STUDY ON PLASTIC RECYCLING

IN PETALING JAYA

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ABSTRAK

Kitar semula adalah merupakan satu kaedah dalam pengurusan sisa untuk mengurangkanpenghasilan sisa pepejal. Biarpun terdapat beberapa bahan-bahan yang tidak boleh diguna semula atau dikitar semula, namun dalam tempoh dua dekad yang lalu,plastik adalah bahan yang sering dikitar semula. Kajian ini bertujuan untuk mengenalpasti jenis sisa pepejal perbandaran di Petaling Jaya (PJ), Malaysia. Di samping itu, objektif kajian juga adalah untuk mendapatkan peratusan tahap kesedaran di kalangan penduduk mengenai kitar semula plastik sekaligus untuk mengenalpasti masalah-masalah yang mempengaruhi pelaksanaan kitar semula plastik. Kajian soal selidik telah dibuat dan diedarkan kepada penduduk di kawasan kajian. Kaedah kajian ini adalah meliputi pengumpulan data daripada kajian lapangan iaitu; persampelan, pengasingan dan pengukuran berat basah sisa dan pengedaran soal selidik. Analisis data turut digunakan untuk mendapatkan pampasan sisa dan soal selidik dengan menggunakan 'Microsoft Excel' dan perisian software statistik (SPSS). Berdasarkan daripada kelompok sisa di PJ, jumlah 21% adalah terdiri daripada plastik, manakalasebanyak 42% adalah daripada komponen organik besar. Terdapat 67% daripada penduduk PJ yang memahami istilah kitar semula, namun daripada jumlah penduduk tersebut hanya 22% yang mengamalkan kitar semula. Sebanyak 60% daripada sisa plastik di PJ masih dilupuskan ke tapak pelupusan sampah. Hal ini menunjukkan bahawa penduduk masih tidak prihatin akan konsep 3Rs (kitar semula, guna semula, dan pengurangan). Antara faktor-faktor berlakunya masalah pembuangan plastik adalah disebabkan kemudahan yang tidak mencukupi dan kekurangan pendidikan mengenai kitar semula plastik. Di kawasan PJ, sebanyak 31% daripada responden menunjukkan rasa tidak puas hati terhadap penyediaan

tong kitar semula yang tidak mencukupi untuk pengasingan sisa plastik. Penduduk di PJ juga merasakan bahawa kurangnya pengetahuan terhadap kitar semula dan sikap tidak prihatin di kalangan penduduk adalah halangan utama untuk penduduk bekerjasama dalam pelaksanaan kitar semula plastik. Jumlah plastik yang diperolehi daripada kelompok sisa adalah tinggi. Kajian mendapati bahawa PJ merupakan kawasan yang paling bermasalah dan tidak efisien dalam pelaksanaan kitar semula plastik. Masalah-masalah tersebut berpunca daripada; kurang prihatin (39%), kurang pengetahuan (36%) dan tiada kemudahan kitar semula (31%). Oleh itu, penglibatan rakyat yang lebih progresif dalam isu kitar semula plastik dapat dicapai sekiranya pihak kerajaan dan pihak pengurusan sisa memainkan peranan penting dalam menyediakan infrastruktur asas yang mencukupi.

ABSTRACT

Recycling is an option in waste management that basically helps in the reduction of solid waste generation. While some materials cannot be reused or recycled, plastic is a material that has been more frequently recycled in the last two decades. This study was aimed at characterizing municipal solid waste (MSW) in Petaling Jaya (PJ), Malaysia. It also investigated the degree of residents' plastic recycling awareness in relation to identifying the problems affecting plastic recycling. An outlined questionnaire was designed and distributed to residents in the study area. The research includes data collection through field survey; sampling, segregation and wet weight measurement of the wastes and distribution of questionnaires. Analysis of data for waste compensation and questionnaires were carried out using Microsoft Excel and the Statistical Package for Social Sciences (SPSS) software. Plastic component was approximately 21% of the waste stream in PJ, though organic component formed the bulk portion (42%). Although about 67% of PJ residents knew the meaning of recycling, only 22% of the respondents practiced it. About 60% of plastic waste in PJ is still being disposed off into landfill. This finding indicated that residents are not aware of 3Rs (Recycling, Reuse, and Reduce). This might be attributed to lack of facilities and suitable training methods on plastic recycling. In PJ area, 31% of the respondents showed their dissatisfaction over insufficient recycling bins provided for plastic waste separation at source. The citizens from PJ felt that inadequate knowledge on recycling and ignorance are the major setbacks for citizens' non-cooperation over plastic recycling. The concentration of plastics obtained in the waste stream is high. However, the research identified a number of problems that hinder efficient recycling of plastic is PJ. Such problems ranged from lack of awareness (39%), level of literacy (36%)

