The Evolution of Solid Waste Management in Bangkok: Implications for the Future

S. Muttamara and Shing Tet Leong
Environmental Engineering and Management Program, School of Environment, Resource and Development, Asian Institute of Technology, P.O. Box 4, Khlong Luang, Pathum Thani 12120, Thailand.

Chairat Somboonjaroensri and Wicha Wongpradit
Garbage Disposal Dision, Department of Public Cleansing, Bangkok Metropolitan Administration, Bangkok, Thailand.

Abstract

The increasing quantity of solid wastes in Bangkok Metropolis causes serious problems in solid waste management. Until recently, about 90% of the waste was carried directly from transfer stations without any treatment to landfill sites because there is no other available disposal facilities such as sorting, compost plants and incinerators. The solid waste management problems can be categorized as financial, administrative, technical expertise and environmental awareness activities. Resource recovery and recycling was not performed efficiently, due to lack of enforcement system. However, the time has come when integrated technologies and maximum utilization should be considered as a strong disposal option against landfilling. Sustainable option such as mechanical-biological pretreatment (MBP) for landfilling and incineration could be employed in the future management of solid waste. The objective of this paper is to provide an overall view of the waste management in Bangkok and to examine appropriate technical and economical viability that could be taken in waste management.

Keywords: Bangkok, composting, incineration, landfill, recycling, solid waste management.

Introduction

Bangkok is the capital of Thailand with a registered population of 8.4 million. It is facing economic transition and experiencing rapid social changes. These problems present tremendous challenges to both policy makers and the communities concerned. Bangkok as a mega-city suffers notoriously for its inadequate sanitation, public services, pollution and congestion. Likewise, a rapid increase of wastes due to the trends of increasing population, mass production and mass consumption and the spread of a throw away lifestyle, causes serious problems in solid waste management in Bangkok Metropolis. Consequently, attention should be paid, in priority, to the waste situation and the existing waste management system. There is no proper solid waste management system to solve the municipal waste problem concerning collection, recycling, reduction and reuse, transformation and final disposal. For example, about 90% of waste is carried directly from transfer stations without any treatment to landfill sites because of no other disposal facilities such as sorting, composting, and incinerators. In addition, the general perception of people about waste problems is still lacking awareness of the seriousness of this problem. They make no effort to reduce waste.

The evolution of waste management in Thailand

Thailand's solid waste legislation has been based on the major revision of the following laws in 1992 to achieve the following objectives:

- Public Health Act-promotion of sanitation and disposal of solid waste

- Public Cleansing Act-the cleanliness and orderliness of the country
- Factory Act-avoidance of waste generation from factories
- Hazardous Substance Act-protect the public from hazardous substances

The responsible agencies for municipal solid waste within the Ministry the of Natural Resources and Environment are the Pollution Control Department (PCD) and the Department of Environmental Quality Promotion (DEQP). These agencies are assigned duties under the regulations for environmental enhancement, project consideration, and consultancy. All hazardous wastes are under the responsibility and regulation of the Ministry of Industry (MOI) and its agency, the Department of Industrial Works (DIW). The Department of Health (DOH), an agency under the MOPH, is responsible for health care waste and infectious waste management. The Pollution Control Department (PCD) is supposed to oversee waste within the Bangkok Metropolitan Region (BMR). The relationship between Bangkok Metropolitan Administration (BMA) and the central government is that BMA is one of the organizations under the Ministry of Interior. BMA has its own management, on which the is quite independent from the central government [1]. The BMA policy, direction and decision-making are agreed on within the BMA organization, and mostly do not have to be approved by the central government except for supporting budget requests.

Current status of solid waste management in Bangkok

There exists a great variation of daily per capita waste generation in the BMR area, a production rate of 0.6-3 kg/capita/day is reported [1]. The Bangkok Metropolitan Region is facing a serious waste disposal problem, with amounts of generated solid waste per day outstripping collection capacity by nearly 2,000 uncollected tons of MSW per day. Bangkok currently generates 9,400 tons of solid waste per day. The BMA collection capacity is only 7,500 tons per day. The challenge will increase with a predicted waste generation of around 16,000 tons per day in 2015 (Figure 1). Most previous solid waste management studies do not consider the waste generating factors, but focus solely on the waste generation rates and the amount of waste at the transfer stations. However, Figure 2 shows the present waste management system in Bangkok Metropolis is greatly influenced by various factors such as the waste generation/discharge amount, social system, distribution system, etc. Thus, it is absolutely essential to understand the current waste stream for appropriate solid waste management of the Bangkok Metropolis.

