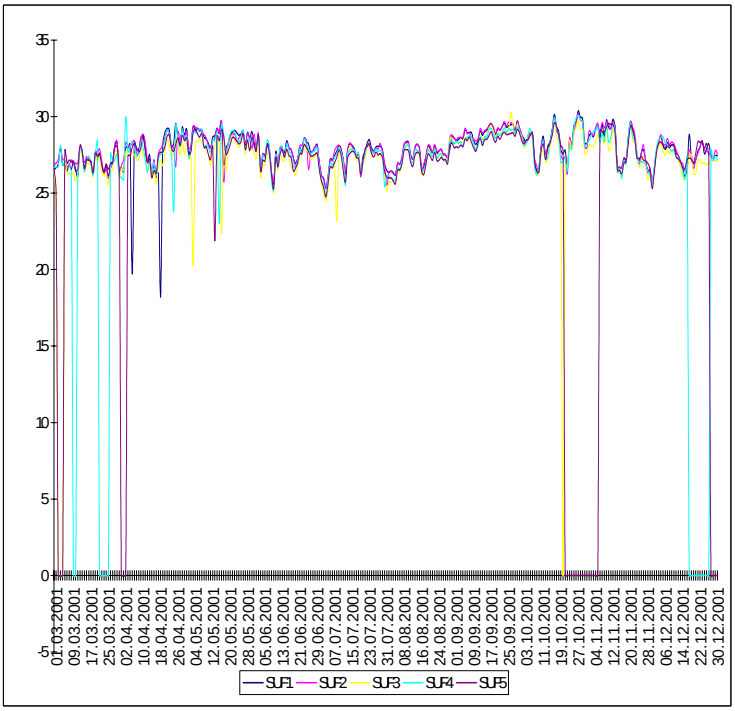


Figure 6. Measurements of Ambient Temperature for Year 2001

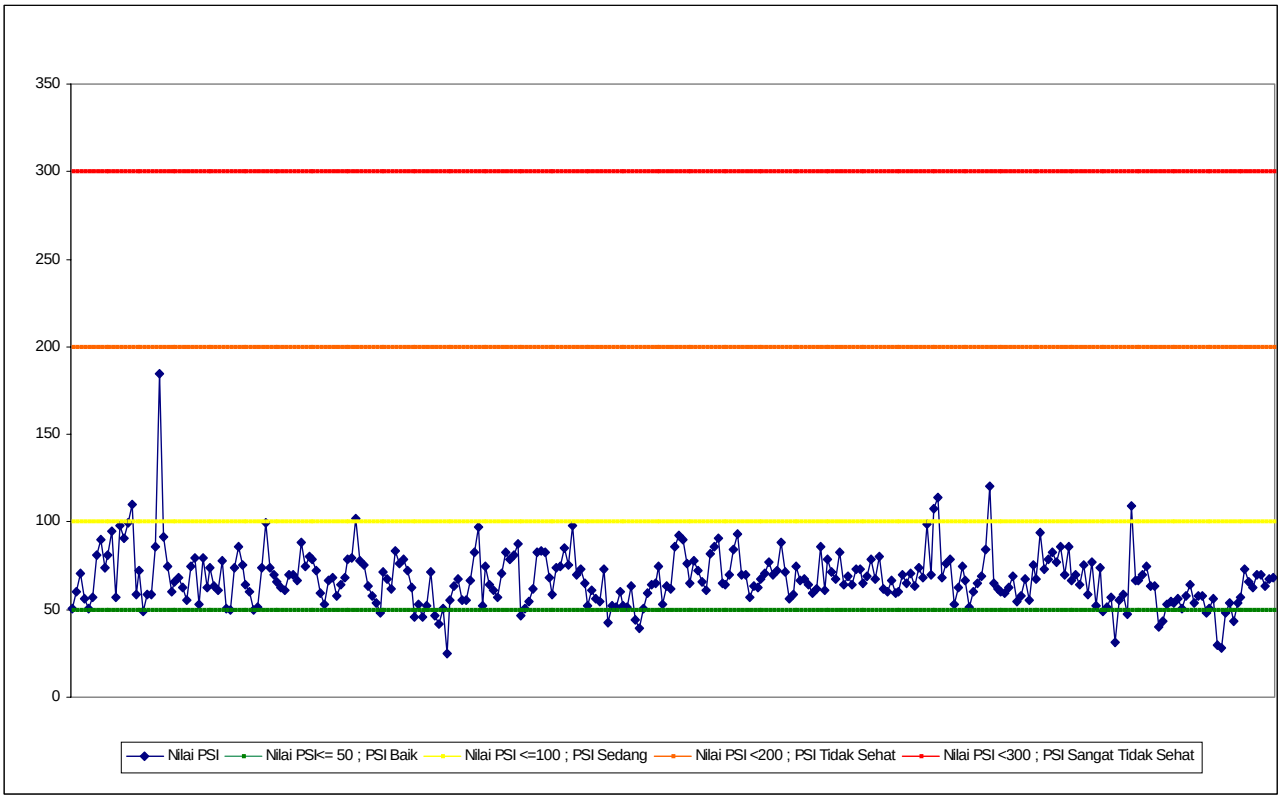


Figure 7. PSI/ISPU values for the Parameters PM_{10}, SO_2, CO, O_3 and NO_2 Year 2002