to unavailability of recycling facilities (31%). For a more progressive citizens' involvement in plastic recycling in PJ, government and waste management authorities should play a key role in providing the basic infrastructures.

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ABBREVIATION

ABS	Acrylonitrile Butadienne Styrene
BHET	Bis-(2-Hydroxyethyl) Terephthalate
CPET	Crystal Polyethylene Terephthalate
DMT	Dimethyl Terphtalate
EG	Mono Ethylene Glycol
FW	Fresh weight
GPET	Glycol Polyethylene Terephthalate
HDPE	High Density Polyethylene
IGES	Institute for Global Environmental Strategies
LDPE	Low Density Polyethylene
MATRADE	Malaysia External Trade Development Corporation
MBPJ	Petaling Jaya City Council
MHLG	Ministry of Housing and Local Government
MOIM	Ministry of Industry and Mines
MPMA	Malaysian Plastics Manufactures Association
MRF	Materials Recovery Facilities
MSW	Municipal Solid Wastes
NAPCOR	National Association for Plastic Container Recovery
NGO	None-governmental organization
NIMBY	Not in My Back-yard
NPIC	National Petrochemical Industry Company

PC	Polycarbonate
PE	Polyethylene
PET	Polyethylene Terephthalate
PJ	Petaling Jaya
PJCC	Petaling Jaya Community Centre Recycling
PMMA	Polymethyl Methacrylate
PP	Polypropylene
PS	Polystyrene
PVC	Polyvinyl Chloride
3R	Recycle, Reduce and Reuse
RM	Ringgit Malaysia
RVM	Reverse-Vending Machines
SPI	Society of Plastics Industry
SPM	Equivalent to O- Level
STPM	Equivalent to A- Level
TEI	Thailand Environment Institute
TPA	Terephthalic Acid
TrEEs	Treat Every Environment Special
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UV	Ultraviolet
V/D	Volume/Density
WMS	Waste Management Services

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Increasing population, industrial development, change of consumption patterns and many other factors caused the increase in environmental pollution (Claudia and Mosler, 2007; Agamuthu, 2009). This affects human life directly and indirectly. Some of these sanitary pollutions are non-compensated. The increase in solid waste generation is one of the most serious environmental problems since it disrupts the ecological and ecosystem balance (Omran, 2008).

Many countries in the world have taken efforts to recycle and reuse waste materials in different sectors of the production. It proves to be an option to reduce environmental pollution and increase the duration of natural resources (renewable and non-renewable). Annually, 8 million tonnes of solid waste in Malaysia are generated (MHLG, 2010). One type of waste component which can be recycled is plastic. Recycling of plastic helps to improve environmental safety and creates economic saving. The consumption of plastic has increased over the last years (Penjor, 2007). Increasing plastic consumption in daily life is a result of various factors: light weight, density, flexibility, resistance to heat, transmission of light and tensile strength, easy transportation, cheap market price, easy application, and long duration (Sangobtip *et al.*, 2008).

Over the past few decades, the use of plastic in consumer goods has grown tremendously. Plastics are the main sources of non-biodegradable municipal solid

waste. Its disposal is a major problem although they make up only 6–7% by weight of the total solid waste (Lopez, 2009). The growth of plastic utilization requires larger space for disposal in landfill is necessary, since it reduced the capacity of landfill areas and caused environmental pollution. Furthermore, the raw materials for these plastics are obtained from petroleum, a limited non-renewable resource and are highly non-degradable (Lopez, 2009).

To reduce the demand for landfill space and the consumption of limited petroleum reserves, recycling of plastic has become a subject of concern. Plastic is one of the most recyclable materials in municipal solid wastes (MSW) with a high application rate over the last decades. Recycling helps to reduce the volume of solid wastes and prevent environmental pollution.

