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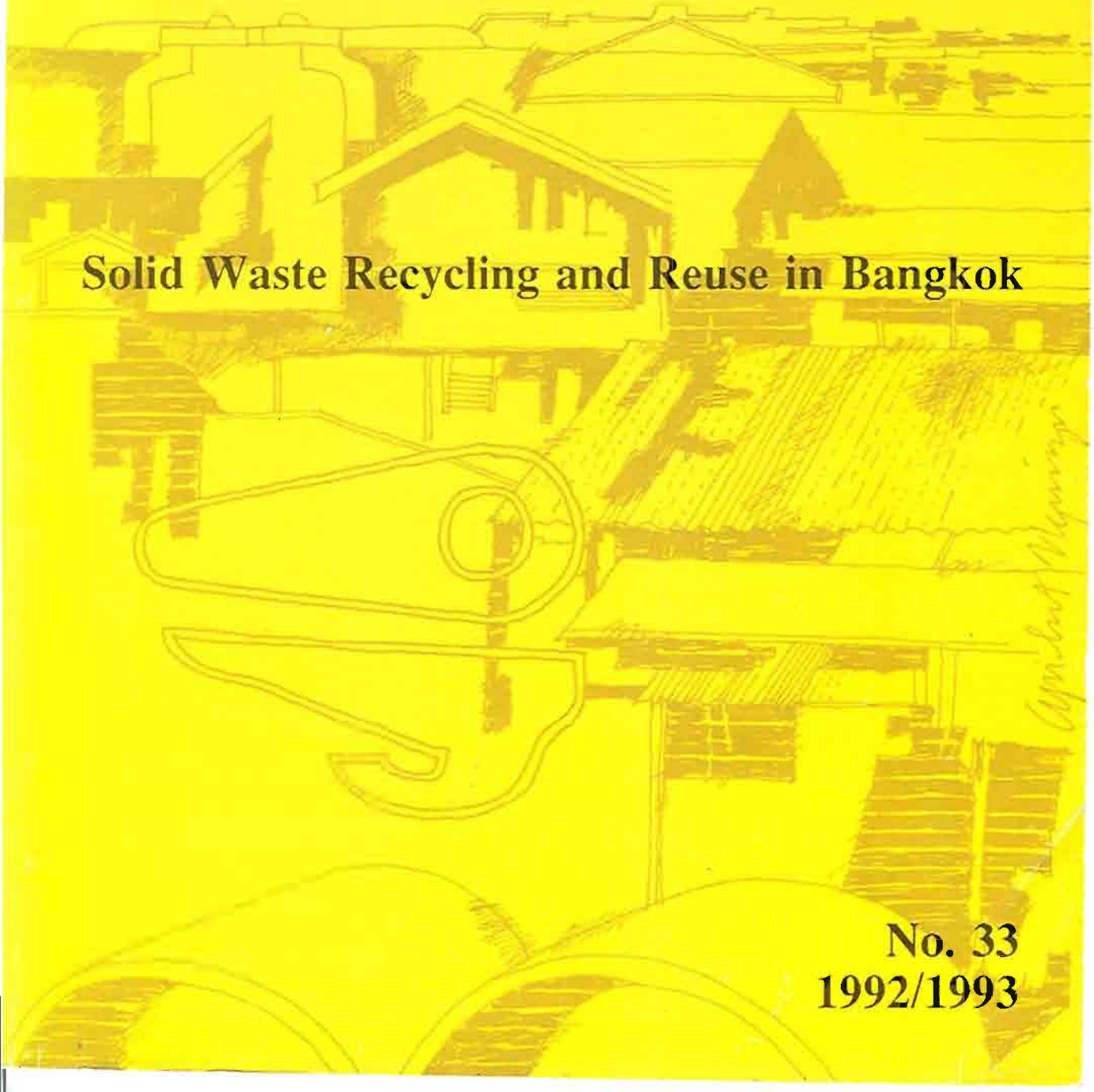

Solid Waste Recycling and Reuse in Bangkok

No. 33
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C. Visvanatha
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Environmental Systems Reviews

No. 33, 1992/1993

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SOLID WASTE RECYCLING AND REUSE IN BANGKOK

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ENVIRONMENTAL SYSTEMS REVIEWS

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ABBREVIATIONS

BMA	:	Bangkok Metropolitan Administration
DPC	:	Department of Public Cleansing
GDP	:	Gross Domestic Product
GPP	:	Gross Provincial Product
NGO	:	Non Governmental Organization
SSR	:	Small Scale Recycling Shops
TECDA	:	Thai Environmental and Community Development Association

I. INTRODUCTION

1.1 General

Recycling offers a substantial reduction in the cost of waste disposal. It saves energy and expensive raw materials, and it protects the environment. In order to enhance recycling, legislative measures need to be introduced and enforced. In Thailand, there is, however, no law concerning recycling. The (informal) private sector collects, separates and processes recoverable solid waste and sells it to manufacturers for reuse. However, there is no incentive for the consumer to separate solid waste for recycling, as the prices of waste in Bangkok are low and inconsistent. By the time solid waste is collected, shredded, separated, cleaned and transported, the costs have usually increased to a point where the recycled materials are not competitive with virgin materials. On the other hand, because solid waste is not separated, waste recovery is inefficient and the cost of recovery is high. It is hoped that this report will contribute to the active promotion of solid waste recovery, recycling and reuse in Bangkok.

1.2 Scope of the Report

The aim of this report is to contribute information which can be used for the active promotion of solid waste recycling and reuse in Bangkok. The report also reviews the environmental, social, economic and legal opportunities and options regarding the same.

The cost-benefit analysis of recyclable/reusable materials used by a number of industries is also presented.

1.3 Justification of the Study

1.3.1 Environmental Opportunities and Options

The environmental aspect of waste recycling and reuse has two sides. First, recycling and reuse of any kind of waste components reduce the volume of the waste that has to be dumped, which means a reduction of the severe pollution of the environment by waste disposal sites and in this way an extended life for existing landfill sites. The second effect of waste recycling and reuse is the saving of resources which adds significantly and in a positive way to a sustainable development. The saving of resources also has a substantial effect on the economy. It is estimated that on average 7.5% of the waste is recycled in the big cities of the developing countries. Potentially, the recycled proportion could be increased to 40%.

Waste is one of the biggest threats to a healthy environment. Without intervention by the government the amount of waste produced will keep on growing. This is mainly due to population growth, and to changes in life style and consumption patterns. For sustainable development it is necessary to take measures to reduce waste. Initially, the attention has to be focused on the maximum use of recycling and reuse processes. Secondly, measures have to be taken to process the waste produced in an environmentally sound way.

1.3.2 Economic Opportunities and Options

The need for waste recycling and reuse is driven by a variety of economic arguments which are centered around reducing the cost of waste collection and disposal, and reducing the requirements for new raw materials and energy by industry. In addition to these direct benefits additional economic advantages can be achieved in the generation of employment and the reduced costs of health care resulting from an improved environment for urban residents.

Economic assessment of waste recycling and reuse is a difficult task as some of the economic benefits are difficult to quantify. Initially, resource recovery should be of interest to any responsible authority as a means of reducing their waste disposal costs. The impact of the recycling and reuse sector on the waste management sector in the Asian cities is potentially considerable. Solid waste disposal operations currently absorb between 30-50 percent of municipal operating budgets and the services provided may only cover the collection of a fraction of the wastes generated. The daily volume of waste produce in Asian megacities is around 4,700 tons which costs municipal authorities of the order of US$ 15 million annually for collection and disposal. Current recycling rates (on average, 7.5%) result in an annual cost reduction of waste management of between US$ 2-3 million. If recycling is increased to an estimated potential of around 40% the cost savings will be even greater. The attractiveness of resource recovery and recycling as a method of handling wastes depends on how the costs and benefits of the available resource recovery and recycling methods compare with the costs of conventional methods of waste collection and disposal that would otherwise be employed. There should be a ready market for the recycled raw materials from both the major manufacturers who buy them directly from middle men and the small scale cottage based industries who produce a wide variety of goods for the domestic markets and export. The potential to produce compost from the organic fraction of the municipal waste will further contribute to the cost recovery if a market for the products is sufficiently well identified.

Other economic benefits which are not easy to quantify are the external costs of environmental pollution and the heavy toll on human health. Inadequate solid waste disposal affects the health of all sections of the urban community. This includes those who scavenge the waste containers and the dumps, those who are exposed to the effects of waste-related disease vectors and also those who consume potentially contaminated water resources. Inadequate solid waste disposal practices affect the health of municipal workers, thereby reducing their productivity through absence. Municipalities must therefore consider all cost benefits.

In order to assess the desirability, from the community's point of view, of any separate collection and recycling scheme or program it is essential to develop a framework which will enable judgements to be made of its economic efficiency. This involves securing the largest possible net gain to the community as a whole by operating with the least possible total revenue and welfare costs.

The economic benefits to be gained by industry from waste recycling are also worthy for consideration. Industries' operating costs are greatly reduced as the use of recycled materials are invariably cheaper than the use of virgin materials, especially where they are imported and paid for in foreign exchange. Recycling will also reduce the degree of energy usage nationally.

1.3.3 Social Opportunities and Options

People engaged in waste recycling can play an important role in the existing solid waste management system of big cities in developing countries. A significant portion of the reusables in solid waste is recovered by these people and provides local industry with an inexpensive source of production materials. Many of these industries are in fact economically dependent on the activities of the waste recycling workers, and they could not continue without the availability of secondary resources.

The starting point for understanding the social dimensions of this waste recovery is recognition of the centrality of waste recycling in the lives of the poor. Waste reuse and recycling is intimately linked to patterns of self-help in many growing cities. Were it not for this, the majority of cities in poorer countries could not supply the basic needs of a substantial number of their populations.

There are different social groups involved in the waste recycling process, the householders, the initial buyers, the street scavengers, the waste collectors, the dump site scavengers and the middle man. On top of this a large number of people are employed as dealers and processors who derive their materials from secondary sources. In total, several tens of thousands of people make a living in the recycling process. Establishing the exact number of these people is very difficult due to lack of information.

1.3.4 Institutional/Legal Opportunities and Options

In most developing countries today governments have not established effective pollution control and waste management programs that take into account country-specific problems, nor have they had the capacity to adequately develop and implement standards, regulations, and charge systems. The implementation and enforcement of regulatory and economic instruments have been constrained by: inadequate expertise, funds and charging systems, inadequate equipment, lack of political will, limited public awareness and overlapping and uncoordinated institutional responsibilities.

Many countries in Asia have adopted laws and regulations which were designed in the developed countries. Overall constraints are the outdated existing laws and regulations on solid waste management, environmental protection and recycling of waste materials. Another constraint is the too generalized formulation of legislation with regard to disposal of industrial waste.

In Thailand most of the present acts deal with either regulation of the refuse containers or general tidiness of refuse in the city area, in particular from the public health point of view. In addition, there is leniency in enforcement which makes the laws ineffective. There are four main items of legislation concerning solid waste management in Thailand: The Public Cleansing Act, the Act for the Cleanliness and Orderliness of the Country, the Bangkok Metropolitan Administration Ordinance and the Ordinance for Sanitation and Orderliness in Bangkok Metropolis. Furthermore, there are several laws concerning solid waste management in Bangkok as well as city regulations concerning the storage and collection of waste, but no legislation exists concerning waste recycling.

II. SOLID WASTE GENERATION, COLLECTION AND DISPOSAL IN BANGKOK

2.1 Background Information

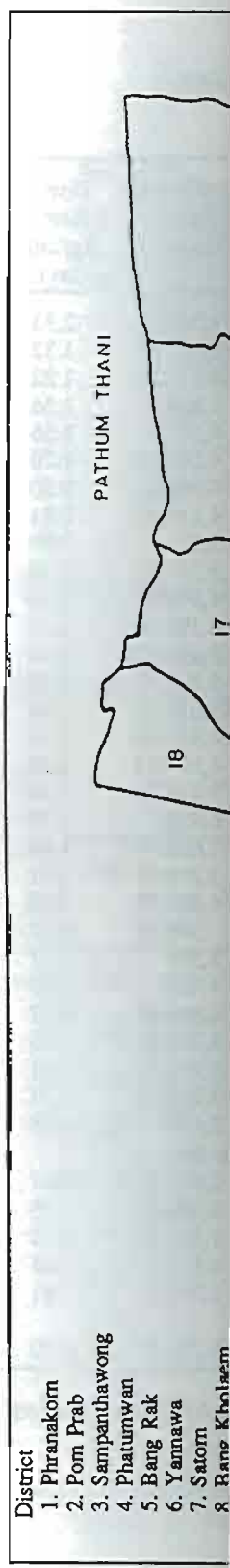
One of the major problems faced by most of the developing countries is the need for proper disposal of the millions of tons of solid wastes generated everyday. This is an ever growing problem especially in the city of Bangkok, the capital city of Thailand and one of the largest cities in South East Asia. As a result of rapid industrialization in the area, which is directly proportional to population increase, the solid waste problem has become one of the prime concerns of the city government for environmental, social and aesthetic reasons.