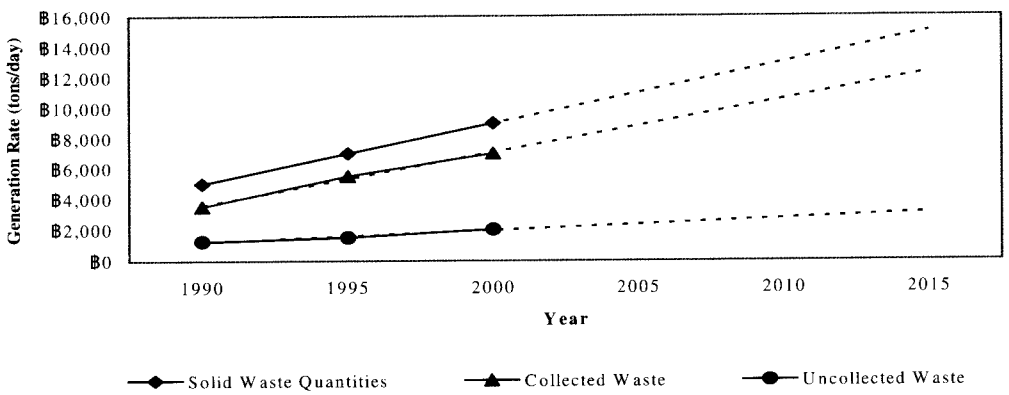


Figure 1. Prediction of municipal solid waste generation and collection in the Bangkok Metropolitan Region

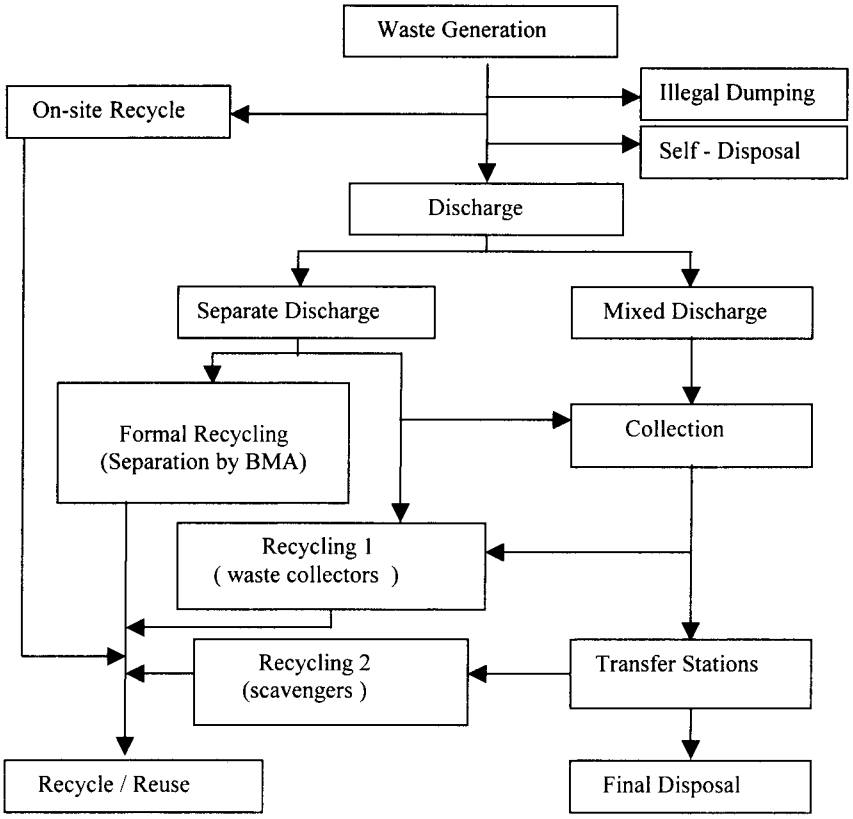


Figure 2. Present solid waste management system in Bangkok Metropolis
Source: Department of Public Cleansing (BMA, 2001).