Ambient Air Quality in Surabaya
2002

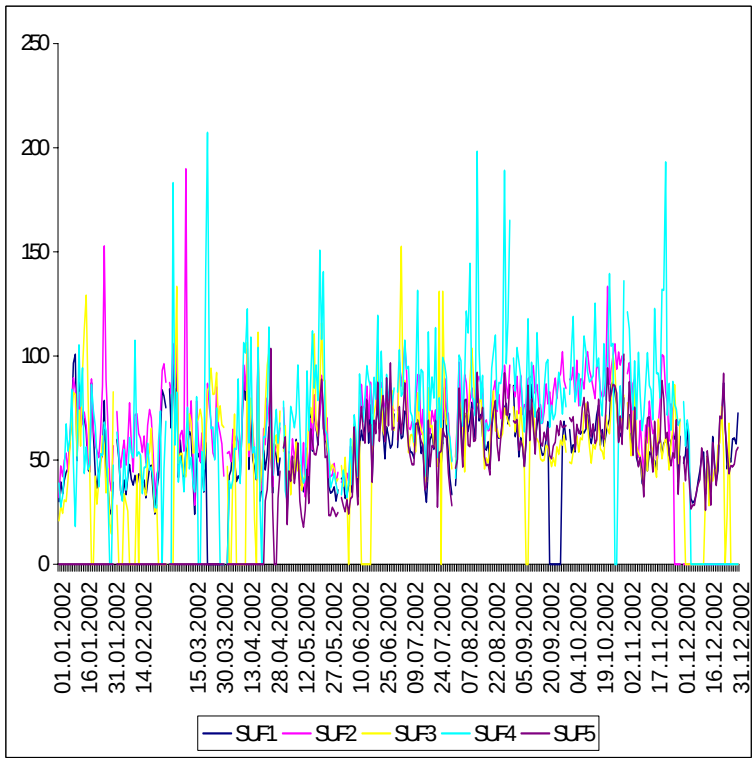


Figure 8. Measurements of PM_{10} for Year 2002

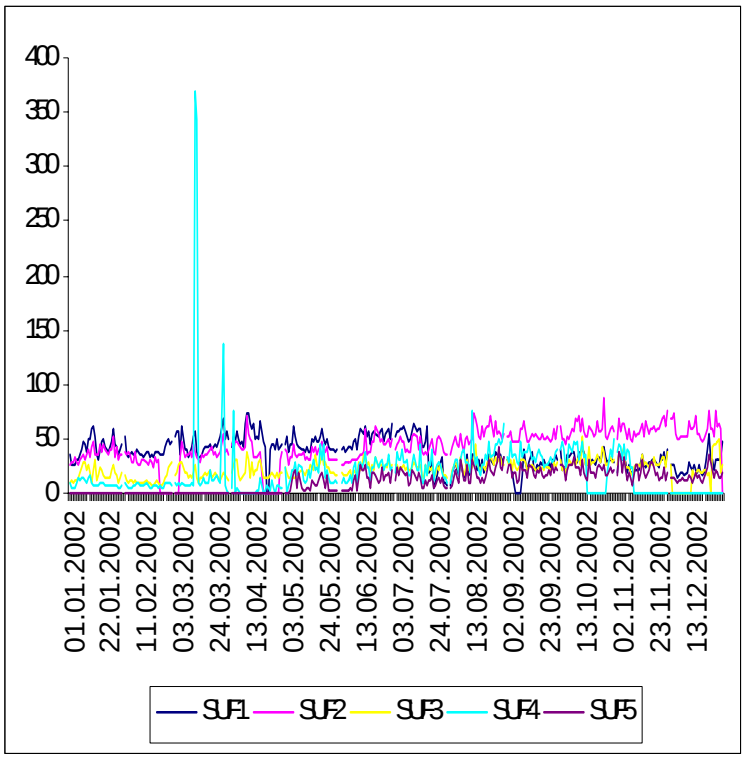


Figure 9. Measurement of SO_2 for Year 2002

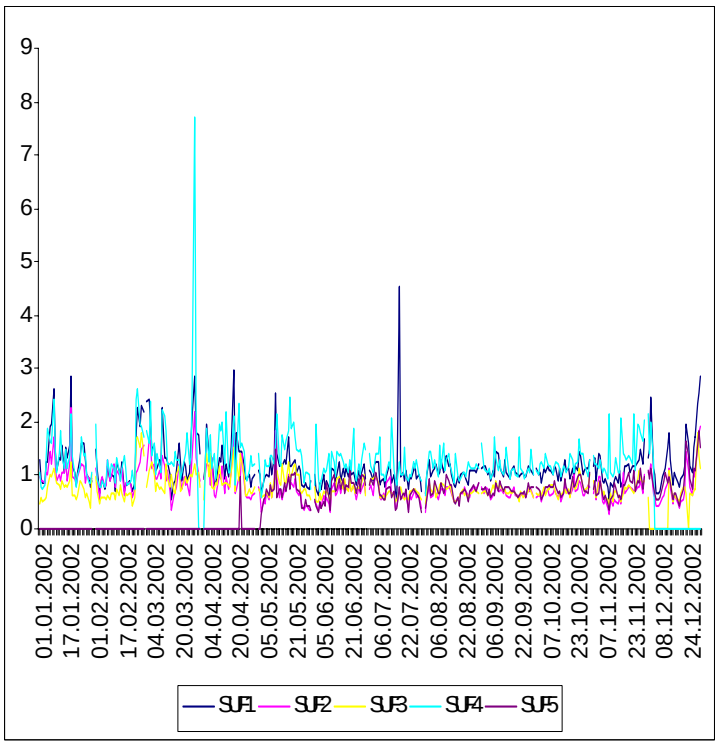


Figure 10. Measurements of CO for Year 2002

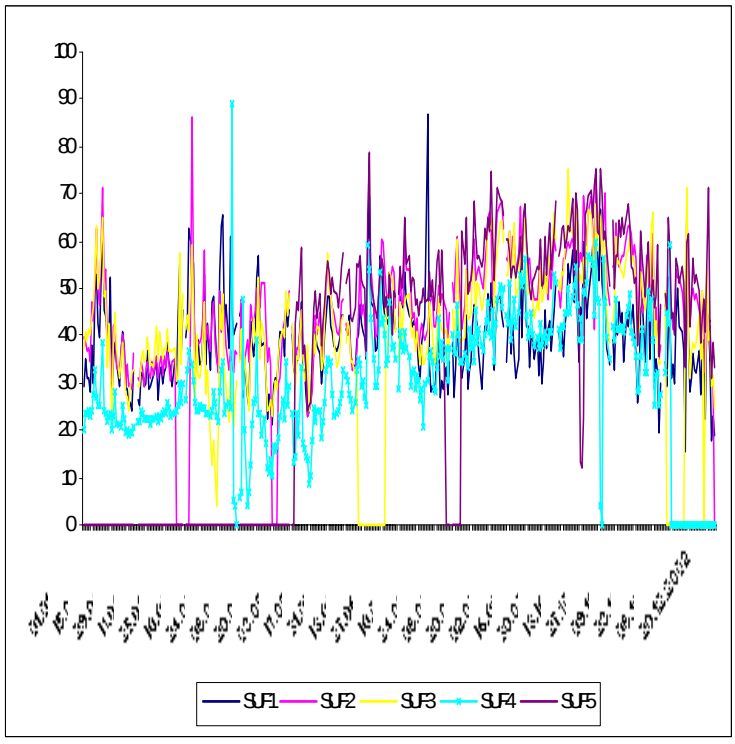


Figure 11. Measurements of O_3 for Year 2002

Continued

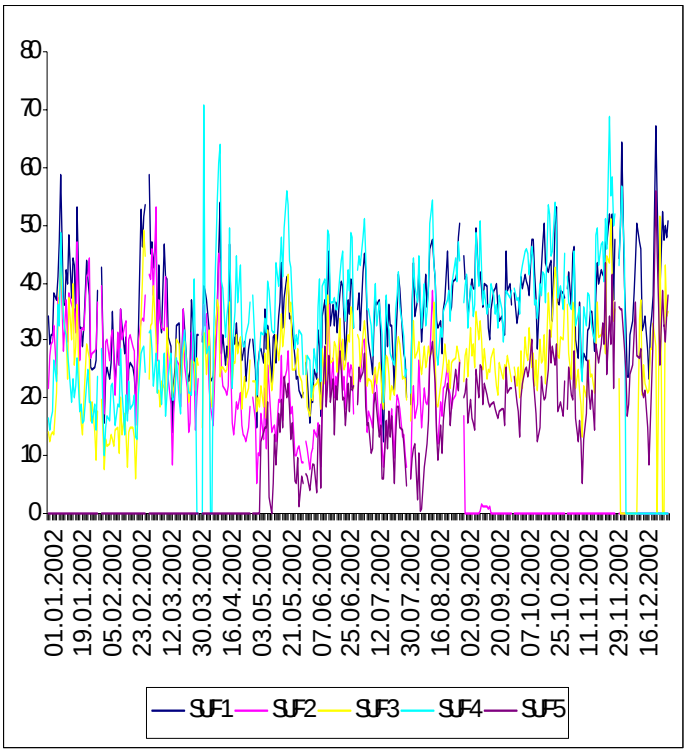


Figure 12. Measurements of NO_2 for Year 2002

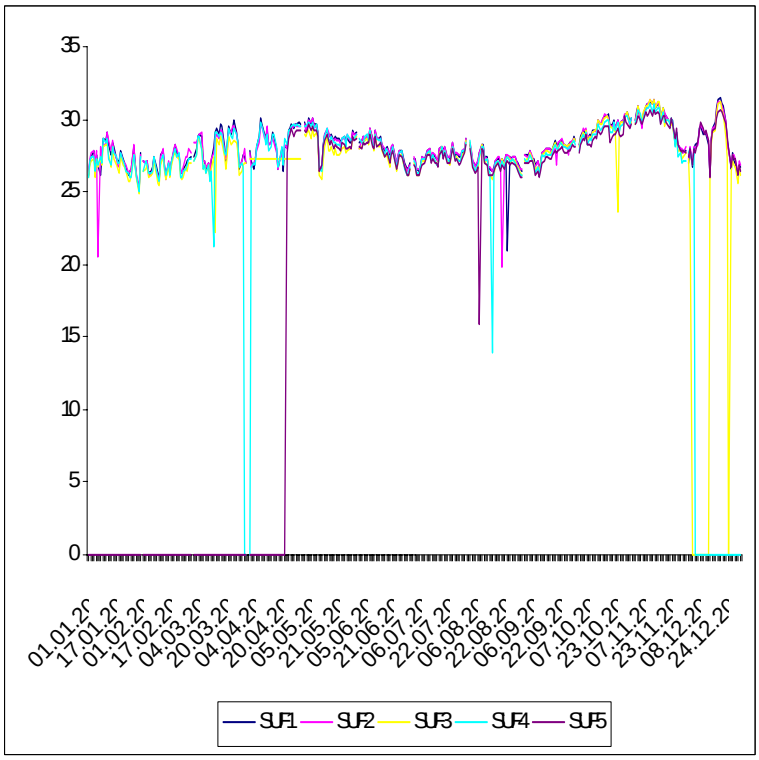


Figure 13. Measurements of Ambient Temperature for Year 2002

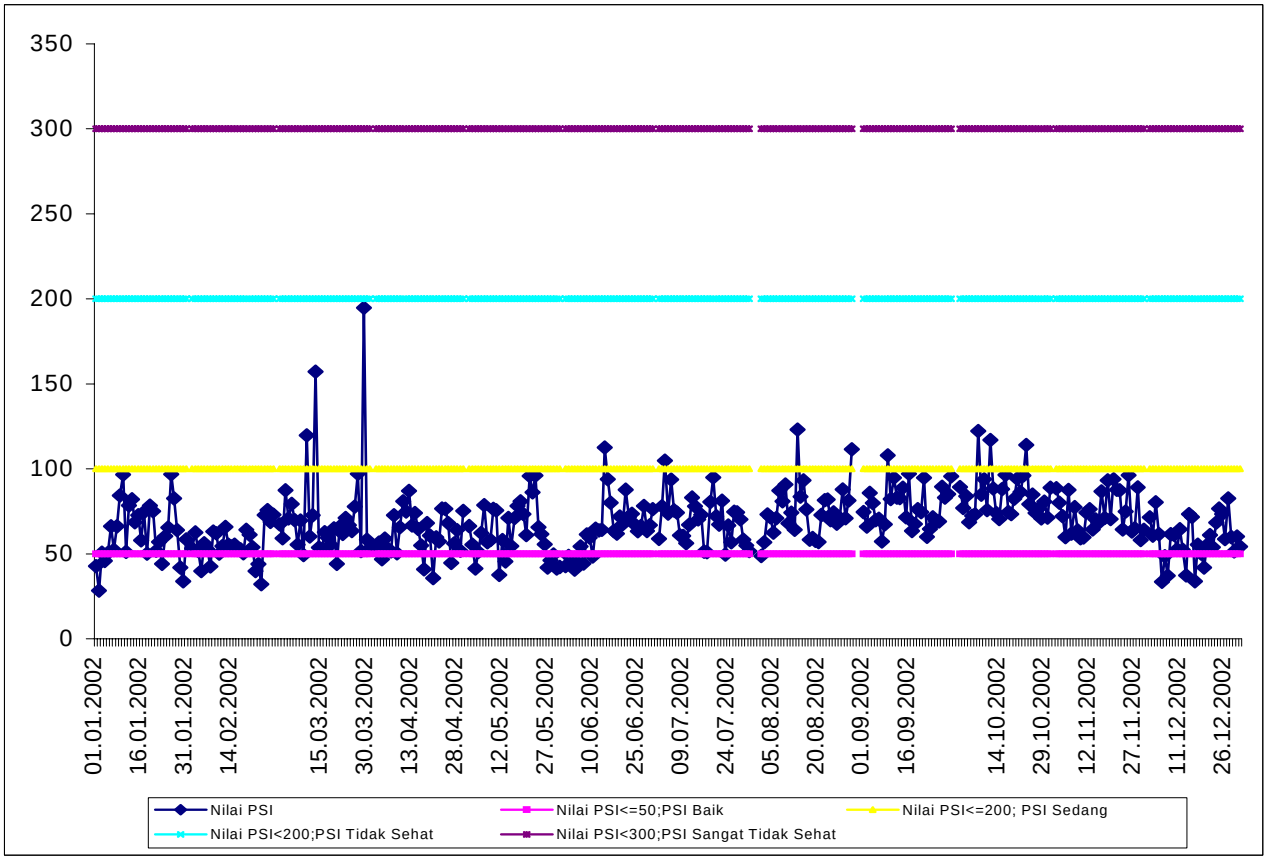


Figure 14. PSI/ISPU values for the Parameters PM_{10}, SO_2, CO, O_3 And NO_2 for Year 2003

F. Kitakyushu, Japan
Urban Air Quality Management Experiences

1. Abstract

Air pollution in Kitakyushu City is controlled by the Environment Department, is based on various laws and ordinances and is under the control of the Mayor who can announce pollution warnings, which facilitates quick and effective remedial actions. Although steel remains its primary industry high tech industries are increasing. Due to public pressure and effective enforcement industries initially introduced flue gas desulphurisation equipment but due to its expense a move away from end-of-pipe treatments and towards promoting cleaner production (CP) technologies is being seen. These include measures like the Oxygen Converter Gas Recovery System (OG) method for treating fuel converter gases, which was developed in Kitakyushu City and adopted worldwide. In addition the introduction of liquefied natural gas (LNG) with flue gas denitrification equipment was introduced for electric and steel industries in an effort to reduce NO_x and eliminate SO_x emissions. Automobile pollution countermeasures include promotion of low-pollution vehicles such as natural gas or electric vehicles. Success and responsiveness in controlling urban air quality also stems from the capacity development that has taken place within local government. Wind tunnel tests are done in environmental assessments to estimate influence of new enterprises. The establishment of an air-monitoring centre allows timely and rapid smog warnings as well as special weather conditions to be reported to 30 target large-scale factories to request reduction in amount of dust in emergency cases. Using its many achievements in improving its own environment Kitakyushu City has been promoting international cooperation, developing new technologies and offering training in the form of despatching experts, organizing international meetings and joint enterprises and accepting trainees worldwide.

2. Environmental Setting

The City of Kitakyushu, formed in 1963 with the merger of five cities (Moji, Kokura, Yahata, Wakamatsu, and Tobata), is located halfway between Tokyo and Shanghai and has an area of 484km^2 (32.5km east-west, 33.5km north-south). These former five cities, in cooperation with one other, have developed into one of the most prominent heavy chemical industrial areas in Japan, overcoming both the destruction inflicted on the city during World War II and the effects of energy conversion from coal to oil with the change in its industrial structure. In recent years, Kitakyushu has proceeded to promote urban planning to exploit the conversion from secondary industries to tertiary industries and its location close to other Asian countries.

The city's population increased from 1920 to 1960, peaking in 1980 at 1,065,000. The current population has since stabilised. In October 2000, the population of Kitakyushu was 1,010,000, with a density of 2,090 persons per km^2.

General production in Kitakyushu has increased 5.5 times since 1970. In 1970, general production amounted to JPY (Yen) 656 billion. By 1999 it was JPY 3.62 trillion (JPY 511.84 trillion nationwide). Looking at the industrial structure of Kitakyushu from the amount of revenue generated by general production, the contribution of tertiary industry was largest at 61.8% in 1999 (66.4% nationwide), followed by secondary industry at 37.3% (32% nationwide), and primary industry at 0.9% (1.6% nationwide). Shipment of products in 2000 amounted to JPY 1.86 trillion. Predominant industries include steel, electronic machinery/appliances and general machinery/appliances manufacture, chemical and

manufacture of metal goods. Although steel remains as a primary industry, the importance of material industries has decreased. However, the importance of high-tech industries such as general or precision instruments, which are expensive and require high processing skill, has been increasing.

Kitakyushu City Government consists of 27 Departments; the Environmental Department controls and regulates air pollution. The annual revenue of the city in 2001 amounted to JPY 1.04 trillion while the budget of the environmental department was JPY 20.5 billion. Of the total budget, JPY 129 million was budgeted for air pollution management and regulation (excluding personnel costs).

Air Pollution Situation in the City:

(a) General Environmental Air Pollution Measurement Stations [14]: The levels of sulphur dioxide (SO_2), nitrogen dioxide (NO_2), and carbon monoxide (CO) were within the environmental standards at each of the fourteen measurement stations. However during the spring, all stations did not conform to the standards because of the high amount of suspended particulate matter (SPM) due to yellow sand. Photochemical oxidants, which must be assessed regularly (short-term assessment) at proper assessment times (05:00 - 20:00 hrs), were 0.1% - 7.2% at each measurement station.

(b) Roadside measurement stations [5]: Levels of NO_2 were within the environmental standard at three of the five measurement stations while CO levels were within the environmental standard at every measurement station. SPM was higher than the environmental standard at every measurement station due to yellow sand.

(c) Benzene, Trichloroethylene, Tetrachloroethylene and Dichloromethane: Benzene levels were measured at four stations, and was found to be within the standard value at three stations. Trichloroethylene and tetracholoroethylene levels were within the environmental standard at all four measurement stations. The amount of dichloromethane, for which the city recently set a standard, was also within the environmental standard at all four measurement stations.

Air regulations are based on various laws and ordinances, such as the Air Pollution Control Law, Polychlorinated-dibenzodioxins (PCDDs) Countermeasure Law, and the Kitakyushu City Pollution Control Ordinance, among others.

The authority of the prefectural governor of Fukuoka with regard to the Air Pollution Control Law was transferred to the mayor of Kitakyushu City. It is the only case in Japan that the authority to announce warnings was entrusted to the mayor of a city, thereby facilitating quick and effective actions for warnings since the regional situation can be easily considered. Additionally, Kitakyushu City is actively working to set up monitoring systems such as air pollution monitoring systems.

3. Issues and Challenges

(a) Environmental Protection Actions of Businesses:

After World War II, the restoration of industries progressed, with large industrial areas as the focus. The Kitakyushu Heavy Chemical Industry Area, where steel, chemical, ceramic, and electronic enterprises were located, developed rapidly from 1955 to 1965, and the heavy emissions from factories, otherwise known as “seven colour smoke”, was then considered a symbol of prosperity. However, together with this prosperity, air pollution such as dust, soot and dust smoke, SO_X, and offensive odours, became serious in various

areas. In particular, the conversion of fuel from coal to oil caused extensive environmental problems with regard to SO_X emissions. Furthermore, the rapid increase in population, the concentration of industries, and the emergence of a consumer lifestyle brought about overcrowding, consequently traffic noise and automobile exhaust fumes became a problem.

A few enterprises tried to install dust and soot collectors before pollution laws were enacted, but the main objective was pollution control measures for the working environment including the protection of manufacturing machines and improvement of labour sanitation. As the government and the municipalities began to enforce pollution control laws, environmental pollution began to be recognized as a social vice. After some enterprises lost pollution trials, they were required to compensate the victims, so production activities of enterprises became difficult. This position rapidly affected the enterprises' attitudes toward pollution problems, and they began to work actively to implement environmental pollution control measures.

Since the middle of the 1960s, investment in air pollution control equipment rapidly increased. At the beginning, enterprises focused on the collection of dust and soot, the desulphurisation of heavy oil, and increase of effective stack height. At the time, flue gas desulphurisation equipment was not popular and diffusion from high stacks was the only way to control SO_X to meet with environmental standards, unless low-sulphur fuels were used. However, there was criticism that this method only diffused smoke and soot into the atmosphere but did not reduce them.

During the 1970s, the installation of flue gas desulphurisation equipment was considered because it became obvious that existing technology could not reduce sulphur content in heavy oil sufficiently. At the time as developing and installing large-scale desulphurisation equipment was expensive only small-scale equipment was in use. Concerned about its negative impact on the Japanese economy, the industrial sector was reluctant to develop desulphurisation equipment. However, there were limits to the existing heavy oil desulphurisation technology and in order to meet environmental standards installation of flue gas desulphurisation equipment was undertaken.

The introduction of flue gas desulphurisation technology began to spread rapidly around 1975. Currently, there are approximately 2,000-flue gas desulphurisation units are in operation. It is popularly viewed as one of the main technologies to overcome serious air pollution problems in Japan. Flue gas desulphurisation equipment is expensive and requires much electricity to operate. A major issue is what should be used as reaction materials and how the by-products produced should be used. As there is a lot of limestone in Japan this was used as the reaction material. The gypsum produced is collected and used as gypsum boards or materials in cement.

Around 1975, air pollution due to nitrogen oxides (NO_X), created when fuel is burned, became a serious problem and began to be strictly regulated all over the world. As a result the technology to contain NO_X was researched comprehensively. Businesses promoted the use of high quality fuel, improvements in the method of burning, and adoption of low-NO_X burners or flue gas desulphurisation techniques.

After the first oil shock in 1973, Japanese environmental pollution control measures were greatly changed. To deal with the rise of energy costs, enterprises actively consolidated various aspects such as equipment and technologies, and operations. The second oil shock in 1979, promoted energy saving measures, which mainly consisted of heat recovery. Energy saving measures greatly contributed to the reduction of costs and air

pollution with improvements in productivity and quality. Thus the environmental measures by the enterprises shifted its importance from "End of Pipe Method," which is the method to remove discharged pollutants, such as dust and soot collection or desulphurisation, to methods designed to improve manufacturing processes by economizing resources and energy. Today, Japanese energy saving technology is one of the most effective in the world.

In spite of the enormous amount of investment in pollution control the economic growth of Japan did not slow down; rather, because of investments on environmental measures, technology innovation was promoted, quality improved, and costs were reduced. Following this, the environmental pollution control equipment industry was established. Enterprises developed various environmental pollution control technologies and tried to conform to strict emission standards through environmental pollution control measures. It is important to note that organizing technical experts within the enterprises such as heat managers or pollution control managers formed the technological bases for environmental pollution control measures. In 1971, the laws on pollution control organizations were approved. Each enterprise formed pollution control organizations, set pollution control rules, and held discussions and improved pollution control technology. Efficient environmental controls were possible when the environmental managing organizations and technologies were evenly balanced.

(b) Automobile Pollution Countermeasures:

Because of the increase of the number of diesel vehicles, there are some areas around highways where the amount of NOx and SPM is higher than the environmental standard; this means that air pollution from automobiles has not yet been solved. Recently, carbon dioxide (CO_2) discharged from automobiles has come to be regarded as a factor in global warming, and CO_2 reduction measures will be needed very soon.

(c) Capacity Development of Local Government in Urban Air Quality Management:

From 1960, the plan to double the nation's income began, and the Japanese economy made rapid progress. Community development was promoted to address the gaps in various areas, but air pollution that used to be local and scattered, extended and became more serious throughout Japan, because laws to regulate environmental pollution had not been implemented at that time. Finally, solving environmental pollution became a very important national problem.

In the Shiroyama Area of Kitakyushu (located between industrial areas) dust fall in 1965 was 80 ton/km^2/month and together with SO_2 emissions was rapidly became major social problems. While in 1960, there were 24 complaints and petitions about environmental pollution, in 1964 and 1970, complaints numbered 168 and 386, respectively. This meant that with the intensification of environmental pollution, people's concerns about environmental pollution also grew. People residing around the Shiroyama Area, which was surrounded by large-scale factories of the ceramic, chemical, and steel industries were affected by dust fall or offensive odours. Around Nakabaru and Sanroku Areas, which were also located close to large-scale factories, an anti-pollution movement began in 1950, started by a local women's group, which had suffered from the dust fall from power plants as well as smoke and soot from chemical factories. Under the slogan, "We want our blue skies back", the women's group petitioned the government and called for enterprises to improve the environment, based on their own investigations and tests.

Meanwhile, Kitakyushu City became one of the target areas of an industrial pollution general feasibility study conducted in 1969 by the Ministry of International Trade and Industry, Fukuoka Prefecture. Investigations and studies were targeted at enterprises that used more than 5 kl/day of heavy oil, 54 major factories and Kitakyushu City. Through these investigations, field surveys to prevent pollution before it occurs and scientific forecasts of future pollution conditions were developed to improve the enterprises' attitudes towards environmental pollutions. The reasons as to why Kitakyushu City was selected included the fact that air pollution was already serious in the city and development projects were planned in the Hibikinada Area, located in the northern part of the city.

In 1973, Kitakyushu City, which had an objective to achieve environmental standards, concluded the "Agreement on Environmental Pollution Control on SO_X" with 54 major factories to ensure that the factories would conduct improvement plans. Although there was criticism at that time that the increase of effective stack height only scatters pollution over a wider area, as a result this action contributed to air pollution control measures in Kitakyushu City. Until the enterprises concluded the agreement, they were apprehensive about the reinforcement of regulations by the government. Since smog warnings were announced, social watchdogs such as the mass media became strict; therefore, the agreement would be a permit for the enterprises to build more factories.