The city of Bangkok is situated in the Chao Phraya River Plain, characterized by flat terrain, a high ground water table, clay soil and seasonal flooding events. The climate of Bangkok is tropical, average temperature is between 25°C to 33°C. Bangkok city consists of 36 districts as shown in Figure 1. These districts are classified under 4 categories, namely: City Core (a highly urbanized area), urban district which are urbanized to a lesser extent, semi urban districts and semi rural districts (TAMS PIRNIE, 1989).

The registered population of Bangkok is 5.7 million on 1566 sq km of area, and the annual population growth rate is reported to be 1.16%. According to JICA (1991), the population density in 1989 was 3738 persons per sq km. Bangkok shares about 11.3% of the population of the whole kingdom.

In 1989 the GPP (Gross Provincial Product) of Bangkok was estimated at 225 billion baht, about 40% of the GDP (Gross Domestic Product) of Thailand. According to the National Economic and Social Development Board, the GPP of Bangkok is estimated to grow at an average of 7.9% per year from 1997 to 2000. The GPP per capita in 1989 was estimated at about 39,400 baht and 68,300 baht in 2000. The GPP growth is a major factor explaining the increase in waste generation in Bangkok. Manufacturing industries share about one third of the GPP. The wholesale and the retail trade share about 20% of the GPP. The composition of GPP in Bangkok is presented in Figure 2.

According to ESCAP (1990), the amount of solid waste collected in 1990 was 5240 tons per day, a per capita rate of 0.93 kg/day. Total amount of industrial solid waste was 0.258 ton per factory per day. The waste disposal rates per district are given in Table 1.



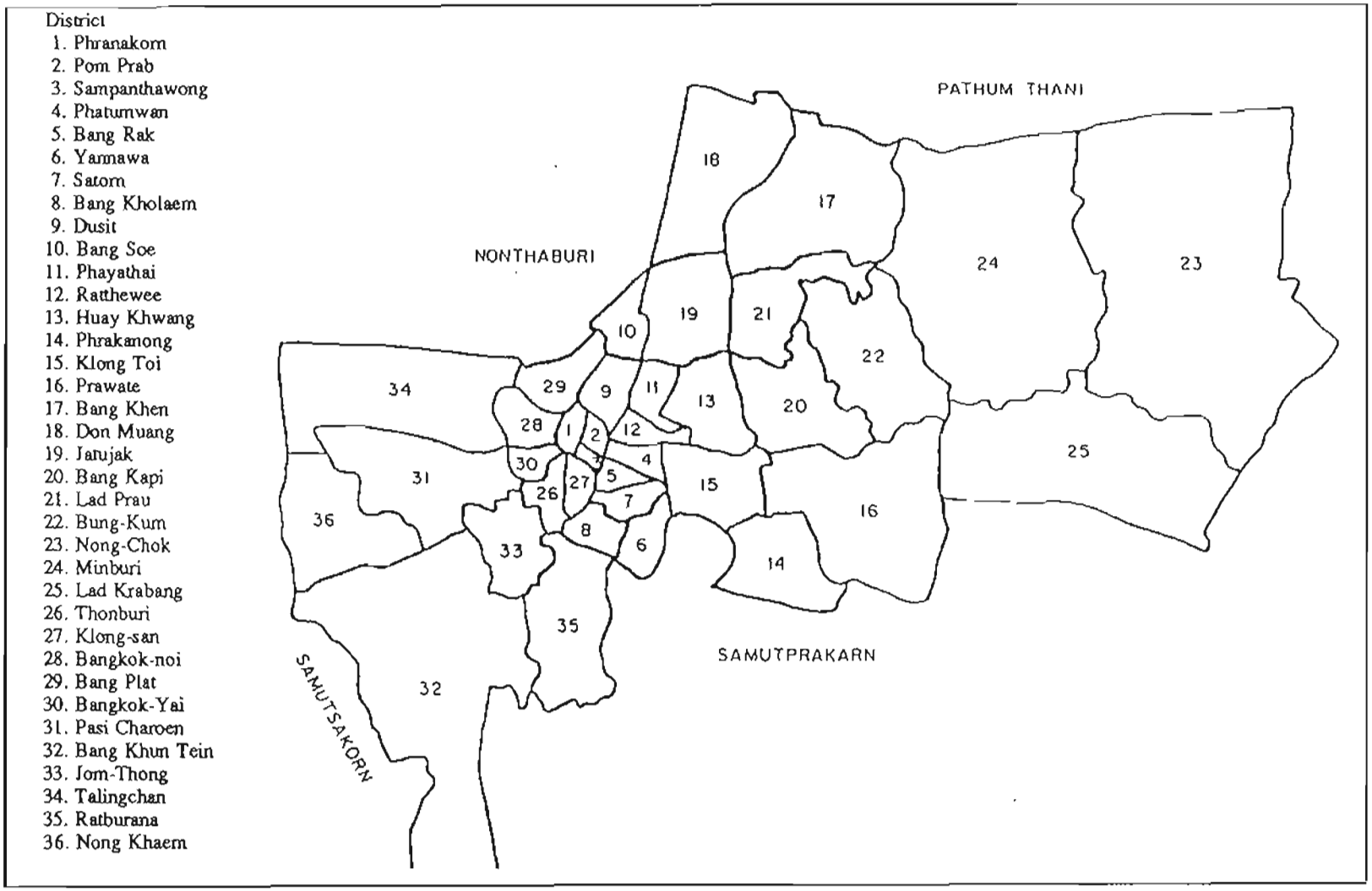
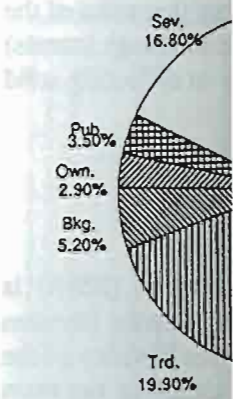


Fig. 1 Districts of Bangkok
(Source: DPC, 1991)

Table 1. Service Population and Per Capita Disposal Rates by District
(Source: DPC, 1991)

District	Total Pop.	Pop. Served	Solid Waste Generated (ton/m)	Solid Waste Collected (ton/m)	Disp. Rate (kg/cap /day)
1. Phranakorn	100,601	100,601	8,000	7,044.50	2.33
2. Pom Prab	84,251	84,251	3,340	3,336.96	1.32
3. Pathumwan	141,509	141,509	5,200	5,171.76	1.22
4. Samphanthawong	45,656	45,656	1,864	1,864	1.36
5. Bang Rak	87,489	87,489	4,200	4,105	1.56
6. Yannawa	115,142	115,142	4,500	4,140.90	1.20
7. Satorn	150,000	150,000	4,100	4,040.93	0.90
8. Bang Kholaem	151,625	151,625	4,119.13	4,119.13	0.91
9. Dusit	267,654	267,654	6,000	5,527	0.69
10. Bang Sue	306,392	301,146	5,300	5,237.05	0.58
11. Phayathai	203,285	203,285	5,000	4,844.70	0.79
12. Ratthewee	97,836	97,836	7,500	6,399.14	2.18
13. Huay Khwang	266,500	256,269	3,460.06	3,155.15	0.41
14. Phrakanong	207,304	207,304	5,101.58	5,101.58	0.82
15. Klong Toi	250,557	250,557	16,000	15,639.48	2.08
16. Prawate	199,470	180,504	4,357.02	4,357.02	0.81
17. Bang Khen	234,110	153,400	4,200	4,167.32	0.59
18. Don Muang	208,990	205,106	8,609.23	3,476.15	1.38
19. Jatujak	206,284	206,284	8,000	6,950	1.12
20. Bang Kapi	235,840	235,840	15,000	7,653.24	1.08
21. Lad Prau	117,371	117,371	3,300	3,219.09	0.91
22. Bung-Kum	186,472	169,295	4,900	4,884.79	0.96
23. Nong-Chok	60,523	49,962	350	309.37	0.17
24. Min Buri	98,431	30,080	1,900	1,598	1.77
25. Lad Krabang	67,811	44,500	1,430	1,428	1.07
26. Thonburi	269,436	268,839	4,900	4,604.62	0.57
27. Khlong-san	120,714	120,000	4,000	3,761.53	1.05
28. Bangkok-noi	143,827	143,827	3,800	3,475.31	0.81
29. Bang Plat	181,388	181,388	4,000	3,945.52	0.73
30. Bangkok-Yai	103,144	92,830	2,973.64	2,459	0.88
31. Pasi Charoen	537,827	531,347	no data	no data	-
32. Bang Khun Tein	123,620	120,000	4,195	2,409.20	0.67
33. Jom-Thong	175,011	175,011	4,600	3,920.43	0.75
34. Talingchan	124,175	104,800	1,400	1,382.31	0.44
35. Ratburana	168,544	100,000	4,900	4,826.87	1.61
36. Nong-Khaem	84,954	59,467	2,449.22	1,799.41	1.01
Total	6,123,743	5,764,175	172,954.88	155,354.37	0.90

Note: The Disposal Rates (kg/cap/day) were calculated through the division of "Solid Waste Collected" by "Population Served".



2.2 Solid Waste G

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Year	
1980	
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1984	
1985	
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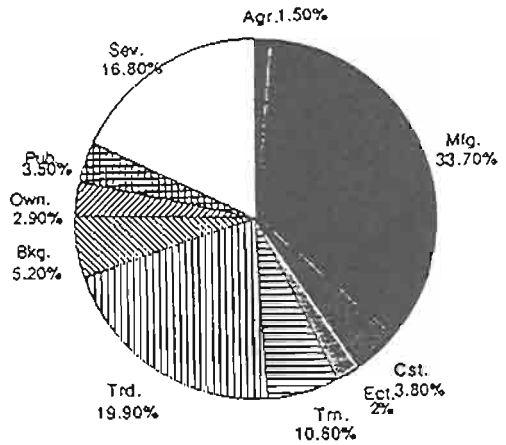
1987	
1988	
1989	

Note: The estimates
Waste" by "Pc



Agr.	Agriculture
Mfg.	Manufacturing
Cst.	Construction
ECT.	Electricity & Water Supply
Tm.	Transportation & Communication
Trd.	Wholesale & Retail Trade
Bkg.	Banking Insurance & Real Estate
Own.	Ownership of Dwelling
Pub.	Public Adm. & Defence
Sev.	Services

Fig. 2 Composition of GPP of Bangkok (1987)
(Source: JICA, 1991)

2.2 Solid Waste Generation

Figures for solid waste generated and waste collected from 1980-1989 estimated by JICA (1991), are given in Table 2.

Table 2. Waste Amounts from 1980 to 1989 in Bangkok
(Source: JICA, 1991)

Year	Collected Waste (t/d)	Collection Ratio (%)	Generated Waste (t/d)	Population (thousand persons)	Per Capita Generated (g/d/person)
1980	1,966	---	---	5,154	---
1981	---	---	---	5,331	---
1982	2,527	78.5	3,221	5,468	589.0
1983	2,723	78.8	3,454	5,018	688.3
1984	2,557	79.2	3,230	5,175	624.0
1985	3,260	79.5	4,099	5,363	764.2
1986	3,738	79.9	4,678	5,469	855.3
1987	4,190	80.3	5,220	5,609	930.6
1988	4,225	80.6	5,254	5,717	919.0
1989	4,085	81.0	5,043	5,717	882.0

Note: The estimates of Per Capita Generated (the last column) were calculated by dividing "Generated Waste" by "Population", for each year.

ESCAP reports that BMA collected about 5,240 tons of municipal waste during 1990, which is 81% of the estimated generated waste. It is obvious therefore that some of the wastes are not collected. This may be due to the discharge of solid waste to klongs (canals) or disposed of by burning from households and also due to the difficulty in collecting solid waste in narrow sois (small lanes).