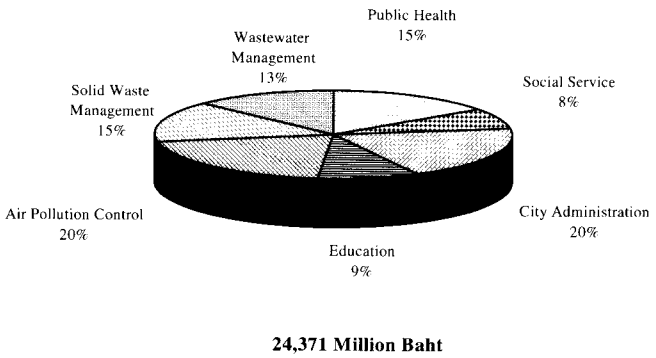
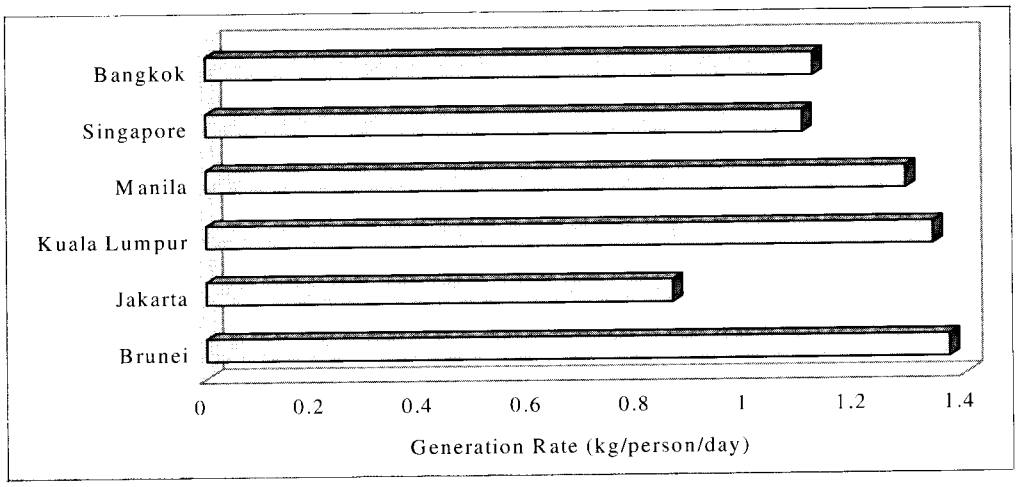
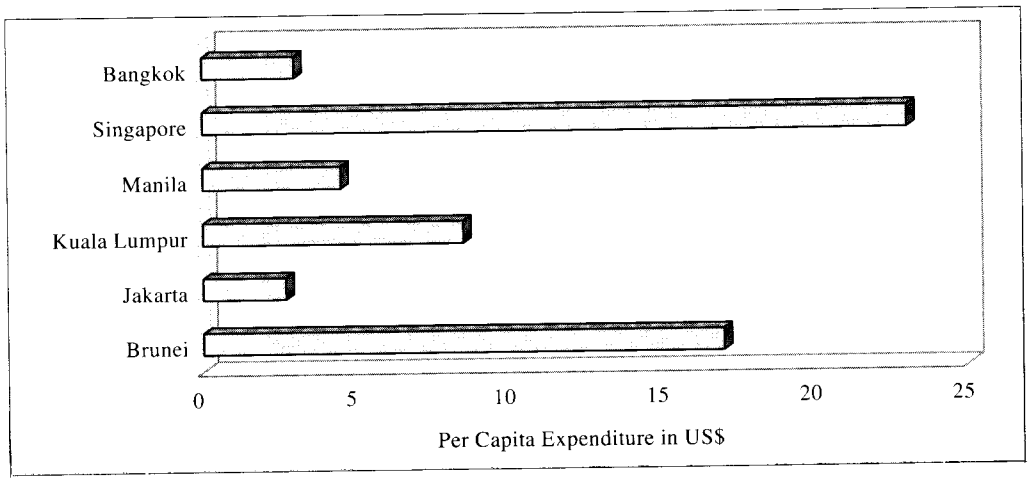


Figure 3. Expenditure classified by Bangkok Metropolitan Administration, Year 2001



(a)



(b)

Figure 4. Municipal solid waste management in Southeast Asian cities associated with (a) MSW generation rates and (b) per capita expenditure

Funding of municipal solid waste management

Local authorities that provide the collection service also take care of the collection fees of municipal solid waste. The current scale of collection fee is limited to 40 Baht per capita per month. The fees collected cover only 3-10% of the operational costs of waste management. In addition, BMA can generate its own income and revenues from local taxes, fee, fine, permits and service charge, rental from BMA assets, and income from public utilities and enterprises as

well as from miscellaneous activities. Operational costs of municipal solid waste disposal often exceed 20% of municipal budgets (Figure 3). Compared with other cities in South Asian countries, major constraints of municipalities of MSW management in BMR were due to inadequate financing [2]. Figure 4a. shows that the MSW generation rate of BMR was comparable to that of Singapore. However, the per capita expenditure associated with solid waste management in BMR was much lower than Singapore (Figure 4b). This could be due to the differences between the two cities in economic level and living standard. Singapore contributes higher financial expenditure toward waste management. With limitations in operational budget, the municipal solid waste management in BMR has to rely on either subsidizes by the central government or foreign donors who have financed many of the waste management projects in Bangkok.