4. Implementation Strategy

(a) Business Sector Actions

(i) Treatment of Converter Gas (OG Method): In 1970, the discharge amount of SO_X from "S" Iron Mill was 27,575 ton/year, but in 1990 it was reduced to 607 ton/year. This was effected through fuel conversion and energy and resource saving as well as the effect of emission gas treatment facilities. Emission gas is produced when oxidation-reduction reactions occur in LD converters that are used in the steel making process and consist mainly of CO. Once, this gas was burned completely by supplying approached or secondary air, and collected heat from a boiler tube passed through a wet type dust collector, and was dispersed into the air. Because this gas had a high temperature and high speed, it often caused abrasions in boiler tubes and problems in wet type soot and dust collectors, leading to an adverse effect on the environment. As a consequence the "S" Iron Mill developed a method to control fuel gas from LD converters under non-burning conditions (OG Method) rather than a large waste heat boiler. OG Method is an abbreviation of "Oxygen Converter Gas Recovery System"; it is a method to collect emission gases generated thorough the steel smelting process in oxygen converters without being burned and subsequent conversion of the emission gas into fuel gas. The merits of the OG Method are that the temperature of the emission gas is low and that the grain size of the dust is comparatively large enough to collect easily.

(ii) Introduction of Natural Gas for Electric and Steel Industries: The power plants of the electric power companies had used coal from the neighbouring Chikuho coalfield to supply the electrical demands of the Kitakyushu industrial area. However, from 1958 co-combustion of coal and heavy oil was promoted during the energy revolution. In 1973, this was switched to single fuel combustion of heavy oil with the reinforcement of environmental pollution control measures. With the effects of Oil Shock in 1973, the introduction of liquefied natural gas (LNG) was planned to diversify fuel. Electric companies

and iron mills planned to build more LNG power plants, and the government favourably promoted this trend, due to the fact that the introduction of LNG could cut down the amount of SO_X to zero and the government was looking to reduce SO_X by the regulation of total emissions. However, the government was concerned that constructing more power plants with single fuel combustion of LNG would become an obstacle to achieve the environmental standard of NOx.

(b) Vehicle Sector Actions:

Related organizations and departments cooperated to carry out various pollution reducing initiatives such as automobile measures (improvement of automobile structures, promotion of low-pollution vehicles), automobile traffic measures (traffic distribution measures, physical distribution measures), and roadside measures (proper utilization of roadsides, obstacle preventive measures). These measures were based on the "Kitakyushu Basic Plan for Automobile Pollution Countermeasures" established in 1990. In 2002, the city government organized the "Kitakyushu Automobile Pollution Control Measurement Promoting Conference" and developed a system to promote automobile pollution control, together with citizens and private enterprises. Through the "Kitakyushu City Automobile Pollution Control Measures Third Mid-term Plan" enacted in 1989, Kitakyushu City tries to implement attainable measures and promote the usage of low-pollution vehicles such as natural gas vehicles or electric vehicles.

(c) Capacity Building in Local Government Sector:

(i) Wind Tunnel Tests for Environmental Pollution Control Programme: How much does the air that we breathe every day contain the smoke from each factory? Clarifying this problem was the most immediate and important aspect to consider in air pollution control measures. So Kitakyushu City implemented the latest scientific method - the wind tunnel test. In this method, the models of the geographical features and the buildings were reduced to a 1/2500 scale model, geographic features and building effects on the diffusion of the smoke was examined, and the diffusion conditions of each chimney was measured. From this data, the total concentration of pollutant was estimated.

The results of these wind tunnel tests showed that the pollutant concentration was high because of the large number of low chimneys; therefore, it became clear that if these chimneys were concentrated and increased in height, pollution would improve greatly. Kitakyushu City then guided enterprises to develop improvement plans to achieve environmental standards with the goal that the maximum pollutant concentration would be within 0.2ppm.

(ii) SO_X Reduction through Special Weather Information:

(a) *Establishment of the Air Pollution Monitoring Centre*: From the 1960s, environmental pollution became severe; in particular air pollution was severe around Dokai Bay where many factories were located. At first, observation stations were established in Yahata and Tobata in 1964, and measurement instruments were set in public health centres. In 1970, the air pollution-monitoring centre was established for a concentrated observation using telemeters and for quick actions in emergency cases. The centre functions were enriched with the improvements of a measurement network and a new system was introduced in 1993.

(b) *Transference of Authority to City Mayor Regarding Smog Warnings*: Prefectural governors usually have the authority to issue smog warnings and

alerts, but this authority was transferred to the mayor of Kitakyushu City in 1970. This was the only case in Japan. In Kitakyushu City, a total of 27 warnings and alerts were issued for SO_X. Smog warning (18 times -17 times in 1970, once in 1971) and alerts (9 times - 9 times in 1970), which was a main factor of air pollution at that time.

(c) *Foundation of Special Weather Information Report System*: Kitakyushu City developed an original system to report special weather information to the enterprises beforehand to promote earlier actions for pollution control when smog conditions were expected because of specific weather conditions, such as occurrence of sub-inversion layer. Compared to the standard 0.15ppm of SO_X warnings, under the special weather conditions, the warnings were announced at 0.07ppm (one-half of the usual standard). Kitakyushu City reported special weather conditions to the factories and requested a voluntary reduction of 20% of discharged dust, so the smog was reduced before it became serious. Also there was a merit that the factories could shorten the time to reduce production activities. From 1971 to 1974, the special weather information was reported 95 times (1971—34 times, 1972—37 times, 1973—23 times, 1974—once). In 1997, a warning regarding photochemical oxidants was announced once.

5. Impacts

(a) Business Sector:

(i) Treatment of Converter Gas (OG Method): The effect of fuel conversion and energy and resource saving was 89%, and the effect of emission gas treatment facilities was 11%. It is clear that the effect of fuel conversion, improvement of production facilities and processes, and energy and resource saving was higher than that of End of Pipe treatment methods. The OG Method could reduce the amount of discharged dust and improve the environment, while also contributing to energy saving by recycling collected gas as fuel.

(ii) Introduction of Natural Gas for Electric and Steel Industries: The introduction of LNG could cut down the amount of SO_X to zero so efforts were concentrated in reducing NO_X. The enterprises installed flue gas denitrification equipment, and Kitakyushu City established guidelines for NO_X. From 1977 to 1983, 6 groups of power plants were constructed using LNG. In Kitakyushu City, the amount of discharged SOx was greatly reduced, and the amount of discharged NOx could be controlled.

(b) Automobile Pollution Countermeasures

Related organizations and departments cooperated to carry out various pollution reducing initiatives such as automobile measures (improvement of automobile structures, promotion of low-pollution vehicles), automobile traffic measures (traffic distribution measures, physical distribution measures), and roadside measures (proper utilization of roadsides, obstacle preventive measures). These measures were based on the “Kitakyushu Basic Plan for Automobile Pollution Countermeasures” established in 1990.

(c) Capacity Building in Local Government

Because each enterprise kept track of the maximum pollutant concentration per industry, impartiality among enterprises was maintained, and enterprises could have choices in pollution control. Since the enterprises considered the attainability of their plans, the government expected that their plans were conducted smoothly. Also, as the diffused condition of atmospheric pollutant and the polluted condition were demonstrated concretely by the wind tunnel tests, the persuasiveness for the necessity to invest in environmental

pollution control was reinforced, and had a major influence on the decision making process in each enterprise.

When the warnings and alerts based on the Air Pollution Control Law were issued, the city ordered factories to reduce the amount of discharged dust and soot (20%-50%). However, once the concentration of air pollution became high, it tended to continue for a long time even though the factories reduced the amount of discharged dust, and it was difficult to see the effect of the reduction immediately. The government as well as the enterprises understood that air pollution should be treated immediately to prevent air pollution because it impacted on people's health and also disturbed the production activities of the enterprises. Furthermore, it took long time to lift the warnings and alerts in order to ascertain the improvement of smog conditions. If that type of situation continued for a long time, the factories would be severely affected.

6. Lessons

The introduction of these low-pollution production technologies (Cleaner Production or "CP" technology) was promoted in many factories in Kitakyushu City. In particular, the method to treat fuel gas from LD converters under non-burning conditions (OG Method) was developed in Kitakyushu City, and has been adopted all over the world.

The general industrial pollution investigation using the wind tunnel tests was the first environmental assessment in Kitakyushu City to estimate the influences by new enterprises before the problem occurred and was a pioneer of environmental assessments in Japan.

Although the reduction request based on special weather information was not compelling, it was an agreement between the government and the enterprises following comprehensive discussions. Because the city mayor had the authority to announce the warnings and alerts, requests for reduction worked effectively. This also supported the system in which Kitakyushu City checked the conditions of flue gas desulphurisation equipment in the factories and confirmed the implementation process.

In these ways, the Air Pollution Monitoring Centre, which observes the conditions of air pollution, has contributed to the improvement of air pollution by using a system to report warnings and alerts to large-scale target factories (approximately 30 factories) and request the reduction of the amount of discharged dust in cases of emergency

7. Future Prospects

Once Kitakyushu City suffered from serious pollution as a result of high economic growth, but cooperation with citizens, enterprises, research institutes and the local government have contributed to the solutions for air pollution, as well as the collection of valuable technologies and experiences.

Now Kitakyushu promotes international environmental cooperation utilizing these achievements, and has developed technologies and trained people through its own process of overcoming pollution. In particular, Kitakyushu City implements international cooperation activities such as acceptance of trainees from developing countries, dispatching of experts, organization of international meetings, and joint enterprises. The city accepted 1,208 trainees from 79 different countries as of 2001, and supports and contributes to environmental improvement in Dalian Model Environmental Zone in China.

At the Johannesburg Summit 2002, Kitakyushu City was recognized as a "World's Environmental Model City." Regarding it as a successful result, Kitakyushu City plans to work actively for the network cooperation among cities in the proper field for each city to promote the Kitakyushu Initiative.

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G. Dalian, China
Strengthening Air Quality Management for Sustainable Development in Dalian

1. Abstract

As an important port, trade and tourism base in China, Dalian City is also heavily industrialised. Air pollution control is under its Environmental Protection Agency (EPA) while the Environment Monitoring Centre handles air quality monitoring of both stationary and mobile sources. The main source of pollution is coal smoke and automobile emissions and the main pollutant is PM10 occasionally aggravated by sandstorms and sulphur dioxide from industry Measures implemented by the government to control air pollution include increased investment, closing down polluting industries and rapid execution of action plans. In addition high polluting industries have been relocated and new construction severely restrained, vehicle maintenance and use of high quality diesel is encouraged. Despite these measures some problems still remain. High coal usage, rather than electricity and gas use, produces smoke, this together with automobile exhaust emissions are still a problem. Dalian hopes to overcome this by encouraging high tech industries and closing down or relocating polluting industries outside the city, encouraging clean energy like wind, tidal and solar energy by levying a compensation fee in future for coal use. Cleaner production management systems will be implemented and enhanced with audits. All enterprises failing to meet cleaner production standards in future will not be allowed to expand and laws will be enforced more rigorously.

2. Environmental Setting

Dalian city is located in the southern-most tip of the Liaodong peninsula in the Northeastern part of China with one side bounded by mountains and the other three sides encircled by sea (**Diagram 1**). Its long coastline encompasses the Bohai Sea on the west, and the Yellow Sea on its eastern border. The "Bohai Rim" is one of China's fastest growing regions. Dalian's nearest international neighbours are Japan and Korea, and it enjoys close commercial and cultural links with both countries. Its geographic location is between 120º58' - 123º31' East longitude and 38º43' - 40º12' North latitude. The land area is 12573.85 km^2 including an urban area of 2414.96 km^2 occupying 6 districts, 3 satellite cities and 1 county with a total population of 5.90 million including non-peasant population of 2.75 million and average density of 468-persons/ km^2 and natural growth rate of 1.08 %. It has mild weather and four distinct seasons with semi-humid continental monsoon climate of warm temperate zone with annual average temperatures of 8 - 10ºC, the highest being 35.3ºC and lowest 21.1ºC, and no-frost period of 170 - 190 days. In summer, winds blow from the south to the southeast and in winter north to northwest with the average speed of 5.3 m/second. The highest precipitation occurs from July to September with the annual precipitation of 590 - 800 mm. The land utilization ratio is 92.8 % including 13.8 % of non-farming lands. It has vast marine spaces with a total coastline of 1906 km, which includes a and beach area of 646.7 km^2, a mainland shoreline of 1288 km and an island shoreline of 618 km (there are a total of 226 islands).

Dalian, a heavily industrialised city, is also port, trade and tourism base in China. It is one of the most open to outside world with the most vigour and is the most developed city in the northern part of China. In 2002, a total GDP of RMB 123.56 billion has been realized increasing at the rate of 11.8 % with a per capita GDP of RMB 22,340. The total investment in relation to environment protection was RMB 2.538 billion accounting for 2.05 % of the GDP and included RMB 1.405 billion for environmental infrastructure construction and RMB 1.133 billion for industry pollution control. The industrial pollution

control costs were composed of RMB 27.15 million for waste water treatment, RMB 65.42 million for air pollution control, RMB 4.56 million for solid waste and sludge disposal, RMB 2.62 million for noise control and RMB 13.25 billion for personnel management and equipment.

In Dalian, there are some 40 organisations (Agencies, Bureaus or Commissions) working for local government and each having their respective responsibilities. The Dalian Environment Protection Agency is in charge of urban air quality management and oversees planning, execution, enforcement, coordination, monitoring, etc. (the organisational chart is given in **Figure 1**).

There are more than 800 people working directly or for affiliates of the Dalian Environmental Protection Agency. Three (3) satellite cities, one county and two districts have their own environmental protection agencies supervised and guided in terms of environment protection management by the Dalian EPA. The Planning and Financial Department in the Dalian EPA, provides domestic financial support to air pollution control projects. The Pollution Control Department is in charge of formulating air pollution control schemes and project selection. The Development and Construction Supervision Department is in charge of examination and evaluation of project applications according to China's environment protection law and local regulation. The Science, Technology and Industry Department provides technical consultation for air pollution control projects and selects suitable air pollution control technology. 5 other branches are in charge of air pollution control and enforcement in 5 districts. The Dalian Environment Monitoring Centre takes the responsibility of air quality monitoring including stationary and non-stationary source. More than 1.04 million items of monitored data are collected each year. There are 10 automatic air-monitoring sub-stations set up in urban areas.

China's environmental legislation includes 2 environmental protection laws relating to air pollution control and management namely the environmental protection law and the air pollution control law, in addition more that 23 rules or regulations as well as many administration and management documents have been issued by central, provincial and local government. Also, there are more than 20 monitoring and emission standards relating to air pollution.

3. Issues and Challenges

In Dalian presently, air pollution is still the combined type of coal smoke and automobile tail gas and the main pollutant is PM-10. In 2001, the Air Pollution Index (API) was first class in 89 days, with 262 days being second-class, accounting respectively for 24.4 % and 71.8 % of the whole year. The air pollution is lighter in summer, but heavier in spring and winter. The annual average for dust in urban area is 17.4 t/km^2/month exceeding by 1.2 times the Liaoning provincial standard with PM-10 = 0.079 mg/m^3, NO_2 = 0.024 mg/m^3, CO = 0.59 mg / m^3, SO_2 = 0.031 mg/m^3 and Dust 17.4. All the main indices of air quality comply with a second class of the national air quality standard. In the whole city, emissions included were 113.2 thousand tons of SO_2 emitted (which was a 14.2 % decrease as compared with 2000), smoke 74.5 thousand tons (a 13.8 % decrease) and dust 20.4 thousand tons (a 5.1 % decrease).

In 2001, there were 7 sand storms in the Dalian area, mainly occurring in the winter and spring with the duration time of 10 – 20 hours per occurrence and an average PM-10 concentration of 0.24 to 0.80 mg/m^3. No acid rain fell during the year.

