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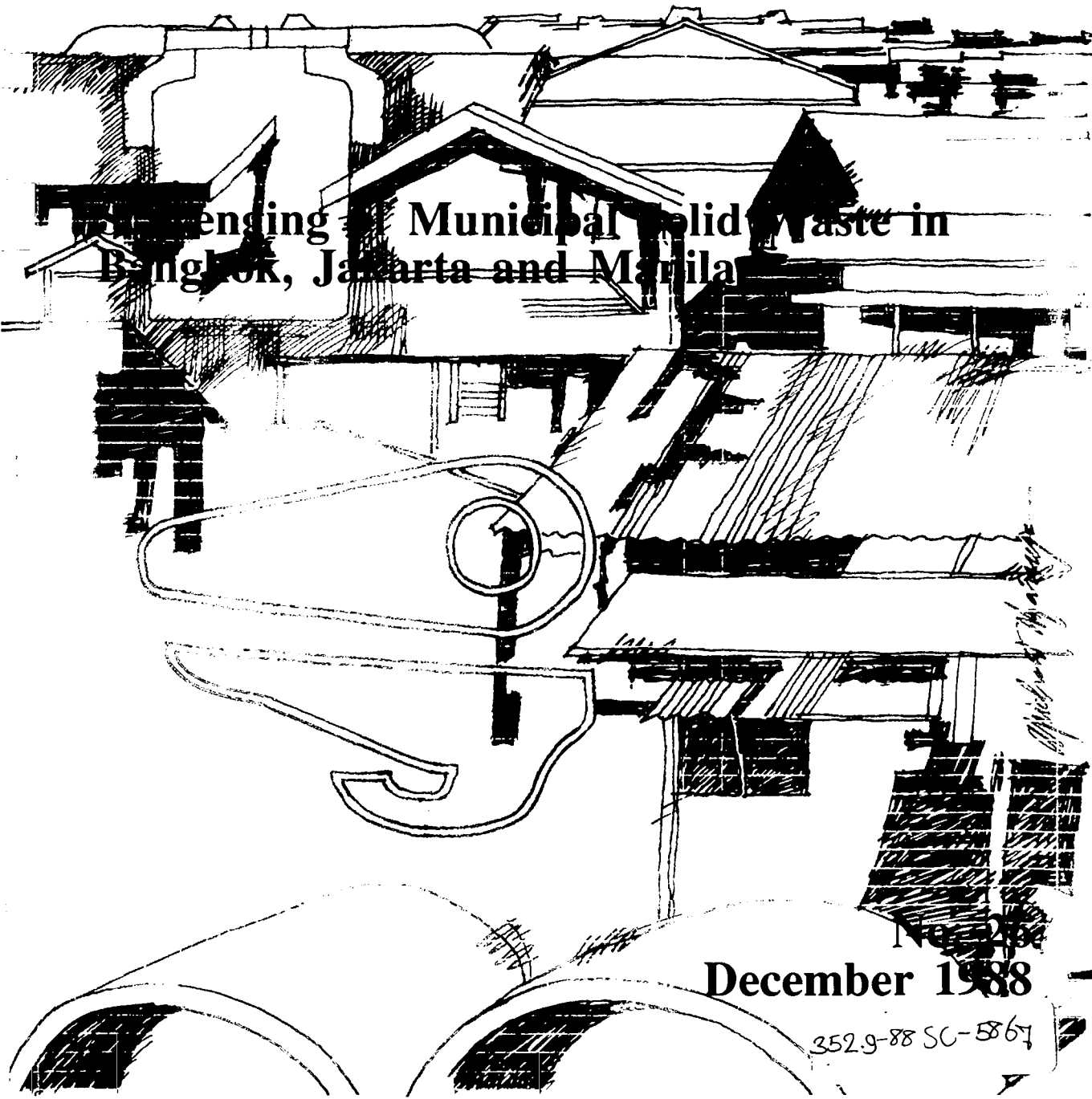

## ...enging ... Municipal Solid Waste in Bangkok, Jakarta and Manila

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# ENVIRONMENTAL SANITATION REVIEWS

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# SCAVENGING OF MUNICIPAL SOLID WASTE IN BANGKOK, JAKARTA AND MANILA

by

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Asian Institute of Technology
December 1988

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# SCAVENGING OF MUNICIPAL SOLID WASTE IN BANGKOK, JAKARTA AND MANILA

by

**Julito M. Baldisimo & B.N. Lohani**

## I. INTRODUCTION

### 1.1 Purpose of Report

The purpose of this report is to evaluate information from available, pertinent references and from survey questionnaires regarding the role of scavenging in urban solid waste management in Asia. The evaluation is focussed primarily on information collected for Manila, Bangkok, and Jakarta though the results are believed to be applicable to most other major Asian cities. The objective of the report is to develop a background document which will provide a basis for recognition of the importance of scavenging in the socio-economy of such urban areas and, consequently, the inclusion of scavenging/waste recycling as an integral component in the planning of solid waste management systems.

### 1.2 Scope of the Review

This report reviews some socio-economic aspects of solid waste scavenging and recycling: It is based on surveys carried out: (i) at the source of generation, (ii) during collection and (iii) at the disposal sites.

It is based primarily on information available on municipal solid waste in Bangkok, Jakarta, and Manila where solid wastes management problems are believed to be relatively serious and representative of the problems faced by many Asian cities.

The cost-benefit relationship of solid waste recycling with respect to the common practice of salvaging reusable refuse materials is also covered in this report.

An assessment of the health aspect of scavenging is limited to dumpsite scavengers and garbage crew members.

Finally, a study of the technical-economic aspect of reuse of the salvaged refuse materials by various manufacturing industries is presented.

### 1.3 Justification of the Study

#### 1.3.1 Solid Waste Scavenging and Recycling

The problems created by increasing volumes of refuse requiring disposal are becoming more serious daily: the volume of refuse is growing constantly as a result of increasing population concentrations in urban areas; existing management practices can

no longer cope with the quantities of solid wastes being produced; collection practices are inadequate and proper disposal is virtually absent.

The people engaged in "waste reclamation" or "salvage" are playing important rules in recycling and recovery of valuable resources in the waste. A large percentage of recyclable solid wastes such as metals, papers and bottles are salvaged by handpicking. The waste is sold to the traders who then separate the various type of wastes and sell it to wholesalers or manufacturers.

Recycling of salvageable waste materials: (i) may provide scavengers with a decent livelihood, (ii) reduces the volume of solid waste, thus a consequent reduction in municipal collection and disposal costs, (iii) provides extra cash for households, and (iv) improves garbage disposal habits of households paving the way for more sophisticated recycling projects in the future. However, refuse scavenging should be supported further on public health and socio-economic grounds and recognized as an integral component of solid waste management so that the potential benefits noted above are maximized and the related health hazards are minimized.

### 1.3.2 Macro-Economic Value of Recycling

Developed and developing countries are increasingly experiencing serious problems of energy development, and resources management as well as pollution control. Energy demands, resource limitations and environmental pollution are believed to be interrelated, and recycling can make a contribution to solve these three problems (Barton, 1979).

Recycling, or reuse of waste materials has potential as a partial solution to these current world problems. Rather than dispose of most municipal waste generated, many authorities are encouraging recycling of refuse for a number of social, economic and aesthetic reasons.

The assessment of economic viability is by no means a simple task; however, one must not only consider processing costs in the light of income and market potential of the recovered materials, but also the social costs and perhaps more important, social benefits associated with the alleviation of pollution, health hazards, and other problems associated with traditional disposal techniques. These latter considerations relate to the socio-economic aspects of solid waste recovery.

Henstock (1983) identified economic considerations of salvage as:

1) Salvage is often an alternative to waste disposal, and the economics must be considered in that context. Thus, a salvage operation costing for example US$20/tonne of product and realizing US$15/tonne in revenue may be deemed economic if the cost of the disposal that would otherwise be necessary exceeds US$5/tonne.

2) Where an established refuse collection system exists, it will continue to operate regardless of whether or not materials are recovered; thus the salvage operation has a zero operation cost. In fact, this cost is externalized to the refuse collection service.

3) A certain degree of de facto subsidy attaches to the fact that some salvage activities are carried out voluntarily by members of the public, to whom the relevant costs are externalized.

Economic analysis is essential before deciding to adopt any waste management strategy because it is concerned with the assessment of the costs and benefits that are attached to any particular course of action. All relevant costs and benefits should be taken into account first to achieve the best possible solution or decision.

The attractiveness of resource recovery and recycling as a method of handling waste 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.

Recovery should be of interest to any responsible authority if the cost of collecting the material or product plus any cost of sorting or separation of the material or by-product generation less any saving in overall waste collection and disposal costs is lower than the revenue obtained from the sale of recovered materials, energy or other by-products (Lohani, 1983). The use of recovered rather than virgin materials and the level of extra costs for the user to be set against any saving in price depends in practice on a number of factors (Lohani, 1981) such as:

- the technical ability to turn reclaimed material or by-product into an acceptable substitute material;
- the market's attitude to final products made with recovered materials;
- the supply conditions for reclaimed as compared with virgin materials;
- the location of production facilities in relation to the sources of materials.

On the whole, detailed examination of the economics has produced a general agreement that revenues from the sale of recovered products can, at best, reduce overall disposal costs (Abert, Atter & Bernheised, 1974). An alternative statement is that, materials recovery can be justified economically, only if part of or all of the tipping costs are included in the balance sheet.

### 1.4 Terminology

Scavenging refers to the common practice of collecting things which are unwanted by others. It involves the removal of waste from a waste disposal system and the eventual reuse of the materials collected. Synonymously, it implies reclamation, recycling and therefore by-product generation.

Recycling differs from resource recovery in that the final product obtained from recycling is similar to or, in the case of some bottles, for example, is the original product. However most of the available literature does not present distinctions when it comes to presentation of the technological options.

Recovery by materials separation is the sorting of the groups of materials contained in the waste mixture without changing their chemical and physical properties and the reclamation of the fractions so obtained as secondary raw materials or sources of energy (solid fuels). There are two principal possibilities of achieving this:

a) Materials separation at the place of origin of the waste, separate collection wherein the user separates selected groups of materials in his own home and prepares them for separate collection/selling.

b) Materials separation after conventional collection at central plants or buyer's warehouse by manual selection and/or process of mechanical treatment.

Scavengers refer to independent entrepreneurs who devote either part of or most of their working time in this field. The term includes:

a) Refuse collectors - who remove from the collected waste immediately saleable objects or valuable materials, e.g., lead batteries or copper wires.

b) So called 'rag and bone men', or door-to-door collectors.

c) Dump scavengers - who are resident at landfill sites in many parts of the world. They forage for saleable materials in public and private landfills.

All three are similar in that they support themselves wholly or partially by obtaining waste materials from a variety of sources and selling them to secondary materials dealers.

Salvage is the recovery and eventual utilization of waste materials which often come from the municipal refuse.

# II. SOLID WASTE GENERATION, COLLECTION AND DISPOSAL IN BANGKOK, JAKARTA AND MANILA

## 2.1 Sources and Generation Rates

### 2.1.1 Major Categories of the Sources of Solid Waste

Domestic or residential refuse has widely varying characteristics. Variations in the composition and the quantity of the solid waste produced exists from city to city, from section to section, from season to season and from day to day. Factors affecting its composition and quantity include type of sources, population diversity and income, frequency and efficiency of collection, amount and type of on-site disposal or burning, social habits of population, type of scavenging, market for scavenged materials and others.

Major sources of solid waste in different cities of Asia-Pacific region may be classified as follows:

1) Domestic Source

Domestic sources in a city includes single family dwellings, duplex, multifamily dwellings, low-, medium-, and high-rise apartments. Household wastes are the chief constituents of municipal solid wastes. They mainly comprise food wastes, rubbish (paper, plastics, cardboard, leather, furniture and garden trimmings), ashes and special wastes.

2) Commercial Area

Among the sources are stores, restaurants, markets, office complexes, and others. Solid waste generated from commercial sources in different parts of a city therefore consist of many varieties of refuse.

3) Institutional Sources

This refers to universities, schools, hospitals, government offices, and others. Generally, institutional solid wastes contain a large proportion of paper and other light materials, that could easily be separated for recycling or combusting to recover heat energy.

4) Street Sweeping Source

This refers to streets, alleys, parks, highways and others. The types of solid waste include rubbish and special wastes.

### 2.1.2 Generation Rates

In Jakarta, measurements from World Bank sponsored pilot projects showed that the average waste generation is 0.60 kg/capita/day. Flintoff (1978) estimates the following municipal refuse generation rates for Jakarta:

1) Residential refuse : 0.3 to 0.6 kg/capita/day
2) Commercial refuse : 0.1 to 0.2 kg/capita/day
3) Street sweepings : 0.05 to 0.2 kg/capita/day
4) Institutional refuse : 0.05 to 0.2 kg/capita/day

Waste generation in Bangkok and Manila is shown in Tables 1 and 2, respectively (JICA, 1982; MMSWMS, 1982). It is estimated that there will be an 89% increase in solid wastes generated in Manila by the year 2000 (MMSWMS, 1982).

Table 1 Solid waste generation in Bangkok

| Type of discharge | Generation units |
|---|---|
| 1. Household | 315 g/person/day |
| - Residential | 296 " |
| - Commercial or Industrial | 343 " |
| 2. Market | 17 L/store/day |
| 3. Office | 190 g/employee/day |
| 4. Hotel | 1.6 g/room/day |
| 5. Large Retail Store | 0.5 L/sq.m floor area/day |
| 6. Hospital | 660 kg/hospital/day |
| 7. Textile Factory | 4 L/worker/day |
| 8. Car Assembly Factory | 21 " |
| 9. Sawmill | 21 " |

Table 2 Summary of total solid waste generation and collection in City of Manila

| | | |
|---|---|---|
| | Population | 1,682,114 |
| Total solid waste Generation and collection (tonnes/day) | Total SW generated | 688 |
| | Collected by ESC | 588 |
| | Other private haulers | 54 |
| | Total collected | 642 |
| Per capita Generation Collection (kg/capita/day) | Total generation | 0.409 |
| | Collected by ESC | 0.349 |
| | Collected by other haulers | 0.033 |
| | Total collected | 0.382 |

## 2.2 Solid Waste Characteristics

### 2.2.1 Composition

Components that typically make-up most municipal solid waste are: food wastes, paper, cardboard, plastics, textiles, rubber, leather, garden trimmings, wood, glass, tin cans, non-ferrous metals, dirt, ashes, brick, etc.

Table 3 shows the composition of solid waste in the three cities. One of the key problems of comparison or discussion of solid waste characteristics is related to the point of measurement. A major source of error is due to the fact that a great deal of solid waste is salvaged and sold at the source and thus does not reach the collection truck or disposal site where most of the samples are taken. This is particularly true of newspapers, bottles, and similarly readily collected and sold wastes.

Table 3 Composition of solid waste in Bangkok, Jakarta and Manila

| | Bangkok | Jakarta | Manila |
|---|---|---|---|
| Vegetable/putrescible | 29.9 | 60.0 | 43.0 |
| Paper | 18.3 | 2.0 | 17.0 |
| Metals | 2.0 | 2.0 | 1.5 |
| Glass | 2.4 | 2.0 | 5.3 |
| Textiles | 3.6 | - | 3.7 |
| Plastics | 7.5 | 1.0 | 4.5 |
| Rubber | 1.4* | 1.0 | 1.0 |
| Misc. combustibles | 23.2 | 7.0 | 1.0 |
| Misc. non-combustibles | 5.9 | - | 17.2 |
| Other materials | 5.8 | 25.0 | 5.8 |
| Total | 100.0 | 100.0 | 100.0 |

Jakarta generates the highest amount of garbage (vegetable/putrescible), while Bangkok produces the least. Bangkok and Manila have similar compositions of paper (17 to 18%) which are much higher than reported for Jakarta (2%).

### 2.2.2 Density

Average refuse density is reported to be about 250 Kg/m$^3$ in Bangkok (JICA, 1982) and 400 Kg/m$^3$ in Jakarta (200 Kg/m$^3$ in pushcarts and 600 Kg/m$^3$ after being compacted in balers, Flintoff, 1977).

## 2.3 Collection and Disposal Methods

### 2.3.1 Bangkok

The total amount of solid waste collected in Bangkok in 1982 was about 2,612 tonnes per day. Table 4 shows the volume of solid waste collected and disposed of in the year 1979-1981 (JICA, 1982). The quantity of refuse collected from each major source is shown in Table 5.

Solid waste disposal is the responsibility of the Garbage Disposal Division of the Department of Public Cleansing of the Bangkok Metropolitan Authority (BMA). At present, landfilling and composting are the two disposal options used. The major landfill sites are located at On-Nooch, Nong Kham and Ram Indra. Three minor landfill sites are in Tung-Kru, Bang Tranode and Bang-Praya-Suren. The three compost plants have an overall capacity of 1,120 tonnes/day. The capacity of each plant has been summarized in Table 6. The landfills are basically controlled dumpsites.

Table 4 Volume of solid waste collected and disposed of in Bangkok from 1979-1982

| Year | Volume of solid waste collected (tonnes/year) | Volume of solid waste disposed (tonnes/year) |
|---|---|---|
| 1979 | 638,000 (1,750 tonnes/day) | 608,000 |
| 1980 | 717,000 (1,966 tonnes/day) | 683,300 |
| 1981 | 737,000 (2,008 tonnes/day) | 677,900 |

Table 5 Volume of solid waste collected in Bangkok at the source of generation in 1980 (JICA, 1982)

| Source | Volume (Tonnes/day) |
|---|---|
| Household | 1,315 |
| Market | 135 |
| Hotel | 20 |
| Office | 66 |
| Hospital | 40 |
| Road | 34 |
| Klong (canal) | 22.5 |
| Park | 2.5 |
| Sunday market | 4.3 |
| Others | 326 |
| Total | 1,966 |

Table 6 Capacity of compost plants in Bangkok (8 hours operation)

| Compost Plant | Capacity (tonnes/day) |
|---|---|
| Nong Kham | 160 |
| Ram Indra | 320 |
| On-Nooch 1, 2 | 640 |

2.3.2 Jakarta

Collection and disposal of solid waste is a major problem in Jakarta (Cointreau, 1982), where open land dumping remains the most prevalent form of disposal. The City Cleansing Department (DKKK) is responsible for the collection and disposal of municipal solid waste.

The solid waste collection service in poor areas is relatively low due to accessibility. Local governments have provided a system of refuse collection which involves trucks servicing all paved roads from the communal containers, open collection points, and individual household garbage bins. In inaccessible areas with low population, dwellers are likely to bring their refuse to open areas and dump it. Sometimes this refuse is along the route of collection vehicles. Other times it accumulates in open areas that are not accessible to trucks to pick it up. In inaccessible areas with large populations, residents dump the refuse between houses, in drains, and on remote corner lands, where it accumulates, and partially degrades. Frequently houses are built on low-lying land filled with solid waste. Solid waste projects as part of urban upgrading for these neighborhoods involve the use of pushcarts to a provide door to door service to residents, and transfer of the waste materials to metal containers that can be lifted or trailered to disposal sites (Flintoff, 1978).

2.3.3 Manila

A summary of solid waste generation and collection in Manila is presented in Table 2. An average of 2,650 tonnes of municipal refuse is generated per day, of which 1,675 tonnes (63%) is collected daily by the Environmental Sanitation Center of the Metro Manila Commission (ESC-MMC), and 155 tonnes per day (7%) by the private sector. On average, 70% of the generated waste is collected. The balance of 920 tonnes per day (30%) is either recycled, burned, scavenged by itinerant scavengers, falls in the sewers or esteros, or not collected at all (MMSWMS, 1982). In low income areas with no refuse bins a high percentage of refuse is dumped on the road.

The frequency of collection is governed by the volume of waste produced, the type of service (commercial, residential, etc.) and accessibility, which is affected by flooding). The current routing process used by MMC is shown in Fig. 1 (MMSWMS, 1982).

The size of collection crew varies according to the type of equipment in use and type of service provided. Generally, crews consist of 3 to 5 men including the driver.

In the city of Manila, only one open dumpsite accommodates all the solid waste collected within the city (Ayson, 1979). Fig. 2 shows the location of the dumpsite, near the running waters of Manila Bay which thereby pose a pollution threat and potential health hazard.