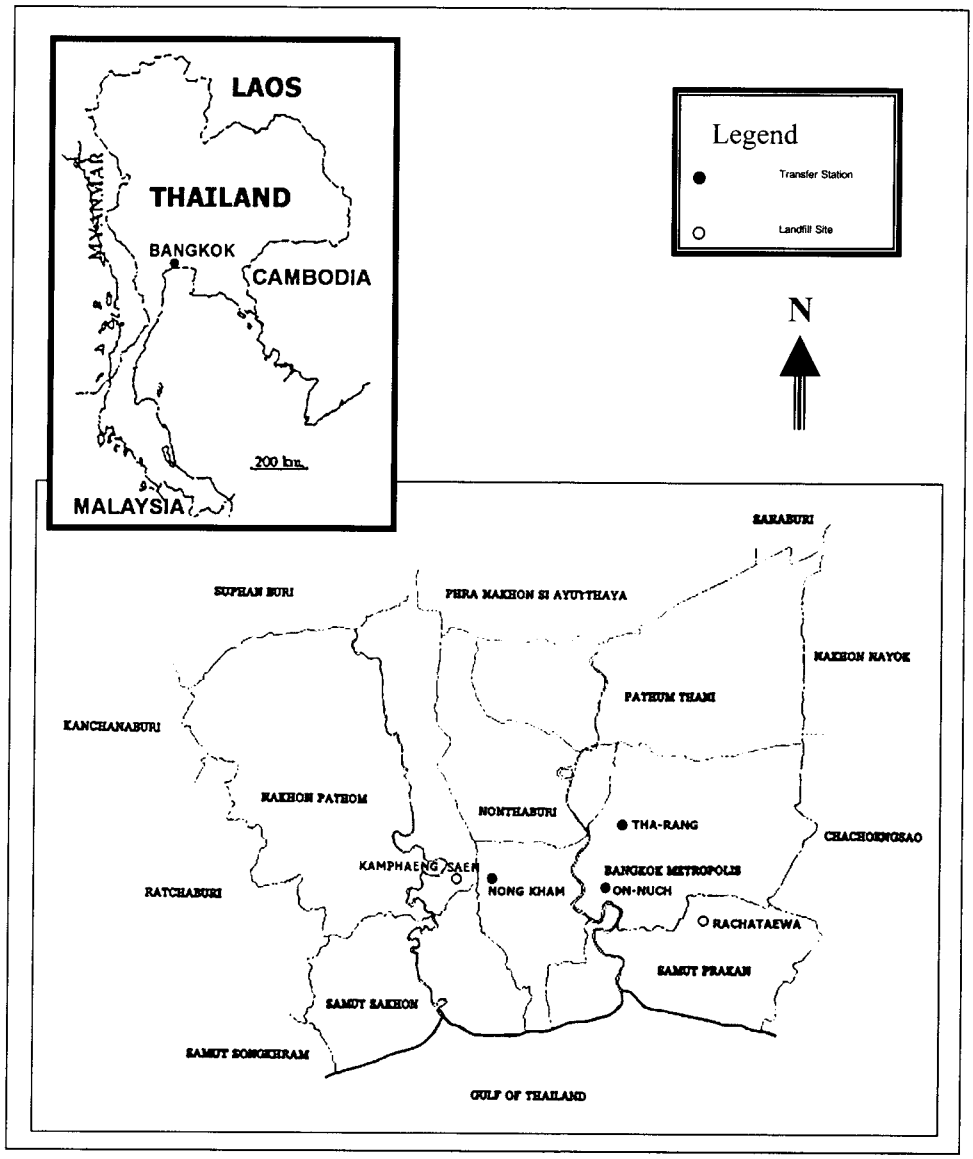


Figure 5. Locations of Solid Waste Transfer Stations and Landfill Sites in Bangkok