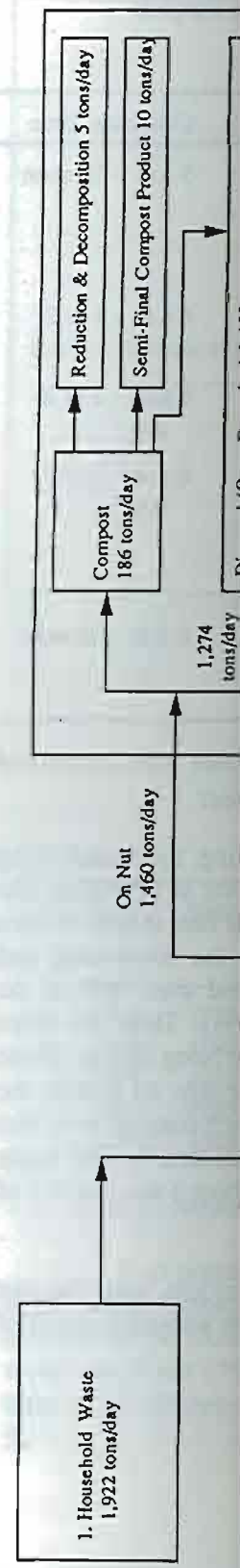
2.3 Collection, Treatment and Disposal

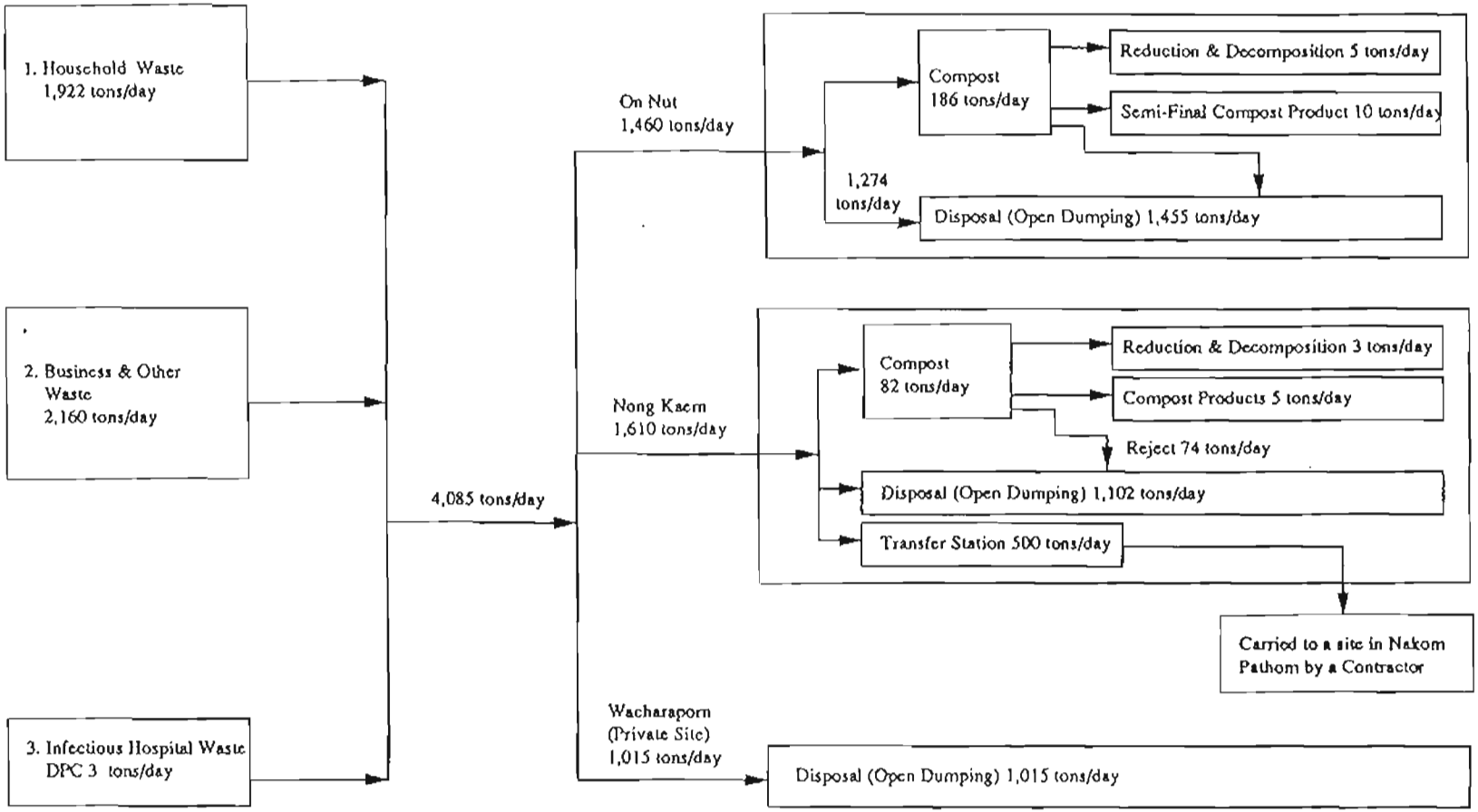
Solid waste generated in the Bangkok Metropolitan Administration (BMA) is collected by the Cleansing section of each district and the Public Cleansing Service Division of the Department of Public Cleansing (DPC). The Public Cleansing Service Division of the DPC is responsible for street sweeping by using sweeping trucks and cleansing the main roads. This division collects waste from hospitals, health centres, public markets of BMA and central government buildings. It also provides the trucks and containers whenever the districts require.

The Cleansing Section of each district is responsible for street sweeping by man-power, refuse collection from residences, markets, commercial small industries and uncollected refuse in the public areas of the 36 districts, and transport to the final disposal site (DPC, 1992). The collection, treatment and disposal of solid waste in Bangkok is shown schematically in Figure 3.

There are two types of collection processes; direct collection (door to door method) and indirect collection (separate containers are placed near the markets, department stores) (DPC, 1992). Table 3 gives the collection points and frequency of waste collection in Bangkok.

In the residential areas, collection workers pick up waste receptacles one by one and load the collected waste into the vehicle. Hand carts and bamboo baskets are used to collect and carry waste from narrow streets (soi). In the multi-storied buildings, dust chutes are used for the collection of wastes. One worker enters the chute and collects the waste and the remaining workers receive waste and carry it to a truck where recyclable materials are sorted out. The recycling process is one of the activities carried out by the collection crew. According to JICA (1982), about 40% of the time is spent by the crews on collecting the recyclable materials.





Note: 1. Infectious hospital waste is incinerated at an incinerater in On Nut
2. Business and other waste includes: waste collected from markets, offices, hotels, shops, restaurants, factories, etc.

Fig. 3 Waste Flow in Bangkok
(Source: JICA)

Table 3. Collection Points and Frequency of Waste Collection in Bangkok
(Source: JICA, 1991)

	Collection Points	Collection Frequency	Collection Time
Commercial Buildings	Storage area inside the premises or dust-chute or communal container ($1m^3$)	Daily	5 a.m. - 12 noon
Residential Areas	Frontage of the premises	1 - 3 times/week	6 a.m. - 1 or 2 p.m.
Apartment Buildings (5 stories typically)	Dust-chute	1 - 3 times/week	6 a.m. - 1 or 2 p.m.
Slum Areas	Waste stations provided on the main streets	Once a week at maximum	6 a.m. - 1 or 2 p.m.
Houses Located Along Canals	Barge is used on experimental base		
Markets	Open space in the markets or hauled-in containers ($8\ m^3$)	Daily	6 a.m. - 12 noon

Note: Collection frequency, time and days are not very regular. They change often at the discretion of the crew and as a result of poor vehicle conditions.

The main disposal practices are open dumping and composting, the former being the most common practice. At present BMA has two disposal sites. One in On-Nooch (On Nut) and the other in Nong-Khaem as depicted in Figure 4. The disposal sites consist of open dumping areas, composting facilities and small incinerators. Since the composting and incineration facilities are not functioning effectively at all the disposal sites, 90% of the delivered solid waste is disposed of by open dumping (JICA, 1991). There are three composting plants at the two disposal sites: two at On-Nooch and one at Nong Khaem. These three plants are designed to dispose of about 960 tons of refuse per day. At present the capacity of the three plants is about 150 tons per day (DPC, 1992). Each compost plant has an incinerator with a capacity of 100 tons per day. On average about 20 tons of solid waste per day per incinerator is disposed of. At the On-Nooch disposal site about 3 tons per day of hospital hazardous waste are incinerated.

The average cost for open dumping is about 10 baht per ton or less, while the cost for composting is 530 baht per ton of incoming waste (JICA, 1991). The amount disposed of at each disposal site is presented in Table 4.

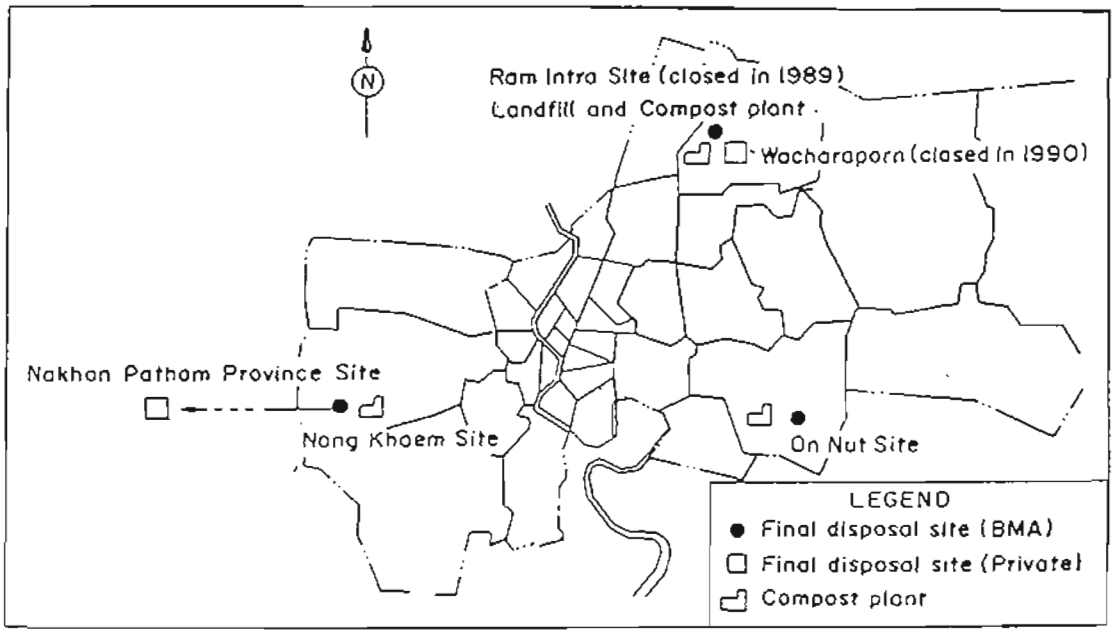


Fig. 4 Location Map of the Existing Disposal Sites
(Source: JICA, 1991)

Table 4. The Amount Disposed of at Disposal Sites (tons/day)
(Source: JICA, 1991)

Year	BMA Area	Ram Intra		On-Nooch		Nong Khaem	
		1	2	1	2	1	2
1986	3738	56	871	217	1202	28	1364
1987	4190	31	1584	158	1340	14	1063
1988	4225	1	1190	263	1051	139	1581
1989	4085	125	328	187	1276	83	1529
1990	4340	0	0	139	1214	52	1652

Note: 1 - compost plant; 2 - disposal site

With population increase and economic growth, the waste generated will increase significantly. According to JICA (1991), in the year 2000 the amount of waste collected amount will be about 8,700 tons per year. It is also predicted that the share of household waste which was 47% in 1989 will decrease and at the same time the share of business and other waste will increase. Future projections in terms of collection rates are presented in Table 5.

Table 5. Future Projections of Solid Waste (Source: JICA, 1991)

Year	Unit Discharge (g/d/p)	Population (thousands)	Waste Generation (t/d)	Collection Ratio (%)	Waste to be Collected (t/d)
1991	930	5620	5227	81.6	4668
1992	1111	5978	6643	82.2	5458
1993	1162	6068	7050	82.5	5819
1994	1213	6159	7468	82.9	6193
1995	1263	6251	7896	83.3	6579
1996	1314	6345	8336	83.7	6977
1997	1365	6440	8787	84.1	7389
1998	1415	6536	9250	84.5	7815
1999	1466	6635	9724	84.9	8254
2000	1516	6734	10211	85.3	8708

Note: All the 1991 figures are actual ones.

According to JICA (1991), there will not be significant changes in waste composition during the next 10 years. Although paper and plastic contents will increase in the future, it is expected that their share will not change much as an increasing recycling activity can be expected.

Recycling offers a substantial reduction in the cost of waste disposal. It enables industry to save energy during manufacturing since production from recovered materials uses much less energy than production from the parent material. Therefore, it saves energy and expensive raw materials and also protects the environment. In order to enhance recycling, legislative measures need to be introduced and enforced as presently in Thailand there are no laws concerning recycling.

2.4 Characteristics of Solid Waste

The solid waste of Bangkok reflects a unique blend of residential, commercial, tourist, institutional and industrial activities. The per capita waste production is the highest in the commercial and industrial zones and the lowest in the residential areas. In Bangkok, about 23-44% by weight is garbage. Paper and plastics constitutes 8-22% and 6-13% respectively (TAMS PIRNIE,1989).

2.4.1 Physical Composition

Table 6a and 6b show the physical composition of waste on dry weight basis at the final disposal sites of Nong-Khaem and On-Nooch during the rainy season and the dry season, respectively.

