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Technological and Economic Evaluation of Solid Waste Scavenging and Recycling Practices

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ABSTRAK

Kewujudan kegiatan guna semula bahan sisa pepejal dan pencari sampah di kawasan majlis-majlis perbandaran di Malaysia telah dikaji melalui lawatan dan kaji selidik ke tapak pelupusan sampah, syarikat-syarikat pemborong bahan terpakai dan kilang-kilang yang terlibat dalam industri guna semula. Pengasingan bahan sisa telah lama dijalankan di tapak pelupusan sampah kerana ia menguntungkan pihak yang terlibat. Syarikat-syarikat pemborong bahan terpakai beroperasi di sekitar tapak pelupusan sebagai pembekal kepada kilang-kilang berkenaan. Industri pembuatan botol dan kaca meraih keuntungan melalui penggunaan semula serpihan kaca yang meningkatkan keberkesanan bahan api. Halangan-halangan utama dari segi ekonomi dan teknikal berkaitan dengan penggunaan semula turut dikenal pasti.

ABSTRACT

Existing solid waste scavenging and recycling practices in the Klang Valley, Malaysia were investigated through personal visits and field surveys to landfill sites, trading companies and factories involved in recycling. Collection of recyclable material has long been practised in landfill sites as it provides good additional income. Dealers of scrap and recyclable items who operate at the landfill sites provide a source of supply to manufacturing concerns. Glass recycling industries benefit greatly by using recycled cullet, which improves fuel efficiency. Major economic, technical and other constraints related to recycling are discussed.

Keywords: recycling, scavengers

INTRODUCTION

Rising standards of living and associated increases in the consumption of goods have led to increasing amounts of solid wastes. A single disposal method such as sanitary landfills is inadequate given the shortage of new economic sites and wastage of potential resources. Integrated waste mana-

gement must be flexible and should incorporate waste reduction, recycling, processing and treatment in an optimal manner to minimize costs and negative environmental impacts (Wilson 1981).

Malaysians discard massive volumes of wastes every year. Solid waste generation in urban areas has increased from 1.2 million tonnes in 1988 to 2.0 million tonnes in 1992 (241 kg/person/year[1]). However, only 2% of the wastes collected each year are being recycled, whilst the bulk of the waste is buried (Ministry of Housing and Local Government 1992). Many authorities are now encouraging recycling of wastes for a number of social, economic and aesthetic reasons (Baldisimo *et al.* 1988). The absence of a comprehensive recycling scheme could bring about many problems such as pollution, volume wastes, high collection and disposal costs, maintenance and handling problems in landfills and short life-span of landfill space. At present, many recycling activities of solid waste are carried out by municipal workers and full-time landfill scavengers. However, such activities may not be regarded as part of a formal recycling scheme as they may create serious problems in the waste management system and could jeopardize a national recycling programme.

A major factor which influences the growth of resource recovery and recycling systems is its economic credibility, that is the costs of the project against potential income from recovered materials. Recycling activities will continue if the benefit exceeds the cost. Indeed, even if recycling is not directly profitable, the idea of it being an 'avoided disposal cost' is a major benefit. In 1994, waste disposal costs for Kuala Lumpur and Petaling Jaya were RM2.00-5.00 per tonne. A reduction in the flow of waste to the landfill would bring a matching reduction in disposal costs.

The purpose of this study was to evaluate the socio-economic aspects of scavenging and recycling of solid wastes in selected urban areas in Malaysia.

METHODOLOGY

This study is based on analysis of secondary information from pertinent references and from survey questionnaires regarding the role of recycling and scavenging in urban solid waste management in Malaysia. It covers socio-economic aspects of solid waste scavenging and recycling. Basic data were also obtained from the following sources:

a. Surveys carried out at the sources of waste generation, especially during collection, and at the disposal sites.

[1] These figures are expected to increase with increases in per capita income and economic activities. The latest figures supplied by Nasir *et al.* (1995) have shown that the annual per capita waste generation rate has increased to 365 kg or 1 kg/capita-day. The figures presented above are relatively lower than those generated in OECD countries in 1990, which range from 287 kg/capita-year in Portugal to 601 kg/capita-year in Canada (World Resource Foundation 1995).

b. Government department publications.
c. Visits and interviews with individuals working in the recovery business.
d. Public surveys.