Refuse generation, collection and disposal in Bangkok

In Bangkok, the Department of Public Cleansing accounts for 80% of the overall municipal cleansing services, which includes cleansing and waste collection from streets, schools, markets, hospitals, commercial centers, etc. Curbside waste collection in Bangkok is done from 6 pm to 3 am on the main streets and from 3 am to 10 am on the smaller lanes. Therefore, the delivery of waste to the transfer station may take place from 3 am to 11 am. Residents take their refuse out and place it in curbside bamboo baskets. Wastes are picked up by municipal waste collection crews and emptied into packer trucks. The capacity of each truck is 5 tons. When fully loaded, the wastes are sent to one of the three transfer stations, On-Nooch (3500 tons/day), Nong-Khaem (3000 tons/day) and Tha-Rang (2000 tons/day) and sent directly to landfill sites in (Kampaeng Saen) Nakon Pathom and Rachataewa (Samut Prakan) which are the nearby provinces (Figure 5). About 20 tonnes per day of hospital hazardous waste is incinerated at the On-Nooch disposal site. Sorting of the raw waste is done by the waste handling crew in parallel to the normal activities of waste collection. The BMA has to pay an average of 987.5 Baht per ton for transportation fee. An average of 500 trips per day was made for each transfer stations. In practice, this waste collection services 85-90% of the urban population in Bangkok Metropolis. The remaining uncollected waste is serviced by several private organizations. These small companies account for approximately 20% of cleansing services in Bangkok (Figure 6).

Options for solid waste management in Bangkok

In Bangkok, the conventional methods for treating and disposing of most mixed solid wastes may be generally summarised as follows: Landfilling (options range from simple sanitary landfill of untreated domestic refuse through various transfer stations and bulk haul alternatives to remote landfill sites); Recycling (separation and processing of solid wastes at source); Incineration (hospital waste treatment; this is without recovery of heat and residual slag); Composting (with varying degrees of product refinement), Land filling is the most common practice. The final choice of various options available to the waste disposal authority depends on selecting the level of capital cost, pollution risk and environmental impact. Every one of these alternatives requires land for its residues and, in general, operational costs and capital investment are much higher for the incineration and composting systems.

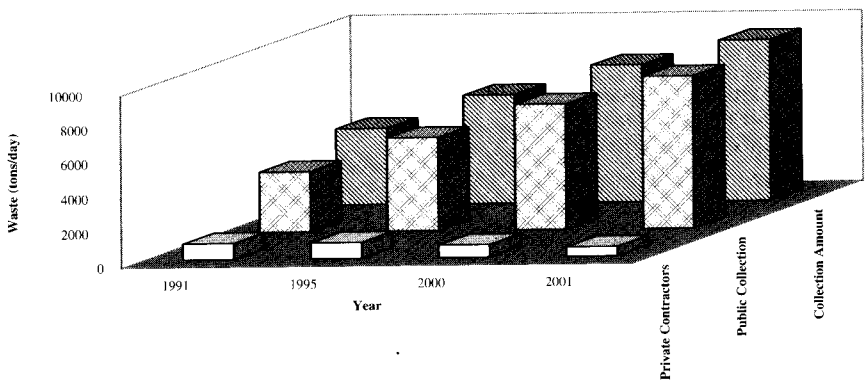


Figure 6. Collection of municipal solid waste in Bangkok, (1991-2001)

Landfilling

Landfilling

Since the composting and incineration facilities are not functioning effectively at all the disposal sites, 97% of the solid waste in Bangkok is disposed of by landfilling. However, there is a capacity crisis at most of the landfill sites and this is becoming more serious because of the limitation of land availability due to the rapid growth of population, economic development and utilization of the facilities. Weak enforcement of land-use plans will make landfilling facilities to be unpleasant sites, since the community will enlarge closer to the site. NIMBY (Not in my backyard) syndrome makes it more difficult for the municipality to find a new landfill site. In addition, there are potential risks to health and environment from improper handling of landfill sites. Water pollution problems experienced at landfill sites have resulted from the percolation of rain through the fill (called leachate) which affects the quality of nearby surface water and may threaten the quality of the ground water [3]. Likewise, major air pollution produced at landfill sites is due to the gas generated in the process of decomposition. The gas contains CO_2 and CH_4 principally and a small quantity of NH_3, H_2S and CO. Apart from the toxicity of these components, the most serious problem at the landfill site is the accumulation of flammable gas inside the landfill layers which is diffused to the land surface and on some occasions may cause fire or explosion.