Table 6a. Physical Composition of Solid Waste (dry weight basis)-Rainy Season.
(Source: Tsai Chin I, AIT, 1993)

Physical Composition (%)	Nong-Khaem		On-Nooch	
	30/9/92	13/10/92	23/9/92	21/10/92
* Paper	15.94	14.81	22.69	11.83
* Fruit/Vege.	20.18	36.05	15.80	21.47
* Textile	11.31	1.67	2.34	4.65
* Wood/Leaves	3.47	2.96	8.79	4.23
* Plastic	19.02	13.52	19.91	20.79
* Leather/Rubber	0.13	1.24	0.11	0.51
* Metals	2.57	0.39	9.35	8.45
* Glass	8.10	8.11	1.33	10.23
* Stone/Ceramic/Bone	5.91	1.55	10.34	5.92
* Miscellaneous	13.37	19.70	9.34	11.92
<5mm	9.39	13.65	7.56	7.52
>5mm	3.98	6.05	1.78	4.40
Bulk Density (kg/l)	0.372	0.363	0.391	0.351

Table 6b. Physical Composition of Solid Waste (dry weight basis)-Dry Season.
(Source: Tsai Chin I, AIT, 1993)

Physical Composition (%)	Nong-Khaem		On-Nooch	
	18/1/93	3/2/93	12/1/93	27/1/93
* Paper	12.83	10.75	16.08	20.06
* Fruit/Vege.	32.51	22.54	33.10	17.68
* Textile	4.56	3.54	3.98	6.12
* Wood/Leaves	5.15	11.21	5.93	8.23
* Plastic	16.22	18.09	19.91	15.24
* Leather/Rubber	3.32	1.96	0.23	0.07
* Metals	3.98	11.93	2.34	4.76
* Glass	9.97	6.29	7.88	18.84
* Stone/Ceramic/Bone	2.40	3.73	3.91	3.28
* Miscellaneous	9.06	9.96	6.64	5.72
<5mm	7.04	6.68	4.68	3.73
>5mm	2.02	3.28	1.96	1.99
Bulk Density (kg/l)	0.351	0.295	0.317	0.287

The physical composition of the waste by weight base by type of collection area is given in Table 7. It can be observed that commercial waste has a higher percentage of paper, garbage and textiles, while industrial waste has a higher percentage of paper, textiles, rubber and leather, and residential waste contains more garbage and plastic. Thus, the commercial waste and the industrial waste show higher calorific value than residential waste.

Table 7. Physical Composition of Waste by Weight by Type of Area
(Source: Feasibility Study on the Management of the Disposal of Bangkok Municipal Waste, 1989)

Analytical Parameter	A1	A2	B	C	D1	D2	E	F
Waste Components, wet weight								
1. Combustible								
1.1 Paper	17.73	12.80	22.03	15.15	11.64	13.76	7.73	12.40
1.2 Garbage	40.02	43.35	23.41	27.86	28.71	34.46	43.46	39.19
1.3 Textile	5.55	10.13	11.42	1.96	9.12	7.18	3.97	3.22
1.4 Wood/Glass	10.10	9.38	7.70	22.99	12.29	16.62	21.92	15.16
1.5 Plastic	10.62	10.68	9.23	13.17	10.18	13.60	6.59	9.44
1.6 Rubber/Leather	0.17	0.58	10.74	2.13	1.17	2.16	7.39	1.91
Sub-Total	84.19	87.12	84.59	83.26	83.11	87.78	91.12	81.32
2. Non-Combustible								
2.1 Ferrous Metal	1.71	1.58	4.01	1.46	1.21	1.52	0.94	1.59
2.2 Non Ferrous	0.21	0.11	0.05	0.19	0.62	0.11	0.12	0.07
2.3 Glass	2.14	2.39	0.62	1.88	2.24	2.45	0.97	3.24
2.4 Stone/Ceramics	5.58	2.56	2.14	8.56	5.20	3.68	3.20	6.77
Sub-Total	9.64	6.64	6.02	12.03	9.27	7.76	5.23	11.67
3. Miscellaneous								
3.1 Size >5mm	4.30	4.41	5.44	3.81	5.84	3.32	3.12	6.43
3.2 Size <5mm	1.89	1.85	3.17	0.83	1.76	1.14	0.58	0.60
Sub-Total	6.19	6.26	8.61	4.64	7.60	4.46	3.71	7.03
Total	100	100	100	100	100	100	100	100
Waste Components, wet weight								
1.Moisture	60.52	60.05	43.19	56.08	60.44	59.50	67.00	60.45
2.Ash	10.29	10.01	21.25	17.28	12.37	11.92	9.05	15.01
3.Combustible	29.19	29.94	33.37	26.64	27.19	28.58	23.93	24.54
Total	100	100	100	100	100	100	100	100
4. Gross Calorific Value (Kcal/kg, adjusted dry basis)	4126	4180	4234	3214	4018	3909	3653	3535
5. Combustion Content of Miscellaneous against Miscellaneous	---	23.43	---	---	46.18	---	14.59	---
Number of Samples	6	6	4	5	7	14	6	2

Notes: A1 - Commercial Refuse, Central City Core and Urban Zones
A2 - Commercial Refuse, Semi-Urban and Semi-Rural Zones
B - Industrial Wastes, Factories within Industrial Estates
C - Institutional Wastes, Government Offices and Educational Institutes
D - Residential Refuse, Households in the Central City Core and Urban Zones
D2 - Residential Refuse, Semi-Urban and Semi-Rural Zones
E - Market Waste, Fresh Products Markets which include some Rating Stands
F - Residential Refuse, Low Income Level (slum) Housing Areas.

2.4.2 Chemical Composition

The chemical composition is analyzed in order to determine the probable composition of compost products and of the waste generated gases from the incineration plant. Table 8 shows the chemical composition of combustible wastes from the On-Nooch and the Nong-Khaem disposal sites.

Table 8. Chemical Composition of Solid Waste (Tsai Chin I, AIT, 1993)

Chemical Composition (wt. % in wet basis)	Nong-Khaem		On-Nooch	
	30/09/92	13/10/92	23/09/92	21/10/92
Moisture	57.98	60.97	60.10	56.80
Ash	11.83	13.17	14.79	16.52
Combustible	30.19	25.86	25.11	26.68
C	16.29	13.98	13.33	14.38
H	2.48	2.86	1.89	1.75
N	0.42	0.29	0.46	0.51
O	10.59	8.46	9.18	9.70
S	0.11	0.08	0.12	0.08
Cl	0.30	0.19	0.13	0.26

III. POTENTIAL FOR RECYCLING

Materials recovered from solid waste in Bangkok are as follows:

1. glass bottles, both whole and broken;
2. paper and paper products including newspapers, magazines, books, writing papers, paper boards or cardboard boxes;
3. plastic products including clear (eg. cooking oil containers), soft (eg. containers for liquid soaps, shampoos) and hard (eg. toilet seats, plastic bags);
4. metals such as Al, Cu, Fe and steel; and
5. used household items and clothing (mainly shoes)
   (TAMS PIRNIE, 1989).

The recycling process can be classified into two, material separation and material conversion. In the material separation process, sorting out of the materials from the waste mixture takes place without changing the physical and chemical properties. The reclaimed materials are used as secondary raw materials in the material conversion process.

The recovery process is an intricate structure involving several multi-level systems starting from the commercial or industrial establishments generating the solid wastes (Figure 5).

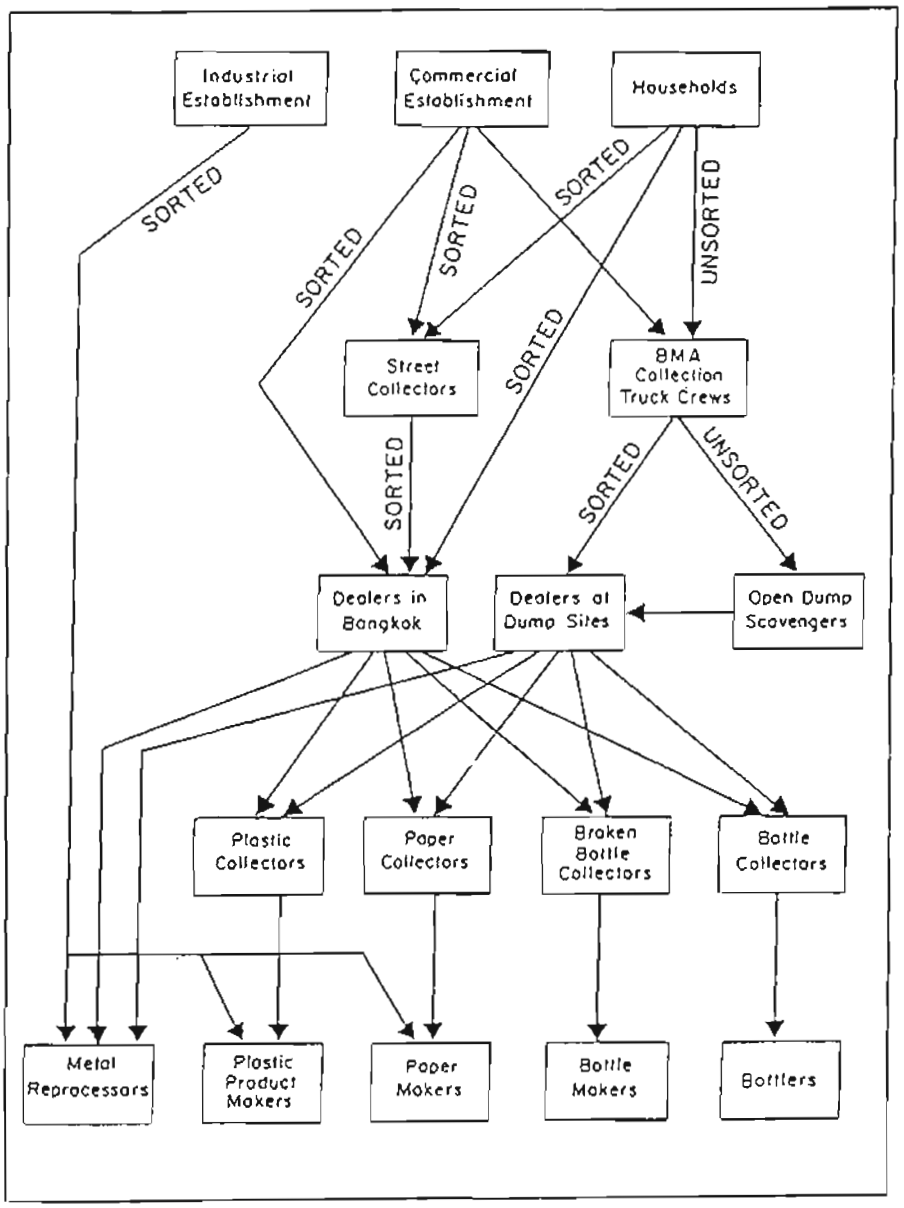


Fig. 5 Flow Chart of Recyclable Materials
(Source: TAMS PIRNIE, 1989)

In Bangkok, materials are separated at different stages of the collection process as given below.

- At the source, prior to collection;
- By the crews of the collection vehicle; and
- By the scavengers at the dump site.

A survey conducted by ESCAP in 1990 indicated that there were 954 persons involved in door to door collection as well as 2584 and 307 persons involved in the collection at the main dump sites and at the intermediary sites, respectively.

The collected materials are sold through middlemen 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. In addition to the above process there is also a considerable amount of direct recycling of industrial waste.

3.1 Waste Collection and Separation at the Source

Materials such as newspapers, magazines, cardboard and bottles are separated at the source, often at the residence itself. For example, a deposit has been paid, for returnable bottles. Alternatively, they may also be sold to the collectors who operate door-to-door with a three wheel cart. A similar process is carried out at the industrial and commercial establishments. Street scavengers also sort out the most valuable items from the waste bins and containers prior to the collection by the BMA crews.

According to the ESCAP (1990), the total daily tonnage of recyclable garbage collected by waste pickers is estimated at 286.03 tons, about 5% of the garbage collected by the city. Types of garbage collected by waste pickers are represented in Table 9.

Table 9. Percentage of Waste Materials Collected by the Waste Pickers in Bangkok (Source: ESCAP, 1990)

Materials	Percentage (%)
Plastics and rubber	26.49
Glass and porcelain	48.08
Cloth	0.68
Newspaper and magazines	3.28
Other paper based	6.62
Bones	4.32
Wood based	1.17
Metal based iron	8.67
Others	0.48
* aluminium	
* electric wire	
* electric machine	
* electric bulb	

3.2 Waste Separation and Collection by the Collection Crew

The second part of the recycling process is carried out by the collection crews, separating mainly the most valuable items such as larger and cleaner pieces of paper, cardboard, plastic products, bottles, etc., which are segregated in separate baskets according

to the type of material and are stored on top of the truck or inside the hopper for the trip to the disposal site. According to the JICA (1982), about 40% of the time was spent by the crews on collecting the recyclable materials (TAMS PIRNIE, 1989).