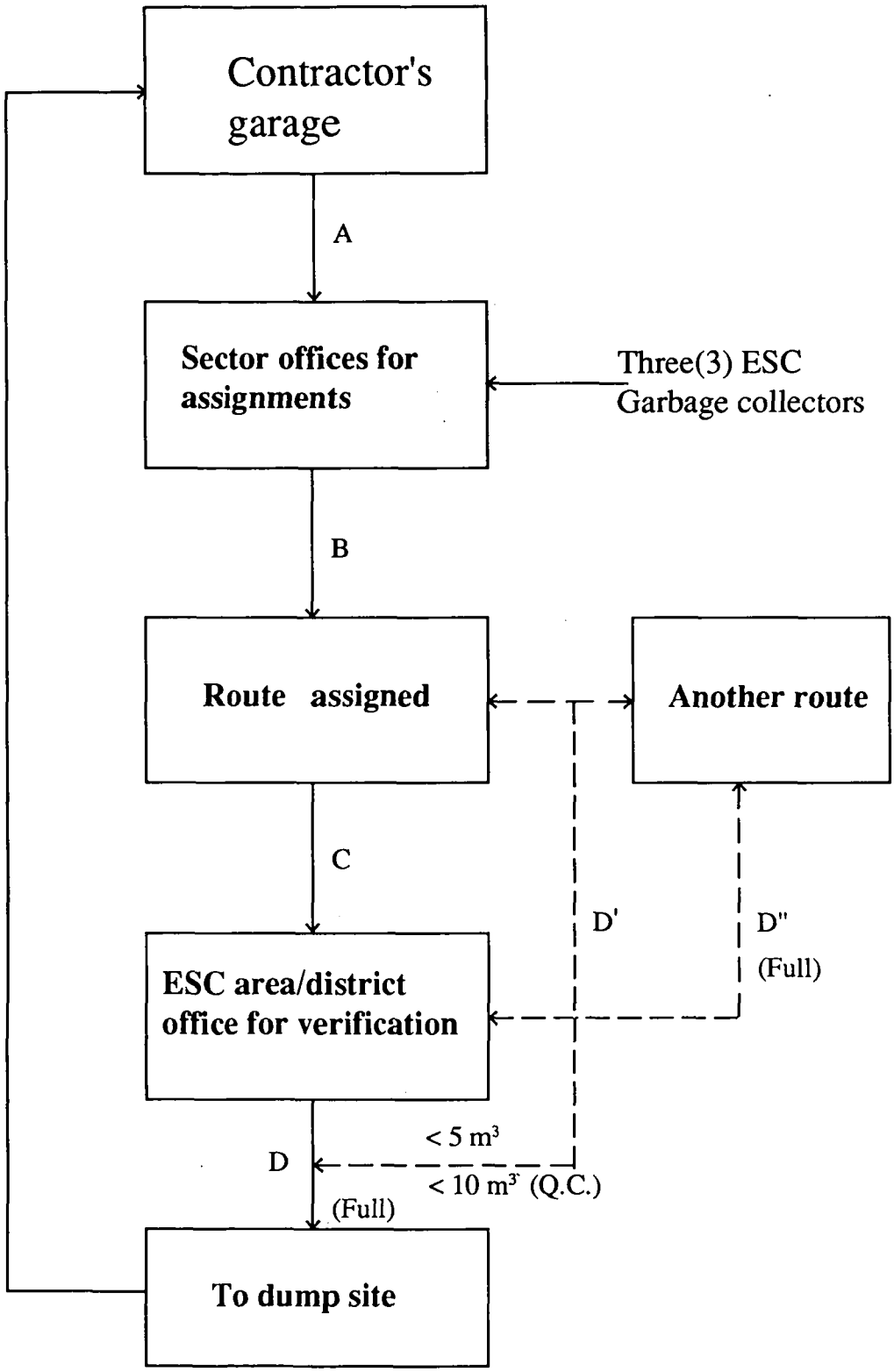


Fig. 1 Current routing process (after MMSWMS, 1982)

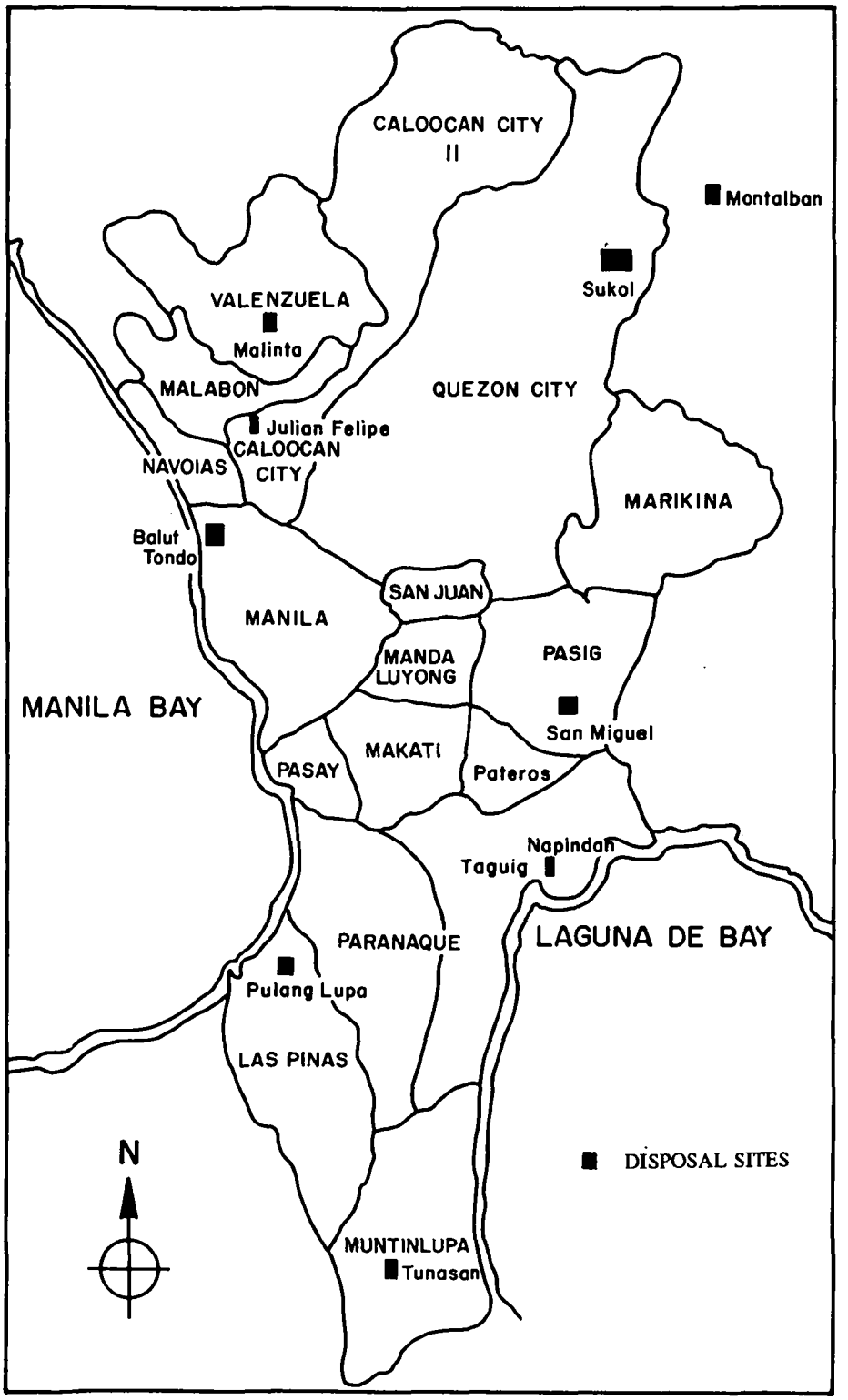


Fig. 2 Existing solid waste disposal sites in Manila

## III. SOLID WASTE SCAVENGING AND RECYCLING IN BANGKOK, JAKARTA AND MANILA

The salvage industry generally has three strata as shown in Fig. 3. Henstock (1983) has identified the three primary levels of persons involved as follows:

a) The scavengers such as refuse collectors, so called 'rag and bone' men or door-to-door collectors, and dump scavengers.

b) The small salvage dealers who buys or handles metals, papers and textiles from scavengers.

c) The secondary materials processors who are large dealers with extensive connections in processing industries.

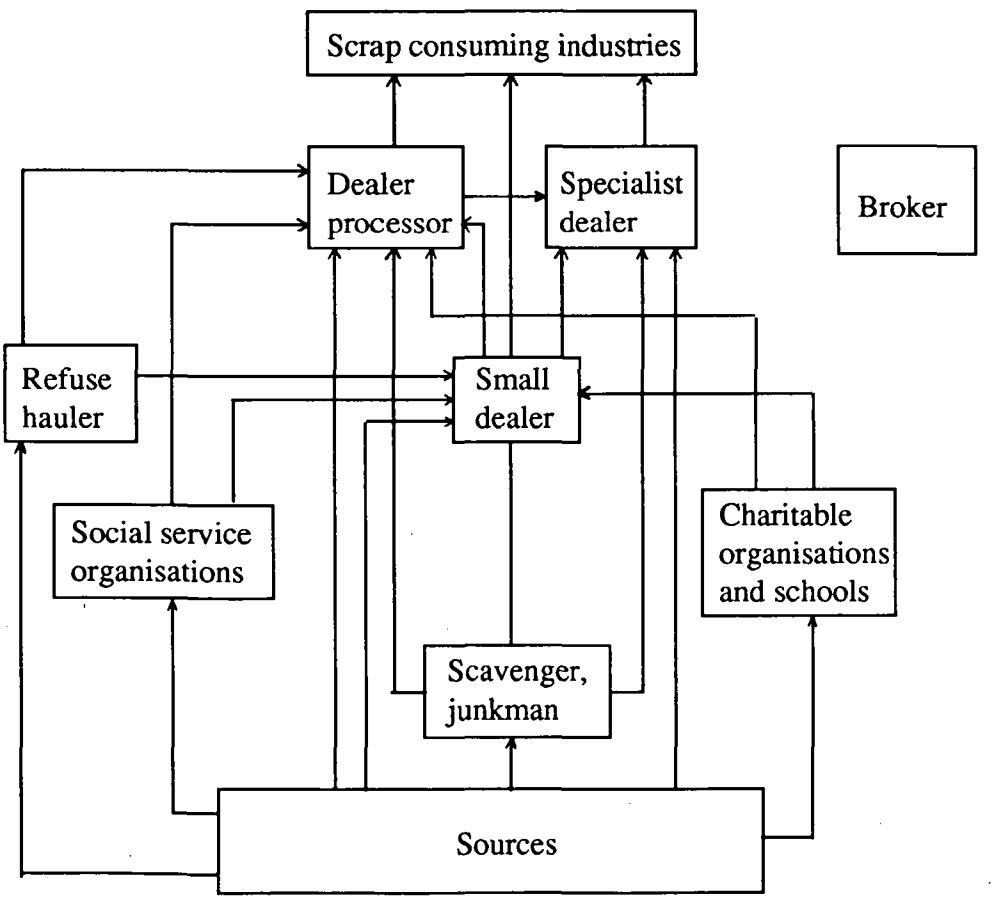


Fig. 3 Structure of the Salvage industry and flow of commodities (after Henstock, 1983)

### 3.1 Recycling at Source (Household Level)

The household is the major source of municipal solid waste collected. Due to this, it can be inferred that a large volume of these refuse materials has potential for recycling. A great number of households, who are aware of this feasibility sort out, store, recycle or sell refuse materials right from the source.

Surveys was conducted in Jakarta and Manila (Harahap, 1984; Baldisimo, 1985) to determine the levels and types of recycling of refuse materials at the household level. A survey questionnaire (see Appendix A) was used to obtain pertinent information.

#### 3.1.1 Socio-Economic Profile of Respondents

A total of 2,000 respondents was selected randomly from the two cities (1,000 from Jakarta and 1,000 from Manila). Table 7 shows the distribution of the respondents by sex and age.

The average household size of respondent was 5-6 members in Manila and 4-5 in Jakarta. Table 8 shows the distribution of family size of the respondents in the two cities.

The educational level of the respondents is summarized in Table 9.

Table 10 shows that the majority of respondents (69%) feel their living conditions/quality of life is satisfactory while 30% say that they are not satisfied.

#### 3.1.2 Refuse Materials Sold/Recycled in the Household

Table 11 shows the percentage of respondents which stored different types of recyclable materials at the household to be sold to collectors or reused at home.

Paper materials (such as newspaper and magazines) are the most common recyclables in Jakarta and Manila; collected by more than 80% of the respondents. Bottles are the second most frequently collected waste. The survey shows that the typical Jakarta household collects more diverse waste materials with almost 50% of the respondents collecting/storing/selling tin cans, plastics, and cardboard as well as paper and bottles. Less than 20% of the respondents from Manila collect waste materials other than paper and bottles.

Because bottles are non-biodegradable they are constantly reused and recycled in the bottling industry. Within the household, big bottles or glass jars are often used as containers for different food materials. Extra bottles which are no longer used are stored and sold to junkshops or sometimes given to garbage collectors for them to sell.

It is expected that conditions in Bangkok are similar to those in Jakarta. Newspaper and other paper is reused by folding and using for small bags, for example.

Table 7 Distribution of respondents by sex and age

| Age | Jakarta | | | Manila | | |
|---|---|---|---|---|---|---|
| | Sex | | Total | Sex | | Total |
| | Male | Female | | Male | Female | |
| 16-20 | | | | 59 | 133 | 192 |
| 21-25 | | | | 61 | 96 | 157 |
| 26-30 | 101 | 3 | 104 | 26 | 89 | 115 |
| 31-35 | 142 | 13 | 155 | 4 | 97 | 101 |
| 36-40 | 209 | 17 | 226 | 11 | 82 | 93 |
| 41-45 | 188 | 27 | 215 | 7 | 119 | 126 |
| 46-50 | | | | | | |
| 51-55 | 286 | 14 | 300 | 18 | 56 | 74 |
| 56-60 | | | | - | 13 | 13 |
| 61 > | | | | 5 | 35 | 40 |
| Total | 926 | 74 | 1,000 | 197 | 803 | 1,000 |

Table 8 Family size of the households

| Family size | Number of respondents in Jakarta | Number of respondents in Manila |
|---|---|---|
| 2 | 89 | 42 |
| 3 | 196 | 98 |
| 4 | 215 | 140 |
| 5 | 182 | 163 |
| 6 | 121 | 198 |
| 7 | 77 | 107 |
| 8 | 64 | 93 |
| 9 | 39 | 79 |
| > 10 | 17 | 80 |
| Total | 1,000 | 1,000 |

Table 9 Distribution of educational level of respondents

| | Jakarta | Manila | Total |
|---|---|---|---|
| Elementary | 308 | 44 | 352 |
| Secondary or high school | 514 | 270 | 784 |
| College or Univeristy graduate and post-graduate | 178 | 649 | 827 |
| No response | - | 37 | 37 |

Table 10 Respondents attitude towards their living conditions

| | Jakarta | Manila | Total | Percentage |
|---|---|---|---|---|
| Satisfactory | 641 | 743 | 1,384 | 69.2 |
| Unsatisfactory | 359 | 249 | 608 | 30.4 |
| No response | - | 8 | 8 | 0.4 |

Table 11 Percentage of respondents storing different types of recycle materials

| Type of waste material | Jakarta (%) | Manila (%) |
|---|---|---|
| Paper (newspapers and magazines) | 87.9 | 89.7 |
| Bottles | 64.1 | 88.6 |
| Tin cans | 44.7 | 18.4 |
| Plastics, hard | 44.5 | - |
| Plastics, soft | 33.7 | 8.2 |
| Cardboards | 42.1 | - |
| Iron scraps | - | 11.3 |
| Used clothes | - | 6.3 |
| Aluminum | 22.6 | - |

### 3.1.3 Economic Aspects of Refuse Recycling at the Source of Generation

The survey indicates that due to the fact that the cyclic process of converting waste to reusable material has received much public attention, recycling at the household level has become a trend not only because of the additional money it provides but also due to the economy/savings and the aesthetic aspects of refuse disposal.

Almost 80% of the respondents favour recycling of recoverable materials. Among the reasons given by those who favour recycling are: a) it saves money; b) less expensive/economical; c) additional cash income; and d) reduces solid waste disposed of/scattered along the streets.

Many respondents were aware that, (i) from the manufacturing point of view, recycling and recovery of waste materials is highly important because it means less import of raw materials and therefore lower production cost and (ii) from the aesthetic point of view, recycling and recovery contributes to a clean environment because it lessens the trash being disposed by households.

Once accumulated in a large quantity, recyclable materials are sold to different buyers. Most of the respondents sell their recyclables to middlemen/traders. A large amount of papers, bottles, and other wastes are sold by the household to collectors who travel the streets on tricycle carts and pay by the kilogram. People sell their recyclable materials to any of the three buyers depending on the value of the item to be sold.

The buying price of recyclables at the household level is presented in Table 12.

Table 12 Buying price of recyclables sold by households

| Type of waste material | Jakarta (US$/kg) | Manila (US$/kg) |
|---|---|---|
| 1. Newspaper/magazines | 0.18 | 0.11 - 0.22 |
| 2. Bottles | 0.02 | 0.002 - 0.14 |
| 3. Tin cans | 0.01 | 0.005 - 0.03 |
| 4. Plastics (hard) | 0.09 | - |
| 5. Plastics (soft) | 0.09 | 0.08 - 0.43 |
| 6. Iron scraps | | 0.005 - 0.04 |
| 7. Cardboard | 0.07 | - |
| 8. Aluminum | 0.27 | - |

Note: 1 US$ = 1,100 Rupiahs = 18.5 Pesos

Selling recyclables on a monthly basis is more common than selling weekly. In Manila, monthly earning from sale of recyclables ranges from P1 to more than P46 (US$1 = P18.50), as shown in Table 13. On average, weekly earning from recyclables is about P6.83, while monthly earning is P20.39 (Baldisimo, 1985). Based on an average income from selling recyclables of about US$1.10/household/month, the total earning in Manila (739 households) would be about US$813.00/month.

Table 13 Distribution of respondents by the amount earned and selling frequency of recyclable materials in Manila

| Amount (P) | Selling frequency (Number of households) | |
|---|---|---|
| | Weekly | Monthly |
| 3 - 5 | 112 | 17 |
| 6 - 10 | 98 | 151 |
| 11 - 15 | 51 | 159 |
| 16 - 20 | - | 127 |
| 21 - 25 | - | 49 |
| 26 - 30 | - | 81 |
| 31 - 35 | - | 41 |
| 36 - 40 | - | 63 |
| 41 - 45 | - | 27 |
| > 45 | - | 24 |
| Total | 261 | 739 |
| Percentage | 26.1% | 73.9% |

Socio-economic relationships of solid waste recycling revealed that the lower the income bracket, the higher the number of people involved in recycling/selling of recoverable materials. As the income increases, collecting and selling of recyclables is less frequent. There is a wider range of earning (P3-46) from those of the middle and higher income groups. The range of earning of the lower income group is P11.00-40.00. This relationship is summarized in Table 14. The data indicates that a low income family (income of say P700/month) may supplement the income by as much as 6% by selling recyclables from home.

The number of family members shows a linear relationship with the amount earned from selling recyclables. As the number of family members increases, the amount earned from recyclable increases too. This is likely to be attributable to an increased generation rate. This is shown in Table 15.

Table 16 shows the amount earned from selling recyclables in Jakarta. Almost 45% of the respondents in Jakarta earn RP4,100 to 5,000 per month. This is considerably higher than the average for Manila (US$3.00 for Jakarta as compared to US$1.00 for Manila).

Table 14 Distribution of respondents by income and amount earned from selling recyclables in Manila

| Amount earned (P) | Income per month | | |
|---|---|---|---|
| | Low income < P900 | Medium income P900 - P3,999 | High income > P4,000 |
| 3 - 5 | - | 19 | 6 |
| 6 - 10 | - | 78 | 34 |
| 11 - 15 | 87 | 64 | 31 |
| 16 - 20 | 89 | 73 | 49 |
| 21 - 25 | 71 | 6 | - |
| 26 - 30 | 63 | 15 | 27 |
| 31 - 35 | 25 | 18 | - |
| 36 - 40 | 18 | 33 | 23 |
| 41 - 45 | - | 7 | 5 |
| > 45 | - | - | 19 |
| Total | 353 | 313 | 194 |
| Percentage | 41.05% | 36.39% | 22.56% |

Table 15 Distribution of respondents by household size and amount earned from selling recyclables in Manila

| Amount earned (P) | Number of members | | |
|---|---|---|---|
| | <5 - 5 | 6 - 8 | > 9 |
| 1 - 5 | 8 | 24 | - |
| 6 - 10 | 3 | 82 | 16 |
| 11 - 15 | 79 | 33 | 49 |
| 16 - 20 | 35 | 105 | 39 |
| 21 - 25 | 25 | 41 | 35 |
| 26 - 30 | 36 | 49 | 48 |
| 31 - 35 | 17 | 25 | 15 |
| 36 - 40 | 26 | 32 | 17 |
| 41 - 45 | 24 | 17 | 18 |
| 46 - 50 | 7 | 9 | 8 |
| Total | 340 | 415 | 245 |
| Mean | P18.25 | P20.64 | P24.14 |
| S.D. | P14.32 | P12.18 | P10.87 |

Table 16 Distribution of monthly income of residents from selling recyclable materials, Jakarta

| Earning range (Rupiah) | Number of respondents | Percentage |
|---|---|---|
| 3,000 - 4,000 | 358 | 35.8 |
| 4,100 - 5,000 | 447 | 44.7 |
| 5,100 - 6,000 | 83 | 8.3 |
| 6,100 - 8,000 | 64 | 6.4 |
| 8,100 -10,000 | 43 | 4.8 |

## 3.2 Garbage Crew Scavenging (During Collection) in Manila

The money earned from scavenging recyclable waste materials is an important job benefit for the collection crew of refuse collection units. As these garbage collectors have access to recyclable materials generated and collected from the households, they sort out and sell recyclables which are in demand in the salvage industry. They have more opportunity to collect choice materials to the disadvantage of the scavengers at the dump. Although this activity provides additional income to the garbage collectors, it prolongs the collection time as well as the hauling time. This is due to the fact that time is taken for sorting and also to bring the sorted materials to the buyer's warehouse (even more time if the buyer's shop is not en-route).