Over these last several decades, the process in plastics recycling has attracted the attention of many scientists. Plastic recycling is very important for at least two main reasons: firstly, to reduced the ever increasing volume of plastic waste coming from many sources (from packaging materials and disposables) and secondly, to generate value-added materials from low cost sources by converting them into valuable materials similar (to some extent) to virgin materials

1.2 RECYCLING OF PLASTIC

Nowadays plastics are very useful for its good characteristics such as their high resistance against fraction, temperature and gases penetration, as well as, its low density and price compared to other materials like metals and glass. Plastic has excellent brightness and gleam, has good barrier properties against carbon dioxide and oxygen.

These are the reasons that increased the production of plastic bottles in the last few years (Showartez and Godman, 1999).

Plastic contributes a large portion in solid waste stream. With growing rate of plastic consumption, environmental and health concerns have been simultaneously increased. Increase in plastic consumption not only increased the volume of MSW but also inducing more problems in collection and disposal of plastics into sanitary landfill. Also, plastic is stable and non degradable (Gradic *et al.*, 2002). And also low weight of plastic and its high volume in MSW transportation caused increasing costs and urban traffic. Plastic bottles and polystyrene containers made up the most components of MSW by considering the current consumption methods. Dedications of big place for burying this kind of wastes due to its high volume and non-decomposability in nature are the factors that imposed importance to plastic recycling (Omrani, 2005).

The recycling of plastic represents one of the most successful and widespread programs. The major factors for this are its widespread use, particularly in the beverage industry which has made plastic the main target for recycling. Plastic is the second highest material value after aluminum. High Volume/Density (V/D ratio) and difficulties during collection, transportation and disposal stages, made Polyethylene Terephthalate (PET) recycling very crucial. In case of non-standard plastic recycling, some hazardous health problems could occur, and therefore, prevention of such condition is suggested (Lu, 2001; Pruss *et al.*, 1999). Plastic recycling and use of proper techniques in regards to climate conditions, technology, economy and cultural factors will help to analyze plastic productions in Malaysia.

Plastic recycling includes mechanical and chemical recycling, incineration and energy recovery (Gradic *et al.,* 2002). The aim of incinerating waste polymers is to recover energy. It is currently the most effective strategy to reduce the volume of organic plastics. This method however is considered as ecological (Lopez, 2009; Achilias and Karayannidis, 2004). Mechanical recycling requires the washing and grinding of plastic materials. Resulting flakes are then processed and blended with virgin polymers. Chemical recycling is another method to recover reclaimed post–consumer wastes though the equipment is relatively expensive (Tchobanoglous *et al.*, 1994).

In Malaysia, plastic applications are growing. Multiple industries import and use plastic pellets as raw material in making food and beverage packaging, as well as, textile, fiber, car flooring, bottle resin, film, engineering polyester resins production. With the development and operation of petrochemical projects in Malaysia, PET usage needs a comprehensive recycling program (Minoru *et al.*, 2003).

1.3 PLASTIC RECYCLING IN MALAYSIA

Plastic constitutes the third largest waste volume in Malaysian MSW, next to organic waste and paper (Osman *et al.,* 2009; Agamuthu and Faizura, 2005). The plastic component in MSW from Kuala Lumpur averages 24% (by weight), whereas the national mean is about 15% (Osman *et al.,* 2009). The 230 waste disposal sites in the country receive about 95% of the MSW, including plastic waste. The useful life of the landfills is fast diminishing as the plastic waste stays undegraded for more than 50 years (Agamuthu and Faizura, 2005).

Solid wastes in Malaysia do not go through any formal processing activities for recycling. However in 1993, a recycling program was launched in 23 Local Authorities and the recycling activities are being carried out in these areas in varying extents. As waste recycling is an effort towards achieving a sustainable urban development, several NGOs in Klang Valley are rapidly expanding their activities to increase waste recycling. As such, TrEEs (Treat Every Environment Special) and Pure Life Society Recycling Program has been organizing a community based recycling program since 1996 (MPMA, 2011). There are two parts to this program such as

i) an in-house recycling program where staff and children use special bins to recycle waste and

ii) Drop-off program where the public can leave their recyclables into recycling bins.