The investigations conducted by ERL (1987), indicated that in July 1987, about 2.5% of the total waste load collected by the refuse collection crews was recovered and sold to the junk shops. Among the recyclable materials about 50% of the recovered materials were paper products, about 20% were glass and another 20% were a mixture of hard and soft plastics, and the remaining 10% were metals. The study conducted by the TAMS PIRNIE team (June, 1987), indicated that 50% of the recovered materials consisted of mixed paper and cardboard, 39% glass, 9% plastics and 2% metal, rubber and textiles. These collected materials are sold to the junk shops at or near the entrance of the open dumps.

Around each of the main waste disposal sites, there are a number of small scale recycling shops (SSR) where collected materials are sold by the collection crews and the scavengers. The quantity of materials delivered to each of these SSR shops by the collection crews vary between 1 to 6 tons per day. The amount of materials delivered to the recycling shops is presented in Tables 10a-c and the amount of materials collected by the junk dealers is presented in Table 11.

Table 10a. Quantity of Materials Delivered to SSR shops at Nong-Khaem (Source: ERL, 1988)

	Quantity of Materials Delivered (kg/day)					
	Nong-Khaem					
Shop No.	3	6	7	8	9	11
No. of Vehicles	20	30	10	20	dump site	50
Shop Size	S3	S4	S2	S3	S3	S5
No. of Employees	7	7	4	7	7	15
Paper	600	2400	400-500	800	500	3000
Cardboard	400		100-200			
Glass	1200	1000	200	400-500	400-500	1500
Soft Plastics	500	20	50	40-50	200-300	1200
Hard Plastics	400			40-50		
Rubber	50	---	---	---	---	---
Textile	---	---	---	---	---	---
Metal	1	---	10	20-30	---	---
Others	0.5-1.0	---	---	---	---	---
Total	3150	3420	860	1400	1200	5700

Table 10b. Quantity of Materials Delivered to SSR Shops at On-Nooch (Source: ERL, 1988)

	Quantity of Materials Delivered (kg/day)					
	On-Nooch					
Shop No.	2	3	4	5	6	7
No. of Vehicles	5-20	30-40	30-40	30-40	50% dump site	80% dump site
Shop Size	S3	S3	S2	S3	S2	S4
No. of Employees	7	10	8	10	7	7
Paper	---	1500-2000	---	1200	400-500	2000-5000
Cardboard	---		---	300		
Glass	---	---	600	400	400-500	700-800
Soft Plastics	---	---	200	500	200	300-400
Hard Plastics	---	---				
Rubber	---	---	---	---	---	---
Textile	---	---	---	---	---	---
Metal	---	---	30-50	20-30	20	200-300
Others	---	---	---	---	---	---
Total	2000	2000	850	2030	1220	3200-6500

Table 10c. Estimated Quantity of Recycled Materials Delivered to SSR Shops at Nong Khaem and On-Nooch (Source: ERL, 1988)

Shop Size	Quantity of Recycled Materials (kg/day)	Nong-Khaem		On-Nooch	
		No. of Shops	Total Quantity (kg/day)	No. of Shops	Total Quantity (kg/day)
S5	4000-6000	2	10000	---	---
S4	3000-4000	2	7000	3	10500
S3	2000-3000	7	17500	3	7500
S2	1000-2000	5	7500	2	3000
S1	---	5	---	2	---
Total			42000		21000

Note: Shop size is determined by the physical size and the number of refuse trucks that unload materials at the shops per day.
S5 - more than 40 vehicles
S4 - 30-40 vehicles
S3 - 20-30 vehicles
S2 - 10-20 vehicles
S1 - sorting or storage shop. No vehicle unloads at the shop.

Table 11. Recyclable Items Collected by the Junk Dealers
(Source: ESCAP, 1990)

Waste Category	Percentage (%)
Plastics/Rubber	16.68
Glass/Porcelain	29.27
Cloth	0.22
Newspaper/Magazine	8.61
Other paper based	11.03
Bones	0.48
Wood based	0.39
Metal based	21.19
Others	12.33
* Electric wire	
* Electronic machine	
* Scrap silver/gold	
* Aluminium	

3.3 Recovery at the Dump Sites

This is the final stage of the recovery process. The amount of materials recovered by the scavengers varies between 50-150 kg/person/day and daily income varies between 30-300 baht/person (TAMS PIRNIE, 1989).

The survey conducted by Butsapak (1984), showed that there were 170, 300 and 280 scavengers working at Ram-Intra, On-Nooch and at Nong-Khaem, respectively. The average waste collected per day at the three disposal sites is presented in Table 12.

In Bangkok, the largest amount of salvaged refuse at the dump site is glass, while in Jakarta and Manila it is paper (Baldisimo, J.M., Lohani, B.N. and Evan, W., 1988). Soft plastics are also abundant in Bangkok refuse and much of it is retrieved by scavengers to be recycled for use as packing materials. In Manila hard plastics are more popular with dump scavengers due to having a good price.

Table 12. Average Waste Collected (kg per day) at the Disposal Sites
(Source: Butsapak, 1984)

Type of Waste	Ram-Intra	Nong-Khaem	On-Nooch
Paper (hard)	294.10	484.40	519
Paper (soft)	334.90	551.60	591
Plastic (hard)	853.40	1405.60	1506
Plastic (soft)	2534.70	4174.80	4473
Glass	6716.70	11062.80	11853
Leather/Rubber	198.90	327.60	351
Iron (thin)	790.50	1302.00	1395
Iron (thick)	720.80	1187.20	1272
Bone	967.30	1593.20	1707

Ferrous metal is also recovered from the compost plants. The amount of recovered ferrous metal by the magnetic separator from the raw waste entering the compost plants is approximately 0.8 ton for each 100 tons of raw waste. The recovered ferrous metal is compressed into blocks weighing 30 kg on average. There were 2,404,616 blocks (about 72,000 tons) recovered by the 4 compost plants in 1980 (JICA, 1981).

The materials collected by the scavengers are sold to the middlemen. Approximately 7-10% of the middlemen buy these salvageable materials from the scavengers. Each scavenger will have a dealer with whom they deal for selling their materials. These middlemen generally buy bottles, plastic, iron and paper separately. The selling prices for recyclable materials collected at the disposal sites are given in Table 13.

Table 13. Selling Prices at the Disposal Sites
(Source: DPC, 1992)

Materials/kg	Selling Price (baht)
Plastic Bottles	3.20-3.30
Broken Bottles	0.20-0.30
Mekhong Bottles (white)	0.70-0.80
Beer Bottles (brown)	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

In Bangkok the price for each material is different at each level of the recycling process as given in Table 14. Generally an adult earns about 30-150 baht per day and the children about 50-80 baht per day. According to ERL 1988 report, about 41.9% of the

scavengers earn about 30-60 baht per day, while 36.7% earn from 65-90 baht per day. The rest earn about 100-200 baht per day. The average income is 75 baht per day. About 45.3% earn an average annual family income of 10,000 to 50,000 baht, while 42% are within the 50,000 to 100,000 baht range. The remaining percentage earn more than 100,000 baht.

Table 14. Prices for Recycled Materials (Source: DPC, 1992)

Material Category	Price (baht/kg)	
	Collector	Junk Shop Dealer
Paper:		
Newspaper	1.00	1.50-2.00
Writing Paper		3.50
Waste Paper		1.00-1.30
Cardboard		1.50-1.70
Bottles:		
Beer (brown)		0.30-0.40
Mekhong (white)	0.50	1.00
Broken Bottles	0.20	0.50
Metal:		
Iron		1.80
Aluminium		15.00-18.00
Copper		40.00-50.00
Plastics:		
Bottles	3.00	3.50
Tiles	5.00	
Kapok	3.00	

Note: Collector - collects recyclables from households

3.4 Conversion of Reusable Materials into New Products

The reclamation process involves the removal of a component from the waste stream and physical reprocessing into a useful product. Finally, chemical conversion processes such as pyrolysis, hydrogenation, wet oxidation and hydrolysis transform it into a new product for the market.

Among the reusable materials, ferrous metal, paper, glass and plastic are used for recycling processes. Paper products which account for 55% of the total waste stream are considered as the largest "Product Group" in the municipal solid waste.

The main sources of paper generation in Bangkok are computer offices, printing shops, newspaper presses, offices, warehouses, factories, shops, households, refuse dumps and disposal plants.

In Bangkok both formal and informal sections manufacture paper pulp, cardboard boxes and magazines from the recyclable paper. The flow chart of the paper processing at Mahachai Paper Production Company is given in Figure 6.

In Bangkok, recyclable glass or cullet is used to manufacture plain glasses or cups. Glasses are sold at a rate of 0.1-0.33 baht/kg. Glass constituted about 1-3% of the general waste stream in 1987 (TAMS PIRNIE, 1989). The main sources of generation of glass in Bangkok are glass making factories and work shops, breweries, dairies and beverage industries, hotels, restaurants, shops, factories, office canteens, households and refuse dumps. Glass production process at the Thai Glass Industry, which uses recyclable glass is shown in Figure 7.

Plastics constitute about 10-15% of the waste stream. Plastic increases oxidation if used with recycled material. Therefore careful sorting is essential if these plastics are used as one of the raw materials of granulated plastics. Plastics are purchased at a rate of 39 baht/kg for polypropylene and 26 baht/kg for polyethylene, respectively (TAMS PIRNIE, 1989). Plastic recycling process at Mahakhun Plastic Factory is given in Figure 8.

Table 15 gives some of the factories using recyclable materials and the Benefit/Cost ratio of the production.

Table 15. Benefit/Cost Ratio of Production

Factory	Waste Material Used	Benefit/Cost Ratio
* East Industrial Co.	wood pulp, 600 t/m waste paper, 1,200 t/m	1.260
* Mai Num Paper Mill Co. Ltd.	wood paper, 70 t/m waste paper, 400 t/m	2.132
* Mahachai Paper Production Co.	waste paper, 200 t/m	2.132
* Mahakhun Plastic Factory	waste plastic, 1 t/d (washed), 1.2 t/d (unwashed)	1.43
* Sang Charoen Plastic Factory	waste plastic, 1 t/d (unwashed) 850 kg/d (polypropylene)	1.260
* Thai Glass Industry Co. Ltd.	waste glass, 3150 t/m	1.64
* Glass Organization	cullet, 1800 t/m	1.577

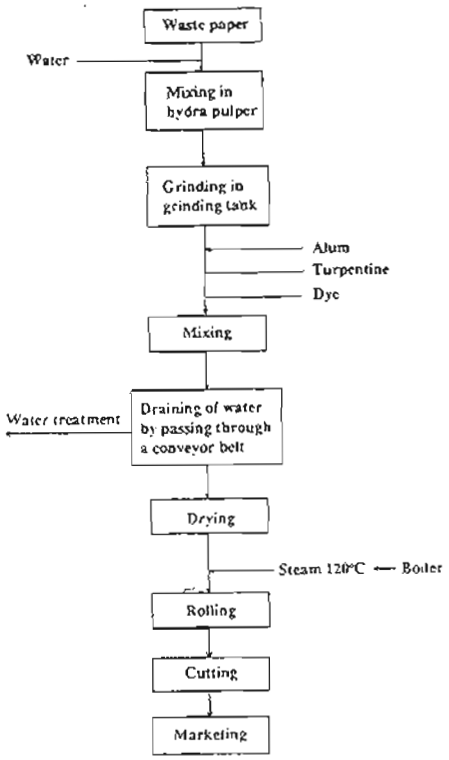


Fig. 6. Paper Production at Mahachai Paper Manufacturing Company
(Source: Butsapak, 1984)

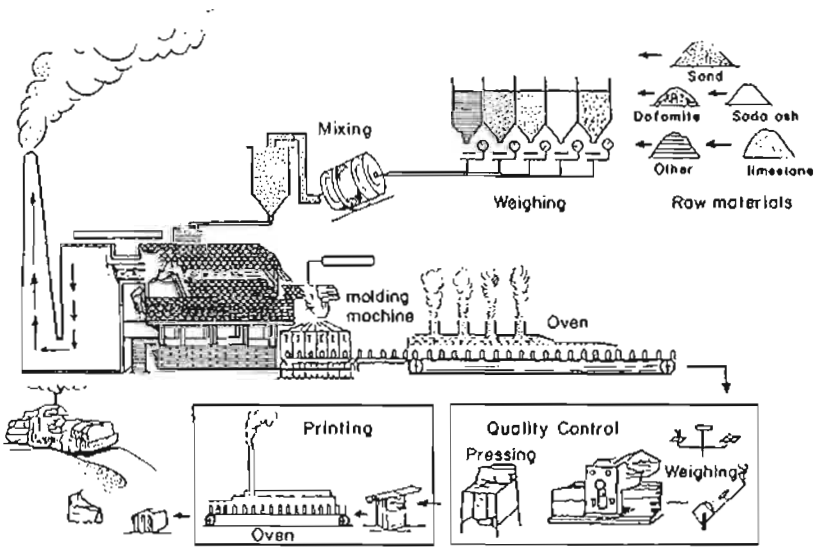
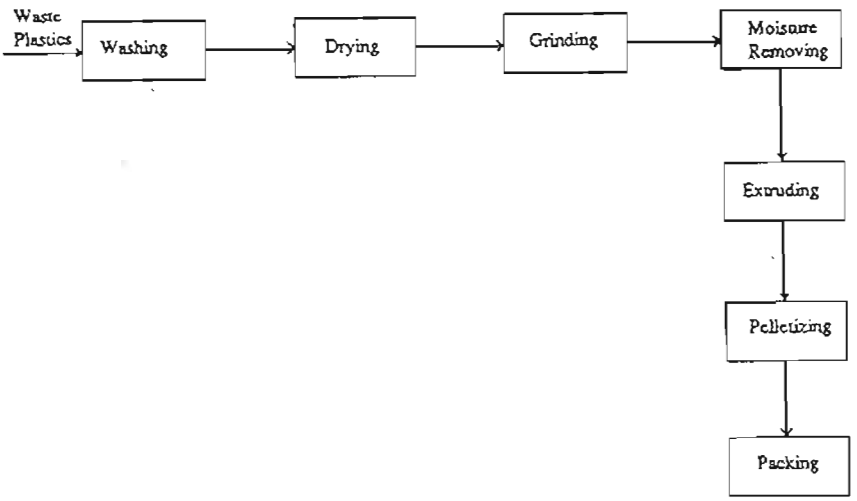