The field data were collected from August to November 1993; all figures presented in this paper are 1993 data.

SOLID WASTE COMPOSITION AND GENERATION RATES

Solid wastes may be differentiated by their origin, physical form and detailed composition. The classification of wastes in the study area, distinguished mainly by source, is shown in Table 1, together with an indication of the quantities generated and recycled[2]. Domestic or residential waste has widely varying characteristics. Table 2 shows the principal components of residential wastes in two areas. The waste composition is quite similar in both areas, with food wastes forming the major component. However, variations are quite obvious for plastics wastes, non-ferrous metals, timber products and garden wastes. These variations are probably due to population diversity and differences in cultural and socio-economic backgrounds.

TABLE 1
Fate of waste in existing solid waste managment systems

Source	Daily Generation tonnes/day	Recycled Quantities tonnes/day	Quantities Percentage	Wastes Disposed tonnes/day	Disposed Percentage
Residential	183.1	17.1	9.3	166.0	90.7
Commercial	42.0	1.4	3.3	40.6	96.7
Industrial	198.0	0.0	0.0	198.0	100.0
Markets	5.5	0.0	0.0	5.5	100.0
Garden	30.0	0.0	0.0	30.0	100.0
Institutional	9.2	0.0	0.0	9.2	100.0
Landfill scavengers	0.0	3.0	0.0	–3.0	
Total (tonnes/day)	467.8	21.5		446.3	
Percentage	100.0	4.6		95.4	

* Data from Petaling Jaya Municipal Council

Notes:

(a) Garden wastes normally include leaves, grass clippings, bush and tree clippings. Because they are collected separately from household or residential wastes, most literature categorised these two wastes separately.

(b) Demolition and construction wastes are normally considered as industrial waste.

[2] In 1995, the amount of waste generated in Petaling Jaya Municipal Council has increased to 550 tonne/day (Nasir *et al.* 1995)

TABLE 2
Average composition of residential solid wastes in two areas

Percentage by Weight Components	PJMC	PDC
Newspaper, cardboard, paper products	27.00	24.70
Food wastes	36.50	46.30
Textile and leather	3.10	0.60
Plastics	16.40	5.60
Rubber products	2.00	2.90
Glass	3.10	4.10
Ferrous metals	3.00	5.50
Non-ferrous metals	0.90	3.80
Timber products	7.00	0.40
Garden trimmings	0.60	6.00
Other incombustible, ceramics	0.40	0.10
Total	100.00	100.00

PJMC = Petaling Jaya Municipal Council PDC = Petaling District Council
Source: Field survey
Notes: Composition of waste was analysed by separating waste emptied from a truck into 4 portions. Each portion was further divided into 4 more portions until the weight of each portion was around 100 kg and sorting of waste was done. About 10% of the collection trucks (8 trucks) were sampled at random. This method is suggested by Tchobanoglous *et al.* (1993).

ECONOMIC ASPECTS OF SCAVENGING

Scavenging refers to the informal practice of collecting unwanted items either at the source, during the collection process or from waste disposal sites. Scavengers refer to individuals who devote part or most of their working time foraging for saleable materials. In Malaysia, collection is carried out by both full-time landfill scavengers and municipal waste collection crews.

Municipal Crew Scavenging Activities

The money earned from scavenging of recyclable waste materials provides additional income to the collection crew. As the crew have easier access to recyclable materials generated from households than dumpsite scavengers, the recyclables collected are of higher value.

A total of 33 (53.2%) waste collectors in the Petaling District Council (PDC) (Serdang and Puchong areas) were interviewed in the study. The type of waste materials and average quantities retrieved daily are shown in Table 3.