TrEES also conduct training workshops for companies and organizations, as well as, initiating in-house recycling programs. Petaling Jaya Community Centre Recycling program is a voluntary community group established a recycling program in Section 17 of Petaling Jaya since 1997. The public is encouraged to donate or sell recyclable items such as glass, aluminium cans, wearable cloths, paper, plastics and household items such as refrigerators, washing machines and furniture. These items are sold for a nominal price or donated. In reality, the recyclable items accepted by Alam Flora, PJCC and TrEES do not vary much in terms of type and price.

Most plastics in Malaysia are recycled mechanically (MPMA, 2011). The national target, 22% of the total solid waste can be recycled by the year 2020 (Agamuthu *et al.,* 2009). The Recycler's Network consists of various levels, such as the itinerant

recyclable item buyer (usually called the old newspaperman), scavengers, middlemen, manufacturers and producers. Table 1.1 lists out the buyers/purchasers of recyclable items who make up the recyclers' network in the Klang Valley (Malaysia country report, 2001).

Table 1.1: Recyclers' Network in Klang Valley

Items	Recycler
Paper	Genting Sanyen Industrial Paper Sdn Bhd
	Malaysian Newsprint Industries Sdn Bhd
	Persis Hijau Sdn Bhd
Glass	Kuala Lumpur Glass Manufacturers Co Sdn Bhd
- Aluminium cans and - Metal tins/cans	Kian Joo Can Factory Sdn Bhd
Plastic	Malaysian Plastic Manufacturers Association
Old clothes	Charity and goodwill homes

Source: Norshamleeda and Chamhuri, 1999.

1.4 PROBLEM STATEMENT

The current research aimed to investigate plastic recycling in Malaysia specially evaluation of plastic generation in the Petaling Jaya in municipal solid waste. There are many advantages in recycling such as saving energy and money, reusing items. These advantages are not the limited. We can mention more benefits. Recycling is good for the community and economy. It reduces pollution. It saves natural resources which can be used for more important things believe it or not, it creates jobs as more people are involved with recycling it's environmentally friendly and overall good for the

environment. It saves energy it prevents more landfill sites from being built, so people don't have to live near them. It protects wildlife as the forests don't need to be damaged, such as trees being cut down. It’s a positive thing as it creates demand for recycled products, resulting in profits. Many people can benefit of recycling, for example families and overall communities can save money when enough recycling facilities be available.

The current study concentrated on plastic recycling. There are some reasons behind the topic. With comparing the rate of plastic and glass in municipal solid waste (MSW). We can see the high rate of plastic in MSW and also plastic need huge space in landfill. By recycling one plastic bottle not only saves anywhere from 100 to 1000 years in the landfill but also saves the environment from the emissions in producing new bottles as well as the oil used to produce that bottle. For every1 ton of plastic that is recycled we save the equivalent of 2 people’s energy use for 1 year, the amount of water used by 1 person in 2 month’s time and almost 2000 pounds of oil.

The major recyclable items in MSW include plastics, bottles, paper, cardboard and metal. There is a great potential for resource recovery as is evident from the presence of scavenging activities in some landfill sites and at collection points. Apart from recycling, no other formal processing activity has been carried out. As recycling helps in reducing waste and it is inline with the concept of sustainable development, it has the potential of becoming one of the national tools in combating problems related to solid waste management (Ministry of Housing and Local Government Malaysia, 2000).

Quantities of plastics waste have been on the rise from a value of 7 billion RM to 16 billion RM in recent years (1998- 2010) due to industrialization and rapid improvement in the standard of living (MPMA, 2011). Unfortunately, the majority of plastic waste is not fully recycled but rather abandoned. Therefore, this had caused many serious issues such as the wastage of natural resources and environmental pollution (Park *et al.,* 2008).

Millions of tonnes of packaging materials are discarded each year. In Malaysia, the method of disposal for MSW has been largely through landfilling (90%) with a very little share of recycling (8%) and incineration (1-2%) (Plastic technology center 2008). As it becomes increasingly difficult to obtain new landfill areas due to the indifferent of public attitude namely phenomenon, the alternatives is via waste reduction either by recycling or the use of degradable polymers (Momoh and Oladebeye, 2010).