Fig. 7. Glass Production Process at Thai Glass Company
(Source: Butsapak, 1984)



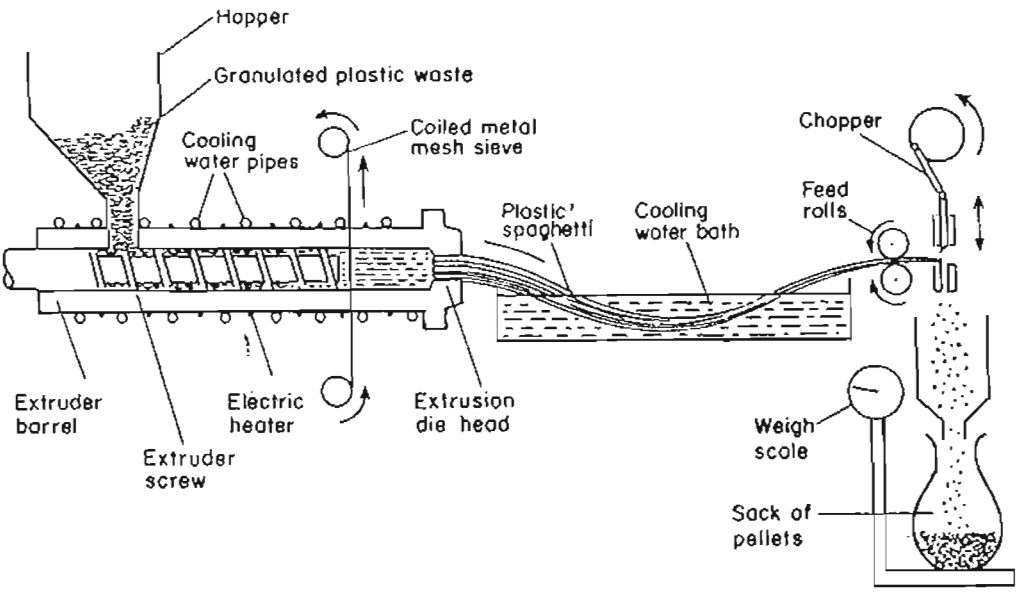


Fig 8. Plastic Recycling Process at Mahakhun Plastic Factory
(Butsapak, 1984)

IV. LEGISLATION

In Thailand, the existing laws and regulations on solid waste management are outmoded. Most of the present acts deal with either regulation of the refuse containers or general tidiness of refuse in the city area, particularly from the public health point of view, and there are no laws governing the recycling process.

The government can introduce the laws like those in western countries such as the USA which would encourage recycling. The United States of America has taken the following steps to curb the solid waste problem to a great extent.

Disposal Bans

Most of the states of USA have implemented laws and regulations concerning disposal bans specially focused on dry batteries and materials coming from vehicles (batteries, tires and oil), yard waste and white goods, etc. (Table 16). In this way a reduction of waste disposal can be achieved.

Mandatory Deposits and Return Requirements

The aim of this is to shift some of the burden of waste disposal and the recovery of materials back to the manufacturers of products. The approach is a deposit/take back requirement of some of the goods such as mercuric oxide batteries, vehicle batteries, vehicle tires (Table 17). What has become more prominent than deposits is requiring retailers, and then wholesalers in turn, to take back products.

Advanced Disposal Fees (ADF)

Advanced disposal fees have been considered for a wide variety of products and packages, but states have put fees on only a narrow range of products (eg. motor oil and tires). The retailers or wholesalers are responsible for the collection of fees. This system is very popular as it provides a substantial funding source. In most cases the funds are utilized to fund tire cleanup and for recovery programs. In South Carolina and Texas, the funds will be used to help finance all state waste reduction efforts.

Targeting Special Wastes

In a number of instances, states have gone further than simply putting an ADF on a material and/or banning it from disposal sites and have developed comprehensive management programs. In 1991, Arkansas passed laws which developed a permit programs for waste tire facilities, required solid waste management districts to establish collection sites and provided grants for the clean-up and processing of waste tires. Texas has put a program in place which again permits waste tire facilities and also helps to pay the cost of shredding and processing tires. South Carolina permits tire facilities and uses grants to fund a variety of activities related to cleanup and processing.

Table 16. Disposal Bans for Selected Waste Materials
(Source: BIOCYCLE; Journal of Waste Recycling, May 1992)

State	Vehicle Batteries	Tires	Yard Waste	Motor Oil	White Goods	Others
Arkansas	x	x	x	---	---	---
Arizona	x	x	---	---	---	---
Connecticut	---	---	---	---	---	x[1]
Florida	x	x	x	x	x	x[2]
Georgia	x	---	---	---	---	---
Hawaii	x	---	---	---	---	---
Idaho	x	x	---	---	---	---
Illinois	x	x	x	---	x[3]	---
Iowa	x	x	x	x	---	x[4]
Kansas	---	x	---	---	---	---
Louisiana	x	x	---	---	x	---
Maine	---	---	x	---	---	---
Maryland	---	x	---	---	---	---
Massachusetts	x	x	x	---	x	x[5]
Michigan	x	---	x	---	---	---
Minnesota	x	x	x	x	x	x[6]
Mississippi	x	---	---	---	---	---
Missouri	x	x	x	x	x	---
New Hampshire	x	---	---	---	---	---
New Jersey	x	---	x[7]	---	---	---
New York	x	---	---	---	---	---
North Carolina	x	x	x	x	x	---
North Dakota	x	---	---	x	x	---
Ohio	x	x	x	---	---	---
Oregon	x	x	---	x	x	x[8]
Pennsylvania	x	---	x[9]	---	---	---
Rhode Island	x	---	---	---	---	---
South Carolina	x	x	x	x	x	---
South Dakota	x	x	---	---	---	---
Tennessee	x	x	x	---	---	---
Texas	x	x	---	x	---	---
Utah	x	---	---	---	---	---
Vermont	x	x		x	x	x[10]
Virginia	x	---	---	---	---	---
Washington	x	---	---	x	---	---
West Virginia	x	x	x	---	---	---
Wisconsin	x	x	x	x	x	x[11]

Note: [1] mercuric oxide batteries, [2] demolition debris, [3] white goods containing CFC gases, mercury switches and PCBs, [4] nondegradable grocery bags and carbonated beverage containers, [5] glass and metal containers, recyclable paper and single polymer plastics, [6] Ni-Cd rechargeable batteries, [7] leaves, [8] discarded vehicles, [9] leaves and brush, [10] various dry cell batteries, [11] metal, glass and plastic containers, and recyclable paper.

Table 17. State Mandatory Deposit Laws
(Source: BIOCYCLE; Journal of Waste Recycling, May 1992)

State	Type of Product	Deposit/Take Back	Act ID	Effect. Year
Arizona	vehicle batteries	take back	HB 2012	1990
Arkansas	vehicle batteries	deposit	HB 1170	1991
Connecticut	beverage containers	deposit	22A-243-246	1978
	HgO batteries	take back	HB 7216	1991
Delaware[a]	beverage containers	deposit	T.7,Chap.60	1979
Idaho	vehicle batteries	deposit	HB 122	1991
Illinois	vehicle batteries	deposit	PA86-723	1989
Iowa	beverage containers	deposit	Chap.445C	1978
Kansas	tires	take back	HB 2407	1991
Louisiana	vehicle batteries	take back	185	1989
Maine	beverage containers	deposit	PL1975C.739	1975
Massachusetts	beverage containers	deposit	301CMR4.00	1981
Michigan	beverage containers	deposit	MCL445.571	1976
	vehicle batteries	deposit	PA 20	1990
Minnesota	vehicle batteries	deposit	115A.9561	1989
Mississippi	vehicle batteries	take back	SB 2985	1991
Missouri	vehicle batteries	take back	SB 530	1990
Nevada	tires	take back	AB 320	1991
New Jersey	vehicle batteries	take back	SB 2700	1991
New York	beverage containers	deposit	T.10C.200	1983
	vehicle batteries	take back	Chap.152	1990
North Carolina	vehicle batteries	take back	HB 620	1991
North Dakota	vehicle batteries	take back	HB 1060	1991
Oregon	beverage containers	deposit	ORS459.810	1971
	vehicle batteries	take back	HB 3305	1989
Pennsylvania	vehicle batteries	take back	101	1988
Rhode Island	vehicle batteries	deposit	23-60-1	1987
South Carolina	vehicle batteries	deposit	SB 366	1991
Texas	vehicle batteries	take back	SB 1340	1991
Utah	vehicle batteries	take back	HB 146	1991
Vermont	beverage containers	deposit	T.10, C.53	1972
Washington	vehicle batteries	deposit	ESHB 1671	1989
Wisconsin	vehicle batteries	-[b]	335	1990
Wyoming	vehicle batteries	take back	WS35-11-509	1989

Note: [a] Any container that holds a carbonated beverage, except aluminium cans.
[b] Retailers are required to accept old lead acid batteries when a person purchases a new one and may place up to a $5.00 deposit on a battery which is sold.

Market Developmer

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Market Development Initiatives

States have come to recognize that the glue that holds recycling together is the market place. One approach several states have taken is to directly intervene in the market. Most of the states passed recycled content standards for paper, plastic, glass, etc. (Table 18).

Table 18. Recycled Content Standards, Passed in 1991
(Source: BIOCYCLE, Journal of Waste Recycling, May 1992)

State	Material	%	Deadline
Maryland	phone directories	40	2000
North Carolina	newsprint	40	1997
Oregon	newsprint	7.5	1995
Oregon	phone directories	25	1995
Oregon	glass containers	50	2000
Oregon	plastic containers	25	1995
Rhode Island	newsprint	40	2001
Texas	newsprint	30	2001
West Virginia	newsprint	80	1997

They have already developed tax credit incentives for equipment used in the recycling process and most of the states give a tax deduction to encourage businesses to purchase recycled goods (Table 19).

Virtually every state in the country has passed some form of legislation encouraging governmental purchase of products made from recycled materials. Legislation tends to focus on two things: eliminating any biases against recycled products; and price preferences, particularly for paper and paper products.

On-going Projects in Bangkok

BMA recently operated a three stage project to improve the recycling process. In the first stage, recycling materials were separated at the BMA City Hall II at Din Daeng, Bangkok. About 2000 kg of waste was collected of which paper (29.8%), plastics (1.82%) and others (68.38%) were separated. The project was accomplished with success. In the second stage of planning BMA has decided to extend it further in schools managed by BMA, to make the younger generation more aware of solid waste management. In the third stage, BMA has decided to execute the project in a small village called Muban Sevallai at Bangkok Yai district. BMA, National Bureau, Ministry of Education along with Thai Environmental and Community Development Association (TECDA) are jointly organizing projects to enhance the solid waste management effectively. BMA also has decided to convince the people to use easily bio-degradable materials such as bags made out of water hyacinth for their household rubbish, as the BMA has failed to clear the plastic bags.