### 3.2.1 Socio-Economic Profile of Garbage Collectors

A total of 150 garbage collectors were interviewed in a study conducted in Manila (Baldisimo, 1985). The distribution of respondents' age (all of whom were male) is shown in Fig. 4. The average (mean) age of the respondents is 30 years.

The study revealed that most of the respondents (62%) are elementary school (6 years) graduates. 25% have reached at least second year in high school or have graduated from high school and 13% of these garbage collectors have at least reached second year of college education. A part of their monthly income plus earnings from scavenged recyclables have enabled them to pursue degree courses (Baldisimo, 1985).

As the garbage collection crew is a part of the government service for solid waste management, all the respondents have either regular or permanent working status. They receive a daily wage of P24.26 to P26.00 for regular and permanent status respectively. In addition, there are medical care benefits and a cost of living allowance.

### 3.2.2 Refuse Materials Scavenged by Garbage Crew Members

Not all potential recyclables are collected by the garbage collection crew, although they have the opportunity to do so. Choice materials are preferred by the crew members due to their attractive prices and/or abundance whilst other recyclables are left for the scavengers on the dumpsite. The recyclables most preferred by collection crews are kraftboard (corrugated boxes), hard plastics, chipboard (cardboard), iron scrap and tin cans. These are bigger in size, and easier to retrieve, sort out and clean. Table 17 shows the amount accumulated by the crew on the process of collection in Manila.

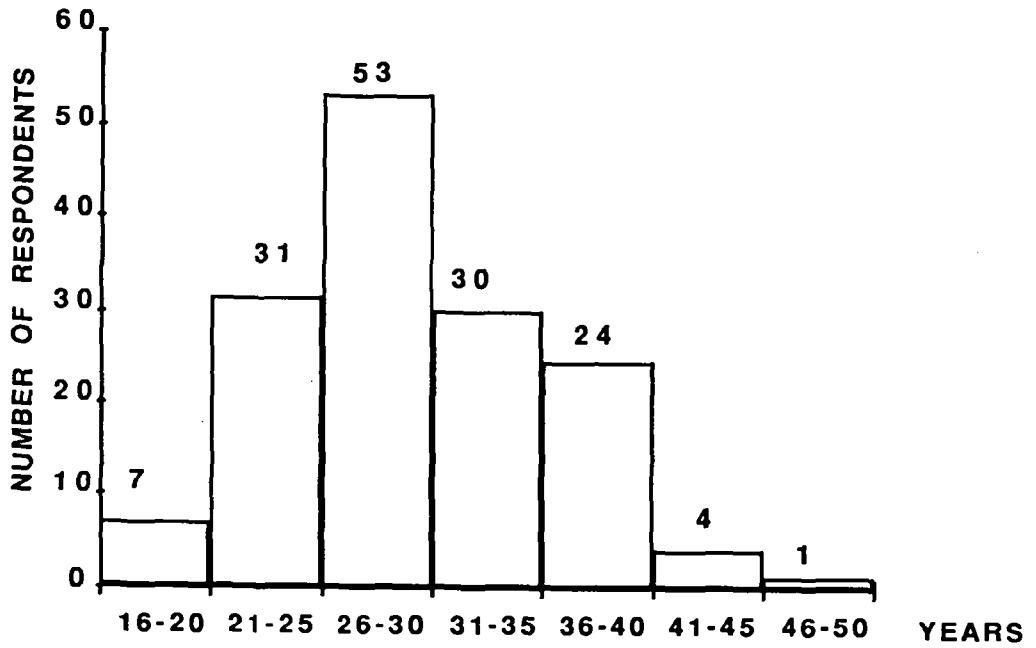


Fig. 4 Age distribution of garbage collectors

Table 17 Materials picked-up/sorted by garbage collectors from the collection trucks, Manila

| Materials | Amount accumulated/truck load (kg) | |
|---|---|---|
| | Low | High |
| Kraftboard | 4 | 15 |
| Hard plastics | 1 | 10 |
| Chipboard | 16 | 40 |
| Scrap iron | 5 | 30 |
| Tin cans | 12 | 75 |

The buying price reported by the collection crew is shown in Table 18.

The types of waste materials and daily quantity retrieved in collection trucks is shown in Table 19. This table shows that a large quantity of kraftboard, paper, and tin cans are collected daily by the crew.

Kraftboard and white paper have the greatest waste value as collected by the garbage crew. In general, only unsoiled or partly soiled recyclables are retrieved by the garbage crew, unlike dumpsite scavengers who sort and clean (partially) the collected recyclables before selling. On average, the value of recyclable waste salvaged from collection trucks daily amounts to P4,200 as shown in Table 20. The amount tends to increase during the opening of classes in the month of June and the Christmas season in December when more paper materials are recovered from the trucks.

Often, these recyclables are sold to traders/middlemen along the collection route because the dumpsite buying price is much lower.

### 3.2.3 Economic Aspects of Scavenging During Garbage Collection

The profitability of solid waste recycling has long been recognized by garbage collectors and thus recycling has gained much support from this group of public workers.

In Manila the collection crew earns from P20 to as high as P100 per truck . This is divided among the 5 members of the collection team. Each individual receives P5 to P20, depending on the amount of recyclables gathered. This is equivalent to 20 to 80% of their daily income.

As solid waste recycling is known to be a gainful business, the Metropolitan Manila Commission attempted to set up Recovery Centers to develop a more sophisticated scheme of salvaging recoverable refuse materials. However, the program was a failure and was eventually discontinued. The precise reasons for this are not known.

### 3.2.4 Health Aspects of Scavenging/Garbage Collection

A survey was conducted to determine the health hazards and common health problems of the garbage crew members. The health survey questionnaire results indicate that the most common complaints are sore muscles (more than 50% of respondents) and accidental injuries (more than 90% of respondents). Most accidents are caused by handling glass and sharp objects resulting in cuts and bruises (common injuries to hands and feet). About 11% of the workers suffer from chronic diarrhoea. Other health problems appear to be relatively minor.

Table 18 Buying price of recyclable materials accumulated by garbage collectors, Manila

| Materials accumulated | Buying price (Peso/kg) | |
|---|---|---|
| | Low | High |
| Kraftboard | 0.30 | 2.00 |
| Hard plastics | 1.20 | 3.00 |
| Chipboard | 0.10 | 0.40 |
| Scrap iron | 0.15 | 0.25 |
| Tin cans | 0.05 | 0.10 |
| White paper (Selected) | 2.00 | 2.50 |

Note: US$1 = 18.50 Pesos

Table 19 Types of wastes and daily quantity collected from collection trucks, Manila

| Waste materials | Quantity collected per district (kg) | | | | | Average amount collected (kg/truck/day) |
|---|---|---|---|---|---|---|
| | I | II | III | IV | V | |
| Kraftboard | 5 | 12 | 10 | 15 | 8 | 43.60 |
| Hard plastics | 2 | 10 | 15 | 12 | 4 | 13.55 |
| Chipboard | 8 | 20 | 15 | 40 | 10 | 18.60 |
| Scrap iron | 3 | 5 | 12 | 30 | 5 | 11.00 |
| Tin cans | 12 | 40 | 50 | 30 | 15 | 29.40 |
| White paper | 5 | 12 | 12 | 40 | 15 | 16.80 |
| Mixed paper | 16 | 40 | 16 | 60 | 20 | 24.76 |

Note: Average number of trucks = 30

Table 20 Average value of recyclable wastes collected per day from collection trucks, Manila

| Waste materials | Average Collection per truck per day (kg) | Average waste collected per day (kg) | Buying Price (Peso/ kg) | Waste value (Peso/day) |
|---|---|---|---|---|
| Kraftboard | 43.60 | 1,308.00 | 1.20 | 1,560.60 |
| Hard plastics | 13.55 | 406.50 | 2.10 | 853.65 |
| Chipboard | 18.60 | 558.00 | 0.25 | 139.50 |
| Scrap iron | 11.00 | 330.00 | 0.20 | 66.00 |
| Tin cans | 29.40 | 882.00 | 0.10 | 88.20 |
| White paper | 16.80 | 504.00 | 2.25 | 1,134.00 |
| Mixed paper | 24.76 | 742.80 | 0.40 | 296.80 |
| Total | | | | 4,212.10 |

Note: US$1 = 18.50 Pesos

### 3.3 Refuse Scavenging in the Dumpsites

Dumpsite scavengers generally depend solely on scavenging as their main source of income. These scavengers are frequently considered by solid waste management personnel as a nuisance and rarely considered as an integral component of solid waste management. They are vulnerable to environmental, social and political influences. They frequently live at the dumpsite as squatters. Since scavenging is not included in solid waste management planning, there are rarely facilities for washing or bathing or first aid at the dumpsite. Competition among scavengers is stiff. Working hours for scavengers are long as they are dependent on the arrival of the collection vehicles. Typically, the scavenger is equipped with an L-shaped metal rod with a pointed end. This is used to pick-up and throw the recovered materials into the collection basket or sack. Most of the time, while scavenging, the scavenger is in a bent position. When the container is full, collected materials are brought to buyers within or near the dumpsite. The materials are sorted and weighed with payment according to current prices. Studies conducted in Bangkok (Butsapak, 1984), Jakarta (Harahap, 1984) and Manila (Baldisimo, 1985) revealed significant aspects of the living and working conditions of the scavenges.

In some cities such as Manila scavenging starts at the roadside while the trucks await their turn to proceed to the dumps to dispose of their contents. This contributes to roadside litter, and is to some extent a disadvantage to the dumpsite buyers. This practice is advantageous to some scavengers because they are free to sell collected items to outside buyers who pay higher rates.

The number of scavengers in different disposal sites is presented in Table 21 and the distribution by age and sex of the scavengers is shown in Table 22.

Table 21 Number of scavengers at different dumpsites

| City | Location | Male | Female | Children | Total |
|---|---|---|---|---|---|
| Manila | Balut | 44 | 38 | 6 | 88 |
| Bangkok | Ram Indra | 54 | 82 | 18 | 154 |
| | On-Nooch | 97 | 132 | 44 | 273 |
| | Nong Kham | 107 | 130 | 21 | 258 |
| Jakarta | Ancol | 145 | 67 | 38 | 250 |
| | Cakung-Cilincing | 70 | 49 | 18 | 137 |
| | Kapuk | 88 | 69 | 19 | 176 |
| | Taman Mini | 59 | 44 | 16 | 119 |
| Total | | 664 | 611 | 180 | 1,455 |

Table 22 Distribution of scavengers by sex and age

| Age | Bangkok | | Jakarta | | Manila | | Total |
|---|---|---|---|---|---|---|---|
| | Sex | | Sex | | Sex | | |
| | Male | Female | Male | Female | Male | Female | |
| 16-20 | 6 | 3 | 4 | 1 | 12 | 6 | 32 |
| 21-25 | 1 | - | 6 | 4 | 16 | 11 | 38 |
| 26-30 | 7 | 5 | 10 | 6 | 7 | 8 | 43 |
| 31-35 | 1 | 7 | 7 | 7 | 4 | 3 | 29 |
| 36-40 | 4 | 5 | 11 | 5 | 3 | 2 | 30 |
| 41-45 | 5 | 9 | 6 | 6 | 2 | - | 28 |
| 46-50 | | | | | 3 | 1 | 4 |
| 51-55 | 3 | 4 | 5 | - | - | - | 12 |
| 56-60 | | | | | 1 | - | 1 |
| 61>65 | 1 | | 2 | | 1 | - | 4 |
| Total | 27 | 33 | 51 | 29 | 49 | 31 | |
| Percentage | 45 | 55 | 63.75 | 36.2 | 61.2 | 38.7 | |

In Manila and Jakarta, the number of male scavengers outnumbers the females while in Bangkok the opposite occurs. The age range of the scavengers in the dumpsite is between 16-65 years old. Most of the scavengers are less than 45 years old with the largest group being in the 26-30 age bracket.

The family sizes ranges from 2-12 persons. Table 23 shows the distribution of the scavengers by the number of family members. The study revealed that the average number of family members of scavengers in Jakarta and Bangkok is 5 members per family while in Manila, scavengers have 6 members per family.

Due to poverty, most of the scavengers have a low level of education with only about 12 percent having more than an elementary level education (see Table 24).

### 3.3.1 Health Aspects of Scavenging in the Dumpsites

The health aspect of scavenging in dumpsites in Bangkok, Jakarta and Manila was studied by means of a survey using the health questionnaire shown in Appendix A. The summary of responses is shown in Table 25.

Eye irritation in the dumpsite is due to smoke and dust in the area. Contamination is the chief cause of this disorder. Because the hands are used to pick up recyclables, unconscious rubbing of the eyes often leads to sore eyes and inflammation.

Respiratory disease is common amongst scavengers in almost all dumpsites. Coughing and sneezing is very common. Scavengers suffer from chronic colds and lung diseases due to constant stress and exposure to dust and airborne pathogens. In a study conducted for the MMSWM (1982), four leading upper respiratory ailments were found to have affected dumpsite scavengers in Metro-Manila. These are pneumonitis, pneumonia, bronchitis, and haemophysis.

Parasitism of all forms exists among dumpsite scavengers. Because cleaning or washing facilities are virtually absent, unhygienic conditions prevail in the area. Gastroenteritis and diarrhoea are common illnesses.

Bending position and carrying heavy loads of scavenged items causes backache and pains in the arms and legs. These complaints are most common among people in the dumps between the ages of 45-60. Stiffness of joints and muscles were also common complaints.

Skin diseases due to unhygienic conditions at most dumpsites are common to more than half of the scavengers. Scabies is the most prevalent skin problem. Cuts and wounds due to sharp objects in the refuse further result in infection of the exposed skin.

The scavengers suffer severe headaches during the hot seasons of the year, when they are exposed to too much sunlight. Malnutrition, anemia, vitamin deficiency and urinary tract infection (among females) are also common health problems suffered by scavengers.

Table 23 Distribution of scavengers by number of family members

| Family Size | Bangkok | | Jakarta | | Manila | |
|---|---|---|---|---|---|---|
| | No. of respon-dents | Total number in group | No. of respon-dents | Total number in group | No. of respon-dents | Total number in group |
| 2 | 5 | 10 | 6 | 12 | 2 | 8 |
| 3 | 8 | 24 | 11 | 33 | 7 | 21 |
| 4 | 7 | 28 | 19 | 76 | 10 | 40 |
| 5 | 14 | 70 | 14 | 70 | 12 | 60 |
| 6 | 8 | 48 | 11 | 66 | 18 | 108 |
| 7 | 4 | 28 | 7 | 49 | 11 | 77 |
| 8 | 6 | 48 | 8 | 64 | 7 | 56 |
| 9 | 6 | 54 | 3 | 27 | 4 | 36 |
| 10 | 1 | 10 | 1 | 10 | 5 | 50 |
| 11 | 1 | 11 | - | - | 1 | 11 |
| 12 | - | - | - | - | 1 | 12 |
| Total | 60 | 331 | 80 | 407 | 80 | 479 |
| Mean | 5 | | 5 | | 6 | |

Table 24 Distribution of scavengers by educational level

| Educational Level | Bangkok | Jakarta | Manila |
|---|---|---|---|
| No schooling | 6 | 27 | 8 |
| Elementary | 49 | 46 | 46 |
| High school | 5 | 7 | 15 |
| College | - | - | 1 |
| Total | 60 | 80 | 80 |

Table 25 Scavengers' responses to health questionnaire*

| Question number | Bangkok | | Jakarta | | Manila | |
|---|---|---|---|---|---|---|
| | Number of respondents | % | Number of respondents | % | Number of respondents | % |
| 1 | 15 | 27 | 11 | 14 | 14 | 18 |
| 2 | 15 | 27 | 17 | 21 | 17 | 22 |
| 3 | 7 | 13 | 11 | 14 | 4 | 13 |
| 4 | 38 | 68 | 39 | 49 | 62 | 78 |
| 5 | 40 | 72 | 48 | 60 | 55 | 69 |
| 6 | 4 | 7 | 9 | 11 | 78 | 9 |
| 7 | 2 | 4 | 8 | 10 | 6 | 8 |
| 8 | 13 | 23 | 6 | 8 | 11 | 14 |
| 9 | 16 | 29 | 10 | 13 | 14 | 18 |
| 10 | 18 | 32 | 12 | 15 | 16 | 20 |
| 11 | 10 | 18 | 7 | 9 | 9 | 11 |
| 12 | 19 | 34 | 14 | 18 | 17 | 21 |
| 13 | 3 | 5 | 4 | 5 | 5 | 6 |
| 14 | 4 | 7 | 21 | 26 | 14 | 18 |
| 15 | 31 | 55 | 37 | 46 | 35 | 44 |
| 16 | 21 | 38 | 25 | 31 | 23 | 29 |
| 17 | 24 | 43 | 32 | 40 | 29 | 36 |
| 18 | 9 | 16 | 19 | 24 | 14 | 18 |
| 19 | 18 | 32 | 18 | 23 | 17 | 21 |
| 20 | 9 | 16 | 14 | 18 | 12 | 15 |
| 21 | 2 | 4 | 6 | 8 | 5 | 6 |
| 22 | 9 | 16 | 65 | 81 | 42 | 53 |
| 23 | 28 | 50 | 45 | 56 | 39 | 49 |
| 24 | 8 | 13 | 11 | 14 | 10 | 13 |
| 25 | 2 | 4 | 10 | 13 | 7 | 9 |
| 26 | 15 | 27 | 26 | 33 | 32 | 40 |
| 27 | 32 | 57 | 38 | 48 | 46 | 58 |
| 28 | 35 | 63 | 21 | 26 | 42 | 52 |
| 29 | 12 | 21 | 44 | 55 | 47 | 59 |
| 30 | 26 | 46 | 23 | 29 | 25 | 31 |
| 31 | 13 | 23 | 20 | 25 | 17 | 21 |
| 32 | 2 | 4 | 48 | 60 | 39 | 59 |

*see Appendix A.

Table 25 Scavengers' responses to health questionnaire* (cont'd)

| Question number | Bangkok | | Jakarta | | Manila | |
|---|---|---|---|---|---|---|
| | Number of respondents | % | Number of respondents | % | Number of respondents | % |
| 33 | 25 | 45 | 61 | 76 | 45 | 56 |
| 34 | 21 | 38 | 11 | 14 | 17 | 21 |
| 35 | 12 | 21 | 45 | 56 | 30 | 38 |
| 36 | 2 | 4 | 6 | 8 | 5 | 6 |
| 37 | 2 | 4 | 21 | 26 | 13 | 16 |
| 38 | 8 | 13 | 10 | 13 | 9 | 11 |
| 39 | 8 | 13 | 3 | 4 | 4 | 5 |
| 40 | 42 | 75 | 66 | 83 | 54 | 68 |
| 41 | 30 | 54 | 25 | 31 | 29 | 36 |
| 42 | 14 | 25 | 42 | 53 | 33 | 41 |
| 43 | 30 | 54 | 48 | 60 | 42 | 53 |
| 44 | 15 | 27 | 9 | 11 | 13 | 16 |
| 45 | 6 | 11 | 27 | 34 | 19 | 24 |
| 46 | 16 | 29 | 13 | 16 | 15 | 19 |
| 47 | 11 | 20 | 14 | 18 | 14 | 18 |
| 48 | 10 | 18 | 14 | 18 | 12 | 15 |
| 49 | 3 | 5 | 6 | 8 | 5 | 6 |
| 50 | 17 | 30 | 16 | 20 | 17 | 21 |
| 51 | 15 | 27 | 26 | 33 | 23 | 29 |
| 52 | 10 | 18 | 43 | 54 | 31 | 39 |
| 53 | 8 | 14 | 22 | 28 | 17 | 21 |
| 54 | 7 | 13 | 19 | 24 | 14 | 18 |
| 55 | 4 | 7 | 9 | 11 | 7 | 9 |
| 56 | 2 | 4 | - | - | 3 | 4 |
| Number of respondents | 60 | | 80 | | 80 | |

*see Appendix A.

### 3.3.2 Economic Aspects of Scavenging

Upon the arrival of the collection truck in the dumpsite, scavengers quickly collect any recyclable item within sight. In the process, a lot of recyclable items, particularly those of smaller size are buried. It is then necessary for scavengers to sift through wastes to retrieve these items, with a great deal of difficulty.