The main pollutants of industry waste gas are SO_2 = 70 thousand tons showing a 18.6 % decrease when compared with 2000; smoke 35 thousand tons (a 35.2 % decrease) and dust 20 thousand tons (a 5.1 % decrease). The main emission zone of industry waste gas is the Ganjingzi district with SO_2 emission of 31 thousand tons accounting for 45% of the total city's emissions; smoke 8 thousand tons (23 %) and dust 4 thousand tons (20%). The power generation industry is the main polluting sector emitting SO_2 = 37 thousand tons (accounting for 54 % of the total emissions); non-metal minerals emitted smoke = thousand tons (31 %), non-metal minerals also emitted dust = 15 thousand tons (75 %) of which the cement sector contributed about 11 thousand tons.

In Dalian, there are more than 0.35 million automobiles and 30 main traffic roads. From 1998 to 2002, there were RMB 0.699 billion invested by the public communication and transportation system to renew 4948 old vehicles so as to effectively enhance the grade and quality of automobiles run in Dalian with the purpose of reducing the emission of NO_X and CO greatly.

4. Implementation Strategy

(a) Increasing Investment and Implementing Pollution Control & Treatment within a Limited Timeframe:

Since the enactment of its environment protection law in 1979, the Dalian government has constantly strengthened industrial pollution prevention and control work and more funds have been invested so that some major pollution problems have been solved. During Dalian's 7th "five-year plan", the "524" project whose main thrust was air pollution control was implemented resulting in a of smoke and dust control zone of 197.3 km^2 being set up and the urban air quality demonstrably improved. In Dalian's 8th "five-year plan", projects with limited time-frames on smoke and dust control were implemented among the two sides of Shenda highway and in the area of Jinzhou and Ganjingzi districts so that 3420 tons of dust was reduced annually. In order to control dust, Dalian's cement factory installed 62 sets of treatment equipment and reclaimed nearly 10 thousand tons of dust. In Dalian's 9th "five-year plan", air pollution prevention and control was greatly enhanced by means of limited time-frame treatments at the pollution source so that several projects on environment protection were effectively undertaken, for example:

(1) Environmentally Comprehensive Treatment and Control Projects in the Ganjinzi district: Involved removal of 16.95 m^2 of waste and destruction of old factory buildings. One million tons of industrial waste was cleared away and 0.35 million m^2 of green lands were newly opened. Pollution control was carried out on 9 sets of electrical furnaces in Dalian's Iron & Steel Group so as to reduce 4000 tons of smoke and eliminate the air pollution or "red dragon" over the Ganjinzi industrial zone. Dalian Ironworks demolished its ore-sintering workshop and 2 blast furnaces with the purpose of eliminating dust pollution. After these interventions air quality measurably improved in the district.

(2) Limited Time Frame Projects in the North of the Urban Area: 18 enterprises were closed down and 146 pollution sources in 16 enterprises were treated so as to reduce 11 thousand tons of dust annually, eliminate the pollution from a lime factory in the urban area and purify the air quality around the highway exit north of the urban region.

(3) Shutting/Closing down and suspending 15 types of "small-scale" factories: In accordance with the requirement of state council concerning shutting/closing down, and suspending the "15 types of small-scale" factories, 18 factories were shut down, 19 closed down and 30 suspended in 1997.

(4) Project of up to 2 standard: As per the requirements of the State, emissions satisfying standard, had to be realized prior to the end of 1999 for all industries pollution sources in Dalian. Thus a limited time frame control had been instituted by all industrial pollution sources whose discharges did not meet the standards. By the end of 1999, 1311 industrial enterprises listed as having to satisfy standards had realized their goals. To accomplish his RMB 0.282 billion had been invested over time so as to control industrial pollution effectively and lay a solid foundation for air quality to meet standards according to different zones. 655 outlets of industry waste gas had been controlled to meet acceptable standards while pollutant discharges had been dramatically lowered. This resulted in the air pollution comprehensive index for Dalian dropping from 7.88 in 1990 to 4.41 in 2000 (**Chart 1**) and its position had changed among 47 key cities from No.27 in 1995 to No.12 in 2000 (**Chart 2**).

(b) Adjusting Industry Structure and Layout to Implement Removal and Transformation of Polluting Enterprises:

In order to enhance the overall environmental quality of Dalian city, industry structure and layout have been adjusted so that pollution-producing projects are identified and they are either removed or transformed into environmentally acceptable projects. Since 1995, 134 identified enterprises listed for potential removal were divided into lots, among which 105 enterprises fulfilled either removal and transformation criteria so that a land area of 1.3 million m^2 was vacated for development and construction of trade, tourism, residence and landscape projects. The transfer of this 1.3 million m^2 of land yielded RMB 1.1 billion and resulted in the annual reduction of 0.27 billion m^3 of industrial waste gas as well as 5605 tons of smoke and dust.

(c) Strengthen the Management of Motor vehicle to Reduce Exhaust Gas:

Besides routine petrol (gasoline) checking and testing, all diesel stations including private and state-owned enterprises have to use filters to guarantee the diesel quality. Vehicle owners have been actively encouraged to maintain automobiles in reputable motor repair shops, of which a network composed of more than 100 enterprises for checking, maintaining and repairing automobiles have been established. Moreover more than 5000 farm machines and automobiles have been specially examined and repaired. Also detection has been intensified to identify potentially unusable vehicles in order to prevent their continued use.

5. Impacts

As a result of the three "five year cycles being implemented in addition to the strict industrial and vehicular pollution – prevention efforts detailed above the air quality has been greatly improved In Dalian city.

Undertaking environmental protection together with the enhancement of social economic capacity in Dalian city was something that was literally created out of nothing and has since constantly grown and strengthened significantly. Since 1973, surveys have been

made mainly on the "three industry waste" (waste water, waste gas and waste residue) in order to urge enterprises to strengthen management and reduce pollution discharge. Since the enactment of the environment protection law, industrial pollution prevention and control efforts have ensured that enterprises have kept within legal limits. This has not only progressively strengthened overall management by means of improving administration, economy and legal aspects but has also resulted in solving some environment protection problems. Since 1990, the Dalian government has instituted large-scale pollution control and remarkable achievements have resulted from it and the total volume of pollutant discharges have been reduced year by year. By the end of 1999, discharges from all industrial pollution sources had met with established standards.

In this step-by-step manner Dalian city has entered an exclusive domain as one of the China's top cites that have realised national environmental comprehensive rectification and control goals with respect to 10 indices and became the model city for national environment protection and the national garden city. In 2001, Dalian was selected as by UNEP as a "Global 500" city.

6. Lessons

Even though progress in environment protection has been made and air quality improved in Dalian, there still exists a gap between what has been achieved in Dalian and the environmental levels in developed country of the world. These are mainly due to the fact that:

(1) The mixed air pollution is still serious: In Dalian, there are still a lot of coal-burning devices and smoke-exhausting installations so that the air pollution due to smoke has not been completely resolved. Along with this as a result of the rapid increase in the number of automobiles as well as the unplanned development of urban traffic networks and parking lots, pollution from motor vehicles has become significant. Air pollution in Dalian results from a mixture of smoke and tail gas.

(2). Unreasonable energy structure: Coal consumption in Dalian city is nearly 3 times the world average with electrical power and gas used at a low ratio. The excessive proportion of coal consumption results in a series of environmental problems that are difficult to resolve and restrain the enhancement of environment quality.

7. Future Prospects

Main Countermeasures and Tasks

(a) Adjust Economic Structure and Optimise City Layout:

Strategic adjustments to the economic structure will be promoted and the opportunities of economic development and creative innovations in Dalian will be taken advantage of in order to strengthen traditional industry, transform the high-tech product sector by developing high-tech industry and fostering tertiary industry with higher scientific and technological content, encourage higher grade products and higher production capacities, and control pollution to a minimum level during the economic structural adjustment period. By 2005, the ratio of primary, secondary and tertiary industry will reach 9:43:48, the high-tech output value will account for 30 % of GDP, the emission volume of

industrial waste gases will be controlled at 2000 levels under the same annual increase rate of 10 % of the national economic development, and the smoke will be further reduced.

The changes would involve cement plants of less than 0.5 million tons capacity in urban areas and less than 0.2 million tons in the countryside being closed down. In addition, steel casting and forging factories will be moved out of urban areas after reorganization, the stone-making and mining factories which are deleterious to the ecological environment will be eliminated and shut down; all clay brick plants will be closed down and the Dalian glass plant will be moved out of the central area and transformed.

From 2001, all new industrial zones slated for construction without satisfying environment protection requirements will not be approved to avoid any new environmental problems caused by unacceptable layout.

(b) Adjust Energy Structure and Vigorously Promote to Use Clean Energy:

The price of energy such as electricity, gas, coal, etc., should be recalculated. An environment compensation fee will be collected on coal burning and the economic leverage will be applied to encourage enterprises, institutions and households to use clean energy in order to reduce coal consumption. The coal-burning quota of each unit and department will be fixed so as to practice limiting of the supply. The charges of the increasing capacity of electricity and gas use will be reduced or exempted in order to quicken the pace of replacing coal with clean energy such as electricity and gas.

Support will be obtained from national policies encouraging demonstration and implementation for drawing gas into Dalian. The development, usage, production and construction for clean energy such as wind, tidal and solar energy will also be encouraged so as to gradually pursue a system of annual clean energy quotas. The clean energy will be used in all new small towns and residential quarters built after 2001. The clean energy will be used in all catering services in urban areas. The application rate of clean energy will be up to 50% in whole city.

(c) Reform the ways of production and operation to overall promote the industry clean production:

The establishment of clean production management systems will be speeded up. An examination standard for clean production will be formulated so as to become a basic system of enterprise management in combination with energy savings and consumption reduction. Both systems of sewage water reuse quotas and energy consumption rationing will be practiced. A qualification approval system for environment managers of enterprises will be established so that staff who fail to meet the requirements of environmental protection will not be allowed to make enterprise leadership levels and consequently both the environmental consciousness and management level will be enhanced in enterprise. Encouragement will be offered to develop clean production technology and green food.

Clean production audits for old industry enterprises will be launched. Implementation schemes will be formulated for cleaner production. Energy savings, consumption decreases and pollution reductions will be implemented enterprises with big volumes of emission. The goal responsibility system will be practiced. Clean production will be the major content of enterprise mechanism transformation and adjustment through strong policy support. From 2001, all old enterprises failing to meet cleaner production requirements may not be allowed to extend their scale of production.

Clean production audits will be strengthened for newly built, reformed, extended and moved enterprises. From 2001, project approval will mandatory in such phases as raw material purchase, manufacture, transportation, sale, usage, maintenance, reclaim, utilization and final disposal as per clean production requirement.

(d) Enforce Legal System Construction and Enhance the Legal Guarantee:

The existing legislation namely “Regulations for Environmental Protection in the Dalian Municipality” and “Detailed Penalty Regulations for Environmental Protection in the Dalian Municipality” will be amended and improved. New legislation covering “Management Regulations for Preventing & Controlling Marine Waters from Vessel Pollution in the Dalian Municipality” and “Management Regulations for Preventing & Controlling the Environment from Dangerous Chemical Waste Pollution” will be formulated and issued.

Laws will be enforced more strictly. Some stipulations of enforcement authority relating to concerned departments will be formulated and issued to define the enforcement range, balance the relationship between united and separate supervision and foster an unhindered and orderly atmosphere for law enforcement. Actions violating the environmental law will be stringently investigated and handled so as to enhance the authority of law enforcement on the environment.