Composting

A survey of MSW composition trends in Bangkok revealed that the composition of solid waste is largely organic garbage with vegetable cuttings and fruit peels which are suitable to the dispose of by composting, due to the high moisture content (55% - 60%) and optimum C:N ratio. Figure 7 shows that about 53% of Bangkok municipal solid waste contains mostly organic matter or bio-waste. Bio-waste can be used for composting to produce natural fertilizer. There are two approaches currently used in the composting of MSW. The first approach is the typical window system (piling on the ground), and the second approach utilizes mechanical equipment to facilitate the composting process, such as the rotating drum being used at BMA's Nong Khaem Disposal Plant. Composting on a large scale can be effective when the organic fraction is collected separately. This separation can be done at household level. The average cost of composting is 530 Baht per ton of incoming waste [4]. There are some factors which favor composting as a resource recovery option. However, the composting activities only accounted for 3% of the waste management. This is probably due to cross contamination of waste components and the high level of glass, plastics and metal contents in the waste stream, thus reducing the economic value of the compost products [5]. Thus, marketing of the compost products has been a problem in Thailand.

Recycling

Recycling is an attractive strategy to reserve landfill space and reduce cost of transporting materials to landfill sites. Waste recycling includes any source reduction or waste minimization activities undertaken by a waste generator that results in the reduction of total volume or quantity of waste [6]. Waste recycling minimizes the pollution effects caused by waste [7]. The informal sector's involvement in resource recovery from wastes had been widespread in Thailand during the economic boom period (1987-1996). In Bangkok, materials are separated at different stages of the collection process: at the source, prior to collection; by the crews of the collection vehicle; and by the scavengers at the disposal site (Figure 8). The collected materials are sold through middleman to small-scale recycling businesses, who sort and pretreat the materials before selling them to a wholesaler, who in turn deals directly with the user industries. Materials such as newspapers, magazines, cardboard and bottles are separated at the source, often at the residence itself and sold to door-to-door collectors on motor tricycles. Street scavengers also sort out most valuable items from the waste bins and containers prior to collection by the refuse crews. These pickers generally sell the materials to the junk shops, which also buy larger items directly from householders. The second part of the recycling process is carried out by the collection crews. These collected materials are sold near the entrance of the disposal sites. Ferrous metals are also recovered by magnetic separator from the raw waste entering the compost plants. The recovered ferrous metals are compressed into blocks of 30

kg weight. Recyclable items, once separated out, can be sold directly to recycling markets. Traders then sell them to domestic factories that use them as raw materials. Table 1 shows quoted prices of some recyclable items. (Prices quoted as of the beginning of the year 2000). The amount of materials recovered by the scavengers varies between 50- 150 kg/person/day and the daily income varies between 30-300 Baht/person [8]. Though recycling has been practiced for a long time, it is still an informal practice and is not widely developed, due to insufficient technical support, incentives, laws and regulations, etc. The existing recycling system in Bangkok is considered a self-sustaining system in the society or community and is much more efficient than that of other countries [9].

Lohani (1982) reports that the success of recycling programs requires interest and cooperation from the population, along with public education for changing people's habits. It is important that all groups understand both the environmental and economic implication of recycling, as well as the necessary practical instructions, that have to be followed in order to ensure the high quality of the materials and an efficient collection of materials. If the materials are collected at the source, the waste collection workers need information and training in how to handle recyclable materials to ensure the high quality materials are segregated and also to protect themselves against pollution and other occupational health risks. Finally, the workers at the reclamation facilities should be clearly instructed in techniques for handling recyclable materials.

Recyclable components

Figure 7 shows the recyclable components of municipal solid waste generated in Bangkok, during 1991-2000. Among the recyclable components, plastic accounts for the biggest portion (19%), followed by paper, glass, and metal, which contain about 9%, 3%, and 2%, respectively, of total weight of recyclable components. The "other" category comprises organic and non-organic matter such as tree leaves, residues of food and drink, stones, soil, etc.