So this study was carried out to achieve the following objectives:

1.5 PROJECT OBJECTIVES

This study was undertaken

- To characterize the quantity of plastic generation in Petaling Jaya (PJ), Malaysia.
- To determine the degree of plastic recycling awareness in PJ.
- To determine the problems faced in plastic recycling.
- To propose suitable approaches in improving plastic recycling.

1.6 RESEARCH QUESTION

Basic the objectives which were provided the flowing questions where proposed:

- What are the contents of MSW Particularly plastic waste in PJ area?
- Do people aware of plastic recycling in PJ? To what extent?
- What are the problems of plastic recycling?
- Which approaches are suitable to improve plastic recycling?

1.7 RESEARCH HYPOTHESIS

- The contents of MSW are high rate of plastic waste.
- People are not aware of plastic recycling in general.
- The lack of recycling facilities and the degree of awareness about recycling are the major problems of recycling in PJ in Malaysia.
- Increasing the price of recycling is main approach for improving plastic recycling.

1.8 SIGNIFICANCE OF THE STUDY

The current research addresses itself to people in special and to environment and economy in general. Plastic recycling is essential for all cities around the world and for people who live there. There is not enough space for waste and landfill sites are filling up fast so Malaysia will be full by waste in near future. By considering this problem how people can preserve the environment of Malaysia for next generation. Recycling is an important factor for environment.

CHAPTER 2

LITERATURE REVIEW

2.1 DEFINITION OF PLASTIC

Plastics are artificial materials that can be changed to different products and goods through heat, grinding, forming and other methods. The root of this Greek term is "plastikos" which means formation. Since plastics are similar to resins, both terms are mistakenly used. Resins are gummy solid or semi-solid materials that are used in products such as paints, polish materials and plastics. A resin is called plastic when it is turned into solid at its final process. Plastic products are made from solid and processed resins (Ditrish, 2001).

The Society of Plastics Industry (S.P.I) in 1988 defined plastics as "a group of different and broad materials of which whole or part of them consist of carbon combination with oxygen, hydrogen, nitrogen and other organic and non-organic materials". The final products are in solid form. In some part of product process, plastics are turned to liquid to take any form such as granule, bottle and etc (Richardson, 2003). In general, plastics are organic material with high molecular weight that is produced by polymerization, i.e. chemical bonding of low molecular weight materials (monomers) into polymers. Properties of plastic material are determined by size and structure of polymer molecule. Some times, plastics are produced as pellets, liquids, powders and solutions (Hoo, 2006). Plastics can be produced from natural gas, coal, oil, and salt. However, oil from petrochemical industry still remains the main feedstock for plastic production because it supplies the monomers and polymers used (Waltera, 1991). Monomers and plastic

resins with different properties are processed via different methods such as injection molding, rotational molding, blow molding, and extrusion (Aguado *et al.*, 2007).

2.2 ADVANTAGES OF USING PLASTIC

Plastics tend to be very flexible with a range of properties. Basically, plastics are relatively light, cheap, strong and durable; hence the widespread use. Appendix A shows some advantages and properties of plastics. Some peculiar advantages of plastic usage over other materials are:

- Plastics show durability, lightweight, strength and reduce cost over other materials, like paper, glass, wood, metal and etc.
- Plastic application are developed as based on the characteristics offered by the specific plastic; hence restricting it to that plastic.

2.3 POTENTIAL IMPACTS OF PLASTIC ON THE ENVIRONMEN AND HUMAN HEALTH

Plastic usage has potential impacts on the environment throughout its life cycle. Most plastics are landfilled when they are no longer useful to consumers. Though plastics may be regarded as highly stable materials, yet certain chemical compounds may be find their way into the environment considering their use and disposal which cause potential impacts to the environment and human health (Hoo, 2006). Plastics have benefits, but sometimes it threatens the environment and human health (Omrani, 2005). Some hazards could be due to ingestion of plastics. Exposure to sunlight especially increased levels of UVB has impact on plastics. Serious damage can only be made on plastics if there is significant ozone depletion. Also, the toxic substances particularly some plastic waste can contaminate the environment.

2.3.1 Disposal of Plastic Waste

Plastic waste can be disposed off using different methods (Appendix B) which include landfilling and incineration (Hoo, 2006). Recycling is another method to be considered. The advantage associated with recycling activities is the reduction of the waste disposed to the landfill and eventually reduction in the risks of environmental burdens (Pakhare, 2008).