Diagram 1- Map Showing Location of Dalian City

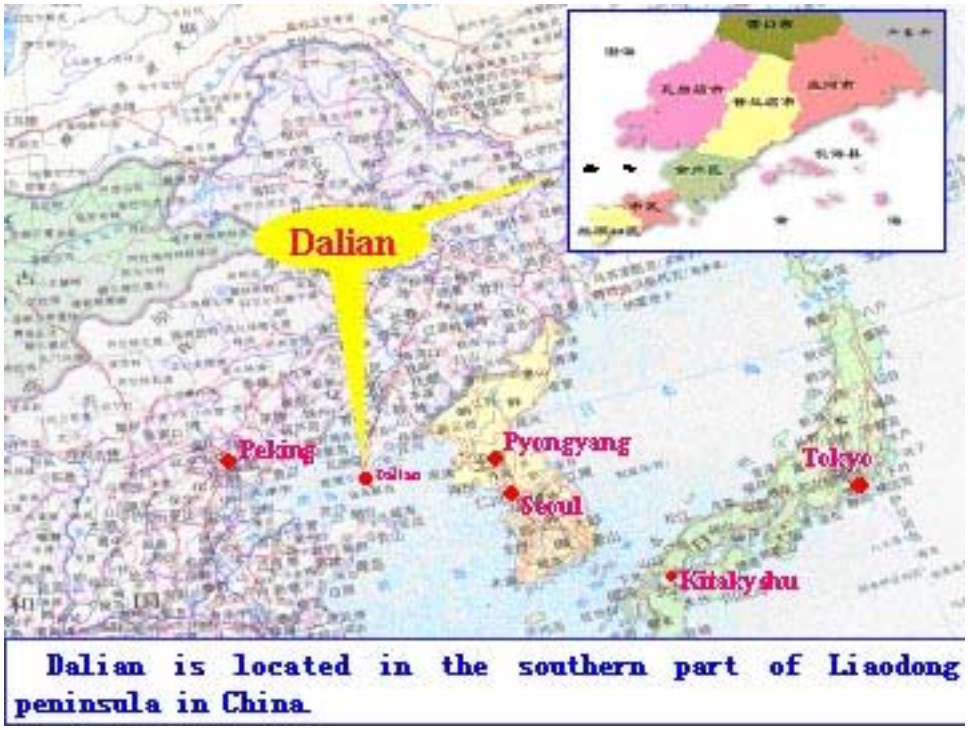


Figure 1: THE ORGANIZATIONAL CHART OF DALIAN EPA

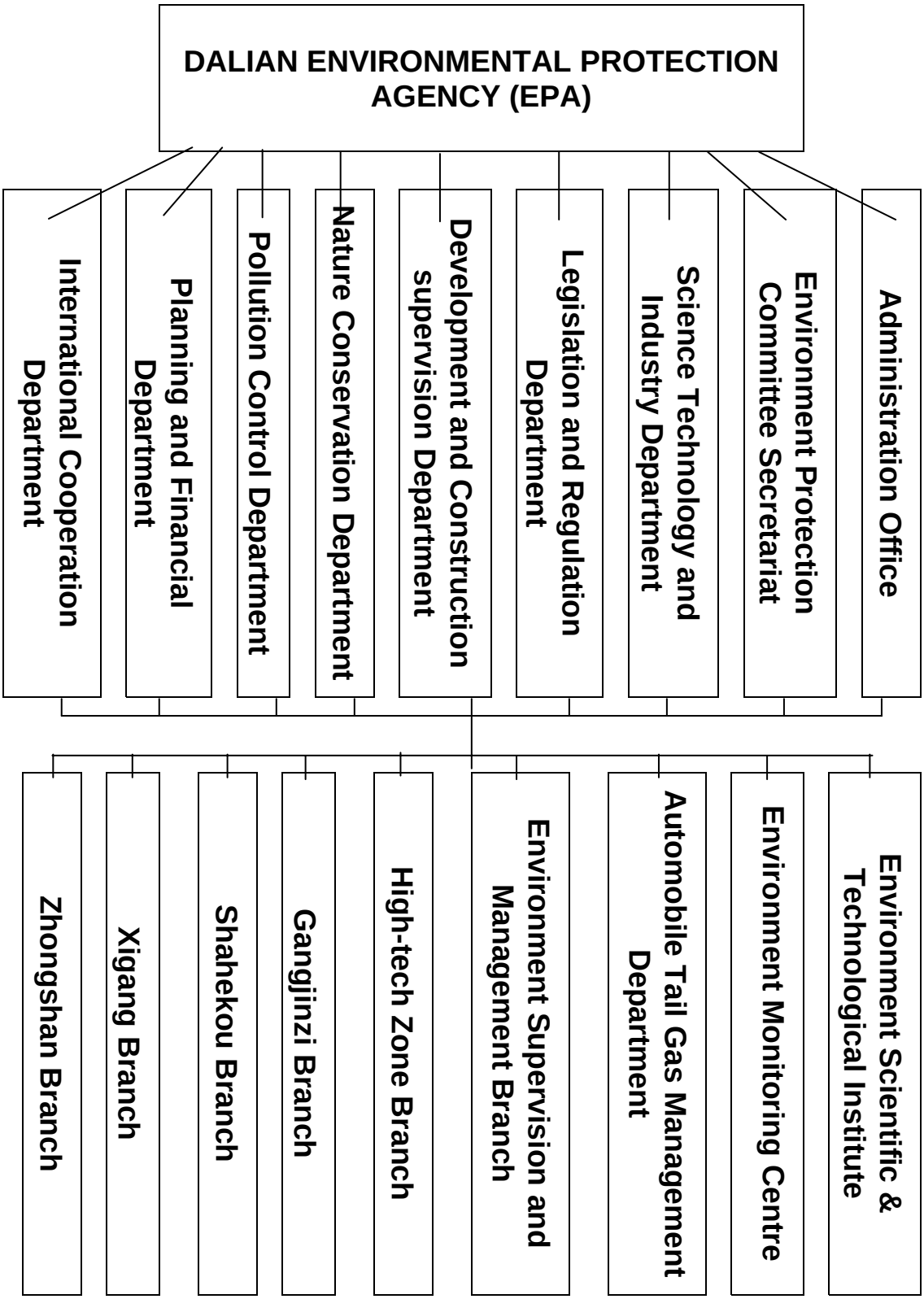


Chart 1

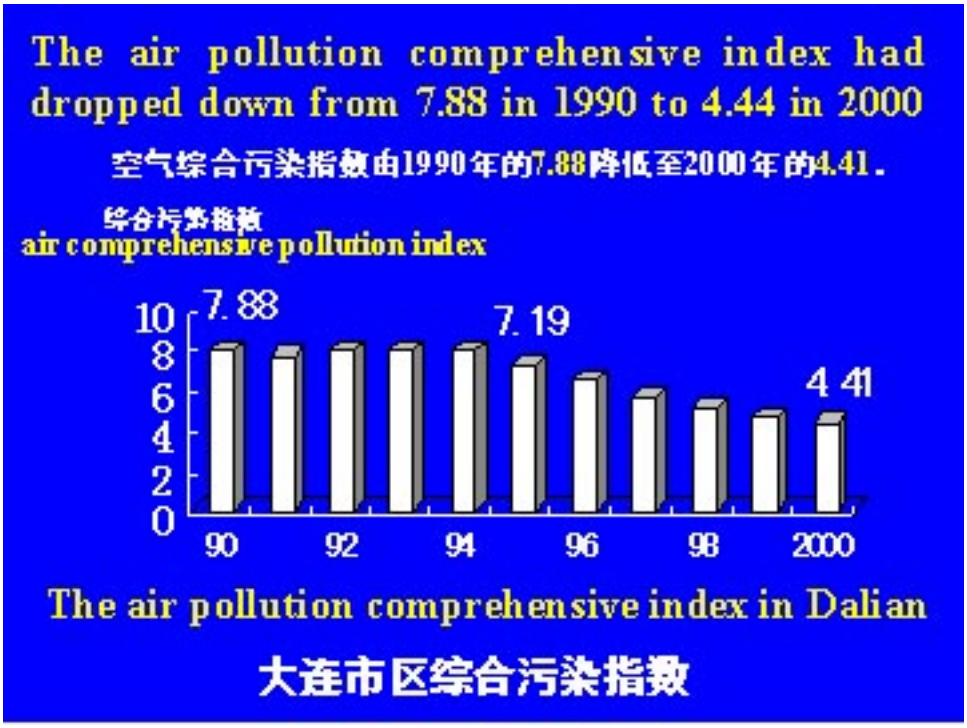
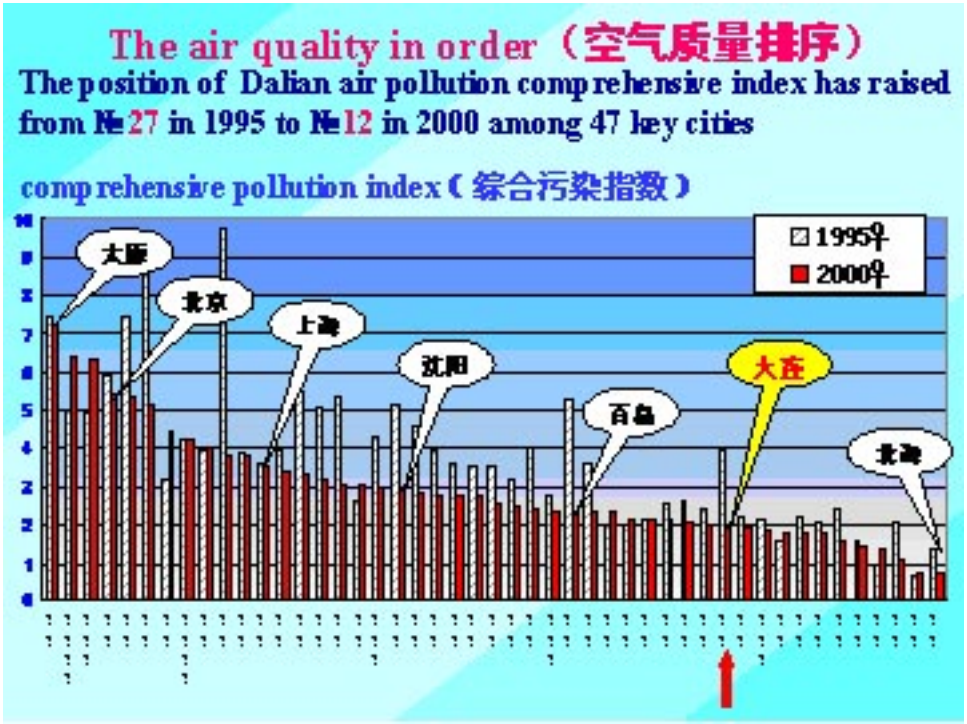


Chart 2



H. Ho Chi Minh City, Viet Nam
Air Quality Management in Ho Chi Minh City

1. Abstract

The Department of Science Technology and Environment (DOSTE) handle air quality in Ho Chi Minh City (HCMC). It has prepared an environmental management strategy from 2002-2010. Some air quality standards have been developed and the air quality management system in HCMC includes 16 monitoring stations, which include 9 ambient (background) and 7 roadside stations. Air pollution si the major environmental concern in HCMC with total suspended particulates and Carbon monoxide being the main roadside pollutants. After introduction of unleaded fuel the roadside lead concentrations though lower than the Vietnam standards even earlier, dropped significantly and is now close to the WHO standards. Air Quality index in traffic areas are in the moderate to poor category while in residential areas they are in the good to moderate category. Emissions from Industrial sources have become serious recently and are being controlled by a variety of command and control measures including imposition of end-of-pipe treatments and cleaner production measures to meet environmental standards. Also energy savings through improved efficiencies have resulted in 15% increase in savings and increased production. Also used have been communication and support measures such as a low-interest fund for pollution mitigation available to industries. Vehicles that are old or use old technologies are also causing air pollution. Use of clean LPG/CNG alternative fuels has been started on a pilot scale. Use of unleaded gasoline, upgrading and widening streets, limiting use of old vehicles in the city are some of the moves towards reducing air pollution from traffic sources. Institutional and financial constraints still exist.

2. Environmental Setting

The total area of Ho Chi Minh City (HCMC) is about 2095 km^2 with 18 inner urban districts occupying an area of 140 km^2 [**Diagram 1**]. The official population is 5.285 million, and the number of unregistered persons is estimated to be over 2 million. The average population density is 2,523 persons/km^2 (*1*).

During the past decade, HCMC has implemented policy reforms and developed a market economy, entering into a period of rapid modernization and industrialization. As Vietnam's major industrial and commercial centre, HCMC in 2001 contributed approximately 17% of the national GDP (VND 484,492 billion = US$32.3 billion). GDP per capita is US$1,460 (1).

Government in HCMC: The People's Committee represents the government in HCMC. The organizational structure of HCMC's government includes a chairman, five vice-chairmen and a number of municipal departments [**Figure 1**]. The environmental management structure in HCMC is shown in **Figure 2**. The Department of Science, Technology and Environment (DOSTE) is one of the key departments that are responsible for the air quality management in HCMC. DOSTE has prepared the environmental management strategy from 2002 to 2010, which includes an air quality management action plan. DOSTE's main functions in environmental protection include:

- Developing and guiding the implementation of strategy and policy of environmental protection, plan to prevent, control and remedy environmental degradation, pollution and incidents;

- Organizing, establishing and managing monitoring systems, periodically assessing the current state of the environment, forecasting environmental changes;
- Appraising EIA reports on projects as well as production or business establishments;
- Issuing or revoking, certificates of compliance with environmental standards;
- Supervising, inspecting, checking the observance of environmental protection legislation; settling disputes, appeals or complaints concerning environmental pollution;
- Educating, propagandising, disseminating knowledge and drafting legislation on environmental protection;
- Organizing research and development activities and application of scientific and technological advances in the field of environmental protection; and
- Developing international relations in the field of environmental protection.

Existing Legislation, Regulations, Standards for Pollutants: Some air quality standards have been developed and issued since 1995 and are as follows:

TCVN 5937: 1995 - Air quality - Ambient air quality
TCVN 5938: 1995 - Air quality - maximum permitted concentration for toxic components in the air
TCVN 5939: 1995 - Air quality - Industrial emission standards - inorganic substances and dust
TCVN 5940: 1995 - Air quality - Industrial emission standards - organic substances
TCVN 6438: 1998 - Air quality - Road vehicles emission - maximum permitted limits

More than 50 TCVN exist on analysis methods for air quality standards and air emissions

Table 1 Vietnamese and World Heath Organization Pollutant Standards

Pollutant	**VN Standard**	**WHO Standard**	**Time Period**
Particulate Matter PM	200 µg/m^3	150 µg/m^3	24 hours
Sulphur Dioxide SO_2	300 µg/m^3	125 µg/m^3	24 hours
Nitrogen Dioxide NO_2	100 µg/m^3	150 µg/m^3	24 hours
Carbon Monoxide CO	10 mg/m^3	10 mg/ m^3	8 hours

Air Quality Monitoring System: The air quality management system in HCMC includes 16 stations established in a stepwise manner:

End 1992: The network included four ambient air-monitoring stations (PM, SO_2, NO_x) and three stations for roadside monitoring (PM, NO_x, Pb, noise).

June 2000: Installed four automatic air quality monitoring stations supported by UNDP & DANIDA, included two urban background stations (monitor PM_{10}, SO_2, NO_x, CO, O_3) and two roadside stations (monitor PM_{10}, NO_x, CO, O_3)

November 2002: Five more automatic air quality monitoring stations were installed with NORAD support, including three urban background stations (monitor PM_{10}, SO_2, NO_x, O_3) and two roadside stations (monitor PM_{10}, NO_x, CO, O_3)

The Budget for HCMC People's Committee covers maintenance and operation of the entire air quality monitoring system including staff.

Air quality situation: The results of ambient air monitoring have reinforced the fact that air pollution is of major environmental concern in HCMC and is likely to be causing significant health impacts. **Figures 3 and 4** show the results of ambient monitoring of particulate matter (PM_{10}) in three roadside air quality-monitoring stations in HCMC.

Besides TSP (total suspended particulates), CO (Carbon monoxide) is also a major pollutant in roadside air in HCMC. **Figure 5** shows results of ambient monitoring of CO in one automatically monitored roadside air station in HCMC. Lead levels monitored in Hang Xanh, Phu Lam and Dien Bien Phu-Dinh Tien Hoang during 1996-2000 are lower than the Vietnam standard, but 4-6 times higher than WHO standards. However, lead concentration decreased substantially after July 2001 due to widespread unleaded gasoline use (**Figure 6**). Monitoring results from the automatic air quality monitoring stations are shown in **Figure 7**. The Air Quality Index (AQI) in traffic areas is mainly in the Moderate to Poor category while AQI in residential areas is usually in the Good to Moderate category.

3. Issues and Challenges

Air Pollution from Sectoral Perspectives

(a) Air Pollution Issues from Industry:

HCMC has about 28,000 industries, the majority of which are small-scale industries located mainly within residential areas. There are about 700 medium- and large-scale industries, about 500 of which are located in the urban districts, but few of them have pollution control facilities. Ten industrial zones (with 104 enterprises in operation) have been created along with two export-processing zones (with 120 enterprises in operation).

In 2001, HCMC had 28,573 industrial establishments, of which 128 were centrally state-owned enterprises, and 152 were locally state-owned, 27,901 private enterprises, and 390 industrial joint venture establishments. Industry comprised 46.6% of the City's GDP. The value of industrial production in 2001 reached VND 66,927 billion, an increase of 16.2% over 2000 (*1*).

Table 2. Industrial Establishments (by Main Industrial Activities) in HCMC (*1*)

Manufacturing industry	**1995**	**1996**	**2000**	**2001**
Foodstuff and Beverage	4770	4083	3665	3784
Tobacco	9	10	6	6
Textile Products	5583	5065	3714	3398
Paper and its Derivatives	552	486	670	752
Chemical and Chemical Products	518	630	651	688
Rubber and Plastic Products	2053	2106	2673	2792

Air quality are has recently become a serious problem as a result of emissions from industries such as cement plants, steel mills, fertilizer plants, chemical factories, rubber processing plants and tobacco manufacturing.

Table 3 Pollution emissions from main industrial activities (tons/year)

	Industrial Activity	Capacity	TSP	NO_2	SO_2	CO	Hydrocarbon
01	Power Plants	1,751 MW	646	8,773	54,633	1,966	727
02	Boilers & Furnaces	210,000 ton FO / year	578	2,016	78	84	52
03	Steel Mills	259,000 ton steel / year	1,787		466	18,907	
	Construction Material (cement, tile,)		12,793	1,336	624	153	40

(Source: DOSTE-2000)

(b) Air Pollution Issue from Transportation:

A survey carried out in October 2002 revealed that there were 2,225,000 motorcycles and 189,000 automobiles of all kinds officially registered in HCMC. While many trucks and buses were old, and used obsolete technology, the majority of the motorcycles, cars and vans were relatively new, but tended to use old technology and have no pollution control devices.

The public transport (bus) network of the city only meets 3% of the total demand (*2*). The remaining 97% demand for transport is satisfied by motorbikes (56%), bicycles (30%), cars (3%) and by foot (8%). Transportation infrastructure is poor; the density of the traffic system is 0.81 km/km^2 (standard = 4 - 6 km/km^2); and average traffic speed is only 4-5 kmph.

The use of clean (LPG/CNG)/alternative fuels for vehicles in HCMC is limited to some pilot projects.

By far, the greatest concerns of air pollution in HCMC are that caused by vehicle emissions and are affecting public health.

Table 5 Estimates of pollution emissions from transport in HCMC (tons/year)

Year	Number of Vehicles		TSP	NO_x	SO_2	CO	Hydrocarbon
	2-wheelers	Automobiles					
1997	1,289,000	105,000	2,014	16,368	4,331	113,255	13,295
2000	1,600,000	123,000	3,182	25,846	6,843	186,843	21,006

4. Implementation Strategy

Controlling Industrial Pollution

(a) Command and Control measures: As a result of a pollution survey of 265 industries in HCMC, two "black books" were compiled that listed 87 polluting industrial enterprises. These enterprises have been asked to undertake pollution control measures (such as end-of-pipe treatment and cleaner production methods) to meet with environmental standards.

(b) Economic Instruments: *Cleaner Production (CP) Measures:* A project entitled, "Reduction of Industrial Pollution in HCMC", supported by the United Nations Industrial Development Organization (UNIDO) and funded by the Swedish International Development Co-operation Agency (SIDA), was launched in 15 companies which included food processing, textile-dyeing processing and pulp and paper industries as a demonstration exercise. Implementation of cleaner production measures in these companies contributed significantly to environmental improvement. The Government and UNIDO are now approving phase 3 of this project.