The data in Table 3 show that cardboard and paper, which constitute 58.1% of recyclable material, have the greatest value. In the Petaling District area, a collection crew earns RM30-50 per truck per day. This is divided among 5 members of the collection team; each receives an average of RM6-10 per day, equivalent to about a third of their daily income. There

TABLE 3
Average quantity of recyclable wastes collected per truck and selling price to middlemen

Waste materials	Average wastes collections (kg/day)	Selling price *(RM/kg)	*(RM/day/truck)	Wastes value 80 trucks *(RM/day)
Cardboard	74.00	0.10	7.40	592.00
White paper	38.00	0.25	9.50	760.00
Mixed paper	46.00	0.03	1.38	110.40
Newspaper	21.00	0.06	1.26	100.80
Plastics	28.00	0.15	4.20	336.00
Grade A iron	2.00	0.15	0.30	24.00
Grade B iron	41.00	0.05	2.05	164.00
Cast iron	3.00	0.25	0.75	60.00
Bottles (mixed)	55.00	0.08	4.40	352.00
Total per day	308.00		31.24	2499.20

*US$1 = RM 2.55

are about 80 trucks entering the Petaling District Council disposal site per day. Thus the average total revenue obtained is about RM2500 per day.

Landfill Scavenging Activities

Scavengers in landfill areas depend on scavenging as their main source of income. They are often considered a nuisance by municipality officials, and are rarely considered as an integral component of solid waste management. Competition among scavengers is quite tough. The working hours for scavengers are long, usually up to ten hours per day, depending on the arrival of the collection vehicles.

Typically, a scavenger is equipped with an L-shaped metal rod with a pointed end to pick up recyclable materials and place them in a collection sack. A similar kind of instrument is also used in Bangkok (Butsapak1984), Jakarta (Harahap1984) and Manila (Baldisimo 1985). The number of scavengers at various disposal sites is presented in Table 4. Surprisingly, the percentage of female dumpsite scavengers in all the councils is similar (20%) except Kuala Lumpur City Hall where female scavengers comprise 25%.

TABLE 4
Average number of scavengers at dumpsites

Municipal Council	Location	Male	Female	Total
Petaling Jaya	Kelana Jaya	55	17	72
Kuala Lumpur	Sungei Besi	49	16	65
Shah Alam	Bukit Kemunting	24	6	30
Petaling District	Puchong	20	5	25
Total		148	44	192

The distribution of scavengers according to age and race is shown in Table 5. Underage scavengers (11-15 years old) detected in Petaling Jaya Municipal Council dump were about 3.5%. In Kuala Lumpur City Hall and Shah Alam Municipal Council dumps the percentage of immigrants are 15% and 30% res-pectively. However, no Indonesian workers were detected in the Petaling District Council landfills. The educational level of most scavengers is only primary school but in the Petaling Jaya disposal site, their educational background varies from primary level to upper secondary level. The dumpsite scavengers obtain an average income of RM17 per day (RM525 per month). This is generally higher than the income of unskilled workers in most Malaysian factories.

TABLE 5
Distribution of scavengers according to age and race

Age range	Petaling Jaya			Kuala Lumpur			Shah Alam			Petaling District		
	Mal	Ind	Indo	Mal	Ind	Indo	Mal	Ind	Indo	Mal	Ind	Indo
11 - 15	1	2	0	0	0	0	0	0	0	0	0	0
16 - 20	4	1	8	7	1	0	0	0	0	0	0	0
21 - 25	1	0	6	3	2	0	0	0	0	0	0	0
26 - 30	1	0	7	4	0	0	4	0	0	0	0	0
31 - 35	5	3	7	10	2	2	2	0	2	3	0	0
36 - 40	10	1	3	9	1	8	9	0	8	5	0	0
41 - 45	7	0	1	4	3	0	1	3	0	8	0	0
46 - 50	13	0	2	7	0	0	0	0	0	8	0	0
51 - 55	1	0	1	2	0	0	1	0	0	0	0	0
55 - 60	2	0	1	0	0	0	0	0	0	1	0	0
61 - 65	1	0	0	0	0	0	0	0	0	0	0	0
Total	44	7	36	46	9	10	17	3	10	25	0	0

Mal = Malay Ind = Indian Indo = Indonesian

In the Petaling Jaya disposal site, the largest amount of recyclable material collected is cardboard, whilst in Kuala Lumpur disposal site, it is plastic materials (Table 6). These differences are probably due to socio-economic variations between populations, and the number of institutions and commercial establishments in these areas.