There is a general tendency for some scavengers to specialize in collecting only those items with higher price, or those which are easier to retrieve. Information on the type of materials and average amount collected daily is shown in Table 26. In Bangkok, the largest amount of salvaged refuse at the dumpsite is glass, while in Jakarta and Manila it is paper.

Table 26 Average quantity of refuse collected by scavengers in different cities

| Type of waste | Average quantity collected/scavenger/day (US$) | | |
|---|---|---|---|
| | Bangkok | Jakarta | Manila |
| Paper | 0.26 | 0.03 | 0.81 |
| Bottles | - | 0.003 | 0.49 |
| Glass | 1.49 | 0.008 | 0.65 |
| Plastics (hard) | 0.19 | 0.004 | 0.65 |
| Plastics (soft) | 0.56 | 0.006 | 0.54 |
| Iron scraps | 0.34 | 0.007 | 0.32 |
| Other metals | - | 0.003 | 0.43 |
| Leather/rubber | 0.05 | - | 0.32* |
| Tin cans | - | 0.010 | 0.54 |
| Bones | 0.22 | - | 0.32 |

* rubber only

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. The buying prices of recyclable materials are shown in Table 27.

Industriousness is important for the dumpsite scavengers since to earn more, one has to be hardworking and spend a long time collecting recyclables. In Manila, scavengers earn an average of P23.19 ranging from as low as P1.00 to more than P36.00 daily, as shown in Table 28. Random interviews in Jakarta disclosed that scavengers earned between Rp1,000 to Rp7,500. The average daily income of scavengers in Jakarta is Rp 3,800, as presented in Table 29. The daily income of scavengers in Bangkok, as shown in Table 30, ranges from B30 to B150 with an average of B60.

Table 27 Buying price of scavenged refuse materials

| Material | Price range (US$/kg) | | |
|---|---|---|---|
| | Bangkok | Jakarta | Manila |
| Paper and Cardboard | 0.02 - 0.15 | 0.02 - 0.05 | 0.02 - 0.05 |
| Bottles | 0.02 - 0.02 | 0.01 - 0.02 | 0.0005 - 0.11 |
| Plastics (Soft) | 0.06 - 0.42 | 0.05 - 0.05 | 0.005 - 0.06 |
| Plastics (Hard) | 0.09 - 0.15 | 0.09 - 0.1 | 0.003 - 0.06 |
| Iron Scraps | 0.02 - 0.04 | 0.05 - 0.05 | 0.005 - 0.03 |
| Other Metals | 0.04 - 0.94 | 0.29 - 0.30 | 0.02 - 0.76 |
| Tin Cans | 0.02 - 0.03 | 0.01 - 0.02 | 0.003 - 0.008 |
| Bones | 0.02 - 0.04 | - | 0.008 - 0.02 |
| Glass (Broken) | 0.02 - 0.02 | 0.01 - 0.02 | 0.003 - 0.01 |
| Rubber Scraps | 0.03 - 0.15 | - | 0.003 - 0.10 |
| Leather | 0.15 - 0.22 | - | - |

Table 28 Distribution by daily income of scavengers in Manila

| Earnings/day (Peso) | Number of respondents | Percentage |
|---|---|---|
| 1 - 5 | 1 | 1.25 |
| 6 - 10 | 2 | 2.50 |
| 11 - 15 | 6 | 7.5 |
| 16 - 20 | 17 | 21.25 |
| 21 - 25 | 19 | 23.75 |
| 26 - 30 | 29 | 36.25 |
| 31 - 35 | 5 | 6.25 |
| 36 - 40 | 1 | 1.25 |
| Total | 60 | 100.00 |

Table 29 Distribution by daily income of scavengers in Jakarta

| Earnings/day (Rp.) | Number of respondents | Percentage |
|---|---|---|
| 1,000 - 1,999 | 9 | 11.25 |
| 2,000 - 2,999 | 15 | 18.75 |
| 3,000 - 3,999 | 25 | 31.25 |
| 4,000 - 5,999 | 25 | 31.25 |
| 6,000 - 7,500 | 6 | 7.50 |
| Total | 80 | 100.00 |

Table 30 Distribution by daily income of scavengers in Bangkok

| Earnings/day (Baht) | Number of respondents | Percentage |
|---|---|---|
| 30 - 50 | 19 | 31.7 |
| 51 - 70 | 28 | 46.7 |
| 71 - 90 | 7 | 11.7 |
| 91 - 110 | 2 | 3.3 |
| 111 - 130 | 1 | 1.7 |
| 131 - 150 | 1 | 1.7 |
| 150 | 2 | 3.3 |
| Total | 60 | 100.1 |

Because daily earnings are basically not enough, scavengers complain of not getting fair prices from dumpsite buyers. In Manila, arrangements are usually made between scavengers and buyers at the dump. For a scavenger to be allowed to collect recyclables at the dump, he must make his intentions known to the dumpsite franchise owner (which is often the buyer) and promise to sell all collected items to him. Nevertheless, higher prices paid by the junk buyers outside the dumpsite tends to lure the scavengers to bring the collected materials outside the dump area. This tendency could account for the presence of armed guards around the area (MMSWMS, 1982). Table 31 shows that the daily values of waste collected from dumpsites in Manila, Jakarta, and Bangkok are US$514, 2,577, and 2,270, respectively.

### 3.4 Traders and Wholesalers in the Salvage Industry

All collected recyclables are delivered to (or collected by) traders and wholesalers in the salvage industry. Fig. 5 shows the relationship of scavenging and the position of traders and wholesalers in the solid waste management system.

Although the materials sold by scavengers and households are already sorted, when they reach the junkshop of traders, some processing is normally required before these materials are sold to manufacturers. Mixed papers are baled, soft and hard plastics are cut and washed, bottles are washed and sacked, and tin cans and scrap irons are flattened.

In Bangkok, traders/middlemen buy scavenged materials right at the dumpsites. A child almost always gets a lesser price than an adult for the same quantity and quality of materials. In some places, the trader prefers to buy the materials by the basketful where the salvaged refuse materials are mixed because in doing so they get higher returns by paying at lower rates.

The wholesaler usually has bigger shops where recyclables are kept and accumulated. Often a number of workers are employed to weigh, pick reject items, sort and re-sort recyclables.

Although it is difficult to obtain accurate income estimates from the wholesalers it is likely that they earn a relatively high income from the business. Table 32 shows the buying and selling rates of the scavenged materials.

The summary of information about the traders/wholesalers is presented in Appendix B. Based on this information it is estimated that the people involved in wholesale of scavenged recyclables in Bangkok, Jakarta, and Manila earn about US$250, 255 and 320 per month respectively, putting them all in the medium income bracket.

Table 31 Value of waste pick-up per day in Bangkok, Jakarta & Manila, US$/day

| Material | Bangkok (B26.5=US$1) | Jakarta (Rp1100=US$1) | Manila (P18.5=US$1) |
|---|---|---|---|
| Paper and Cardboard | 251.60 | 759.87 | 54.49 |
| Bottles | - | 34.19 | 46.70 |
| Plastics (Soft) | 632.97 | 268.43 | 33.73 |
| Plastics (Hard) | 568.30 | 342.95 | 39.23 |
| Iron Scraps | 172.64 | 319.74 | 7.78 |
| Other Metals | - | 612.33 | 280.22 |
| Tin Cans | - | 142.62 | 5.19 |
| Bones | 64.42 | - | 9.34 |
| Glass (Broken) | 447.28 | 105.48 | 9.30 |
| Rubber Scraps | - | - | 28.02 |
| Leather | 132.45 | - | - |
| Total | 2,269.67 | 2,577.41 | 514.04 |

Table 32 Prices of scavenged recyclables, US$/Kg

| Material | Bangkok* | | Jakarta* | | Manila* | |
|---|---|---|---|---|---|---|
| | Buying | Selling | Buying | Selling | Buying | Selling |
| Paper and and Cardboard | 0.02 | 0.03-0.11 | 0.02 | - | 0.02 | 0.07 |
| Bottles | 0.02 | - | 0.01 | - | 0.0005 | 0.01 |
| Plastics (Soft) | 0.06 | 0.30-0.42 | 0.05 | - | 0.005 | 0.15 |
| Plastics (Hard) | 0.09 | 0.15-0.26 | 0.09 | - | 0.002 | 0.15 |
| Iron Scraps | 0.02 | 0.04-0.06 | 0.05 | - | 0.005 | - |
| Other Metals | 0.02 | 0.003 | 0.01 | - | 0.002 | 0.01 |
| Tin Cans | 0.04 | 0.75-1.06 | 0.29 | - | 0.02 | 0.76 |
| Bones | 0.02 | 0.04-0.75 | - | - | 0.008 | - |
| Glass (Broken) | 0.02 | 0.02-0.026 | 0.01 | - | 0.002 | 0.02 |
| Rubber Scraps | 0.003 | 0.19 | - | - | 0.002 | - |
| Leather | 0.15 | - | - | | - | - |

* US$1 = 26.5 Baht = 1,100 Rps. = 18.5 Pesos

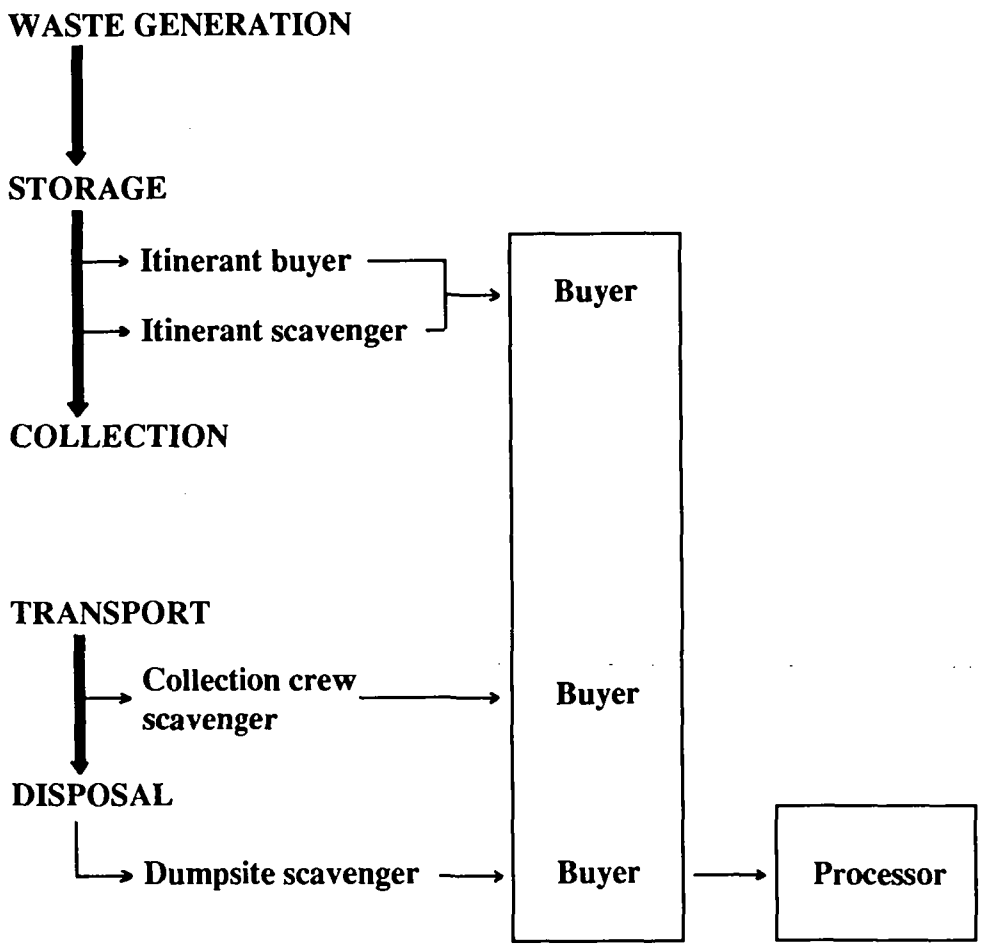


Fig. 5 Relationship between scavenging and the SWM system

# IV. TECHNICAL AND ENGINEERING ASPECTS OF RECYCLING SCAVENGED REFUSE MATERIALS IN BANGKOK

To provide a basis for evaluating the technical and engineering aspects of recycling scavenged materials, it is necessary to consider the various recycling processes used in industry.

## 4.1 Recycling of Paper

The demand for paper products is somewhat related to the level of economic development. As a nation develops, the rate of paper consumption increases due to increased packaging, etc. By converting raw materials in combination with scavenged recyclable, the paper industry fulfills the increasing demands at lower costs than if only raw materials are used.

The reuse of wastepaper products is a growing concern. Waste paper that can be reused encompasses almost every type of paper manufactured. There are some 40 grades of waste paper. However, most of these grades can be classified (Jackson, 1975) as:

- Mixed paper, kraft wrapping, old corrugated containers, etc., from industrial concerns, department stores, etc.
- Old newspapers and magazines collected from private homes or back issues from publishers.
- Waste from printers, envelopes, manufacturers, etc.
- Cuttings from box and bag manufacturers.

In the production of paper, the sources of raw materials are (Colon, 1976):

- Wood (ground wood, semi-chemical cellulose, chemical cellulose)
- Linters
- Straw/Bagasse
- Waste paper

Subsequent processing and techniques of waste paper separation have been discussed in detail elsewhere (Bridgewater, 1980; Drobny et al, 1972; Langer, 1979; Mugg, 1976; Stork, 1979; Sudan, 1979; UNEP, 1977). The processes can be divided into two groups:

- Wet Process - separation of fiber after mixing up domestic waste with water.
- Dry Process - separation without addition of water.

The details of the processes are given in Annex A.

Case studies conducted in paper manufacturing plants in Thailand (Butsapak, 1984), revealed that the combination of wood pulp and waste paper gives benefit/cost ratio from about 1.5 to 2.1. The case studies conducted are presented in Appendix C.1.

### 4.2 Recycling of Glass

Recycling of waste glass (cullets) - The use of cullet is a long established practice in the glass container industry. Since the broken glass is virtually equivalent to the original raw material, and can be remelted many times without suffering degradation, it has been the practice to recover the scrap from defective articles and to put it back into the furnace for remelting. There are two basic reasons why the recycling of cullet is desirable:

i) to reduce the volume or solid waste; and
ii) to reduce the consumption of raw material

(a) Types of cullet - Any glass object may be broken into cullet but not all will produce material free from impurities that can be used for glass-making. Suitable cullet includes:

- breakage from a glass-making workshop or factory.
- breakage from a bottling plant, provided they are free of bottle tops.
- used bottles and food jars minus metal tops.
- glass crockery and household ware such as vases.

(b) Raw materials used in glass making - A typical composition of the glass used in container manufacture is shown in Table 33 (Cook, 1978).

Table 33 Typical composition of glass manufacture

| Component | % by Weight |
|---|---|
| Sand ($SIO_2$) | 72 |
| Soda ash ($Na_2CO_3$) | 14 |
| Limestone (CaO) | 11 |
| Alumina ($Al_2O_3$) | 2 |
| Colorants and Others | 1 |

The process of making glass is given in Annex B.

(c) Manufacture of glass (see Annex B for details)

The use of 75% raw material combined with recycled glass or cullet gives a higher benefit/cost (B/C) ratio as shown by 2 case studies on the manufacturing of glass; about 1.6 B/C when using cullet as compared to 1.4 or 1.5 when using only virgin raw materials (see Appendix C.2). The use of cullet reduces the cost of melting the materials as lower temperatures are required. Also, the rejected products can still be recycled and reused in the manufacturing process.

## 4.3 Recycling of Plastics

The disposability of plastic wastes has been studied in considerable depth and is the subject of on-going research and much public attention (Gross, 1971; Potts, 1970 & Society of Plastics Engineers - Chicago Section, 1972).

### 4.3.1 Major Sources of Waste Plastics

Waste plastics may enter the recycling stream from several major sources, and will vary accordingly in characteristics. From the viewpoint of one in the plastics industries, "waste or scrap plastic comes from three main areas namely: producers of primary polymers, fabricators of plastic products; and consumers themselves" (Sheftel, 1972).

The most likely major source of waste plastics for recycling in developing countries, is from scavenged solid waste.

(1) Reuse of plastic material - The reuse of a material consists in using the plastic as it was originally used after cleaning, if necessary, without submitting it to modification of form (with bottle cases, bottles, pellets, jugs, etc.)

(2) Recycling of plastic material - Four categories of plastic waste recycling are commonly referred to in the literature.

(a) Primary recycling - Primary recycling involves using uniform, uncontaminated plastics waste to manufacture plastics products. Only thermoplastics waste can be directly reprocessed. It can be used alone or more often added to virgin resin at the plant processor or through reprocessors.

(b) Secondary recycling - Secondary recycling utilizes plastics waste unsuitable for direct reprocessing through standard equipments.

The waste received in secondary recycling factories can be classified in three ways.

- Post consumer waste recovered from municipal refuse.
- Post consumer waste obtained from returnable packages.
- Industrial waste consisting of a single type or mixed.

(c) Tertiary recycling - Tertiary recycling requires extraction of chemicals out of plastic waste. It is a difficult process and the economics of the system are questionable.

The two methods used are:

- Pyrolysis which is the physical and chemical decomposition of organic materials caused by heating in an oxygen-free or oxygen deficient atmosphere.

- Chemical decomposition of plastic waste by hydrolysis, glycolysis or other processes.

(d) Quarternary recycling - This involves the recovery of energy out of the waste and is not generally limited to plastics. Energy recovery from municipal solid refuse can take the following routes:

- burning the waste in steam generated incinerators;
- burning the refuse in heat exchangers;
- pyrolysis;
- hydrogenation; and
- anaerobic digestion.

(3) Manufacturing Process - Fig. 6 presents a flowchart of the plastic manufacturing process and the details of processing are given in Annex C.

The use of salvaged plastics in combination with pure raw materials gives more beneficial results to manufacturers, as shown in two case studies (see Appendix C.3). Benefit/cost for combination is about 1.3 as compared to 0.8 for pure pelletized plastic. Although using 100% plastics waste generates more benefit/cost (1.6), the quality of the product is low and is not acceptable in the market.

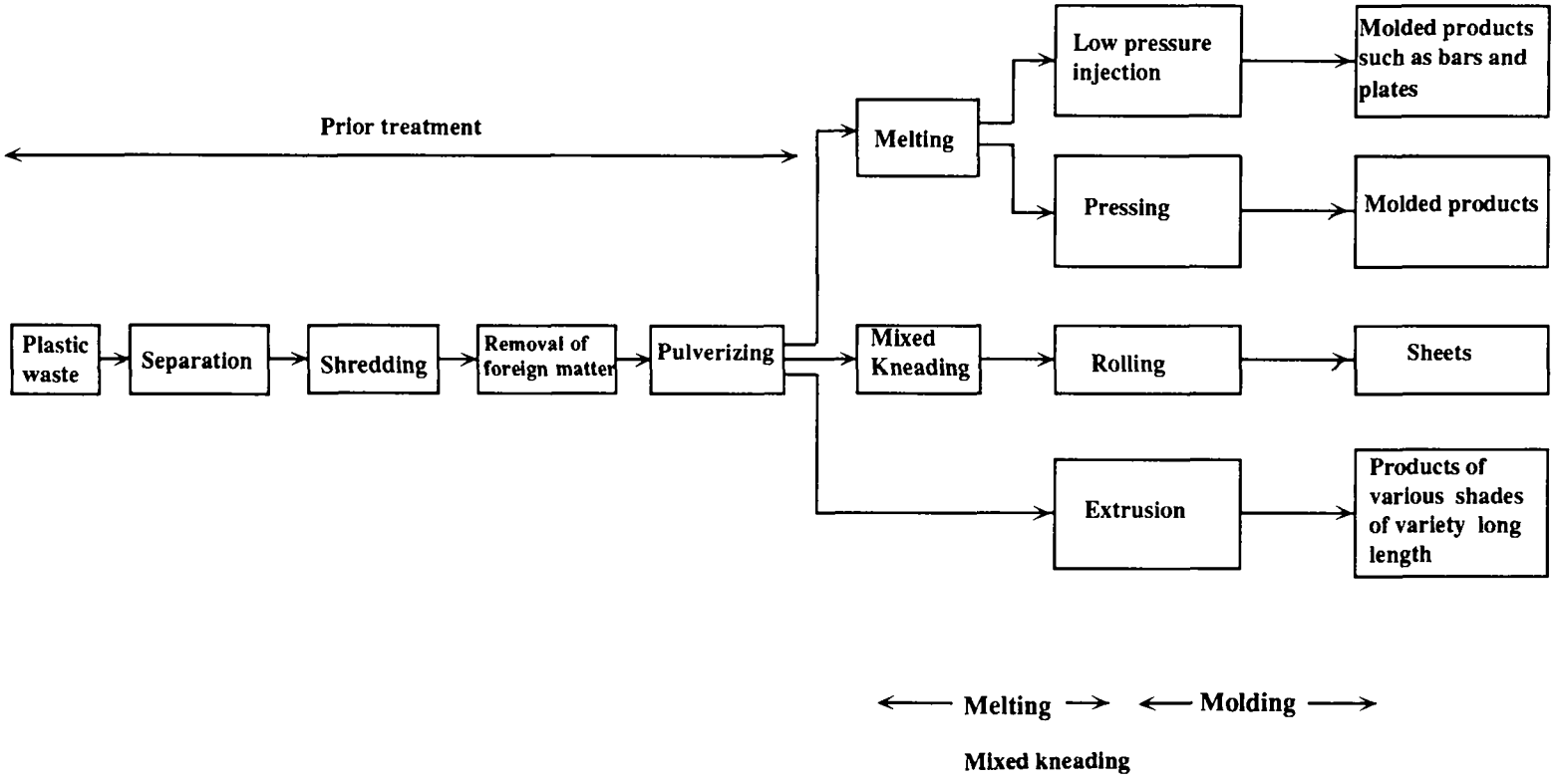


Fig. 6 Flow chart of manufacturing process for recycled products

## V. CONCLUSION

### 5.1 Refuse Recycling at Source of Generation

1) Recycling of recoverable waste materials receives positive public support due to the amount of savings, and extra money it can provide to households.