A project on energy saving and its efficient use, supported by the European Union (EU), has been implemented in HCMC since 1998. Under this project, 40 businesses (including industries, hotels, research centres) attended two training courses on energy audit, cost-benefit analyses, market research and establishing a project; and five pilot projects (in four industries and one hotel) were implemented.

(c) Communication and Support Measures: A Revolving Fund for Pollution Mitigation was established to support industries in environmental protection. A low-interest loan (at 0.85% a year) will be available to industries to invest in pollution control measures and technologies. At present, enterprises are being evaluated for receiving loans from this Fund.

Controlling Air Pollution from Traffic

- By 2003, all vehicles have to be inspected annually to insure that they meet with environmental standards.

- In July 2001, a programme to ensure that all vehicles in Vietnam were using unleaded gasoline was phased in.

- HCMC is one of the cities selected (for the period 1999-2001) for the project "Analyses of Technical Options for Mitigating Environmental Emissions from the Urban Transportation System in Selected Asian Countries", funded by SIDA under its Asian Regional Research Programme in Energy, Environment & Climate at the Asian Institute of Technology (AIT), Thailand.

- A project "Energy, Transportation and Pollution" supported by the French Agency for Environment and Energy Management (ADEME) and AIT aims to establish and conduct a programme on urban transportation in HCMC (2000-2001).

6. Impacts

(a) Industrial Pollution Control:

As a result of CP measures employed the project "Reduction of Industrial Pollution in HCMC", realised significant environmental improvements including reductions in wastewater discharges (20 - 66%), air emissions (30 - 70%) and solid waste generation (up to 27%).

For wider dissemination of CP concepts and benefits, DOSTE conducted series of training programmes that targeted nine environmental sensitive sectors and 1,000 small & medium enterprises in HCMC for two years, in 1999 and 2000.

The EU supported project on energy saving and its efficient use showed a 15% increase in energy savings and an increase in production capacity for the industries that participated.

In early 2001, a "Green Book" listing 50 enterprises that successfully met the environmental protection requirements was published to encourage and raise public awareness about environmental protection.

(b) Traffic Pollution Control:

Apart from the programmes that are to be instituted, projects concerned with improving infrastructure, upgrading and widening streets, planning routes and transportation timetables - especially during rush hour, and limiting the use of old vehicles in the City have contributed to a reduction of pollution from traffic in the past few years.

7. Lessons

Constraints to Air Quality Management Activities in HCMC

(a) Institutional/Organizational Constraints: There is limited enforcement of effluent standards, and consequently, little incentive for industries in HCMC to invest in pollution control. The poor implementation and enforcement are due to a lack of manpower, specific knowledge, technologies and materials.

(b) Financial constraints: The high treatment costs of pollution, which can affect the price of a product, create difficulties in meeting standards. Penalties charged are small compared to the cost of treatment, which means that polluters are prepared to pay the fines rather than take measures to reduce their emissions. Economic instruments (such as environmental fees, pollution fees and the polluter pays principle) are seldom used.

(c) Other Constraints: One of the drawbacks of environmental management is the limited participation of the public in the policy-making activities of the Government. Environmental problems do not appear to be among the priorities of other government agencies. For example, if the police imposed strict fines on vehicle users who create too much noise, smog and dust, the pollution level from traffic would be lower. Enforcement sometimes depends on the prevailing economic situations and on personal attitudes.

HCMC's experiences in air quality management (such as establishing the air quality monitoring system, measures in controlling air pollution, public awareness programs, air quality management action plans, etc.) could be completely replicated in other cities in Viet Nam.

7. Future Prospects

Future Directions: The City will continue to implement the following measures/projects to reduce air pollution:

- Command and Control measures;
- Communication and Support measures (e.g. Revolving Fund for Pollution Mitigation);
- Project on Reduction of Industrial Pollution: Cleaner Production Program in HCMC, supported and funded by SIDA;
- Project on Energy-Transportation and Pollution, supported by the Agency for Environment and Energy Management-ADEME (French) and Asian Institute of Technology-AIT.
- Action plans for air quality management that were included in the Environmental Strategy in HCMC during 2002-2010.

The following are potential air pollution control projects requiring proposals for collaboration and outlined in the *Action Plan for Air Quality Management* (*3*)

(a) Mitigating Air Pollution from Stationary Sources

- Implement programmes for abatement of industrial emissions;
- Review industrial emissions standards for key industries;
- Identify major sources of industrial air pollution;
- Revise penalty charges for exceeding emissions standards;
- Increase the number and improve the quality of emissions inspections;
- Introduce compulsory self-monitoring of emissions;
- Develop a revolving fund for pollution abatement; and
- Examine feasibility and introduce charges for industrial emissions.

(b) Mitigating Air Pollution from Mobile Sources:

- Establish a motor vehicles inspection system; and
- Strengthen vehicle emissions enforcement capability.

(c) Improving Fuel Quality:

- Promote use of cleaner fuels; and
- Examine potential for alternative fuels.

(d) Reducing Emissions from Vehicles:

- Introduce pollution control technologies.

(e) Reducing Traffic Congestion and Improving Traffic Flow:

- Establish transport policies to improve future accessibility and minimize congestion; and
- Formulate transport policies to encourage use of public transport.

(f) Setting up an Air Quality Monitoring & Modelling System

- Monitor air quality in industrial areas;
- Establish GIS-based data including information related to pollution sources; and
- Use modelling software to forecast pollution levels in the city.

(g) Raising Public Awareness

- Develop a public outreach programme.

(h) Political and Institutional Issues

- Enhance the capabilities of the environmental management agency and relevant institutions.

(i) Monitor Implementation, Input and Coordination of the Air Quality Action Plan

(j) Studying the Impact of Air Pollution on Citizen's Health

- Conduct an emission inventory;
- Identify air pollution levels;
- Support studies on pollution-related health problems;
- Analyse the relationships between air pollution and health/mortality; and
- Make recommendations for improvement.

Air pollution problems as a result of emissions from both industry and transportation are of most concern of authorities and people in HCMC. Implementing measures/projects for controlling air pollution in HCMC are more and more effective. However, the air quality management is a multi sectoral issue so it requires the cooperation of many institutions including domestic and foreign partners (**Figure 8**). Implementing the air quality management action plans will contribute to overcoming existing constraints and problems and help achieve in a stepwise manner the City's goals for sustainable development

Cooperation between Kitakyushu Initiatives Network cities should focus on the following main areas: (a) Enhancing the capabilities of local cities in environmental management; (b) Developing public outreach programmes to raise public awareness; (c) Introducing and transferring state-of-the-art pollution control technologies as well as clean fuels; and (d) Studying the impact of air pollution on citizens' health.

8. References

(1) Statistical Yearbook, 2001
(2) Vietnam Register 2002 – Integrated Action Plan to Reduce Vehicle Emissions in Vietnam (ADB)
(3) Environmental Strategy in HCMC 2002 - 2010

Diagram 1 – Map Showing Location of HoChi Minh City

Figure 1. Organizational Structure of Local Government HCMC

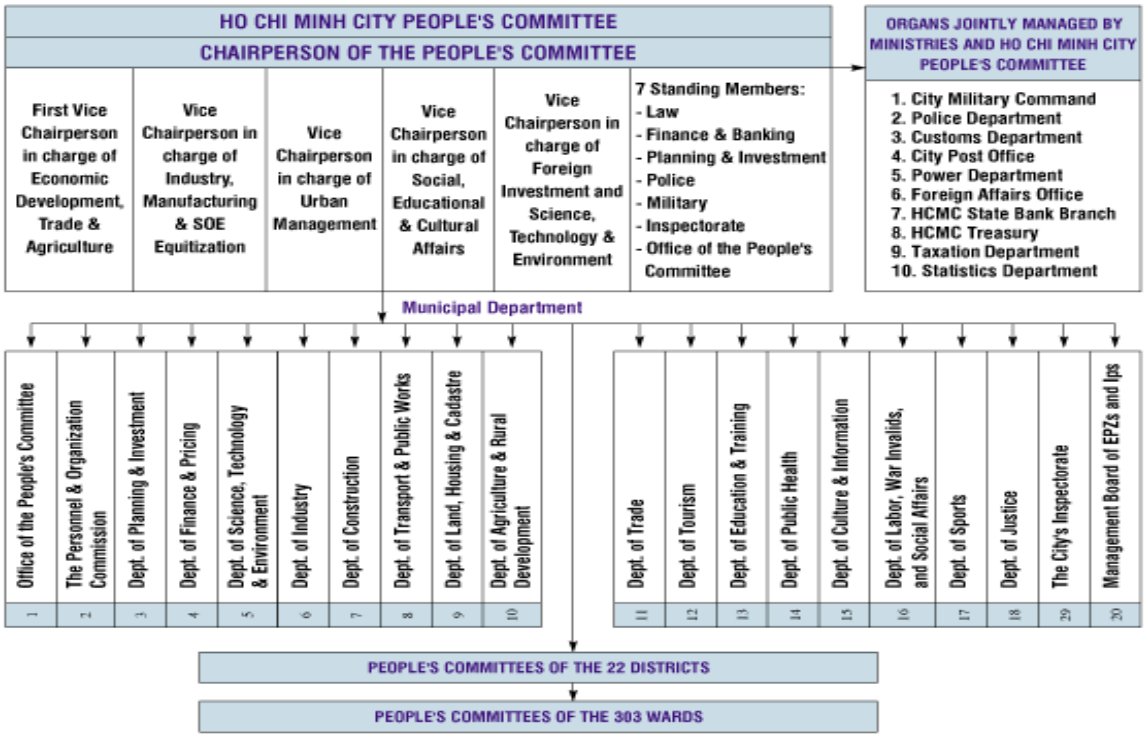
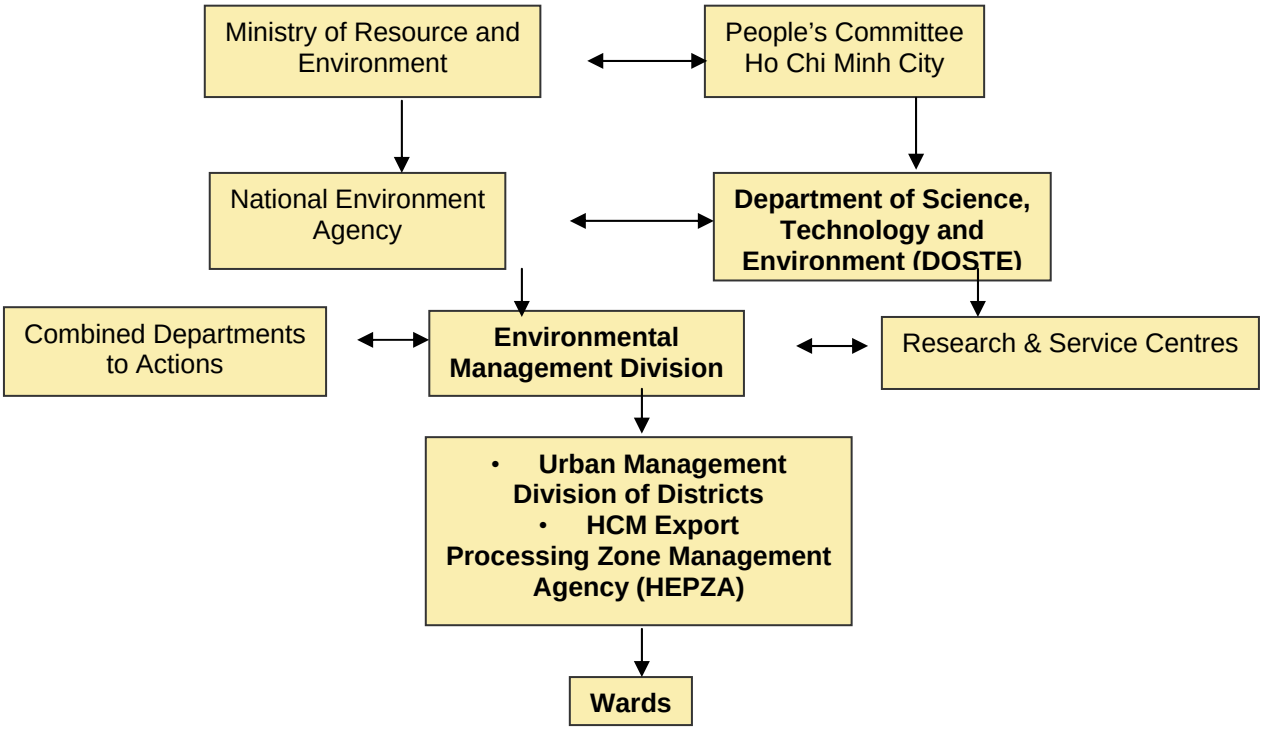