TRADERS AND SCRAP DEALERS IN THE RECYCLING INDUSTRY

All recyclable materials collected by dumpsite scavengers and municipal council collection crews are purchased by scrap dealers at the disposal sites. Although the materials sold by scavengers and collection crews have already been sorted, some processing is normally required before these

TABLE 6
Average quantity of recyclable materials at dumpsites (kg/day)

Type of Wastes	Petaling Jaya	Kuala Lumpur	Petaling District
Bottle	1056.4	500	300
Paper (mixed)	1023.8	950	
Newspaper	1234.3	1000	500
Plastics	143.8	6000	
Iron	175.9	1500	300
Aluminium	186.9	1500	30
Rubber	37	300	

materials are sold to the manufacturers. Bottles are washed and stacked, cans are flattened and mixed papers are baled. The scrap dealer usually has a store near the landfill where recyclables are kept.

Although it is difficult to obtain accurate income estimates from scrap dealers, it is likely that they earn a relatively high income from the business. Table 7 shows the buying and selling rates for scavenged materials. The potential profits obtained by the scrap dealers are estimated from the differences of total value bought and total value sold. The recyclable

TABLE 7
Buying and selling price (1993) of recyclable items by middlemen

Items	Buying Price (RM/kg)	Selling Price (RM/kg)	Profit (RM/kg)	Profit (RM/tonnes)
Newspaper	0.06	0.1	0.04	40
White paper	0.23	0.29	0.06	60
Computer paper	0.32	0.47	0.15	150
Cardboard	0.09	0.19	0.1	100
Aluminium cans	1	1.3	0.2	200
Aluminium scrap	1.2	1.4	0.2	200
Grade A iron	0.22	0.3	0.08	80
Grade B iron	0.18	0.23	0.05	50
Grade C iron	0.13	0.17	0.04	40
Copper	3.1	3.36	0.26	260
Batteries	0.2	0.3	0.1	100
Wine bottles	0.05	0.1	0.05	50
Mixed bottles	0.02	0.07	0.05	50
Plastics	0.15	0.3	0.15	150

* Prices are average of 8 companies
US$1 = RM 2.55
Grade A iron = Compact iron
Grade B iron = Hollow iron
Grade C iron = Scrap iron

materials with the largest differences are cardboard, newspapers, aluminum, and glass bottles. It can be presumed that the scrap dealers benefit a great deal from these four types of materials. Even though the buying price per kg for cardboard is relatively low, the quantity collected is the highest of all recyclable materials. Thus cardboard contributes 64% of the gross profit obtained by the scrap dealers, which is about RM140 per day. Aluminum has the highest buying price per kg. However, the quantity collected is relatively low. The gross income of the scrap dealers is considered high as their expenditures are only transportation and the salaries for 1 or 2 workers. The price range for most of the recyclable materials in the study area is about the same as in Bangkok and Jakarta, but prices in Manila are relatively lower (Table 8). This may be due to tight competition between scrap dealers.

TABLE 8
Buying price of recyclable waste materials in major Southeast Asian cities

Material	Price range (US$/kg)		
	Bangkok	Jakarta	Manila
Paper and cardboard	0.02 - 0.15	0.02 - 0.05	0.020 - 0.050
Bottles	0.02 - 0.02	0.01 - 0.02	0.0005 - 0.110
Plastics (Soft)	0.06 - 0.42	0.05 - 0.05	0.005 - 0.060
Plastics (Hard)	0.09 - 0.15	0.09 - 0.10	0.003 - 0.060
Iron scraps	0.02 - 0.04	0.05 - 0.05	0.005 - 0.030
Other metals	0.04 - 0.94	0.29 - 0.30	0.020 - 0.760
Tin cans	0.02 - 0.03	0.01 - 0.02	0.003 - 0.008
Glass	0.02 - 0.02	0.01 - 0.02	0.003 - 0.010
Rubber products	0.03 - 0.15	-	0.003 - 0.010
Leather	0.15 - 0.22	-	-

Source: Baldisimo and Lohani 1988

FINANCIAL ASPECTS OF RECYCLING INDUSTRIES

To provide a basis for evaluating the technical and economic aspects of recycling it is necessary to consider the various recycling processes used in the industry. In Malaysia, the active recycling industries are glass, paper and plastics. However, only the glass recycling industry is discussed in detail in this study. The technical and economic aspects of the feasibility of recycling waste paper are discussed by Drobny *et al.* (1972); Jackson (1975); Langer (1979) and Bridgewater (1980) whilst plastic recycling activities have been discussed by Sheftel (1972) and Mustafa and Hansmann (1993).