2.3.2 Waste Recycled – Emissions and Energy Requirements

Recycling plastic waste into feedstock or into energy recovery is the key alternative to reuse option which is not environmentally sound way of extracting value. Recycling ensures that the intrinsic value is not lost. Therefore in industrialized countries, large scale plastic waste recovery is done via mechanical recycling and incineration. Some mechanical treatments like cleaning and shredding have been carried out on recyclates, the same as for the production of plastics from feedstock. Though most plastics are recycled mechanically, yet chemical recycling is sometimes adopted but it is still at a developmental stage. Plastic bottles form the bulk of materials collected and recycled from household waste. Recycling process requires energy and it generates some emissions into the environment (Hoo, 2006).

2.3.3 Emission Reduction

Recycling approach generated the least emission to the atmosphere. Energy recovery is marked by reduction in CO_2 and CH_4 emissions into the atmosphere. Besides, plastics can be incinerated together with other combustible products from the waste stream and this helps to reduce the quantity of greenhouse gases, such as methane gas emitted from

landfills. Methane contributes more the CO_2 in terms of global warming (Hoo, 2006); hence the need to reduce quantity of waste from going to landfill.

2.4 CLASSIFICATION OF PLASTIC AND THEIR MAIN APPLICATIONS

The use of synthetic plastics has evolved since the late 19th century in the packaging, construction, electrical, and the automotive industry. Plastics are classified as thermoplastic and thermosetting resins. Every group has special characteristics and different applications (Hoo, 2006). The main uses of some of the major plastics are shown in Appendix C.

2.4.1 Thermoplastic

Thermoplastics are completely polymerized and permanently fusible form of plastics that can melt upon exposure to sufficient heat; hence the potential to be recycled and reused. It refers to plastics which have linear and branched bonding in their structure. These plastics can be reformed due to the fact that the simple structure of their molecules can be heated, remolded, and covalently bonded for several times (Hoo, 2006; Smits, 1996).

Thermoplastics with crystalline microstructure are generally carbon containing polymers. The material distorts at specific temperature (Smits, 1996), but will always retain its newly reformed shape after cooling. This forms the basis of processing methods for thermoplastics. Examples of thermoplastics are polystyrene, nylon, polypropylene, polyethylene, cellulose acetate and polycarbonate. Approximately, 85% of all resins are thermoplastics while 70% of the total volume of thermoplastics is accounted for by resins (John and Timothy, 2003). They are precisely made in a variety

of grades and due to their low cost, they are of are chosen ahead of others for large number of applications (Khorasani, 2005).

2.4.2 Thermoset

Thermoset plastics cannot be remolded and reheated. This is due to the fact that the bonds which are cross linked will have difficulty in recombining themselves (Hoo, 2006). These types of plastics can only be made once and cannot be recycled. Thermosets in the final form are big molecules which are not melted or solved and they become three dimensional lattice through heating under normal condition or though chemical reactions with additional materials in proper maundering conditions. Thermosets have high thermal stability and insulating properties (Khorasani, 2005).

2.5 PLASTIC RECYCLING

Generally, most plastics can be recycled and even new products can be formed from wasted plastic. Plastic recycling entails the process of recovering scrap plastics and reprocessing them to generate new materials that might be quite different from their original state. Plastic waste recycling includes collection and separation. The basic problem in recycling plastics is their variety. To solve this problem, separation of different types of plastic, a coding system for identification of plastic resins is introduced by the S.P.I in 1988. Thus, plastic containers are marked by codes which identify the type of plastic it is made from. This coding system makes the separation of plastic in recycling process possible (Khorasani, 2005).

2.1 2.5.1 Plastics in Malaysia

Plastics products and packaging are becoming more widely used in our daily life. Based on information released by Malaysia External Trade Development Corporation (MATRADE), the plastic products industry is viewed as a leading, most dynamic and vibrant growth sectors within the Malaysian manufacturing sector. The Malaysian plastics industries are basically a diversified sector and produce all sorts of products including household goods, bottles, containers and other packaging materials. It was reported (MATRADE, 2006) that about 2 million tonnes of resins for the plastics industry are produced locally per annum. Figure 2.1 indicated that the plastic production have been on the increase until 2010(MPMA, 2011). The increase of plastic products has direct relationship with the amount of plastic waste going to the landfill.