2) Newspapers and bottles are the most popular recyclable materials at the household level.

3) Selling recyclable materials on a monthly basis gives more extra cash than selling on a weekly basis.

4) The higher the income level, the more recyclables that are generated and therefore the greater the amount of earnings from the sale of recyclable refuse items.

5) High income earners positively support recycling of recoverable materials not for financial reasons but for aesthetic and environmental reasons.

6) Household size is directly proportional to the amount of solid waste generated and will therefore mean more earnings from the sale of recyclables.

### 5.2 Refuse Scavenging during Collection

1) Garbage collectors recycle refuse materials collected from various sources to augment income.

2) Not all potential recyclables are collected/scavenged by the collection crew. A few choice materials are preferred by them due to their attractive prices and their abundance.

3) Collection crew benefits considerably from the scavenging of recyclables because of their position in the solid waste disposal system.

4) Collection crew scavengers are vulnerable to some common diseases attributed to filth.

### 5.3 Scavenging in the Dumpsites

1) Working and living conditions in the dumpsites are detrimental to health and are unsafe.

2) Dumpsite scavenging is very unsystematic and relatively unproductive because whenever collected refuse materials are tipped off, a great deal of recyclables and reusable materials are buried and are therefore not easily retrievable.

3) The amount earned from scavenging is directly related to the number of hours spent in the dumps. The longer time spent in retrieving recyclable, the more a scavenger earns.

4) Due to poverty, most scavengers have a low level of education.

5) Due to an unhygienic environment and constant exposure to it, a number of diseases are common among dumpsite scavengers. These are respiratory diseases, skin diseases, parasitism and intestinal disorders.

6) Buying price in the dumpsite is relatively low compared to other places.

7) Average individual earnings per day are insufficient to support an average family size of 5-6. Some members of the family normally help in scavenging to augment the family income.

8) In general, dumpsite scavengers provide a potential work force for more efficient materials recovery at the dumps.

9) The enormous amount of materials recovered through scavenging at the dumps as well as along the streets is important to the recycling industry and to the Philippine economy.

10) Scavenging is an economic necessity.

   a) It can provide secondary material for the recycling industry.
   b) It can help reduce the need for virgin raw materials and therefore a dollar saving on the economy.
   c) It can provide employment for a great number of people at the dumps and at different levels of the recycling industry.

### 5.4 Trading and Wholesaling of Salvaged Refuse

1) Traders and wholesalers are the real "profit-makers" in the recycling industry due to their low operation costs and the comparatively low prices offered to collectors.

2) The market for trading recyclables is relatively competitive and unpredictable.

### 5.5 In Retrospect

A consideration of the socio-economic aspects of solid waste scavenging in different parts of Asia reveals that it makes a substantial contribution to family economics and to environmental sanitation. However, at present, scavenging is very much an informal activity. Materials recycling is considered to be an indispensable part of the solid waste management system in most developing countries, and resource recovery schemes should be addressed to incorporate it into the management framework. This means that scavenging should be incorporated as an integral component of solid waste management planning and implementation rather than ignored (as if it were a common nuisance not easily resolved). Scavenging as a whole does not only provide income to those without formal employment but reduces the need for highly sophisticated recovery systems as well. Efforts by municipalities, to control specific scavenging points may pose some difficulties. Perhaps scavengers could be organized into a recognized group and scavenging activities permitted only at dumpsites or processing centers (Lohani et al., 1984).

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# ANNEX

## ANNEX A

### Processing and Techniques of Waste Paper Separation

In the wet process of waste paper reuse, paper is made by suspending fibers in water at a fiber concentration of about 0.3%. The suspension is fed on to an endless clot of a continuous paper machine where the water is drained and the leaf is formed. The leaf is then transported to a drying section where, by means of steam heated drums, it is dried. At the end of the machine, the leaf is collected on a roll or cut into sheets. A simplified flowchart of the production process for paper and cardboard is shown in Fig. A.

When wastepaper is used as a raw material, the preparation of the suspension takes place in a series of processes as shown in Fig. B.

In the pulper, the fibers are fed from the paper structure in water by a mixer rotor. At the bottom of the tank is a perforated sieve plate to reject coarse materials. The pulping is repeated in a second pulper. Higher shear rates and fine sieves are applied. The resultant pulp is cleaned by passing through hydrocyclones and leaves. Sand, dirt, and fine fibers are rejected.

A dry process based on air classification and screening has also been applied to the recovery of paper for repulping. This technique has not been popularly used in the U.S.A. However, in Italy and the Netherlands this dry system has been regarded as environmentally and economically feasible.

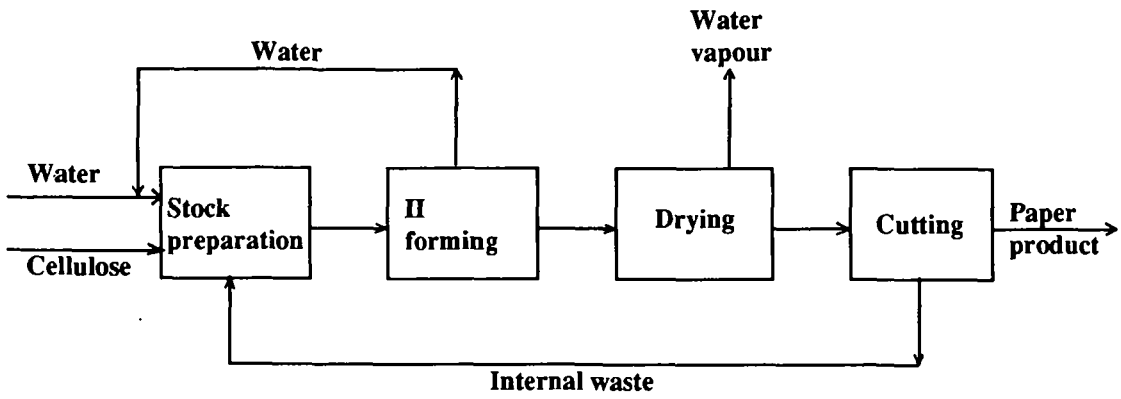



Fig. A. Simplified flow chart of the production process for paper and card board

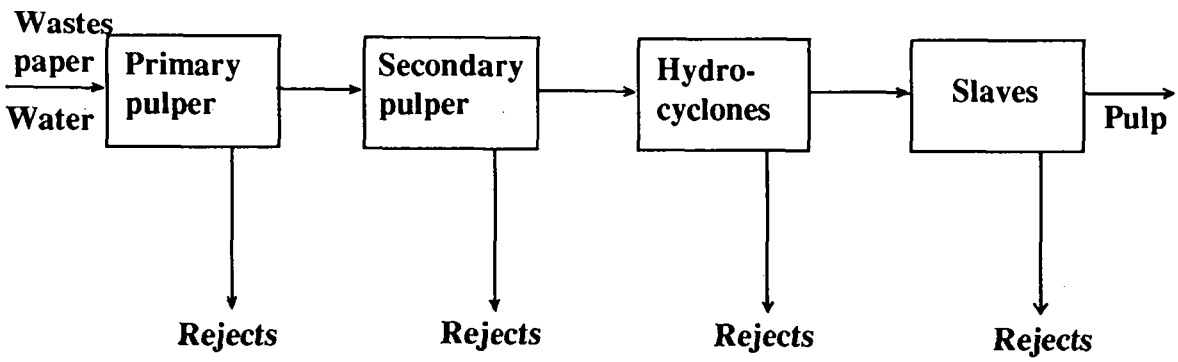



Fig. B. Flow chart of stock preparation using waste paper

## ANNEX B

### Glass Making Process

Sodium oxide (sodium carbonate) is used as flux which reduces the melting temperature of sand from 1700°C to only about 800°C. Calcium carbonate or limestone is used as the stabilizer to make the resulting material insoluble.

These three materials (sand, sodium oxide, limestone) mixed together in the proportion described, are known as the "batch". Various other substances added to the batch include:

- alumnimum oxide to reduce expansion of the glass when heated and therefore to prevent cracking.
- borax (1/2%) to assist and speed up melting.
- decolorizing agents to remove the color resulting from the iron in the sand.
- colorizing agents which help remove the small gas bubbles given off during the glass-making process. The most common refining agent is arsenic oxide with sodium nitrate.
- cullet acts as a flux, reduces damage to the glass furnance from the corrosive, high temperature materials and reduces the cost of raw material.

### Glass Manufacturing

The batch materials are mixed dry and charged into the furnance which needs to be at about 1500°C to melt them into tracy, amber-colored liquid. After it is melted, glass flows into a refining chamber and then drops to automatic feeders where it is finally formed into the required shape.

## ANNEX C

### Plastic Recycling and Processing

Recycling and processing procedures can roughly be divided into three stages:

1) Prior treatment - While prior treatment processes include removal of foreign matter classification by type of resin, shredding, washing, dehydrating, drying and blending processes that can be omitted depending on the type of products to be made, the process to be employed depends on the quality of the plastic waste to be used, type of resin and the removal of foreign matter.

2) Melting/mixed kneading - At this stage, plastic waste given prior treatment is melted or kneaded, after blending with virgin plastics in the latter case. The major techniques used are screw type, plunger type and the combined use of these two types.

3) Molding - There are four molding methods: low pressure injection molding, press molding, extrusion molding and rolling molding.

Porteous (1977), describes the processing of mixed plastics waste are follows:

1) Reverzer Process - The separated plastics will be a mixture of low-density polyethylene film (LDPE), PVC bottles, polystyrene, egg boxes and plastic breakers, etc. The segregated waste requires additional treatment to make it suitable as feedstock for the melting and mixing processes to follow. As described by Shozawa (1974), the plastics are first blended, then fed to a shear and melter "cone" where the compressed material is subjected to friction and shear stresses between the rotating cone and the outside wall. Heat generation is controlled by adjusting clearance, speed of cone revolution, level of compression and degree of cooling or heating. The molten material is then passed to an injection molder where typical products are cattle or horse fencing or pallets.

2) Regal Process - The Regal process consists of a granulator to produce uniform chips from the waste plastics and the pneumatic conveyor which delivers the granules to the converters, which then melts the granules and forms them into a sheet. The resulting sheet has found many applications in industry where the product is, for example, used as a wallboard.

# APPENDICES

# APPENDIX A

# Survey Questionnaires

**QUESTIONNAIRE 1 (Q1)**

**Interview of Household**

General Information

Name : _____ Age : _____ Sex : _____
Marital Status : _____ Educational attainment : _____
Place of Birth : _____
Present Address : _____
Barangay : _____ Zone : _____
Household Size : _____
How many people occupy your house? _____

Living Conditions in the Area:
( ) Satisfactory ( ) Not satisfactory

Occupational Information

| | | Income/month |
|---|---|---|
| Occupation : | _____ | _____ |
| Father : | _____ | _____ |
| Mother : | _____ | _____ |
| Others : | _____ | _____ |

1. What refuse materials do you store for recycling/selling? (Please check)

| | | |
|---|---|---|
| ____ Papers | ____ Card Boards | ____ Hard Plastics |
| ____ Glasses | ____ Soft Plastics | ____ Iron Scraps |
| ____ Tin Cans | ____ Bottles | ____ Newspapers |
| ____ Aluminum | ____ Copper | ____ Others |

2. Do you sell them to

( ) Eco-aides ( ) Recovery Centers
( ) Junkshops ( ) Middlemen/Traders

3. How much does the recyclable materials cost?

| | |
|---|---|
| Newspapers/Magazines | _____ P/kilo |
| Mixed paper | _____ |
| Bottles | _____ |
| Tin cans | _____ |
| Soft plastics | _____ |
| Hard plastics | _____ |
| Scrap iron | _____ |
| Copper | _____ |
| Aluminum | _____ |

4. How much do you usually get from selling recyclable materials?

_____ per week _____ per month

5. Do you favor recycling of recoverable refuse materials?

( ) Yes ( ) No

Why? _____
_____

6. Is there any health hazard or diseases which could be attributed to solid waste within your area?

( ) Yes ; specify _____
( ) No

**QUESTIONNAIRE 2/3 (Q2/Q3)**

**Interview of Scavengers/Garbage Collectors**

Disposal site _____

General Information

Name : _____ Age : _____ Sex : _____
Marital Status : _____ Educational attainment : _____
Place of Birth : _____
Present Address : _____
Barangay : _____ Zone : _____
Household Size : _____
How many people occupy your house? _____

Tenure of the house and land:
( ) Own house ( ) Colony
( ) Rented house ( ) Others (specify) _____

Occupational Information

Number of working hours per day : _____
Number of working days per week : _____
How long have you been working in this job? _____

What kind of materials do you pick up for selling and what processing do you do (if any) before selling?

| Material | Processing before selling |
|---|---|
| 1. | |
| 2. | |
| 3. | |
| 4. | |
| 5. | |

The place you are selling them and their prices

| Material | Selling Place | Selling Price |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | | |
| 5. | | |

Amount of solid waste picked up per day

| Material | Quantity |
|---|---|
| 1. | |
| 2. | |
| 3. | |
| 4. | |
| 5. | |

Present income per day _____
Is your income enough to maintain your family? _____
If you were offered another job with the same earning (with working hours from 8 a.m. to 5 p.m.), would you change your occupation?
( ) Yes ( ) No

Occupational Health Hazards

Do you have any disease that you are aware of?
( ) Yes ; specify _____
( ) No

Have you had any disease before?
( ) Yes ; specify _____
( ) No

Since when have you been cured? _____
How often do you consult a doctor? _____
What kinds of accidents occur in your occupation? _____

**QUESTIONNAIRE (Q4)**

**Interview of Trader/Wholesaler**

Location : _____

General Information

Name : _____ Age : _____ Sex : _____
Marital Status : _____ Educational attainment : _____
Place of Birth : _____
Present Address : _____
Barangay : _____ Zone : _____
Household Size : _____

Tenure of land and house:
( ) Own house ( ) Colony
( ) Rented house ( ) Others (specify) _____

Living condition in the area :
( ) Excellent ( ) Poor
( ) Good ( ) Very poor
( ) Fair

Occupation

Number of working hours per day : _____
Number of working days per week : _____
How long have you been working in this job? _____

What kind of materials do you buy from scavengers/garbage collectors/etc.?

| Material | Buying Place | Buying Source |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | | |
| 5. | | |

Please specify the selling place and price of accumulated recyclable materials.

| Material | Selling Place | Selling Price |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | | |
| 5. | | |

Please give the amount of waste materials that reaches your shop everyday.

| Material | Quantity |
|---|---|
| 1. | |
| 2. | |
| 3. | |
| 4. | |
| 5. | |

What is your present income _____
Is your income enough to maintain your family? _____
If you were offered another job with the same earning (with working hours from 8 a.m. to 5 p.m.), would you change your occupation?
( ) Yes ( ) No

Comment : _____

**HEALTH QUESTIONNAIRE**

Name : _____

Please read the questions carefully and answer "YES" or "NO".

| | Yes | No |
|---|---|---|
| **Eye Irritations** | | |
| 1. Do you often have difficulty in seeing? | ____ | ____ |
| 2. Do you often get red eyes or inflammation? | ____ | ____ |
| 3. Do your eyes feel painful always? | ____ | ____ |
| **Respiratory System** | | |
| 4. Do you often cough and sneeze? | ____ | ____ |
| 5. Have you suffered from chronic colds | ____ | ____ |
| 6. Have you ever suffered from chronic lung disease? | ____ | ____ |
| 7. Have you ever suffered from Tuberculosis? | ____ | ____ |
| **Circulatory System** | | |
| 8. Do you get annoyed with strong pulsing? | ____ | ____ |
| 9. Do you have difficulty in breathing? | ____ | ____ |
| 10. Do you easily feel tired? | ____ | ____ |
| 11. Do you have asthma frequently even at rest? | ____ | ____ |
| 12. Do you suffer from leg cramps? | ____ | ____ |
| 13. Has the doctor told you that you are suffering from heart probes? | ____ | ____ |
| **Alimentary System** | | |
| 14. Do you suffer from pyhorrhoea (teeth disease)? | ____ | ____ |
| 15. Do you suffer from toothache? | ____ | ____ |
| 16. Do you often loose your appetite? | ____ | ____ |
| 17. Do you often suffer from flatulence and constipation? | ____ | ____ |
| 18. Do you suffer from severe stomach ache? | ____ | ____ |
| 19. Does any member of your family have gastritis? | ____ | ____ |
| 20. Do you suffer from diarrhoea? | ____ | ____ |
| 21. Have you ever had worms in your feces? | ____ | ____ |
| 22. Have you ever had severe diarrhoea? | ____ | ____ |
| 23. Do you often have constipation? | ____ | ____ |
| 24. Have you ever had haemorrhoids? | ____ | ____ |
| 25. Have you ever suffered from jaundice? | ____ | ____ |
| **Muscle and Bone Structure** | | |
| 26. Do you often have pains or swelling in your joints? | ____ | ____ |
| 27. Do you often feel pain in your arms and legs? | ____ | ____ |
| 28. Does backache cause you to work slowly? | ____ | ____ |
| **Skin Diseases** | | |
| 29. Do you have skin disease? | ____ | ____ |
| 30. Do you have wounds that take time to heal? | ____ | ____ |
| 31. Do you often perspire even when the weather is cold? | ____ | ____ |
| 32. Do you often get rashes in your skin? | ____ | ____ |
| **Nervous System** | | |
| 33. Do you often have severe headache? | ____ | ____ |
| 34. Have you ever fainted more than twice before? | ____ | ____ |
| 35. Do you feel numbness in any part of your body? | ____ | ____ |
| 36. Have you ever had peritemal epilepsy? | ____ | ____ |
| 37. Do you often talk in your sleep? | ____ | ____ |

Common Diseases

| | | |
|---|---|---|
| 38. Have you ever had any serious injury? | ____ | ____ |
| 39. Have you ever had a major operation at least twice before? | ____ | ____ |
| 40. Do you often have injuries caused by accidents? | ____ | ____ |

Dispositions and Emotions

| | | |
|---|---|---|
| 41. Do you have difficulties in sleeping? | ____ | ____ |
| 42. Is it difficult for you to find time to rest? | ____ | ____ |
| 43. Do you smoke more than 15 of cigarettes per day? | ____ | ____ |
| 44. Do you drink more than 2 glasses of liquor daily? | ____ | ____ |
| 45. Do you often feel unhappy or sad? | ____ | ____ |
| 46. Do you often cry? | ____ | ____ |
| 47. Do you feel despondent? | ____ | ____ |
| 48. Do you often wish to die to escape problems in life? | ____ | ____ |
| 49. Does worrying make you depressed? | ____ | ____ |
| 50. Does any member of your family over-worry? | ____ | ____ |
| 51. Are you often conscious of yourself? | ____ | ____ |
| 52. Do you often tremble because of being scared? | ____ | ____ |
| 53. Have you had nightmares that woke you up at night? | ____ | ____ |
| 54. Do you often imagine frightening stories? | ____ | ____ |
| 55. Are you often scared without any reason? | ____ | ____ |
| 56. Have you ever tried narcotic drugs? | ____ | ____ |