Recycling of waste glass (better known as 'cullet') is a long-established practice in the glass industry. Broken glass is virtually equivalent to the

original raw material and can be remelted many times without suffering degradation. Recycling of cullet is desirable as it reduces the volume of solid wastes, the consumption of raw materials and saves fuel energy during glass manufacture.

MANUFACTURING PROCESS

The raw materials used in the factory are silica, soda ash and limestone. The cullet is mixed with virgin raw material in the ratio of 25-50% cullet and 75-50% raw material, depending on the availability of cullet. There are two major processes involved in glass production, the 'blow-blow process' for narrow-neck bottles and the 'press-blow process' for wide-mouth containers. The process starts with the blending of raw materials. The batch then goes to the mixer glass furnace (temperature range $\sim$ 1000-1500°C). When the batch has melted, the molten glass flows into a feeder. There are two sections in the feeder, the cooling section to lower the temperature and the equalizer to make the uniform glass. The glass that flows to the spout of the feeder and is cut is called 'gob'. This is dropped into the mound and blown by air for 2-3 seconds. The finished product is then passed through the oven by conveyer to reduce the temperature. After quality checks, the product is packed ready for marketing.

THE FINANCIAL PROFITABILITY OF GLASS RECYCLING

A glass manufacturing company in Petaling Jaya was selected for the study. The factory is a large-scale plant which produces 60 000 tonnes/year of glass and bottles operating 24 hours in 3 shifts. Currently, the factory has 5 engineers and scientists, 55 semi-skilled labourers and 210 labourers. The raw materials used for the manufacturing process are shown in Table 9. The investment and operating costs of the plant are summarized in Table 10. A cash flow has been prepared based on the following assumptions:

TABLE 9
Price (1993) of raw materials used in glass processing

Virgin Raw Material	Cost (RM/year)
Soda ash	3,400,000
Sand	800,000
$CaCO_3$	180,000
Alumina	220,000
Other materials	400,000
Cullet	1,000,000
Total	6,000,000

TABLE 10
Operating costs (1993) of a glass manufacturing company

Expenditures	Cost (RM/year)
Energy consumption	9000000
Labour	3000000
Utilities, overheads, others	12000000
Raw materials	6000000
Total	30000000

US$1 = RM 2.55
Note:
The investment costs of the plant, which include buildings, machinery, vehicles and mobile equipment are about RM25,000,000

a. Production capacity is assumed to be constant with full capacity in the first operating year.
b. Project life time is estimated at 50 years.
c. Discount rate used is 10% (the financial rate of discount used in Malaysia).
d. The quality of recycled finished products is similar to the products using virgin raw materials.
e. It is possible to run the same manufacturing process with 100% cullet as raw materials.
f. Other expenditures are assumed to be the same, expect fuel efficiency improves by 25 MJ/tonne for every 1% of cullet used.

The economic evaluation of the company is discussed in terms of benefit/cost ratio (B/C ratio) and net present value (NPV). B/C ratio was once the most popular decision rule, particularly in the early years of applied cost/benefit analysis (Lowe and Lewis 1980). In choosing between mutually exclusive projects, the project selected is the one with the highest ratio. The formula can be written as:

$$B/C \text{ Ratio} = \sum_{t=0}^{n} \frac{\dfrac{B_t}{(1+i)^t}}{\dfrac{C_t}{(1+i)^t}}$$

NPV is the summation of discounted net cash flow over the life-span of the project. The present value requires the use of a predetermined discount rate to discount future benefits. The formula can be written as:

$$NPV = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t}$$

where

B_t = benefits in each year t
C_t = costs in each year t
n = number of years to complete the project
t = year
I = discount rate

Table 11 shows the estimated benefit/cost ratio of glass production by using different raw materials (with and without cullet). The benefit cost ratio of the two options are almost the same. The manufacturer is operating with second options (75% virgin material and 25% cullet) because of higher B/C ratio. Mixing the cullet with virgin raw material lowers the melting temperature and improves fuel efficiency, which reduces cost of maintenance. As stated earlier, fuel efficiency improves by 25 MJ/tonne for every 1% of cullet used. *Fig. 1* shows the increase in energy savings in the furnace as cullet is increased.