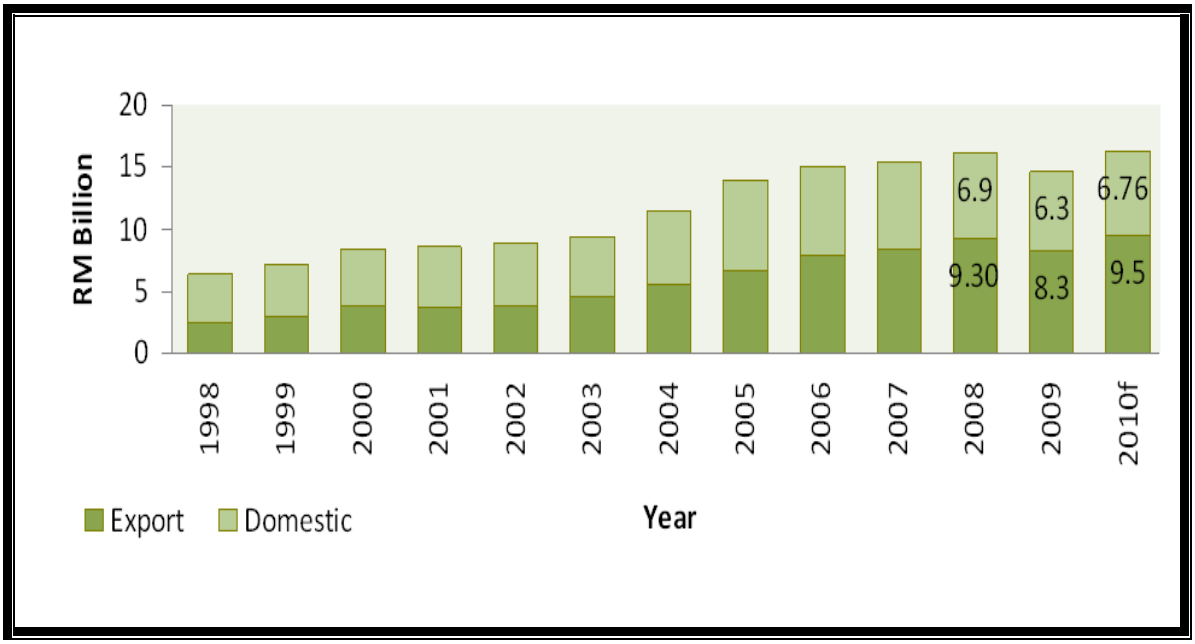


Figure 2.1: Trend of Plastic Production in Malaysia

Source: MPMA, 2011.

2.5.2 Plastic in Municipal Solid Waste (MSW)

MSW management is a big concern among the middle income countries like Malaysia (Ghani and Idris, 2009). Acute waste problems have been brought about by modern lifestyle. This is vivid with the quest for convenient packaging of products, and incessant spending due to high affluence that in turn generate more waste. Most often, wrappers from fest food outlets are discarded indiscriminately which makes the modern day waste to be characterized of much non- degradable material such as plastics.

MSW composition in Kuala Lumpur is divided into 8 categories namely organic waste, paper product, plastic, textile, rubber, glass, metal, and the others. Other category is defined as miscellaneous or beside the other major components. According to Figure 2.2, 15 % from the total composition of MSW in Kuala Lumpur is plastic. Organic waste is the major component of MSW in Kuala Lumpur while rubber, glass and textile have similar percentage, 1% each constitute of the waste stream (Mohamed *et al.*, 2008).