# APPENDIX B

# Profile of Traders and Wholesalers of Scavenged Refuse Materials

**Profile of Respondents (Traders/Wholesalers) in Manila, Philippines**

| Name | Age | Sex | Maritual status | Educational attainment | Place of origin | Working place | Total size of family | Tenure of house | No. of working hours per day | No. of working days | No. of years in business | Approx. monthly income (Peso) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mrs. Mercedita Atillano | 46 | F | Married | Elementary | Leyte | Tondo | 8 | owned | 12 | 7 | 24 | 5,500 |
| Mrs. Carmen Palad | 51 | F | Married | Elementary | Bulacan | Tondo | 12 | owned | 8 | 6 | 25 | 4,800 |
| Mr. Jun Saguy | 33 | M | Married | High School | Pampanga | Moriones | 5 | owned | 12 | 6 | 6 | 6,500 |
| Mrs. Maria Cao | 67 | F | Married | High School | Pampanga | Moriones | 4 | owned | 10 | 6 | 30 | 10,000 |
| Mr. Ernesto Baes | 49 | M | Married | High School | Sorsogon | Paco | 8 | owned | 10 | 7 | 2 | 5,800 |
| Mr. Joe Labadi | 32 | M | Married | High School | Bulacan | Paco | 6 | rented | 8 | 7 | 5 | 6,700 |
| Mr. Danny Maggay | 31 | M | Married | High School | Manila | Sampaloc | 5 | rented | 10 | 6 | 4 | 7,500 |
| Mr. Lino Ching | 47 | M | Married | 2nd Year college | Aklan | Sta.Cruz | 6 | rented | 10 | 6 | 5 | 4,500 |

Profile of Respondents (Traders/Wholesalers) in Jakarta, Indonesia

| Name | Age | Marital status | Educational level | Place of origin | Working place | Total size of family | Tenure of hour | Working hours per day | Working days | No. of years in business | Monthly increase (Rp.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mr. Syamsuddin | 36 | Married | High School | Sukabumi | Ancol | 4 | owned | 10 | 6 | 1 | 600,000 |
| Mrs. Wati | 40 | Married | Primary School | Semarang | Ancol | 6 | owned | 8 | 7 | 1.5 | 120,000 |
| Mr. Tjasma | 20 | Married | Primary School | Cirebon | Ancol | 2 | owned | 7 | 7 | 1.5 | 120,000 |
| Mr. Mat Sarin | 25 | Married | Primary School | Cilincing* | Ancol | 2 | owned | 12 | 6 | 6 | 180,000 |
| Mrs. Santauli S. | 28 | Married | Secondary School | Medan | Cakung-Cilincing | 3 | rented | 10 | 6 | 2 | 600,000 |
| Mr. Nungkat Purba | 28 | Married | High School | Medan | Cakung-Cilincing | 2 | rented | 10 | 6 | 2 | 600,000 |
| Mr. Budi | 23 | Single | High School | Solo | Cakung-Cilincing | 2 | Colony | 10 | 7 | 2 | 360,000 |
| Mr. Misnik | 22 | Married | Primary School | Kerawang | Cakung-Cilincing | 3 | Colony | 8 | 7 | 8 | 180,000 |
| Mr. Udin | 55 | Married | High School | Bandung | Cakung-Cilincing | 5 | owned | 9 | 7 | 6 | 375,000 |
| Mrs. Nursih | 40 | Married | Primary School | Bogor | Kapuk | 7 | rented | 8 | 7 | 2 | 150,000 |
| Mrs. Salam | 35 | Married | Primary School | Madura | Kapuk | 5 | owned | 7 | 6 | 3 | 200,000 |
| Mrs. Maisaroh | 42 | Married | Primary School | Bogor | Manggarai* | 6 | rented | 5 | 7 | 2 | 150,000 |
| Mr. Burhanuddin | 41 | Married | Secondary School | Manggarai* | Manggarai* | 4 | owned | 8 | 6 | 6 | 150,000 |
| Mr. Achmad | 41 | Married | Secondary School | Manggarai* | Manggarai* | 5 | owned | 8 | 7 | 10 | 300,000 |
| Mr. Gatot | 30 | Married | Secondary School | Surabaya | Manggarai* | 3 | rented | 8 | 6 | 1 | 120,000 |

* Sub-district in Jakarta
US$1.00 = Rp. 1,000

**Profile of Respondents (Traders/Wholesalers) in Bangkok, Thailand**

| Name | Age | Marital status | Educational level | Place of original | Working place | Total size of family | Tenure of house | Working hours per day | Working day | No. of years in business | Monthly total income (Baht) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mr. Tum | 51 | Married | P.4 | Minburi | Nong-Kham | 4 | owned | 8 | 5 | 3 | > 5,000 |
| Mrs. Pranee | 50 | Married | P.4 | Bangrak* | Nong-Kham | 6 | owned | 6 | 5 | 10 | 5,000 |
| Mr. Somsak | 40 | Married | - | Yannava* | Nong-Kham | 5 | owned | 14 | 7 | 10 | 10,000 |
| Mr. Songkit | 40 | Married | - | Pomprab* | Nong-Kham | 7 | rented | 11 | 6 | 7 | 6,000 |
| Mrs. Supap | 20 | Married | MS.1 | Bangkok | Dindang | 6 | rented | 10 | 7 | 4 | 5,000 |
| Mrs. Prathung | 46 | Married | - | Bangkok | Ram-Intra | 3 | rented | 11 | 7 | 3 | 4,000 |
| Mrs. Rabiab | 31 | Married | P.4 | Pethbury | Ram-Intra | 7 | rented | 11 | 7 | 7 | 10,000 |
| Mr. Sangpun | 51 | Married | P.4 | Nakornsawan | Ram-Intra | 5 | rented | 9 | 7 | 4 | 7,000 |

NOTE:

P.4 = Pratom 4 = elementary school (4 year in school)
MS 1 = 8 years in school
* = district in Bangkok

# APPENDIX C-1

# Case Studies on Refuse Paper Manufacturing

**Case Study 1**

Mahachai Paper Production Company

| | |
|---|---|
| Location | Samut Sakorn province, Thailand |
| Type of Factory | Small scale<br>Main factory<br>Located in government industrial area |
| Product | Joss paper or Chinese paper as called by the users, for use in various Chinese festivals, low quality paper. |
| Raw Material | Waste paper<br>Alum<br>NaOH<br>Turpentine<br>Dye |
| Capacity | 200 Tonne per month of waste paper utilized.<br>200 Tonne per month of finished product. |

Cost of production

| | | |
|---|---|---|
| Cost of waste paper | 500,000 | Baht/month |
| Cost of other raw material | 20,000 | " |
| Cost of labor | 150,000 | " |
| Cost of maintenance & Others | 150,000 | " |
| Cost of energy consumption | 70,000 | " |
| Total | 1,070,000 | " |

Therefore the approximate cost of recovery = 5,350 Baht/Tonne
Approximate value of fresh product (as reported) = 8,000 "

The benefit/cost ratio = 8,000/5,350 = 1.49

This factory uses only waste paper in paper production. The product is low quality paper. However, it meets the needs of a particular market segment.

Manufacturing process

The waste paper is suspended with a large volume of water in a mixer (hydra pulper), then ground by a grinding machine, and stored in a storage tank. The ground pulp is transferred to an other tank and mixed with alum, dye and other chemicals. After this step the pulp is ready to be graded on a conveyer belt. The water is drained by pressing through drums. The semi-wet pulp then passes through dryers which use steam from a boiler. The dried paper is then rolled, cut and sent to the market.

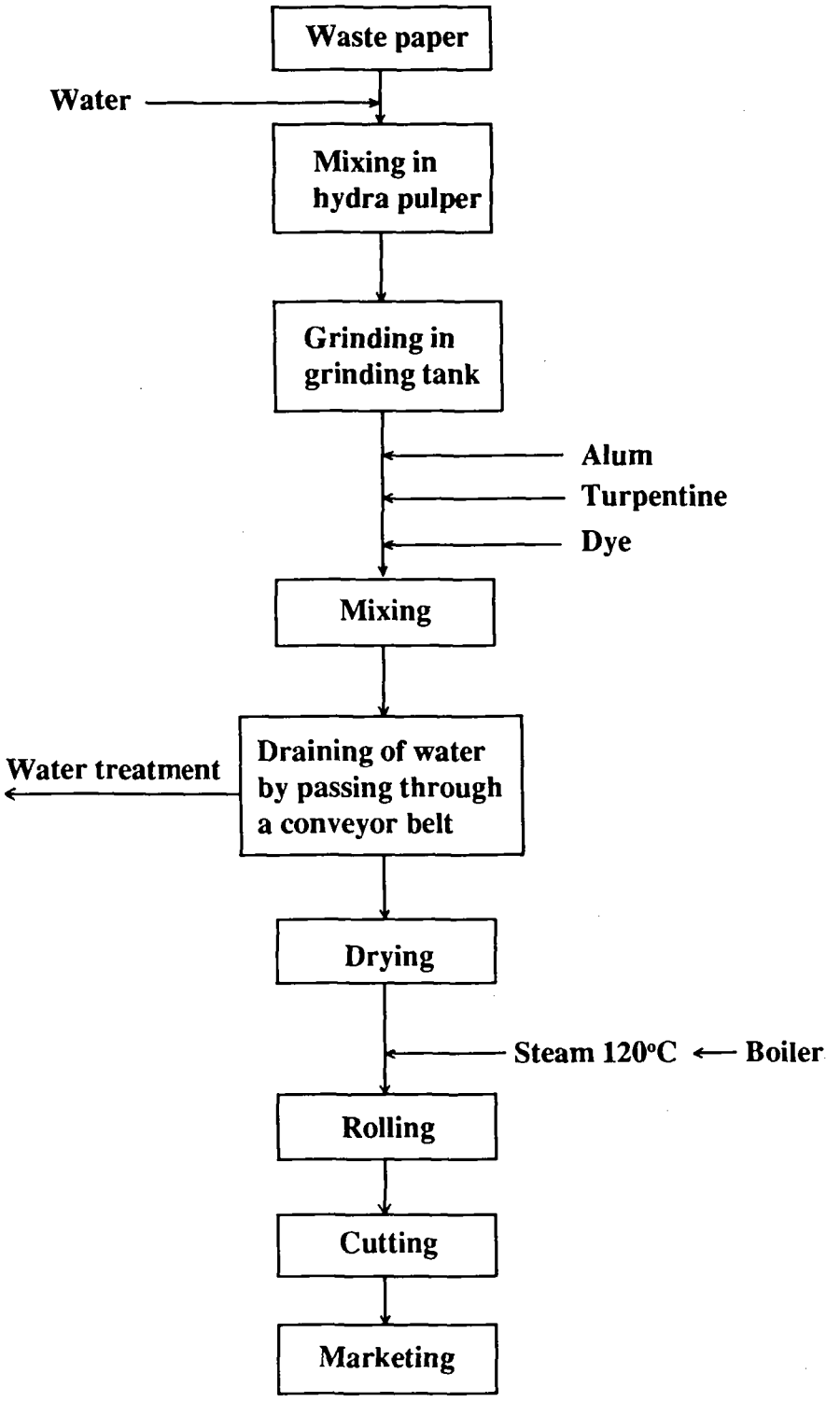



Fig. C1.1 The flow chart of the paper processing at Mahachai Paper Production Company.

**Case Study 2**
**Mai Num Paper Mill Co. Ltd.**

| | |
|---|---|
| Location | Samut Prakarn province |
| Type of Factory | Main factory<br>Middle scale<br>Three shift operation<br>Located in government industrial area |
| Area 10 Rai (1 Rai = 0.0016 $Km^2$) | |
| Engineer | 2 |
| Office Staff | 12 |
| Labour | 170 |
| Raw Material | Virgin pulp/wood pulp (12,000 Baht/Tonne)<br>Waste paper (writing and printing paper)<br>(4,000 Baht/Tonne)<br>Chemical |
| Capacity | Wood paper 70 T/m<br>Waste paper 400 T/m |
| Production | Toilet tissue grade A. 1,000 Cartons/day<br>" " B. 20,000 "<br>" " C. 2,000 " |

Note: Toilet tissue grade A. is the highest quality tissue paper.

| | | |
|---|---|---|
| Therefore, overall production | = 23,000 | Cartons/day |
| Cost of production | | |
| Raw material | | |
| - Wood pulp | = 840,000 | Baht/month |
| - Waste paper | = 1,600,000 | " |
| Subtotal | = 2,440,000 | " |
| Other raw materials and miscellaneous | | |
| - Other raw material and miscellaneous | = 400,000 | " |
| - Labor cost | = 400,000 | " |
| - Energy consumption | = 800,000 | " |
| - Overheads | = 40,000 | " |
| Subtotal | = 1,640,000 | " |
| Therefore, total production cost | = 4,080,000 | " |

Value of finished product

| | | | |
|---|---|---|---|
| Total paper grade A. | = | 500 | Baht/carton |
| " " B. | = | 380 | " |
| " " C. | = | 300 | " |
| Therefore total value of fresh product | = | 8,700,000 | Baht/month |
| Benefit/cost ratio | = | 2.132 | |

The benefit/cost ratio of various options of raw material (100% virgin pulp, 100% waste paper and combined virgin pulp and waste paper) are calculated. The calculation is based on the following assumptions.

1. The production capacity in each option is assumed to be the same.
2. The other expenditures are assumed the same.
3. Using virgin material will produce tissue grade A.
4. Using waste paper will produce tissue grade C.
5. Using virgin pulp and waste paper in combination will produce tissue grade A, B, C.

Table C1.1 shows the result of the calculation.

Table C1.1 Estimated cost/benefit value of paper production by using various raw materials. (Thousand Baht/month)

| Raw material | Cost of raw material | Other expenditure | Total cost of production | Value of finished product | Benefit /cost ratio |
|---|---|---|---|---|---|
| 100% wood pulp | 5,640 | 1,642 | 7,280 | 11,500 | 1.57 |
| 17.5% wood pulp 82.5% waste paper | 2,440 | 1,642 | 4,080 | 87,000 | 2.13 |
| 100% waste paper | 1,880 | 1,642 | 3,520 | 6,900 | 1.96 |

The benefit/cost ratio indicated that the most economical way for the paper production at Mai Num Paper Mill was the use of the combination of wood pulp and waste paper. Although the ratio of the paper production from 100% waste paper is more than 100% wood pulp, the price is low for the low quality toilet tissue. Use of wood pulp as the only raw material in the manufacture would mean a very high expense for raw material.

Step 1. Waste paper (1/3 tonne) and NaOH are mixed with water in a globe digester (10 tonne capacity) at 100°C and 2 kg/sq cm pressure, for 2-4 hours.

Step 2. The suspension is transported to the hydropulper to reject the other waste and then passed to an agitator (1) and then to the stock pit to stock the pulp.

Step 3. Foreign matters are filtered by a screening process consisting of a 3F screen, FN screen and a Johnson screen. The pulp suspension from the FN screen is filtered again at the Valveless filter (or Super filter). Waste water is drained out.

Step 4. From the super filter, the pulp is sent to the Extracter (1) to remove NaOH. The NaOH solution is recycled for use in the first step. The pulp is then sent to the agitator (4).

Step 5. Tank Nos. (2) and (3) receive the pulp from the agitator (4) for bleaching by using OCl from the hydrochloride stock tank. After the bleaching process, chlorine is extracted out by extractor (2).

Step 6. Tank Nos. (5) and (6) are used for mixing dye with the pulp. After dyeing, it is sent to the refiner to improve the pulp quality and then stocked in the agitator (7) and (8). The concentration of the pulp is controlled by the stuff box. The pulp from the stuff box flows to the riffle box. The purpose of the riffle box is to help circulation of the pulp and separate the pulp to the vertical screen which is used to adjust the pulp size. The pulp from the vertical screen is passed through the flat screen to the centri-cleaner tank which is the resting tank. From the centri-cleaner tank the pulp is pumped to the super clone for the first and second cleaner stages. The pulp from this step is sent to the head box. Here the level of the pulp is controlled. The pulp is now ready to be used in the next step. The Uramine (PFO) is put to strengthen the pulp before going to the next step.

Step 7. The water is drained by passing the wet pulp through the set of cylinders (drums) and is dried by passing through the Yankee dryer.

Step 8. The dried paper is rolled and ready for sale.

**Case Study 3**
**East Industrial Co. Ltd.**

| | | | |
|---|---|---|---|
| Type of Factory | Main factory<br>Middle scale<br>Located in the suburb of Bangkok<br>3 shifts operation | | |
| Engineer | 2 | | |
| Staff & labour | 240 | | |
| Products | Printing and writing paper<br>Wrapping paper<br>Card board<br>Blotting paper | | |
| Raw Material | Wood pulp (10,000 Baht/Tonne)<br>Waste paper (3,500 Baht/Tonne)<br>Alum, turpentine, other chemicals | | |
| Capacity | Wood pulp 600 Tonnes/month<br>Waste paper 1,200 " | | |
| Production | Printing and writing paper | 600 | Tonnes/month |
| | Wrapping paper | 150 | " |
| | Blotting paper | 150 | " |
| | Card paper | 900 | " |
| Cost of Production | | | |
| Raw material | | | |
| Waste paper | = | 4,200,000 | Baht/month |
| Wood pulp | = | 6,000,000 | " |
| Subtotal | = | 10,200,000 | " |
| Other expenditures | | | |
| Other raw material | = | 450,000 | " |
| Labour cost | = | 1,450,000 | " |
| Energy cost | = | 1,900,000 | " |
| Overheads | = | 670,000 | " |
| Subtotal | = | 4,470,000 | " |
| Therefore, total expenditures | = | 14,670,000 | " |
| Value of finished product | | | |
| Printing and writing paper (17,000 B//Ton) | = | 10,200,000 | B//month |
| Wrapping paper (9,000 B//Ton) | = | 1,500,000 | " |
| Blotting paper (10,000 B//Ton) | = | 1,350,000 | " |
| Card paper (7,000 B//Ton) | = | 4,200,000 | " |
| Total value of finished product | = | 17,250,000 | " |
| Benefit/cost ratio | = | 1.175 | |

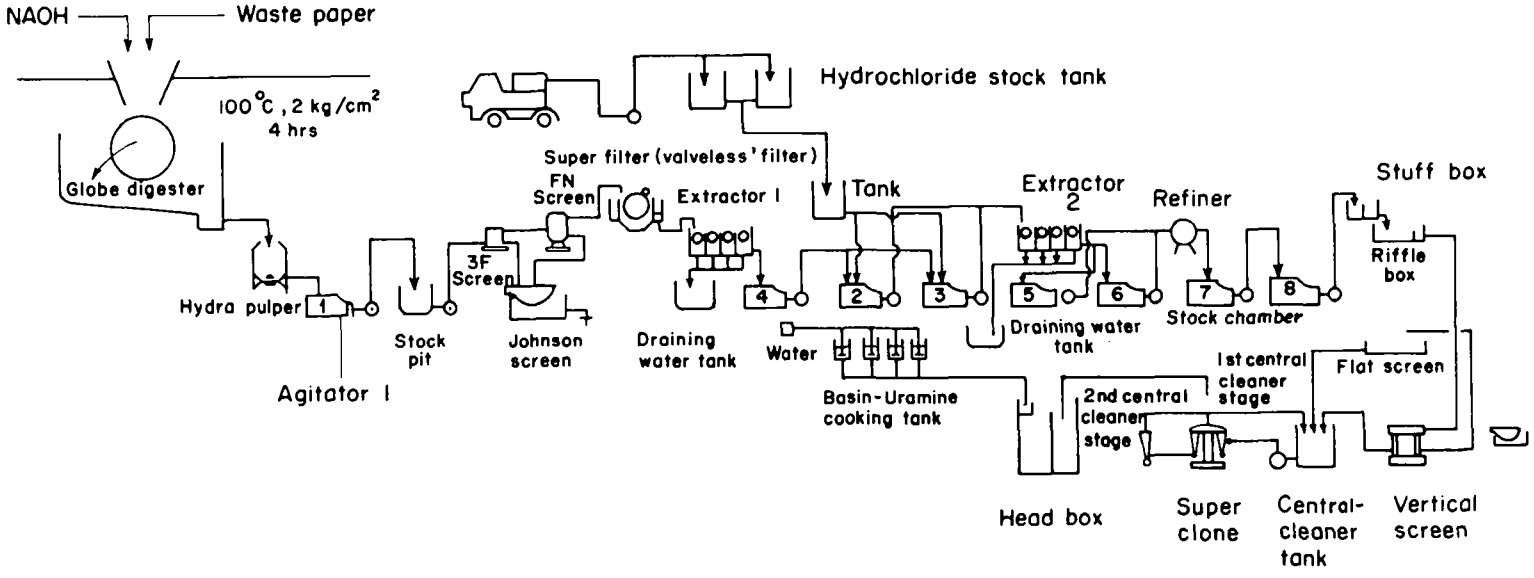



Fig. C1.2 Diagram of the Mai Num paper mill manufacturing process

Table C1.2 shows the estimated benefit/cost ratio of paper making from 100% wood pulp and 100% waste paper. The calculation is based on the following assumptions.

1. The production capacity in each option is assumed to be the same.
2. The other expenditures are assumed the same.
3. Using 100% wood pulp will produce printing and writing paper.
4. Using 100% waste paper will produce wrapping, blotting and card paper.