Table 19. State Financial Incentives to Produce Goods Made with Recycled Materials (Source: BIOCYCLE; Journal of Waste Recycling, May 1992)

State	Tax Credits	Loans	Grants	Other
Arkansas	yes	---	---	---
California	yes	yes	yes	---
Colorado	yes	---	---	---
Florida	---	---	---	sales tax exemption
Illinois	---	yes	yes	---[a]
Iowa	---	---	---	sales tax exemption
Louisiana	yes	---	---	---
Maine	---	yes	---	---
Maryland	yes	yes	yes	---
Mass.	---	yes	---	---
Michigan	---	yes	yes	---
Minnesota	---	yes	yes	---
Missouri	---	---	---	---[b]
Montana	yes	---	---	---
New Jersey	yes	yes	yes	sales tax exemption
New Mexico	yes	---	---	---
New York	---	yes	yes	---
North Carolina	yes	---	---	---
Oklahoma	yes	---	---	---
Oregon	yes[c]	---	yes	---
Pennsylvania	---	yes	yes	---
Vermont	---	---	yes	---
Virginia	yes	---	---	pers.prop.tax exem.
Wisconsin	---	yes	yes	sales tax exemption

Note: [a] Allows local governments to grant property tax abatement.
[b] Missouri has committed $1,000,000 per year over the next five years from its disposal fees to fund market development, but has not determined the exact nature of the programs.
[c] Oregon has three separate tax credits that pertain to market development.

In order to conserve the environment, Seagate company in the Rayong Industrial Park is taking measures to reuse and recycle the supplies of cardboard and paper, recycling chemical materials and locating surplus equipment within the company before purchasing new equipment (Muttamara, 1992). The Asian Institute of Technology (AIT), Pathumthani is conducting a project in connection with recycling and so far several mitigating steps for the possible reuse of solid waste generated (electronic batteries, paper, etc.), have been formulated.

V. CONCLUSIONS

Recycling offers a substantial reduction in the cost of waste disposal. It saves energy and expensive raw materials, and also protects the environment. Growing population, rising incomes and changing consumption pattern complicate the waste management problem. In most of the developing countries the ability to manage the waste effectively lags far behind its rate of growth. To increase the rate of recycling the following steps should be considered.

1. Educational Programs

* Conducting public education programs that stress the benefits of recycling. The public should be made aware of adverse social, environmental and health effects of unregulated open dumping systems prevailing in developing countries.

2. Legislative Measures

* In order to enhance the recycling processes stringent legislative measures should be introduced as there are no laws concerning the recycling process. National legislation, incentives, policies and programs encouraging waste minimization and waste recycling and reuse are vital to the attainment of a successful recycling organization. Legislation could start with encouraging waste minimization through special tax incentives for producers/industries.

* Incentives could be created that may encourage industries to recycle more products like taxes for pollution, tax rebates for non-pollution, special lines of credit or tax incentives to implement recycling activities of the private sector or even assistance in research and development and networking activities that would help promote recycling. Appropriate environmental standards have to be implemented in legislation.

* Incentives could encourage neighborhood initiatives aiming at household separation of waste and separate collection of recyclable materials. Such initiatives should be worked out with all actors involved in the waste collection and recycling including the municipal waste collection system. Workshops and seminars could be organized to secure the participation of the people in addition to financial incentives.

* To design and implement pollution control and waste management strategies, national and local institutions will require substantial strengthening in terms of human resources, organizational structure and financial resources. Inter-sectoral cooperation between environmental units at all levels is necessary.

* Awareness of the public with regard to civic laws and environmental protection should be developed for proper enforcement of legislation and change of attitude towards protection of their own environment. Awareness starts with knowledge. Environmental legislation should enforce environmental monitoring and should make environmental information accessible to the public.

* Legislation of activities of the informal waste recycling sector should be developed. This informal sector is intrinsic for the functioning of Asian cities because of the

need for resources that are discarded by industries and the general public. It creates an employment opportunity for many poor people and it reduces the volume of waste. Prohibition of these informal activities will increase bribes and pay-offs and valuable materials will be transferred to dump-sites, where more scavengers will be attracted and where separation of recyclables is more difficult.

* Recycling programs should be integrated within a city's overall solid waste management plan.

3. Organizational Measures

* In order to operate the system effectively, economic benefits should be given to the consumers. For an example, in Thailand deposit-refund system is implemented for items such as bottles. If operated for the other reusable materials, this system could encourage recycling and prevent pollution.

4. Economic Aspects

* A solid waste pricing system that provides on-going incentives for households and reduces waste generation is needed.

* Subsidies can be provided to waste authorities and the private sector for various aspects of solid waste management. Subsidies for resource conservation, resource recovery and reducing interest on loans financing waste recycling investments could enhance the recycling process.

* A deposit-refund system should be applied to beverage containers, automobile batteries and pesticide containers. From an administrative perspective, these measures are efficient since they require no monitoring or other involvement by authorities.

* The pricing system should be more systematized so that recycling could be more effective. In Bangkok the pricing system is inconsistent.

* The future development of small scale waste recycling industries will provide an excellent return on investment for entrepreneurs. Cost/Benefit ratios in excess of 1.5 have been reported in many of the small scale industries. In order for these industries to be economically viable extended credit should be made available to entrepreneurs to encourage development of small scale waste recycling industries. Funding could be supplied by a combination of private and municipal finance.

* Municipal authorities will greatly benefit from supporting waste recycling. The principal advantage will be a large reduction in waste disposal costs of the order of 40-50 percent. In addition to the direct benefits, there will also be reduced environmental damage, an extension of the life of existing disposal sites and a reduced dependency on the use of virgin materials and energy. Reduced costs of health care associated with poor solid waste disposal practices are also anticipated. Increased awareness to the huge potential cost savings must therefore be demonstrated to municipalities.

* Separation at source should be encouraged wherever possible and will increase the potential for waste recycling. Incentives such as tax reduction, fringe benefits and legislation should be developed by municipal authorities for those who produce large volumes of waste to recycle and/or separate in house. Industries for example could be offered subsidized energy costs. The development of semi-private agencies could combine the management flexibility and financial responsiveness of a private firm with the consultancy of local governments. Waste separation at source will enhance the potential for composting and small scale privatized composting at a household or community level could further reduce the dependency on waste collection.

* Community participation should be strengthened by public awareness campaign organized by local authorities and NGOs which could greatly enhance separation at source, the development of small scale composting and possibly the marketing of recycled products.

* The role of associations in residential areas, established in cooperation with the local authorities for organized collection, separation and marketing of recyclable waste components could be promoted.

5. Technical Aspects

* Discarded products can be reused in the same basic shape as the original. For an example bottles are reused in Bangkok.

* Waste is reprocessed into a new product of comparable composition (eg. glass cullet). In Bangkok there are few small scale industries which use the recyclable materials in the manufacturing process.

* Waste is processed into a different material or a form of energy at this level of recovery and reuse. For an example, composting, biogas and ethanol production.

6. Other Options

Social Opportunities and Options

* Health, safety and the training of operating personnel in waste recovery stream. Scavengers are among the people with the lowest social status, nevertheless they form the biggest group involved in waste recycling. Dump-site scavengers operate at the end of the collection chain, which means that their collection efficiency is low and working conditions are bad. Street peddlers are more efficient and have better working conditions. Separation at source is much more efficient and adds to better working conditions and a higher social status for the workers involved. For this reason governmental efforts should be directed towards maximum separation of the waste at source.

* Street peddlers often operate illegally, at night time till dawn, because of regulations that prohibit street scavenging to avoid littering around garbage bins and dangerous traffic situations. Street peddlers should be given a status comparable to street sweepers and street scavenging could be organized at a semi formal level by establishment of associations at neighborhood level. In this way the workers will derive some recognition

and at the same time it will become easier to secure the basic needs of workers involved.

* Small scale waste recycling industries have a low production capacity because of limited financial possibilities. For this reason the major part of recovered materials is absorbed by big industries and manufactures. Moreover, to these working conditions in the small scale waste recycling industries are often bad due to inadequate tools or lack of knowledge. The financial position of small scale waste recycling industries should be strengthened by creating easier access to credit facilities combined with flexible tax regulations. This could increase the production capacity and improve working conditions. At the same time technical assistance such as training programs and workshops should be used for this purpose.

* Recycling of waste materials contributes to controlling environmental degradation, thus controlling disease transmission. It also provides a living for a substantial part of the city population. The biggest group involved is formed by the scavengers and the street peddlers. With official support, the organization of these people should be stimulated to increase their earnings and to improve their living conditions. This will involve minimizing the role of the middlemen.

* As a return fee for environmental improvement and the economic benefit of the activities of the scavengers, governments should organize the provision of protective clothes, gloves and rubber shoes in order to improve the working condition for the scavengers. They also should provide a better free, medical service and a regular medical back up as well as a financial support for a proper living environment.

* Environmental and health education among scavengers and street peddlers could increase their knowledge concerning the prevention of infectious diseases. Campaigns among middle and high income groups could stimulate them to separate the waste at source thus minimizing the necessity of scavenging. Campaigns aimed at low income groups could stimulate them to dispose of their wastes at proper places.

* Women are unable to improve their earnings unless they create strong co-operative organizations to deal with buyers and traders or to develop skills related to waste recycling. Unionization of women groups to develop a stronger negotiation position should be considered.

* Special programs for education and training for scavengers'children, where school hours are adjusted so as to allow them to gather waste, should be developed.

Environmental Opportunities and Options

* Controlled dump-sites and sanitary disposal sites are preferable to uncontrolled dump-sites. Controlled dump-sites prevent leachate by means of several measures to protect soil, ground water and surface water underneath and around the dump-site. By covering of the dumped waste littering of the environment is prevented and the risk of infection is reduced. Another manner of control is to divide the dump-site into sections. Better monitoring is then possible. In this way waste that already has been scavenged cannot mix with unscavenged waste by which the efficiency of collection is augmented. Fences can be constructed to prevent forbidden people and animals entering the dump-sites.

* The spilling or dumping of oil and grease can lead to serious pollution of the soil and groundwater. One liter of oil can pollute thousands of cubic meters of surface water or groundwater. Therefore separation before dumping is necessary. Preferably this has to be done on household level by the initial buyers who undertake the first phase of separation. After this phase the possibility of the oil and grease mixing with other waste is reduced. Otherwise separation becomes more difficult and pollution of other waste occurs. A separate collection and treatment (regeneration) at household and workshops level could add to better chances for reuse and recycling and could reduce environmental pollution drastically.

* Small chemical wastes such as batteries, storage batteries, paint, felt pens, solvents, spray cans and acids have a decidedly negative influence on the environment once they are disposed of at the dump-site. Collecting these products as close to source as possible after they have been separated out from other wastes and undertaking controlled storage of these wastes would help significantly to reduce environmental pollution. As the amount of hazardous or industrial waste is also growing with the rapid development of industrial processes, there is a need for recycling of these substances, which could then be reused in the production processes. It is of great importance to seek directly for possibilities of reuse in order to maximize the economical feasibility of collecting such products after they have been sorted out from other wastes.

* Composting on a large scale can be effective when the organic fraction is collected separately. This separation has to be done preferably at household level and collected by the initial buyers. In this way unpolluted organic waste is composted. Composting on a large scale could be stimulated substantially by separating more efficiently before collection. Composting on a small scale can also be effective when the organic fraction is composted at household or municipal level. Organic waste leads especially, in these climates, to bad smell, risk of fire and smoke and is a breeding place for germs. When it is composted these risks are minimized. As germs are destroyed the opportunity for disease production is reduced.

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APPENDICES

APPENDIX 1 - HABITAT QUESTIONNAIRE

APPENDIX 2 - PLASTIC COLLECTION AND REPROCESSING

APPENDIX 3 - SCAVENGING RECYCLABLE MATERIALS (PHOTOGRAPHS)

APPENDIX 1 - HABITAT QUESTIONNAIRE

HABITAT SEMINAR

The "HABITAT" international organization sponsored a seminar on "**Promotion of Waste Recycling and Reuse in Developing Countries**" on the 3 rd of September, 1992 in Bangkok. The main aim of the project was to abate the degradation of the urban environment through identification and promotion of economically efficient and environmentally sound practices for managing municipal solid wastes that take advantage of waste reuse. The key focus was on the environment and on the quality of life of poor and disadvantaged urban groups engaged in waste recycling, especially, scavengers who play a substantial role in reuse and recycling of municipal waste in developing countries.

The objectives of the workshop were to disseminate the experience on current recycling and reuse practices concerning domestic solid wastes in Bangkok in both the formal and informal sector; to discuss opportunities and constraints for waste recycling and reuse including the social, economic, environmental, institutional and technical aspects and arguments which would support an enhanced recycling strategy; to review and provide emerging policy options which are relevant to policy makers and groups involved in environmentally sound solid waste recycling and reuse practices. The following questionnaire was given to the participants and the votes counted to enable the conclusions and recommendations for improving recycling and reuse of domestic solid waste to be made as well as to formulate the most appropriate and feasible recycling and reuse options.