Figure 2. Environmental Management Structure in HCMC



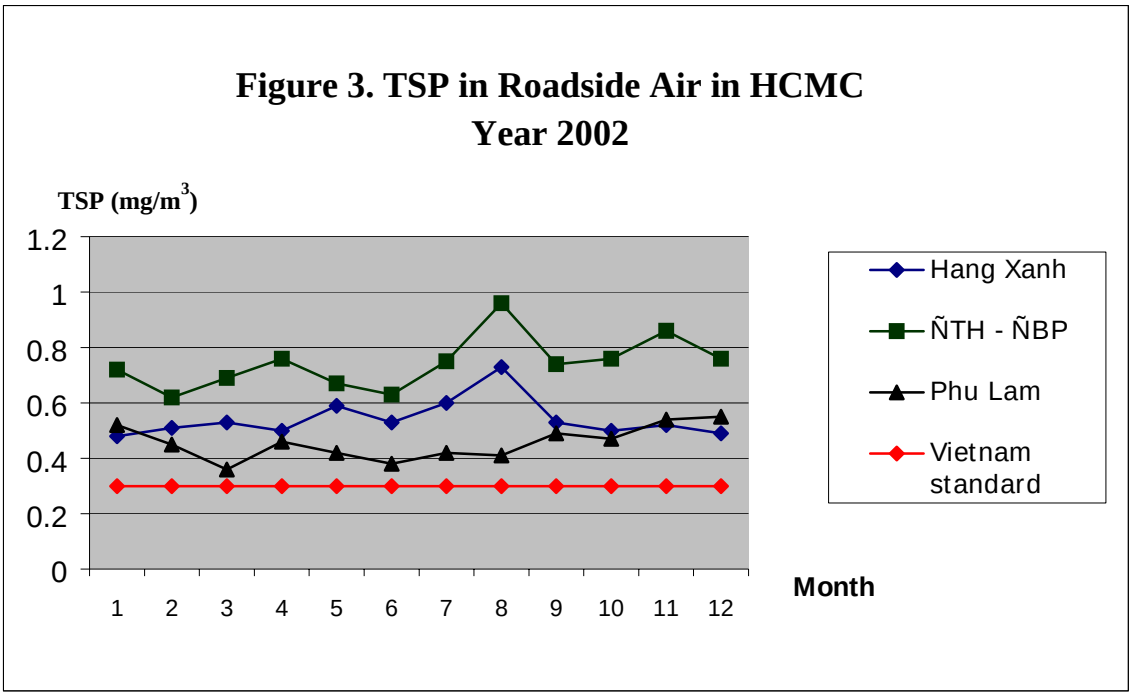


Figure 4. Trend of TSP in Roadside Air in HCMC during 1995-2002

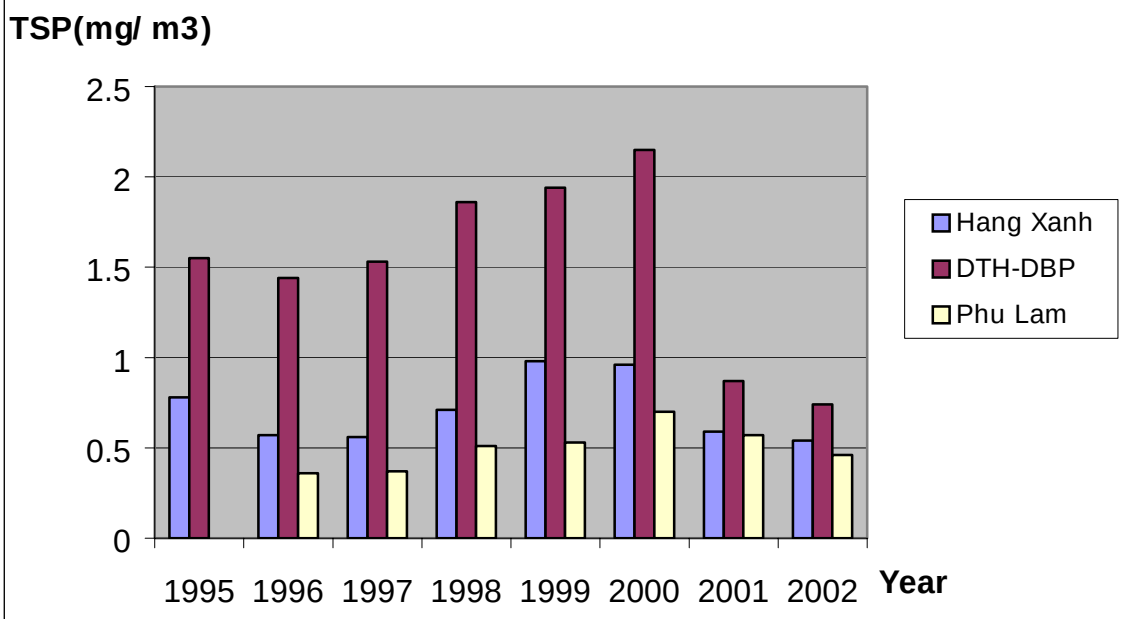
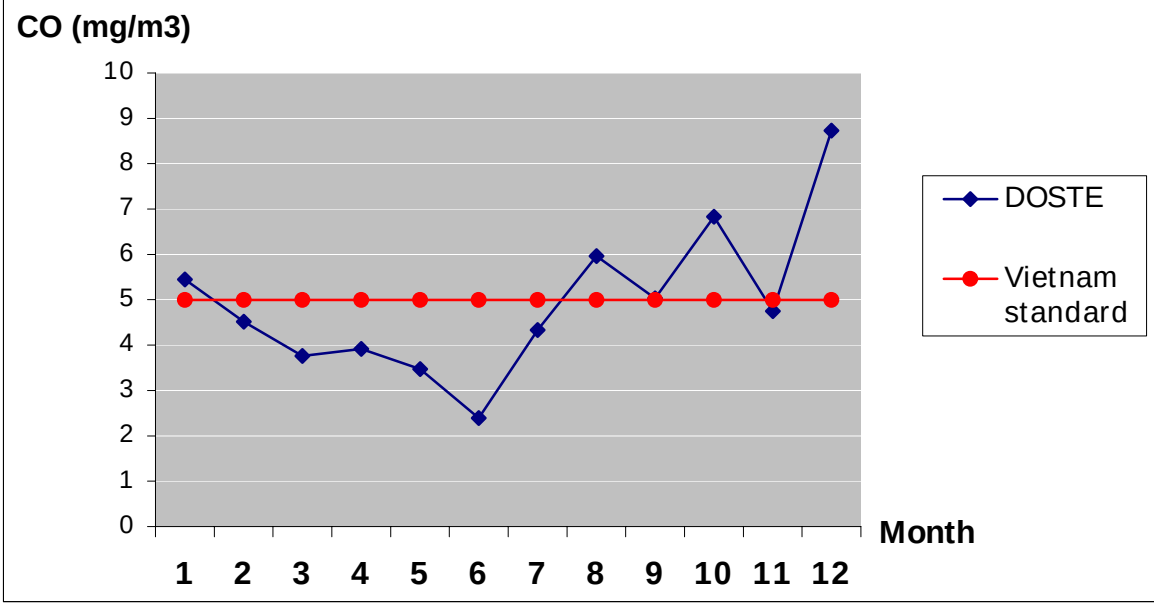


Figure 5. CO Concentration Measured by Automatic AQMS in HCMC (2002)



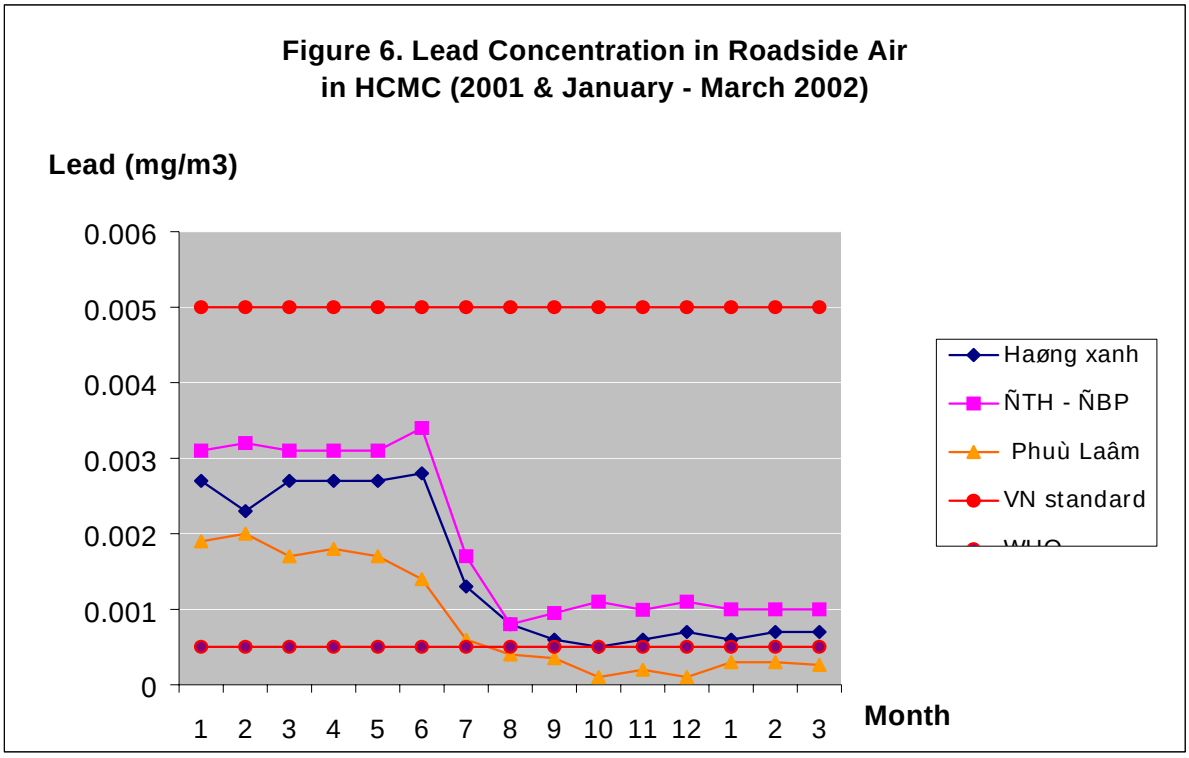
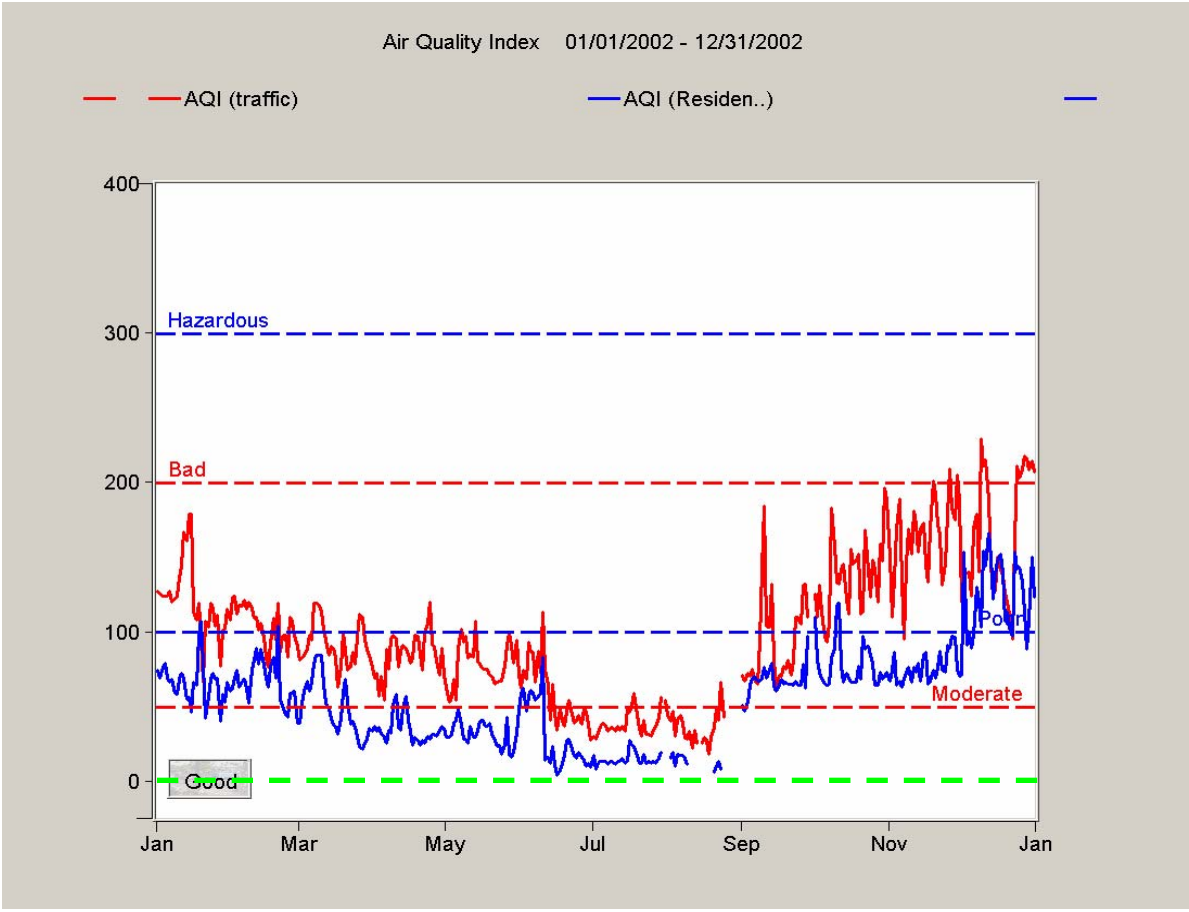


FIGURE 7. DAILY AIR QUALITY INDEX (AQI) IN 2002



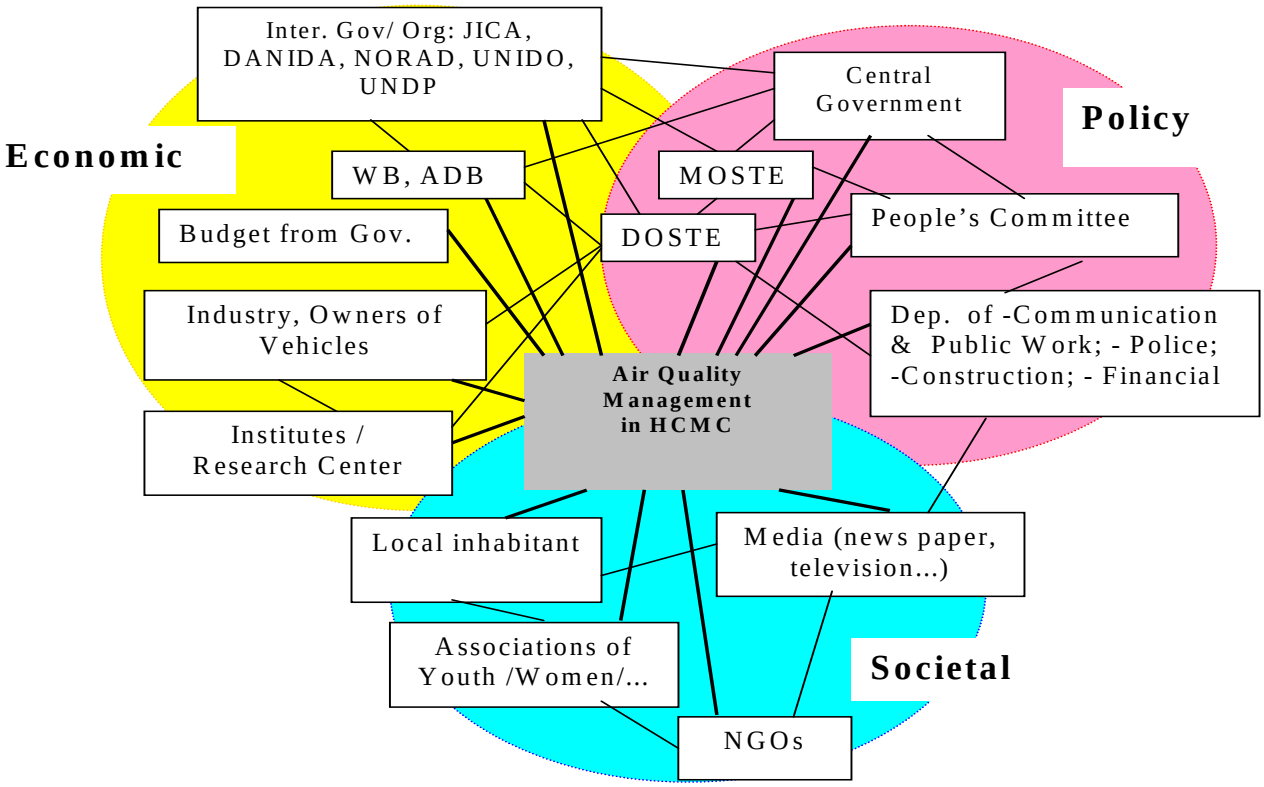


Figure 8. Networks for Air Quality Management in HCMC

I. Weihai, China
Clean Fuel, Centralized Heating System, Efficient Public Transportation, the Key for Urban Air Pollution Control

1. Abstract

Even though this coastal city has had rapid urban, population and economic growth its environmental quality is one of the best in China. Air pollution sources are mainly cooking, heating and vehicle emissions. To overcome this the local government has encouraged the use of clean cooking fuels, central heating systems and an efficient public transport system. This was initially carried out by the government using subsidised LPG but due to the inconvenience of the heavy cylinders involved subsequently switched to piped coal gas. The volatility of coal prices requiring increased government subsidy has mandated the consideration of available natural gas as a joint foreign venture for cooking without subsidies. Similarly wood and coal burning low efficiency stoves, used for heating were replaced by central heating systems through the establishment of a Heating and Power Company, whose plants were fitted with pollution control devices and supplied both electricity and steam to factories and apartments, residents of which had their heating subsidised. The Wehai government developed its transport system to offer the public better service and is moving towards getting the fleet to use LPG, also it is encouraging a taxi service to counter the increased use of motorcycles and private cars. The government has also upgraded its air quality monitoring equipment by installing automatic systems and publishes the results as well as forecasts daily in the press. The public has also been made aware of the health aspects and encouraged to report any violators to the environmental protection agency. Despite these measures use of coal is increasing in China and even though low sulphur coal and desulphurizers are being used, the total sulphur dioxide emissions are rising. Vehicular emissions are also rising due to increased private car ownership and poor maintenance.

2. Environmental Setting

Weihai is a coastal city, located in the eastern tip of China's Shandong Peninsula and is surrounded by sea on three sides facing Liaoning Peninsula to the north and the Korean Peninsula and the Japan Islands to the east. Its area is 5436 km^2, with the population of 2.45 million persons and is the "doorway" to Beijing and Tianjin, thus bearing the name of "coastal front of China". After China opened its borders to the outside world, Weihai developed rapidly. Weihai's GDP increased from 2.56 billion RMB in 1987 to 62.7 billion RMB in 2001 and during that same period the urban population grew from 233,000 to 533,400 and the developed urban area increased from 13.1 km^2 to 43.65 km^2. Though the economy, population and urban area have developed rapidly environmental quality remains the highest in the country. In 1990, the city was honoured by being named the premier National Sanitary City in China. In 1997, Weihai was further honoured by being one of the six cities in China nominated as an Environmental Protection Model City (first cohort). In 1996 and 2000, the city was twice awarded the title "The Best Example For Improving Living Environment In The World" from the UN Human Living Centre. Recently all three cities under its jurisdiction got the award of " Environmental Protection Model City ". That was a first for China.