TABLE 11
Estimated benefit/cost value (1993) of glass production at a selected glass factory

Raw Material	Cost of Raw Materials (RM)	Energy Consumption, Labour, Utilities, Overheads (RM)	Total Cost of Production (RM)	Value of Finished Product (RM)	Benefit/ Cost Ratio	Net Present Value (RM)
	A	B	A + B			
Virgin raw materials	6666666.7	24000000 +1125000[1]	31791666.7	60000000	1.0506	34991032
75% raw materials[2] + 25% cullet	60000000	24000000	30000000	60000000	1.092	54953148

Discount rate used = 10 %
Operating lifetime = 50 years
Note:
[1] Additional cost and energy consumption (about 12.5%) for using 100% virgin raw material
[2] This is the existing composition for glass production by the plant

PROSPECTS FOR THE RECYCLING INDUSTRY IN MALAYSIA

An industry can continue to survive only if those who participate receive fair rewards for their inputs. In the recycling industry, a number of decision

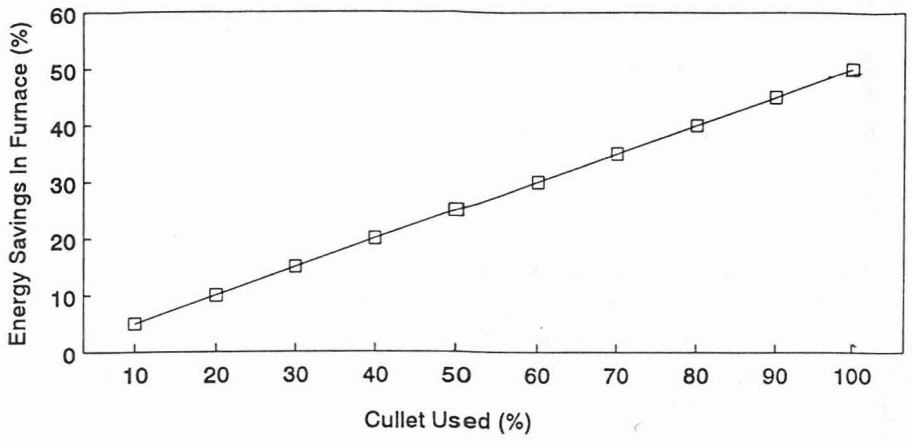

Fig. 1: Energy savings using cullets

makers are involved – consumers, scavengers, scrap dealers, manufacturers and local governments. The people in each group must obtain net benefits from participating in the recycling of materials. Above all, there must be a demand for the collected waste at a suitable price and not least, it must be relatively easy to separate recyclable materials. The findings in the study area have shown that the average amount of wastes separated for recycling purpose is about 5.98% (Table 12). Most separation and recycling activities are concentrated on 3 types of waste: ferrous metal, glass, and paper and card-board. These materials are easily collected and separated from the waste stream on a non-formal basis in addition to their stable market conditions, particularly stable demand from industries. Compared to developed countries (Table 13), the amount of solid waste separated in the study areas is comparable to Austria (6%), but higher than Belgium (3%), France (3%), Ireland (3%), Italy (3%) and United Kingdom (2%).

Consumers can have a vital impact on the economics of recycling. Separation of wastes at household level would reduce the collection time, hence the cost of collection. Nevertheless, this requires some effort and often causes inconvenience to households. Source separation, which is not carried out in Malaysia, can be done if there are adequate social incentives.

The scavengers and scrap dealers will continue to participate if the monetary rewards are adequate. Fluctuations in commodity prices add further uncertainty as they affect the price of virgin raw materials in competition against recycled material.

A manufacturer's decision to recycle wastes depends on the economics of the operation. Cost-benefit analysis is a necessity before adopting any recycling technology. Larger factories also consider their public image; recycling may be of assistance in building consumer goodwill.