QUESTIONNAIRE (ALONG WITH MAJORITY RESPONSES)

1. ECONOMIC OPPORTUNITIES AND OPTIONS

1. Do you think recycling and reuse is economically viable in Bangkok? (yes)

2. Do you think there is a lack of activity in the informal collecting section? (yes)

3. Do you think that reuse and recycling will be stimulated by giving better access to financing? (yes)

4. Should recycling be promoted by encouraging separation at source? (yes)

5. What do you consider to be the best way to stimulate separation at the source?
   a. raising of environmental awareness (third)
   b. financial incentives (first)
   c. legislation (second)

7. What do you co
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   b. mechanical s
   c. combination

8. Should public a

9. Who should be
   a. private secto
   b. municipality
   c. both

2. ENVIRONME

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2. Would minimiz

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   b. odour
   c. health aspect
   d. air pollution

6. Do you feel the

7. and what about

8. and what about

9. What would yo
   a. separation a
   b. adequate tre
   c. both (first)

10. Would you a

11. Would you p

7. What do you consider the best way of separation?
   a. separation at source (first)
   b. mechanical separation
   c. combination of both (second)

8. Should public awareness be stimulated to create better chances for recycling? (yes)

9. Who should be responsible for collection of reusables?
   a. private sector
   b. municipality (first)
   c. both

2. ENVIRONMENTAL OPPORTUNITIES AND OPTIONS

1. Is minimization of waste more important than recycling? (yes)

2. Would minimization of waste be feasible within a period of 10 years? (yes)

3. Should consumption patterns be changed to minimize waste production?

4. Is industry a main target group for efforts to minimize waste? (yes)

5. What is the most important problem with respect to waste?
   a. environmental aspects due to leachate
   b. odour
   c. health aspects (first)
   d. air pollution due to burning of waste.

6. Do you feel the treatment and collection of hospital waste should be improved? (yes)

7. and what about oil and grease? (yes)

8. and what about hazardous waste? (yes)

9. What would you prefer with respect to oil and hazardous waste?
   a. separation at source and separate controlled disposal and treatment
   b. adequate treatment of leachate from disposal sites.
   c. both (first)

10. Would you allow scavengers on a controlled dump site? (yes)

11. Would you promote composting at small scale restaurants? (yes)

3. SOCIAL OPPORTUNITIES AND OPTIONS

1. Could efficiency of scavenging be increased by better organization? (no)

2. Should middlemen be eliminated to increase earning for scavengers? (no)

3. Do you feel that training could promote the small scale waste processing industries? (yes)

4. Would it be feasible in practice to register scavengers? (no)

5. What do scavengers need the most for improvement of their situation?
   a. protective gloves (fourth)
   b. health care (first)
   c. sanitation facilities (fourth)
   d. education (third)
   e. higher income (second)

6. Does it make sense to provide special facilities for scavengers? (no)

4. INSTITUTIONAL/LEGAL OPPORTUNITIES AND OPTIONS

1. What is the most important response at this stage?
   a. development of environmental legislation
   b. enforcement of environmental legislation (first)
   c. both (second)

2. Do you feel there is a need for institutional strengthening? (yes)

3. Should legislation be developed for industries to encourage the use of recycled products? (yes)

4. Would environmental legislation be effective to stimulate recycling and reuse? (yes)

5. Would monitoring and accessibility of environmental information be advantageous for public awareness? (yes)

SUMMARY

The final conclusio
Social, Institutiona
as follows:

Item
1
2
3
4
5
6

SUMMARY

The final conclusions made from each section of the Questionaire (Economic, Environmental, Social, Institutional/legal Opportunities and Options) and the votes counted are summarized as follows:

Item	Description	Poll
1	To assist BMA with institutional support to strengthen its operation	1
2	Schemes directed towards improvement of the position of the scavengers	3
3	Promotion of small-scale composting	3
4	Studies on industrial waste	7
5	Source separation	10
6	Further field investigation on economics of separation and recycling	12

APPENDIX 2 - PLASTIC COLLECTION AND REPROCESSING

PLASTIC COLLECTION AND REPROCESSING

The main constituent of plastic is polymers. Polymers are of two types; thermoplastics and thermosets, each of which has its own problems for the recycling industry.

Molecules in thermosets form crosslinks which prevent the materials from softening when it is heated. Thermosets are robust and durable and they tend to be used in engineering components. They are easy to reclaim but difficult to recycle. Heat softens thermoplastics which can be reformed without any difficulty.

Olefins (PE-Polyethylene, PP-Polypropylene) are one of the major groups of thermoplastics. The main characteristics of PE is, as its density increases, it becomes more crystalline, stiffer, and its resistance to bursting forces improves. High density PEs are found in bottles, tanks, barrels and heavy duty wrapping film. Low density materials can be found in small bags, mulching film, all kinds of packaging and electrical insulators.

PP is harder and stiffer than PE. Its resistance to fracture through repeated bending, which is known as "fatigue" makes it a useful hinge in luggage. Vehicle manufactures also use PP to produce automotive trims and panels.

PVC (Poly Vinyl Chloride) common thermoplastic, is a polymer of vinyl chloride and vinyl acetate. The basic polymer is rigid. Compounders add plasticisers to PVC to increase its flexibility. Plasticised PVC appears in clothing, flooring, wall papers, toys and steel coating. Unplasticised PVC (uPVC) is a common material in window frames, ducting for chemical plants, drain pipes and guttering as well as underground pipes. Rigid PVC is one of the stiffest and most-impact-resistant polymers in everyday life.

Polyethylene terephthalate (PET) is a common packaging material. One moulded form of the polymer is the hardest plastic known. PET is also a good electric insulator.

As there are several types of plastics made out of different polymers, it is better to educate the public on how to distinguish between the three types. That can be easily done by using an exclusive features and chemical coding system. In this way the three types of plastics can be sorted out at the source which increase the efficiency of plastic recycling.

The Thai Packing Centre, Bangkok has designed the following posters to promote waste recycling and reuse.

POSTER I

แยกขยะที่รีไซเคิลประเภท ใช้ระบบเทคโนโลยีที่เหมาะสม เพื่อนำกลับมาใช้ประโยชน์

WASTE RECYCLING REDUCES SOLID WASTE VOLUME THEREBY MINIMIZES ENVI.POLLUTION, PROTECT NATURAL RESOURCES, SAVE ENERGY AND INCREASE INCOME

ลดปัญหาสิ่งแวดล้อม รักษาทรัพยากร ประหยัดพลังงาน ลดปริมาณขยะ เพิ่มรายได้

พลาสติก

1 PETE โพลีเอทีลีนเทเรฟทาเลต (PET, พีอีที)
POLYETHYLENE TEREPHTHALATE (PET)

2 HDPE โพลีเอทีลีนชนิดความหนาแน่นสูง
POLYETHYLENE (HIGH DENSITY)

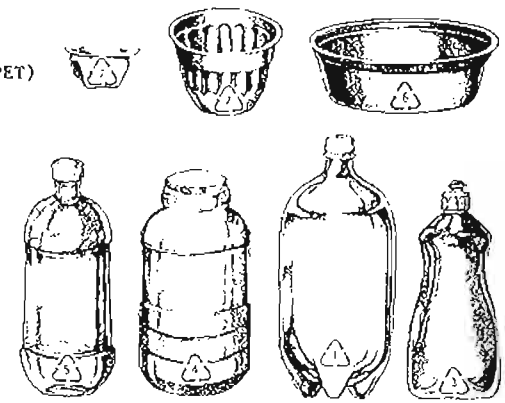
3 V โพลีไวนิล คลอไรด์ (PVC, พีวีซี)
POLYVINYL CHLORIDE (PVC)

4 LDPE โพลีเอทีลีนชนิดความหนาแน่นต่ำ
POLYETHYLENE (LOW DENSITY)

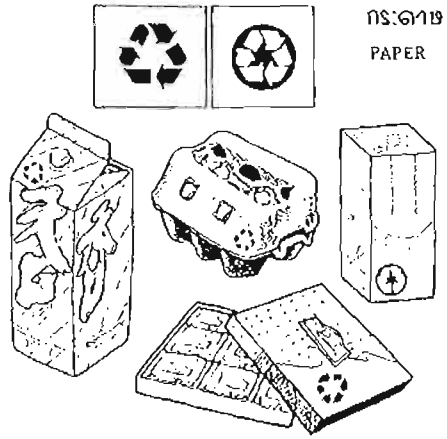
5 PP โพลีโพรพีลีน
POLYPROPYLENE

6 PS โพลีสไตรีน
POLYSTYRENE (PS)

7 OTHER เรซินอื่น ๆ
OTHER



กระดาษ PAPER



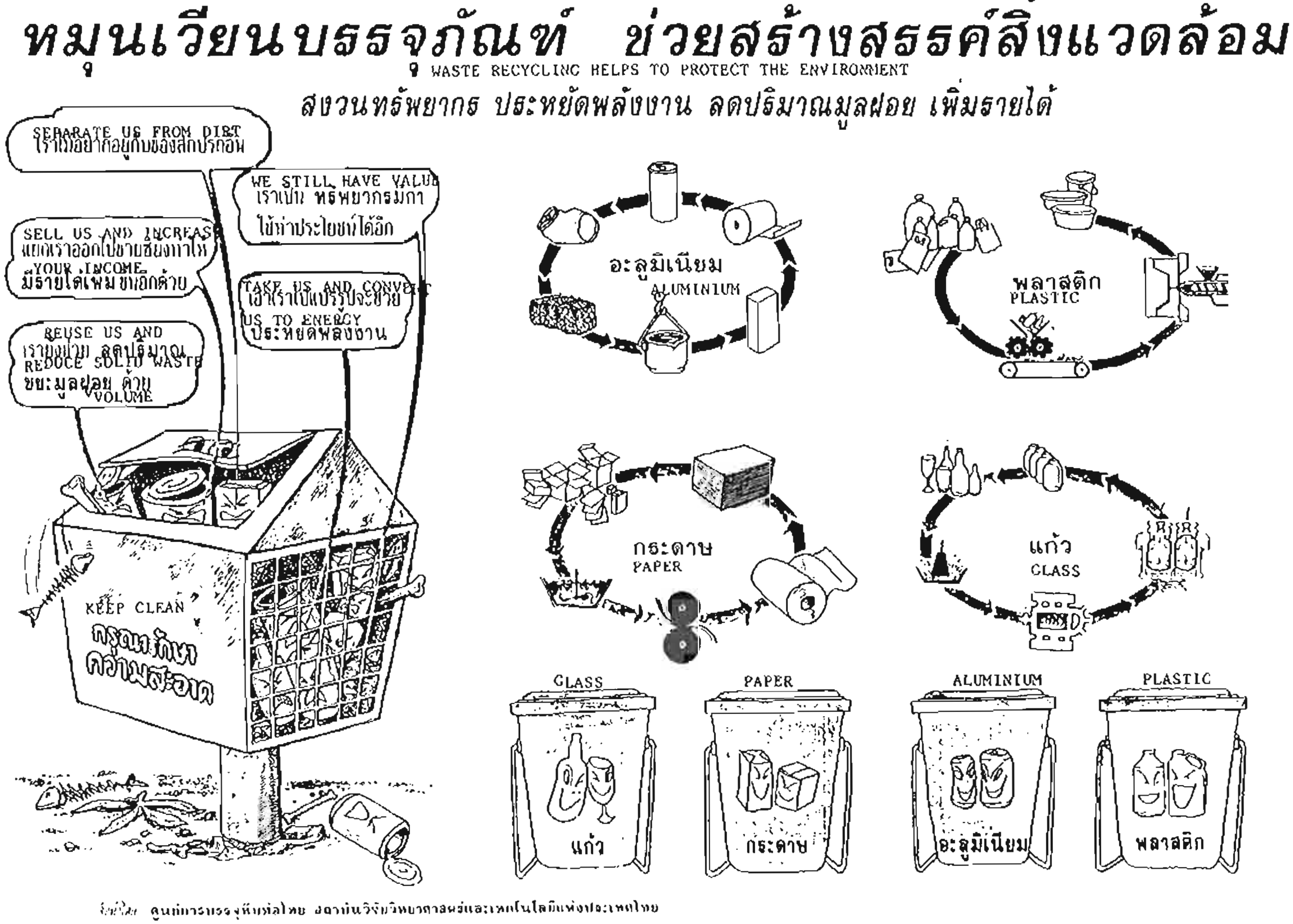
แก้ว GLASS

แผ่นเหล็กเคลือบดีบุก GALVANIZE

อะลูมิเนียม ALUMINIUM

จัดทำโดย ศูนย์การบรรจุหีบห่อไทย สถาบันวิจัยวิทยาศาสตร์และเทคโนโลยีแห่งประเทศไทย

POSTER II



Delivering th

Bamboo Ba

APPENDIX 3 - SCAVENGING RECYCLABLE MATERIALS (PHOTOGRAPHS)

Bamboo Baskets are Used by the Collection Crew to Separate and Segregate the Recyclable Wastes.

Delivering the Recovered Materials to the Small Scale Recycling (SSR) Shops near Dump-Sites.

A Small Scale Recycling (SSR) Shop

Separating Glass by a SSR Shop

Separating Plastic Containers by a SSR Shop

Separating Metal Cans by Scavengers at the Dump-site

Drying of Washed Plastic Bags Before Selling to the Manufacturers.

Packed Recyclable Materials for the Manufacturers

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