Table C1.2 The estimated benefit/cost value of paper production at East Industrial Co. Ltd. (thousand baht per month).

| Raw material | Cost of raw material | Other expenditure | Total cost of production | Value of finished product | Benefit /cost ratio |
|---|---|---|---|---|---|
| 100% wood pulp | 18,000 | 4,470 | 22,470 | 30,600 | 1.135 |
| 100% waste paper | 6,300 | 4,470 | 10,770 | 16,200 | 1.488 |

At present the East Industrial Company produces 600 Tonnes/month of printing and writing paper from wood pulp and 1,200 Tonnes/month of wrapping, blotting and card paper from waste paper.

Manufacturing Process

The paper making process at East Paper Industrial Co. Ltd. is the same as the common paper industry. The process flow diagram is shown in Fig. C1.3.

The waste paper is suspended with a large volume of water in the mixer and then pumped to the cyclone to reject the heavy matters. The ground pulp flows through a long channel. As it flows along the channel the sand settles and is rejected. The pulp is then passed through the screen to the concentration tank. The water is drained to concentrate the pulp. The concentrated pulp is then ground again and sent to be mixed with chemicals in the next agitator tank. The mixed pulp is then pumped to a stock tank which controls the level of the pulp. The pulp from the stock tank is ground again and flows to the cyclone cascade to reject the unwanted material such as metals and clips. The finished pulp then flows through the flow box to the dryer.

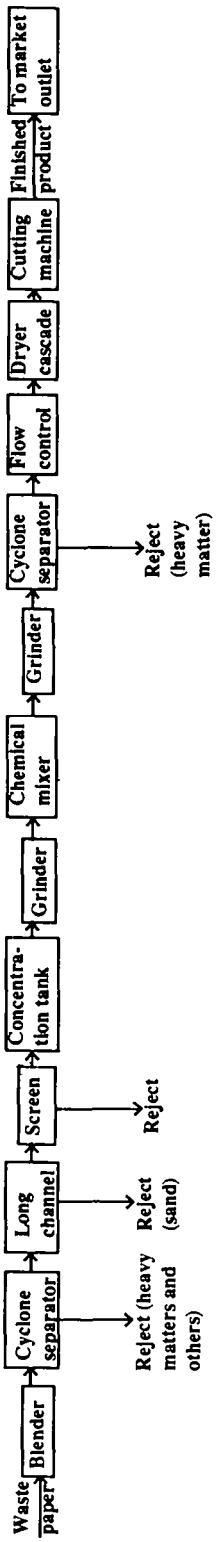



Fig. C1.3 Flow chart of paper recycling process at East Industry Factory

# APPENDIX C-2

# Case Studies on Recycling of Glass Cullet

**Case Study 4**

**Thai Glass Industry Co. Ltd.**

| | | | | |
|---|---|---|---|---|
| Location | | Raj Burana District, Bangkok | | |
| Type of Factory | | Main factory<br>Large scale<br>3 shifts operation | | |
| Area | | 30 rai | | |
| Engineer & Scientist | | 14 | | |
| Staff | | 60 | | |
| Labour | | 992 | | |
| Product | | Glass & bottle<br>Table ware | | |
| Raw material | Soda ash | 1,700 Tonnes/month | (4,300 Baht/Tonne) | |
| | Sand | 5,500 " | ( 320 " ) | |
| | $CaCo_3$ | 1,500 " | ( 250 " ) | |
| | Waste glass | 3,150 " | (1,200 " ) | |
| | Alumina | 200 " | (1,900 " ) | |
| | Other material | 100 " | (9,000 " ) | |

| | | |
|---|---|---|
| Cost of production | | |
| Raw material | | |
| Virgin raw material | = 10,720,000 | Baht/month |
| Cullet | = 3,780,000 | " |
| Subtotal | = 14,500,000 | " |
| Other expenditures | | |
| Energy consumption | = 19,000,000 | " |
| Labour cost | = 9,230,000 | " |
| Utilities | = 3,300,000 | " |
| Overheads | = 1,320,000 | " |
| Others | = 18,500,000 | " |
| Subtotal | = 51,350,000 | " |
| Therefore, total cost of production | = 65,850,000 | " |
| Production capacity : glass, bottle | 13,500 Tonnes/month | |
| Value of finished product | = 8,000 | Baht/Tonne |
| Therefore, the total value of the finished product | = 108,000,000 | Baht/month |
| Benefit/cost ratio of the East Industry Co. | = 1.64 | |

Table C2.1 shows the estimated benefit/cost ratio of the glass production by using different raw materials (with and without cullet) at Thai Glass Industry. The calculation is based on the following assumptions.

1. Production capacity is assumed to be the same.
2. Other expenditures are assumed the same except energy consumption which is raised by 0.29% per percent of cullet increase for the process that use only virgin raw material (Fig. C2.1).
3. The value of the finished product from both options is assumed to be the same. (Note: It is possible to run the process with 100% cullet. Mixing the proper ratio of cullet and virgin raw material will produce a product of almost the same quality as is produced from 100% virgin material).

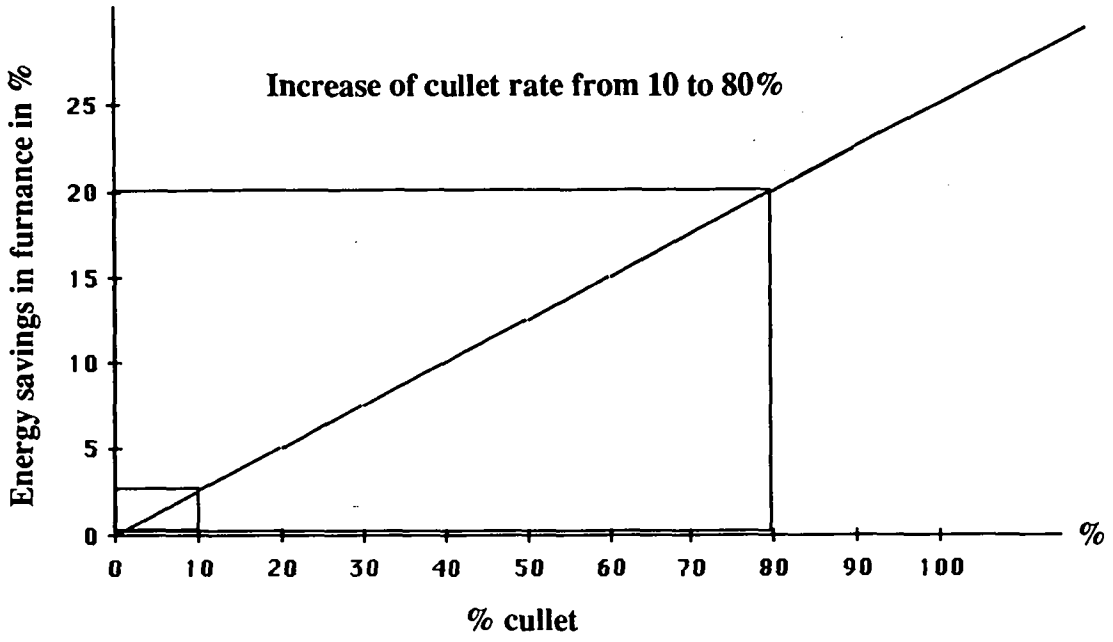



Fig. C2.1 Energy saving in furnance by increasing percentage of cullet

Table C2.1 The estimated benefit/cost value of glass production at Thai Glass Factory

| Raw material | Cost of raw material | Other expenditure | Total cost of production | Value of finished product | Benefit /cost ratio |
|---|---|---|---|---|---|
| Virgin raw material | 16,087,500 | 51,350,000 +3,722,875 | 71,160,375 | 108,000,000 | 1.50 |
| 75% raw material + 25% cullet | 14,505,000 | 51,350,000 | 65,850,000 | 108,000,000 | 1.64 |

The benefit/cost ratio of the two options are almost the same. The manufacturer is operating with the second option because of higher benefit/cost ratio. Mixing the cullet with raw material needs a lower melting temperature which reduces the cost of maintenance. Another important reason is the availability of cullet in the country. The rejected product can also be recycled in the factory.

Manufacturing process

The raw materials used in the Thai Glass factory are:

| | |
|---|---|
| Silica | 72% $SiO_2$ |
| Soda ash ($Na_2CO_3$) | 14% $Na_2O$ |
| Limestone ($CaCO_3$) | 11% CaO |

The cullet is mixed with virgin raw material in the ratio of 25-50% cullet and 75-50% raw material. The amount of the cullet used depends on the color and the quality of the glass product. Flint color in glass needs around 25% cullet. For the amber and green color of glass, the raw material can be mixed with more percentage of cullet.

The factory engineer reported that at present there are 4 furnances, three of which are in operation.

| Type of furnance | Full capacity | Operation capacity |
|---|---|---|
| T 1 | inoperative | |
| T 2 | 80 Tonne/day | 75 Tonne/day |
| T 3 | 155 " | 148 " |
| T 4 | 240 " | 195 " |

Process: There are 3 processes involved in glass production and they are:

1. Blow-blow process for the narrow neck bottle.
2. Press-blow process for wide mouth container.
3. The Press machine for glass production.

The process starts with the blending of raw material. The batch then goes to the mixer glass furnance. The temperature in the furnance depends on the job, but is actually in the range 1,000°-1,500°C. The furnance is operated for 3 to 5 years before repair. After the batch is melted, the glass flows into a feeder. There are two sections in the feeder, the cooling section or rear section to lower the temperature and the equivalizer to make the uniform glass. The glass that flows to the spout of the feeder and cut is called "gob". The gob is dropped to the mold and blown by air for 2-3 seconds. The finished product is then passed through the oven by the conveyor to reduce the temperature. After checking the quality, the product is ready for marketing.

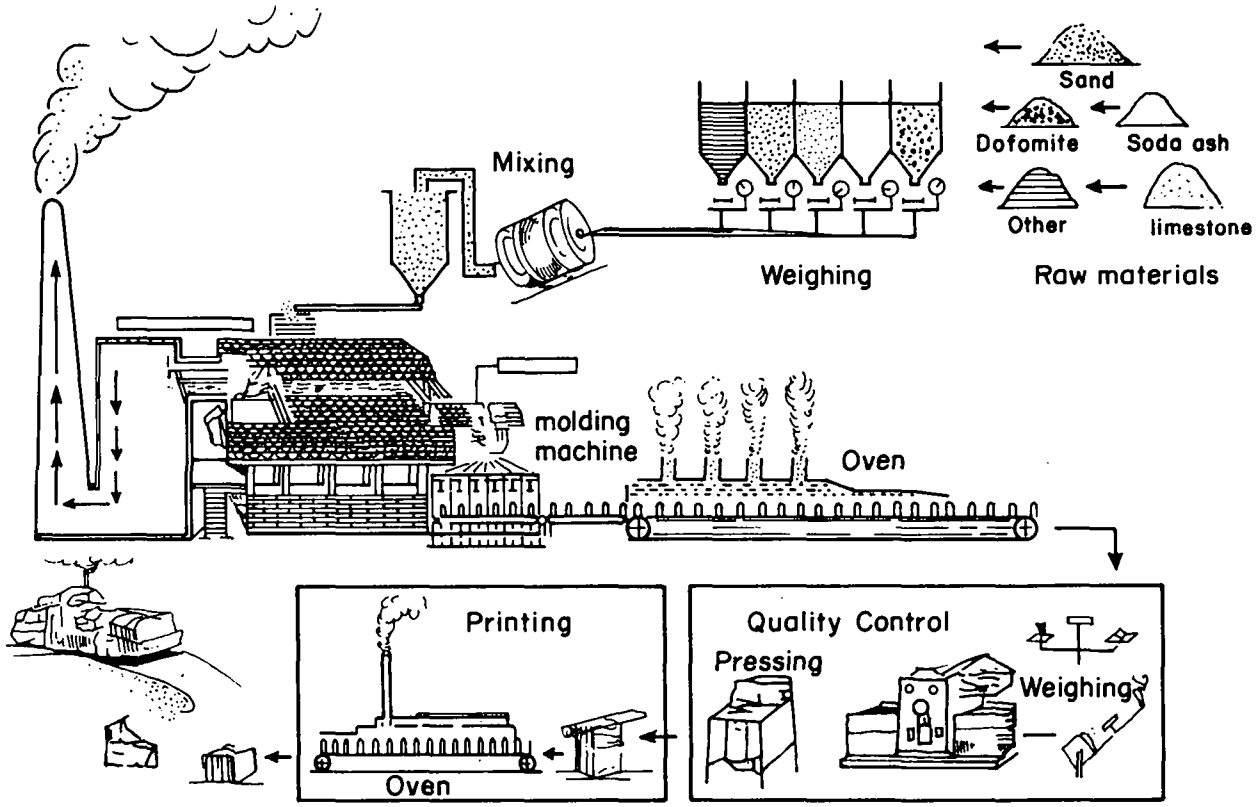



Fig. C2.2 Glass production process at the Thai Glass Industry

**Case Study 5**

**Glass Organization**

| | | | |
|---|---|---|---|
| Location | Bang-na, Bangkok | | |
| Type of factory | Main factory<br>Large scale<br>3 shifts operation | | |
| Area 36 rai | | | |
| Engineer | 5 | | |
| Staff | 302 | | |
| Labour | 903 | | |
| Product | Bottle, table ware, glass | | |
| Raw material | Silica sand | 3,400 | Tonnes/month |
| | Crushed limestone | 900 | " |
| | Fluorspar ($CaF_2$) | 27 | " |
| | Cullet | 1,800 | " |
| | Soda ash dense | 1,200 | " |
| | Arsenic trioxide | 3 | " |

Capacity of production glass 300 Tonnes/day

| | | | |
|---|---|---|---|
| Cost of production | | | |
| Raw material | | | |
| Virgin raw material | = | 5,884,150 | Baht/month |
| Cullet | = | 2,160,000 | " |
| Subtotal | = | 8,044,150 | " |
| Other expenditures | | | |
| Energy | = | 19 | Million Baht/month |
| Labour | = | 7.3 | " |
| Utilities | = | 1 | " |
| Depreciation | = | 1.7 | " |
| Others | = | 1 | " |
| Subtotal | = | 30 | " |
| Total cost of production | = | 38,044,150 | Baht/month |
| Value of finished product | = | 8,000 | Baht/Tonne |
| Capacity of production | = | 750 | Tonnes/month |
| Therefore, value of finished product | = | 60 | million Baht/month |
| Benefit/cost ratio | = | 1.577 | |

Table C2.2 shows the estimated benefit/cost ratio of the glass production at the Glass Organisation. The assumptions are the same as used in the calculation of the benefit/cost ratio at the Thai Glass Industry.

Table C2.2 The estimated benefit/cost value of glass production at the The Glass Organization.

| Raw material | Cost of raw material | Other expenditure | Total cost of production | Value of finished product | Benefit /cost ratio |
|---|---|---|---|---|---|
| Virgin raw material | 8,074,120 | 33,722,875 | 41,796,995 | 60,000,000 | 1.43 |
| 76% raw material 24% cullet | 8,044,150 | 30,000,000 | 38,044,150 | 60,000,000 | 1.58 |

As with Thai Glass Factory, the manufacturer uses a combination of cullet and virgin raw materials. The reasons are the same as reported before.

Manufacturing process

Raw materials used for manufacturing are:

| | |
|---|---|
| Soda ash | 20% |
| Silica | 63% |
| Limestone | 15% |
| Sodium nitrate | |
| Calcium fluoride | |
| Silinium | 2% |
| Cobalt | |
| Arsenic | |
| Cullet | 24-40% of total raw material |

The limestone powder is mixed with sodium cabonate and sand. The cullet is mixed at this step to lower the melting temperature. The batch is then sent to the furnace. The temperature in the furnance is around 1460°C. The batch becomes clear melted glass at the end of the furnace and then flows to the feeder. Here the temperature is reduced to 1200°C. The glass is sticky enough to be blown. The "gob" from the orifice of the feeder flows to the mold and is blown by air. The finished product is cooled by passing through the oven. After checking the quality, the product is ready for sale.

The plant has a small branch for producing gentle glass and stem glass by "Handy craft system". The batch is melted in the furnace. The blow pipe is dip into the melted glass to form a small bulb and then put into the melted glass again. The weight of the glass is automatically known by the skilled men. The air is blown gently at the other end of the blowpipe causing a bubble of glass to form. The pipe is continuously rotated. To make a particular shape needs highly skilled workers. A small number of hand tools are used, including tongs, scissors, various shaping tools and two parallel rails or chair arms and a flat pad of fire clays. The blown glass is passed through the oven and then packed for sale.

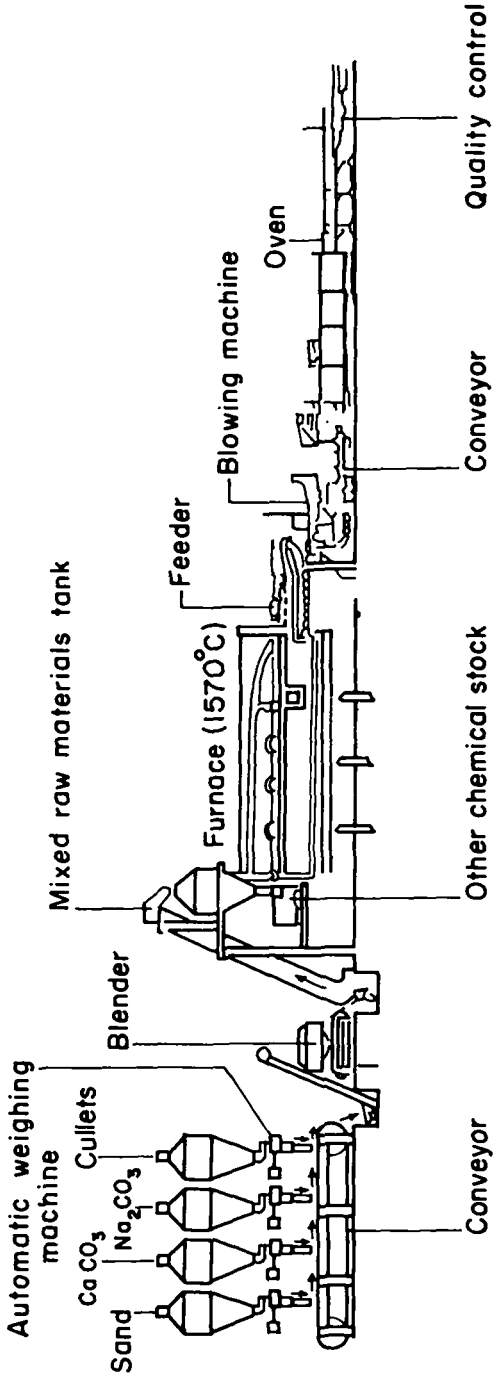



Fig. C2.3 Glass production process at the Glass Organization

# APPENDIX C-3

# Case Studies on Waste Plastics Recycling

**Case Study 6**

**Mahakhun Plastic Factory**

| | | | |
|---|---|---|---|
| Location | On-Nooch Landfill Site | | |
| Type of Factory | Main factory<br>Middle scale<br>3 shifts operation | | |
| Labour | 30 | | |
| Product | Pelletized Plastic | | |
| Raw Material | Waste plastic<br>- washed 1 Tonne/day (8.50 B//kg)<br>- unwashed 1.2 Tonne/day (2.50 B//kg) | | |
| Cost of production | | | |
| Raw material | = | 345,000 | |
| Baht/month | | | |
| Labor cost | = | 70,000 | " |
| Energy | = | 70,000 | " |
| Maintenance | = | 20,000 | " |
| Interest (to Bank) | = | 20,000 | " |
| Total | = | 525,000 | " |
| Production capacity | = | 2 | |
| Tonnes/day | | | |
| Value of finished product | = | 12.50 | Baht/kg |
| Therefore total value of finished product | = | 750,000 | |
| Baht/month | | | |
| Benefit/cost ratio | = | 1.43 | |

This factory is a small scale factory. Only pelletized plastic is produced from waste plastics.

Manufacturing Process

The manufacturer buys mixed types of plastics from various traders. Fig. C3.1 shows the flow diagram of the plastic recycling process at Mahakhun Plastic Factory.

1. Sorting and dry cleaning. The same color plastic film (PE & PP) is separated from the hard plastic or high density polyethylene. Large pieces of plastic waste must be cut into small pieces. Any metal is removed before passing to the next step.

2. Washing. The plastic film is washed until it is clean otherwise the product will have a very dark color. For hard plastic, it is not necessary for the water to be clean because this type of plastic is used for producing petrol containers. After washing, it is exposed to the sun and wind to dry.

3. Granulating. The washed plastic is chopped into tiny pieces in a machine called a "granulator", a drum with a knife at the bottom, consisting of strong mesh of the size of the material required. Only small pieces of material can fall through the mesh.

4. Drying. The drying operation is required to evaporate the moisture from the granulated plastic. The machine look like an oven, having a paddle at the bottom. The oven is warmed by steam through the wall.