TABLE 12
Fate of residential wastes in Petaling Jaya Municipal Council

Components	Average Amount Generated (tonnes/day)	Separated by Collection Workers (tonnes/day)	Separated by Dumpsite Scavengers (tonnes/day)	Amount of Waste Disposed in Landfill (tonnes/day)
Newspaper, cardboard and paper products	128.74	14.32	2.26	112.16 (87.12)
Food wastes	174.03	0.00	0.00	174.03 (100.00)
Textiles and leather	14.78	0.00	0.00	14.78 (100.00)
Plastics	78.20	2.24	0.14	75.81 (96.94)
Rubber products	9.54	0.00	0.04	9.50 (98.58)
Glass	14.78	4.40	1.06	9.32 (63.06)
Ferrous metals	14.30	3.68	0.18	10.44 (73.01)
Non-ferrous metals	4.29	0.00	0.19	4.10 (95.57)
Timber products	33.38	0.00	0.00	33.38 (100.00)
Garden trimmings	2.86	0.00	0.00	2.86 (100.00)
Other incombustible, ceramics	1.91	0.00	0.00	1.91 (100.00)
Total	476.80	24.64	3.86	448.30 (94.02)

Source: Field Survey
Note: Figures in parentheses are percentage of waste being disposed of in landfill

Local governments can promote and encourage recycling activities in various ways, including incentive schemes, subsidies, legislation, promotion of technology development and transfer, and distribution of information. Government initiatives may be necessary to increase the extent of recycling in Malaysia. Consumers and manufacturers would then follow. In a recent study in the Petaling Jaya Municipal Council area, 85.8% of the respondents agreed to co-operate with voluntary separation of wastes if a clear policy is imposed by the council (Petaling Jaya Municipal Council 1993).

TABLE 13
Waste disposal routes (expressed as percentage by weight of MSW)

Country	Amount ktonnes/year	Combustion	Landfill	Composting	Recycling
Austria	2800	11	65	18	6
Belgium	3500	54	45	0	3
Canada	16000	8	80	2	10
Denmark	2600	48	29	4	19
Finland	2500	2	83	0	15
France	20000	42	45	10	3
Germany	25000	36	46	2	16
Greece	3150	0	100	0	0
Ireland	1100	0	97	0	3
Italy	17500	16	74	7	3
Japan	50000	75	20	5	*
Luxembourg	180	75	22	1	2
The Netherlands	7700	35	45	5	16
Norway	2000	22	67	5	7
Portugal	2650	0	85	15	0
Spain	13300	6	65	17	13
Sweden	3200	47	34	3	16
Switzerland	3700	59	12	7	22
United Kingdom	30000	8	90	0	2
USA	177500	16	67	2	15

Source: Warner, 1995 (some figures have been rounded up)
Note:
* MSW levels in Japan are collected after the removal of recyclables

The continued functioning of recycling industries requires the existence of a recycling infrastructure. Manufacturers can be expected to switch to the use of recycled materials as input only if there is a consistent supply of materials. Sometimes the material present particular barriers to recycling, e.g. plastic wastes are often contaminated with additives.

CONCLUSION

The recycling business is quite new in Malaysia. However, many authorities are encouraging recycling for a number of reasons; of which financial reasons are the most salient. At present, there is no proper recycling scheme operated by local governments. Most of the recyclable materials are recovered at landfills by scavengers. Collection crews benefit considerably from the scavenging of recyclable materials because of their position in the waste disposal system. Landfill scavenging is very unsystematic and the amount earned from scavenging is directly related to the number of hours spent at the disposal sites. Nevertheless, the collection crews and landfill scavengers play a prominent role in the collection of materials from the waste stream.

The scrap dealers contribute towards the recycling business as they supply recyclable materials to the manufacturing companies. They operate on door-to-door collection and at the landfill sites.

Reprocessing of waste glass has long been practised. In the case of glass, 100% cullet can be used to replace virgin raw materials. For every 1% of cullet used, fuel efficiency improves by 25 MJ/tonne.

A proper comprehensive national recycling programme should be initiated as soon as possible to stimulate the expansion of recycling activities in Malaysia.

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