Like cities in other developing countries, Weihai faces heavy pressure for urban air pollution control. The air pollution sources are mainly due to cooking, heating and vehicle emissions. Through a mix of administrative and economic mechanisms the Weihai government has encouraged its residents to use clean fuel for cooking and the centralized system for heating. It has also established an efficient public transportation system. Thus although the urban area has developed and the population and GDP has grown rapidly air quality remains first class in China with some parameters like TSP even improving.

Table 1 DEVELOPMENT AND AIR QUALITY IN WEIHAI

Year	GDP (billion Yuan)	Developed urban area (km^2)	Urban Population thousands)	SO_2	NOx	TSP
1987	3.324	13.10	233	0.031	0.017	
1988	5.061	14.00	243	0.035	0.019	
1989	5.729	14.30	251	0.033	0.020	
1990	7.201	14.70	257	0.035	0.016	0.118
1991	8.756	16.80	265	0.014	0.018	0.129
1992	12.742	20.20	278	0.009	0.016	0.124
1993	17.617	32.70	294	0.019	0.020	0.147
1994	26.468	38.61	419	0.020	0.017	0.143
1995	32.660	38.61	438	0.018	0.019	0.156
1996	37.883	43.00	462	0.021	0.020	0.184
1997	42.865	43.27	485	0.021	0.020	0.168
1998	47.000	43.27	496	0.020	0.019	0.148
1999	50.080	43.55	508	0.019	0.021	0.115
2000	56.089	43.65	522	0.023	0.029	0.129
2001	62.710	43.65	533	0.033	0.028	0.101

3. Issues and Challenges

(a) Encourage Clean Cooking Fuel

As a developing country food and food culture in China are both important, rich and the methodology is quite complicated. Most Chinese spend more than three hours in preparing food each day. Consequently, more than half of the energy consumed in households is for cooking. Twenty years ago in Weihai, as is still the practice in most rural areas in China, people used grass, leaves, branches of tree and stems of corn and wheat for cooking. During the winter, all combustible materials that could be used for cooking were collected in the home from the fields and mountains thus leaving the land bare and open to strong winds that caused serious damage to the ecology. Moreover, cooking facilities were also very poor, of extremely low efficiency (only about 15%) and during the cooking process smoke was everywhere, causing serious air pollution.

(b) Use of Centralised Heating Systems

Heating in households and factories is also a big source of air pollution in the urban area. In China, previously there is a regulation during its planning economy period that there be no heating at all south of the Yangtze River; between the Yangtze and Yellow Rivers there was only heating in offices and none at homes; north of the Yellow River there was heating both at offices and homes. Letting one have heating meant that the government gave one the money to be able to afford heating. Weihai was located in the area between the Yangtze River and Yellow River, so Weihai only had heating in the office and none in the homes.

The regulation was abandoned with China's entry to a market economy. Along with the improvement of living standards, residents did not like staying cold homes in the winter. Preferring a comfortable temperature both in the office and at home, they began to heat their homes during the winter. In the beginning very simple facilities like a small stove was used for heating. The stoves were placed in the living rooms with steel pipes connecting the stove to the outside. Coal or wood was used for heating. The efficiency of the stove was very low (less than 30%) and the pollution that resulted was very serious. During mornings when all the stoves were lit, heavy smoke was everywhere and sometimes it was difficult to breathe. By the late 1980's, some apartment buildings working together installed a small boiler to heat the adjacent areas. While this was somewhat better than the stove as the efficiency of the small boiler was about 40-50%, the dust, noise of the blower and the SO_2 produced still contributed to environmental problems.

(c) Developing the Public Transportation System

Vehicular emissions have gradually become the major urban air pollution source in developed countries. Weihai now faces the same challenge. In 1987 Weihai only had 22,000 vehicles by 2002 however the number had grown to 457,200 (a 21 fold increase compared with 1987). The problem of vehicular emission control became a major task for the Weihai government.

Prior to 1973, Weihai had no public transportation facilities and all the residents go to work by bicycle. In 1974, Weihai began to establish a public transportation system, but it only had 4 buses, which grew to 23 buses by 1987. After China opened to the outside of the world and pursued economic reform, urbanization grew rapidly. An improving lifestyle coupled with longer transport distances and low safety, made residents discontented with

using bicycles. They sought a speedier transportation method. During this period, in most countries, a boom in the use of motorised bicycles ea being experienced. Because motorised bicycle emissions are 3 times high than cars, it caused very serious air pollution besides a lot of traffic accidents.

(d) Improving the Monitoring System, Initiating Public Information

Since Weihai began monitoring air quality in 1982, the methods and equipment have been updated several times. In the beginning, only SO_2 and NOx, were monitored. This was done during each of the four seasons, three days a season, three times a day and 20 minutes at a time. The samples were collected in the field and analysed in the lab. In 1988, monitoring for TSP was included and with the use of continuous sampling equipment sampling was undertaken 5 days a season, 24 hours a day. In 1994 the frequency of monitoring was increased to 15 days a season. In 1998, monitoring was done 15 days a month.

4. Implementation Strategy

(a) Encourage Clean Cooking Fuel

Weihai does not have oil or natural gas resources but from the early 1980's, the government began to encourage residents to use clean fuel for cooking. The government established a company to transport the liquefied petroleum gas (LPG) from the oil refinery to Weihai and used containers to distribute the LPG to the residents. Because LPG was expensive a 15 kg container, which could be used for a month, cost 25 Yuan. This represented a half-month's wage of a worker at the time. Without a subsidy the workers would have been unable to afford it. As a result the Weihai government decided subsidize 10 Yuan from its revenue to government servants while factories subsidized the 10-Yuan for their workers, this meant that residents themselves paid only 15 Yuan. In this way the residents of Weihai were encouraged to use LPG for cooking and along with the increase in salary, using LPG for cooking became popular. The government gradually reduced the subsidy, stopping it totally in 1990. However the use of LPG for cooking was not convenient, because the container was very heavy and not easy to carry up and down stairs, especially for women and older people. Also storing an LPG container is not safe, and besides it looked like a bomb alongside the beds in the residences where they were usually stored.

In 1990, the Weihai government invested 200 million Yuan and constructed a 160,000 m^3/d coal gas factory and piped network, using coal to generate gas and through the pipeline was able t0o distribute gas to households. This was convenient, as residents did not need to carry the heavy container. However the cost was higher than LPG and the government had to subsidize the cost to encourage residents to use it. In 2001, because the price of coal increased, the cost of coal gas also grew and reached 1.96 Yuan/m^3. Although the government collected 1.00 Yuan/m^3 from the residents and 1.30 Y/m^3 from commercial users the total subsidy to the coal gas company from government revenue was more than 10 million Yuan in 2001.

In 2000, the Weihai government began a feasibility study of a natural gas project. There was a natural gas field in Bohai Bay. The cities along the bay plan to use the natural gas. The total investment of the Weihai natural gas project is estimated at 510 million Yuan and the expected output is 54 million m^3/a. The investment in the first phase was 287

million Yuan with the main outcome of the project being the construction of the transport pipe and the reestablishment of the pipe network in the urban area expected to start in 2003.

(b) Use of Centralised Heating Systems

In 1990, Weihai established the Heating & Power Company. Initially the first Heating and Power Plant not only produced electricity but also supplied steam for heating to nearby factories, commercial and apartment buildings. In 1992 the second, and in 2001 the third Heating & Power Plants began operating. Now the fourth Heating and Power Plant is under construction. The capacity of the boilers in the Heating and Power Plant are large and their efficiency are more than 85%. Modern equipment was installed to reduce fly ash, and in some cases reduced SO_2 emissions. The plants were constructed in an open area, somewhat removed from sensitive areas such as residential apartments. The Environmental Protection Agency forced the plants to use the low sulphur coal and use high chimneys to disperse the pollutants. Both these measures effectively reduced the pollution in the urban air.

Initially it is not easy for factories and residents to accept the centralized heating system. The factories had to remove their small boilers and pay money to the Heating and Power Plant a hard task especially if the factories are not performing so well. Residents had to pay 35 Yuan/m^3 for the pipe connection and the equipment required in the rooms. Most of the apartments in Weihai have areas of 70-120 m^2, which means that they will have to pay 2450-4200 Yuan. That is a considerable sum for most. In order to compel factories to use the centralized heating system the government set a regulation and stopped approving boiler installations in the urban areas, reengineered the existing small boilers as heat exchange stations, demolished outdated boilers and thus forced the factories to use the centralized heating system. For residents the government issued a regulation directing the unit that the residents worked for to underwrite the conversion costs and subsidize $^1/_3$ the heating fee. Presently all factories and residents have totally accepted the centralized heating system. After the housing reform in 1998 facility installation costs have to be paid by the house buyers themselves, but because increasing incomes many home-buyers prefer to pay more to enjoy a comfortable life style.

Table 2 HEATING & POWER PLANT SPECIFICATIONS

Name	Start of Operation	Investment (million Yuan)	Capacity	Method of fly ash control	Method of desulphurization
No. 1	1990	500	75T/h*3, 220T/h	Electronic	Flowing bed
No.2	1992	320	35T/h*5, 130T/h*2	Electronic	Flowing bed
No.3	2001	340	75T/h*3	Electronic	Flowing bed
No.4	Constructing	340	75T/h*3	Electronic	Flowing bed

(c) Developing the Public Transportation System

Learning from the successful practices in developed countries, Weihai as a latecomer put its main efforts in developing the public transport system. Although the public transportation company was an enterprise the government invested on most of the new buses, allocated land for bus stations, and subsidized more than 1 million Yuan per year for its operation. The government also gave benefits to the public transportation company by allowing them to attract private investment, and lease, to operate the public bus system, use the bus for advertisement as well as giving them tax relief etc. For their part the public transportation company did their best to enhance administration and increase operational efficiency. They lowered the price of monthly tickets, give half price tickets to students, grant free tickets to the old residents over 70 years all designed to encourage public transportation use. In 1997, they began to use the no ticket system, letting passengers themselves put money in a collection box show their monthly tickets to the driver. This was a first for china pioneered by Weihai. In 2001, the public transportation company began to use the electronic ticket system enabling passengers to use public transportation more easily. This too was a pioneering move in China.

The public transportation company paid much attention to environmental protection, they only bought buses that could meet national emission standards, strictly followed regulations and replaced outdated buses and as an innovation converted 40 buses try to use liquefied petroleum gas to reduce polluting emissions. Through such efforts the public transport system developed very fast. In 2001 the number of public buses reached 354 (a 15.4 fold increase compared with 1987) and passengers reached 83.56 million (a 33.3 times higher than in 1987). In order to meet the different levels of service demanded, the Weihai government concurrently developed the taxi service along with the public bus system. With investment channels widened and limitations relaxed, the taxi serveice boomed in a very few years. In 1989, taxis were just beginning to emerge in Weihai. Six years later, in 1995, their number reached 1400. Taxis were cheap and easy to catch. After some taxi owners claimed it was too expensive to keep them running the Weihai government stopped distributing taxi licenses and concentrated on upgrading the outdated taxis. A good taxi service has the added function of limiting motorised bicycles and private cars thus controlling urban air pollution.

Table 3 SOME PARAMETERS OF URBAN AIR POLLUTION CONTROL

Year	Percentage using gas for cooking	Percentage using the centralized heating system	The number of public transport buses	Passenger numbers using public transport system (000's)
1987	62.1		23	2510
1988	66.7		27	3180
1989	81.0		29	4520
1990	81.8		59	5090
1991	82.1		37	6780
1992	85.3		41	8360
1993	93.8		53	11560
1994	94.0	26.9	72	13030
1995	95.0	30.2	145	18330
1996	97.8	31.3	187	25570
1997	97.8	38.0	274	43240
1998	97.9	45.5	287	55030
1999	98.0	52.2	318	57700
2000	98.1	65.9	341	71040
2001	98.3	78.6	354	83560

(d) Improving the Monitoring System, Initiating Public Information

By 2000, with the investment of more than 4 million Yuan, equipment was imported from the USA and an automatic monitoring system was established to monitor air quality continuously. In addition, PM_{10} was monitored instead of TSP.

Environmental quality information was first published in 1995, once a year. In 2000, after the establishment of the automatic monitoring system, air quality information was disseminated daily through newspapers, TV and radio. In 2001, for the first time air quality predictions were made for the next day and publicised along with air quality data.

5. Impacts

(a) Encourage Clean Cooking Fuel

The natural gas project will follow a market economy mechanism and use foreign direct investment to establish a joint venture. According to the real cost, plus a reasonable profit, the joint venture would collect a fee from the end user and the government would not provide any subsidy. Because natural gas is a stable resource, with a higher caloric value per unit, according to calculations the payment would almost be the same for the residents. It is hoped that this is the sustainable way for providing cooking fuel to Weihai. Through the above effort the proportion of residents using gas for cooking gradually increased and is now almost 100%. That is the basis for the air pollution control in the urban area.

(b) Use of Centralised Heating Systems

During the last three years, more than 200 small boilers in the urban area were removed. Except in buildings that are outside the piped network service, warehouses and some workshops, almost all the buildings that need heating during the winter now use the centralized heating system. The rate of use of the centralized heating system (the area using the centralized heating system/The total construction area in the urban area) has grown rapidly.

(c) Developing the Public Transportation System

Currently, most residents in Weihai feel that the public transportation system is convenient, cheap, safe and comfortable, they prefer take public transport to travel. In the street, while there has been an increase in the number of persons travelling, but the number of bicycles has reduced, the numbers of motorised bicycles have not increased while vehicular emissions, which affect air quality, have been kept at low levels.

(d) Improving the Monitoring System, Initiating Public Information

Opening air quality information to the public had a very good affect. Firstly, the environmental awareness of the public has been increased greatly. Through the media, the pubic can now know what the air quality is, the identity of the main pollutant and how it affects health. As a consequence if they find a nearby pollution source it will be reported to the environmental protection agency immediately. Secondly, the city government now pays much more attention to the environment. Because the air quality information is open to the public, everybody is aware of the environmental conditions and consequently realises the efficiency of the government, this puts much pressure on the mayor and the government, especially the Environmental Protection Agency must work harder.

6. Lessons

Although Weihai has achieved much in the way of urban air pollution control, keeping air quality parameters in line with the national standards while experiencing rapid development in population, urban areas and economy, involves having to still face some severe challenges.

One is high coal consumption. In China, more than 70% of the energy comes from coal and most coal has high sulphur content so SO_2, dust and NOx are always the main issues of air pollution control. Although presently the government has encouraged people to use clean fuel, the total coal consumption has still growth rapidly. With a Power Station and 4 Heating & Power Plants, the total coal consumption has increased from 0.69 million tonnes in 1987 to 3.27 million tonnes in 2001 (a 4.7 fold increase).

Another is vehicular emission. In the last few years' private car ownership has grown very fast. In Beijing, 12% of the families have a car. In some cities in southern China, 20-30 % of the families have cars. In Weihai, from 1987 to 2001, the annual growth rate of vehicles is 21.7%. In China, the main problem of vehicular emissions is not only the number of vehicles, but also the poor vehicle condition.

7. Future Prospects

Presently China has policies and regulations in force to encourage factories, especially the power stations, to use low sulphur coal e.g. through collecting sulphur emission fees, control total sulphur emissions e.g. large power station must has desulphurization facilities etc. These are not that effective however as it is hard to find an available technology that can meet the situation in China. Consequently, total SO_2 emissions are gradually increasing and this situation will be hard to change in the near future.

Though emission standards are not as strict as in western countries, most vehicles still cannot meet them. Some outdated cars are still running on the roads and are the cause of more traffic accidents and also seriously pollute the air. With regard to addressing this issue, China, which has just started, still has a long way to go.