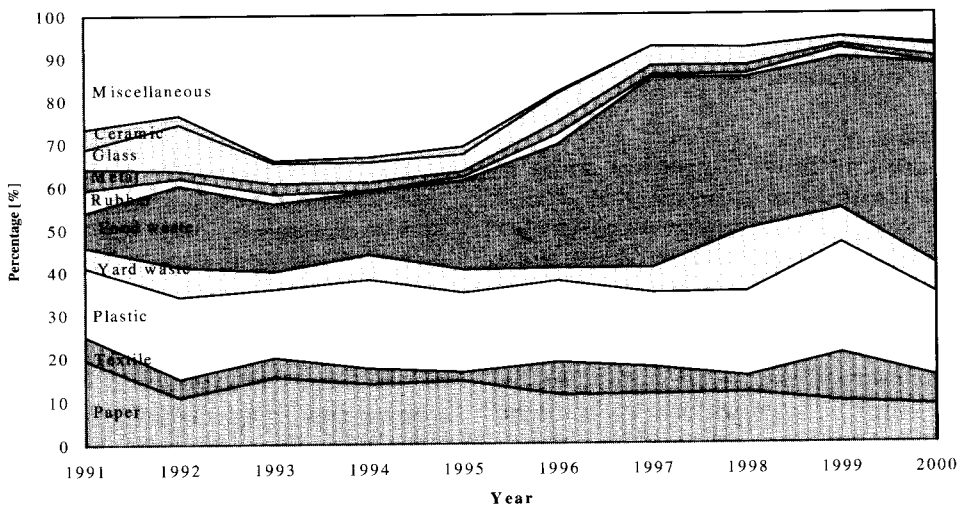


Figure 7. Changes in composition of Bangkok municipal solid waste (1991-2000) Source: Department of Public Cleansing, BMA.

Plastics: Recycled plastic is primarily used in the manufacture of sleeping bags, pillows, protective wrap, grocery sacks, pipe and molded products, etc.

Paper and Cardboard: Approximately 77% of recycled paper is mostly used to produce container board and construction products. The remaining 23% is used for other grades of paper, cellulose insulation and animal bedding.

Glass: The benefits of recycling glass include reuse of the material, energy savings, reduced use of landfill space, and in some cases, cleaner compost or an improved refuse-derived fuel. Almost all recycled glass is used to produce new glass containers and bottles. A minor amount of glass is used to make glass wool or fiber glass insulation material.

Aluminum: Recycling has been so successful for several reasons: a) recycling provides a stable, domestic source of aluminum b) the energy required to produce a can from recycled aluminum is less than 5% of the energy needed to make a can from raw materials c) about 93% of the recycled cans can be remelted and rolled into aluminum sheets [7]. Aluminum cans are accepted at curbside buy–back locations, recycling collection centers, and by scrap metal dealers.

Ferrous Metals (Iron and Steel): The principal recycled ferrous metals are tin cans and scrap metal through curbside collection programs.

Nonferrous Metals: Nonferrous metals compose about 1.5% of solid metal, including tools, copper wire, pipe, automobiles, machinery [7].

Other Wastes: These are comprised of yard wastes, demolition wastes, wood, waste oil, used tires, etc.

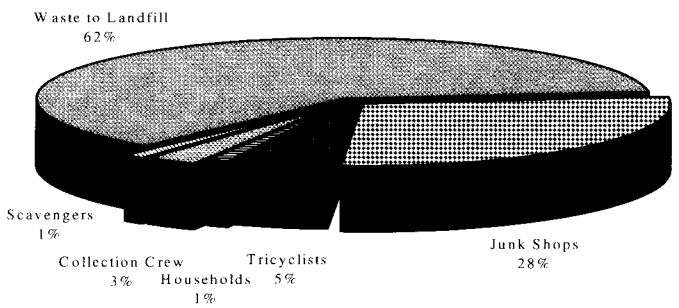


Figure 8. Organisational methods in recycling process

Table 1 Selling Price of Recyclable Items

Materials	Selling Price * (Baht/kg)
Plastic bottle	3.20- 3.30
Broken bottle	0.20- 0.30
Whiskey bottle	0.70- 0.80
Beer bottle	0.10- 0.20
Iron	1.50- 1.60
Aluminium	14.70- 17.70
Copper	39.70- 49.70
Writing paper	3.20- 3.30
Newspaper	1.30- 1.80
Waste paper	0.80- 1.10
Cardboard	1.20- 1.40

Source: Department of Public Cleansing, (DPC, 2000)

*Exchange rate at the beginning of the year: 42 Baht = 1US$

Environmental awareness activities

Institutional planning is the key to achieving an acceptable and affordable system, but the success of any scheme will depend on the cooperation of the people and their aspirations for a safe and aesthetically pleasing urban environment. To cope effectively with waste problems, it is suggested that along with other measures, the education of people on waste awareness and creation of proper, responsible behavior regarding waste and environment must be the long-term strategic approach.

Based on a UNEP 1991 report [10], the experiences gained from activities in environmental education and the institutional set-up developed for this purpose over the years will be useful in the promotion of environmental awareness. The enhancement of environmental awareness among the target population may be achieved through formal and non-formal education as well as mass media.