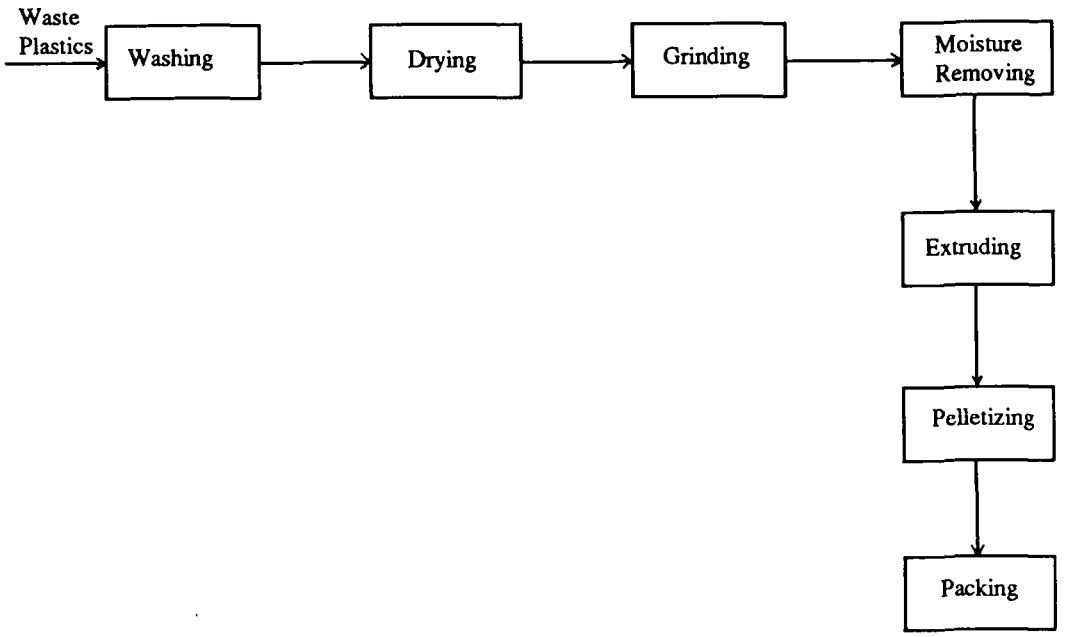



Fig. C3.1 Plastic Recycling Process at Mahakhun Plastic Factory

5. Pelletizing. An extruder with a die, a water bath and a chopper are used.

Fig. C3.2 shows a diagram of the extruding and pelletizing process for plastic waste.

- A hopper to hold the material fed in.
- A banel, heated with electric elements.
- A slow-moving screen or sieve through which the plastic passe to remove grit etc.
- A die, a flat, thick, steel plate with shaped holes through which the molten plastic is forced, coming out of the other side like toothpaste from a tube. The die has a number of small holes, through which the plastic is extended out in a bunch of long strips. These strips pass through a water bath and are cooled to become solid.
- A pelletizer which is a sharp, edged, multi-bladed rotating knife which chops the long strips of plastic into small pellets. The speed is set to match the speed of the feed rollers which match the speed of the extruder. The length of the pellet is about 4 mm.

With this step the pelletized plastic is ready for sale, and for use in the next step.

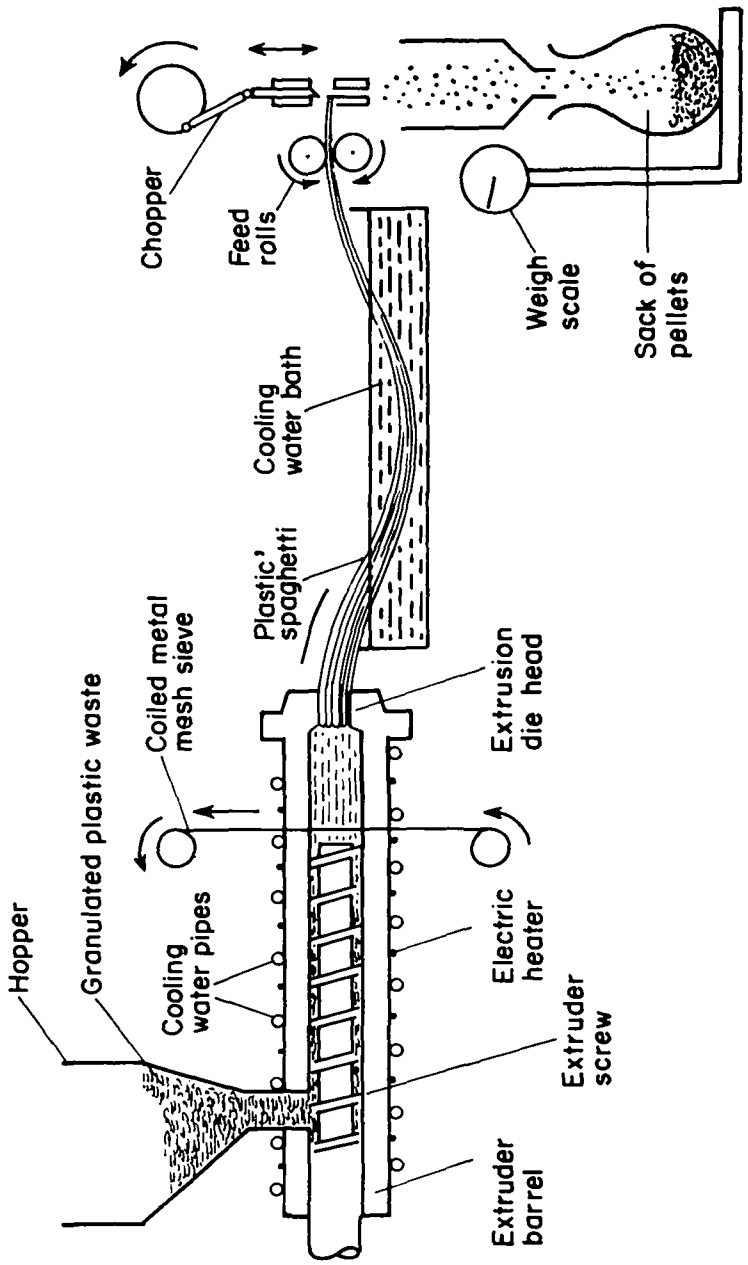



Fig. C3.2 Diagram of Process for Extruding and Pelletizing of Plastic Waste

**Case Study 7**

**Sang Charoen Plastic Factory**

| | | |
|---|---|---|
| Location | On-Nooch Landfill site | |
| Type of factory | Main factory<br>Middle scale<br>3 shifts operation | |
| Labor | 30 | |
| Raw material | Waste plastic | |
| | - unwashed (soft) | 1 Tonne/day (2.50 Baht/kg) |
| | - Hard plastic (poly propylene) | 850 kg/day (6 Baht/kg) |
| | - Pure pelletized plastic | 200 kg/day (31 Baht/kg) |
| Product | Pelletized Plastic | 700 kg/day |
| | Petrol container | 200 " |
| | Plastic bag | 600 " |

| | | | |
|---|---|---|---|
| Cost of production | | | |
| Raw material | | | |
| - Hard plastic waste | = | 153,000 | Baht/month |
| - Unwashed plastic waste | = | 120,000 | " |
| - Pure pelletized plastic | = | 186,000 | " |
| Subtotal | = | 459,000 | " |
| Other expenditures | | | |
| - Labor cost | = | 60,000 | " |
| - Energy | = | 122,500 | " |
| - Maintenance & others | = | 30,000 | " |
| Subtotal | = | 212,500 | " |
| Therefore, total cost of production | = | 671,500 | " |
| Value of finished product | | | |
| - Pelletized plastic | = | 13 | Baht/kg |
| - Petrol container (average) | = | 21 | " |
| - Plastic bag | = | 25 | " |
| Therefore, the total value of the finished product Baht/month | = | 849,000 | |
| Benefit/cost ratio | = | 1.26 | |

NOTE:

- All unwashed plastic waste is used to produce pelletized plastic.
- 100 kgs. unwashed plastic waste produce 70 kgs. product.
- Plastic bags are produced from pure pelletized plastic and hard plastic waste in the ratio of 1:2.

The estimated benefit/cost ratio of the plastic production using pure pelletized plastic only, waste plastic only and a combination are calculated as shown in Table C3.1. The calculation is based on the following assumptions.

1. Production capacity is assumed the same.
2. The pelletized plastic is produced from plastic waste only, no assumption for using pure pelletized plastic to produce pelletized plastic.
3. Value of finished product is assumed the same.

4. No raw material lost in the process if using pure pelletized plastic, but 30% lost if using waste plastic.
5. Use of 100% pure plastic pellet will reduce energy consumption by 30%.

Table C3.1 The estimated benefit/cost value of plastic production at Sang Rung plastic factory

| Raw material | Cost of raw material | Other expenditure | Total cost of production | Value of finished product | Benefit /cost ratio |
|---|---|---|---|---|---|
| Pure pelletized plastic | 864,000 | 175,750 | 1,045,750 | 849,000 | 0.81 |
| All waste plastic | 327,000 | 212,500 | 539,500 | 849,000 | 1.57 |
| Pure plastic and waste | 459,000 | 212,500 | 671,500 | 849,000 | 1.26 |

The manufacturer is operating using pure plastic and waste plastic in combination. Although, theoretically using waste plastic only gives more profit, the quality is very low and there is no acceptable market for it.

Manufacturing process

Fig. C3.2 shows the flow diagram of the plastic processing at Sang Rung Plastic Factory.

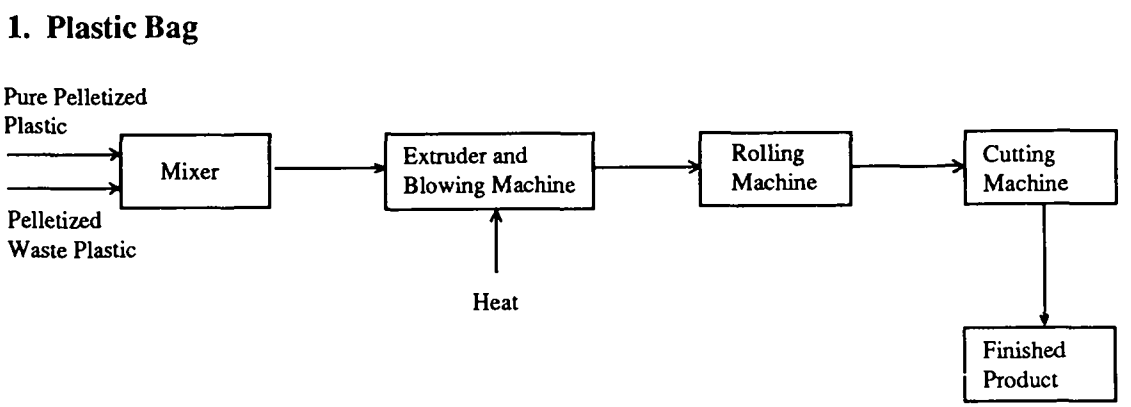



Fig. C3.2 Plastic recycling process at Sang Charoen Plastic Factory

# APPENDIX D

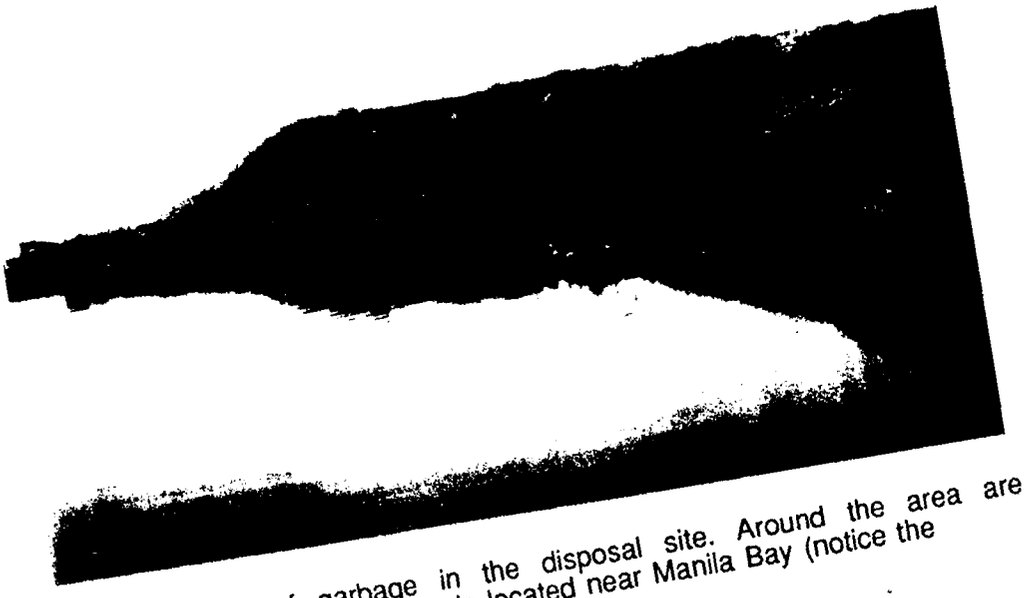
# Scavenging Sites in Manila, Jakarta and Bangkok

## MANILA, PHILIPPINES

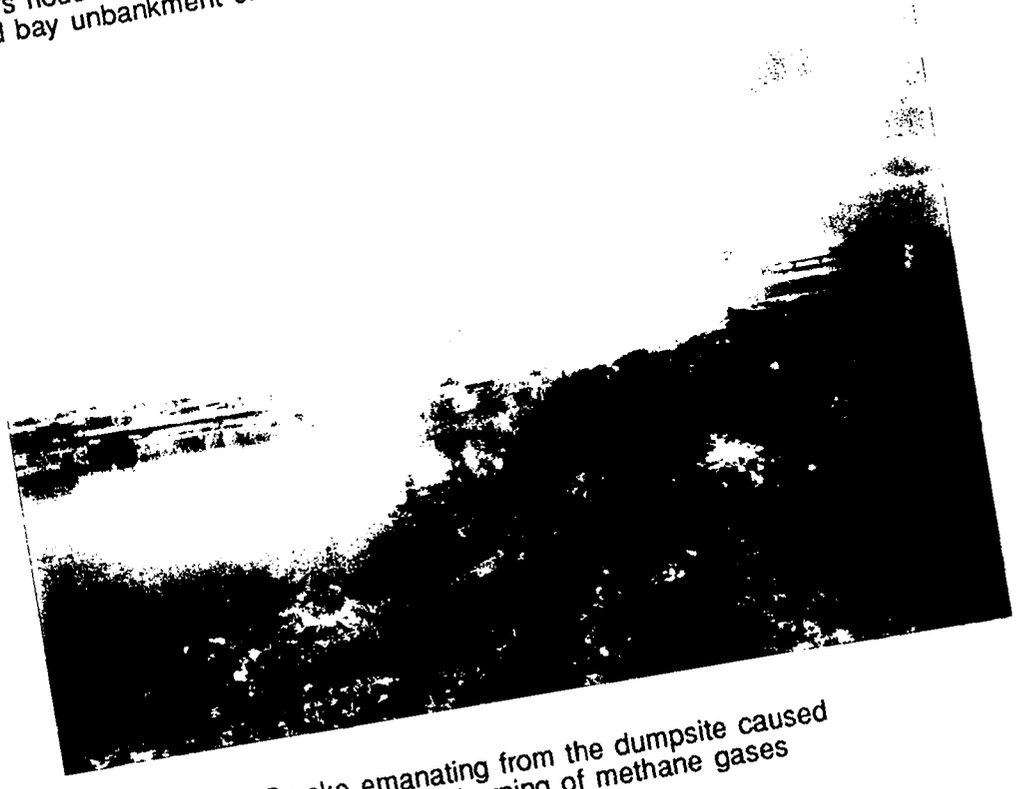
Children of dumpsite scavengers on play while waiting for their parents

Bundled wastepaper ready for delivery to manufactures shops from traders/middlemen

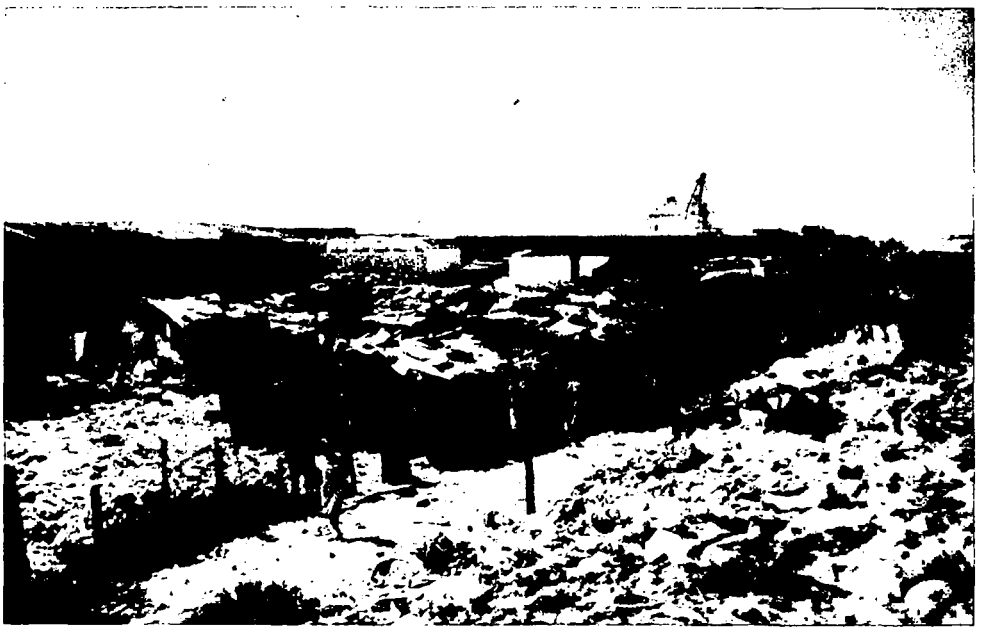
Garbage dumped in the streets



Mountainous heaps of garbage in the disposal site. Around the area are the scavengers houses. This dumpsite is located near Manila Bay (notice the unfinished bay unbankment on the right)

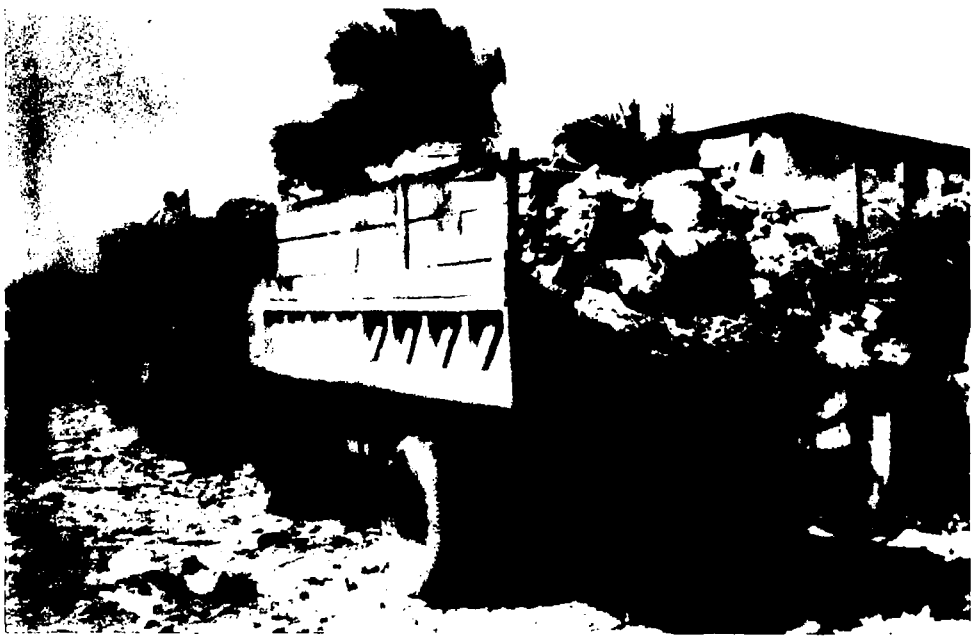


Smoke emanating from the dumpsite caused by natural burning of methane gases



Scavengers houses in the dumpsite

In the trader/middlemen's shop, salvaged refuse are sorted and weighted before selling/delivering to manufacturers



Double loader trucks on the way to
the dumpsite to tip off its contents

## JAKARTA, INDONESIA

Scavengers on the process of retrieving materials from tipped refuse. (Notice the big bamboo baskets on their back, which explains the prevalent of muscle pains of the back among scavengers.)

Scavenger's house in the dumpsite. Refuse materials are kept around the house before selling to traders and junkshops.

A garbage crew and his pushcart while collecting refuse from residential sources

Scavengers retrieving recyclables materials while garbage truck is tipped in the disposal site in Ancol, Jakarta

Traders loading the refuse materials to trucks after being bought from scavengers at the dumpsites

## BANGKOK, THAILAND

Machine for granulating and pelletizing waste plastics

A simple machine for drying washed plastics being run by electricity

Waste paper used as raw material for paper manufacturing

Washing of soft plastics after being bought from scavengers in the traders' warehouse

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