Manufacturers and distributors are obliged to accept returned packaging. Plastic packaging is collected by industry and recycled in an environmentally sound way. Negotiations between the government and producers, suppliers and users are carried out to promote recycling. To enhance recycling and reuse, products are designed in such a way that components and materials can be easily collected and separated after the product is discarded. Such changes lie with product manufacturers. Any environmental program will fail without the people's support on local, regional and national levels. An increasing awareness of the need for an active environmental protection policy is dependent on our collective actions.

Lack of enforcement system

Although the regulation of Bangkok Municipality can be legally enforced on violators, in practice it is very weak because of a poor enforcement system. The separate collection system for the segregation of kitchen waste, recyclable waste, hazardous waste, and general waste was introduced to some areas in Bangkok Metropolis by BMA a few years ago. However, the system is not fully entrenched due to the weak enforcement.

There was a survey carried out by BMA that shows thirty percent of residents in the city are cooperating in the implementation of separate collection. The public opinion survey shows that 32 percent of the respondents use plastic bags for waste discharge, while 51.6 percent use metal containers [1].

Future perspectives

As it can be seen, the present waste management policy of "Each community operates its own disposal facilities" is regarded as impractical. The biggest constraint is lack of budget for the overall operation, despite the growing awareness of the seriousness of ever-increasing waste generation and waste related problems. In future municipal solid waste management, the central government has to support local administration to set plans for centralized disposal centers and to improve sound waste management systems within the environmental regulations. Based on the prediction of waste generation and changes in composition of municipal solid waste, the future solid waste disposal approaches are forecasted to employ both integrated technologies (70%) and maximum utilization (30%); namely:

- Waste segregation for recycling

In future waste management practice, the BMA has launched a public awareness campaign to encourage the separation of wet and dry MSW. BMA's policy has created a recycling centre to sort paper, plastic, glass and metal in each municipal district. For downstream sorting, plastic bags are provided to customers by supermarkets, department stores, etc. and are marked according to the type of waste that it should be used for:

a. Yellow bins: for recyclable waste, i.e. plastics, glass and metals;
b. Green bins: for kitchen waste, i.e. fresh organic garbage;
c. Grey bins with a red lid: for hazardous waste, i.e. bulbs and batteries;
d. Blue bins: for ordinary mixed garbage and trash.

- Composting for organic solid waste

Composting on a large scale could be more effective by separating more efficiently before collection. Composting on a small scale can also be effective when the organic fraction is collected separately at household level.

• Optional mechanical - biological pretreatment (MBP) for landfilling and incineration

Several research programs have already proven that waste pretreatment before disposal is very effective to reduce the environmental impact of landfilling [11]. Compared to untreated waste, mechanical-biological pretreatment (MBP) provides a reduction in organic content of end products and contribute to the reduction of the global greenhouse effect. Biodegradable fractions with high organic content are destined for biological treatment before landfilling. The mechanical-biological pretreated waste mass is reduced by 20-40% and density after compaction is expected to increase from about 0.8-0.9 t/m^3, to 1.2-1.4 t/m^3, with a landfill volume reduction up to 60% in comparison to non pretreated waste [12; 13]. Emission qualities are also significantly improved, with a reduction of about 90% of COD and total nitrogen in leachate, as well as gas production rate reduction. Likewise, mechanical - biological pretreatment (MBP) and incineration techniques are currently adopted as single waste treatment technologies in some developed countries [14]. MBP can be used as a pretreatment step before thermal treatment, with an improvement of the heating value and a reduction of the amount of non-combustible waste to be incinerated.

• Participation from private sector

Increasingly, the private sector and voluntary organizations are playing a part in street cleansing and solid waste management. A suitable plan must achieve desirable objectives, taking advantage of all available resources. In addition, appointing private sector companies to collect and dispose of waste can generate revenues for local governments.

Conclusion

The exploratory nature of this research shows that an integrated waste disposal plan would be the better choice for MSW management in Bangkok. However, it is not possible to decide which option is best. This is partly due to the fact that this study did not cover some other important issues such as; public demonstrations against incinerators, market demand for composting products, the legislative support for landfilling, etc. For example, the physical impacts from landfill site can create NIMBY (Not in my backyard) syndrome,+ making it more difficult for public acceptance. To assist policy makers in identifying viable options for solid waste management, the Life Cycle Assessment (LCA) method is recommended to quantify the environmental and social impacts without consideration of costs of investment.

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