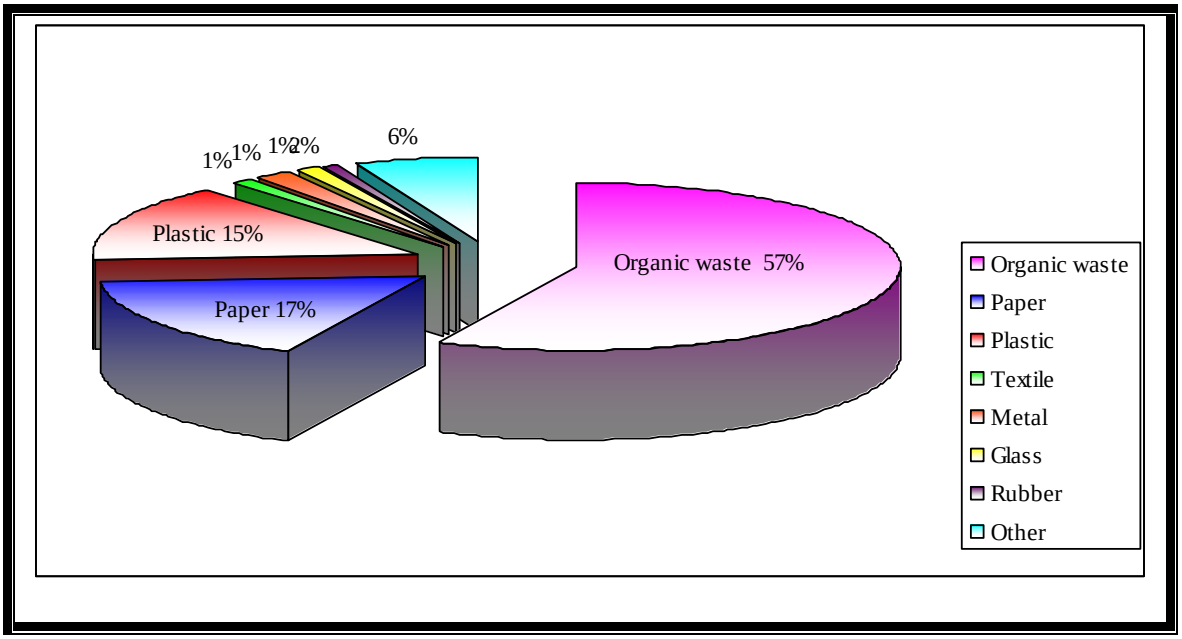


Figure 2.2: MSW Composition in Kuala Lumpur 2008 (Mohamed *et al.*, 2008)

Table 2.1 indicates that MSW in Malaysia is high in plastic content compared to other countries. In year 2008, 15% of MSW in Malaysia was plastics. Thailand contributed 11% plastic waste in MSW composition (Somtip and Cherdchan, 1998). Plastic waste in India is around 7% of the total waste generated in country. China only produced low plastic waste content 4.5% from total composition. It can be proved with increasing efficiencies of the new incinerators in China.

Table 2.1: Comparison of MSW Composition (FW %) between Kuala Lumpur with other Cities

Composition of MSW	Kuala Lumpur 2008	Thailand 1996	India 1999	China 1998
Organic waste	51	51	43	60
Paper	17	18	17	3
Plastic	15	11	7	5
Textile	1	1	0	1
Rubber	1	1	10	0
Glass	1	5	3	1
Metal	2	2	2	0
Other	6	9	20	30

Source: Mohamed *et al.*, 2008; Somtip and Cherdchan, 1998; Pieter *et al.*, 1999; Henderson *et al.*, 2000

2.5.3 Plastic Identification Code

The need to initially identify the category of plastic used for a specific product is very important. In Malaysia, the plastic products are classified into many categories such as plastics film, rigid shape (including bottles), foamed polystyrene etc. and a large part of the plastics products are used as packaging material including containers, wrappers etc.

for both industrial and consumer products. The coding system launched in Malaysia for plastics products divide plastic into 10 categories (Appendix D) (MPMA, 2011). Numerical coding system is used by many consumers to recognize various plastic types alongside the triangle of arrows. This was created by the SPI in the late 1980s which become the universal recycling symbol for costumers and manufacturers. Although there are only ten resin codes in Malaysia in the packaging of household products, yet about a thousand of different types of plastics abound. A combination of different dyes and additives when added to basic resin can produce a desired color, shape and texture of final plastic product. These manufacturing process variations result in different melting points of the plastics and even varying properties within the same resin code, hence the need for careful sorting after collection of plastic wastes. The identification code that is often seen at the bottom of plastic packaging assists the separation process of plastics (Mastellone and Perugini, 2005).

2.5.4 Challenges in Recycling Plastic

Plastics materials may be recycled, but in many countries recycling of plastics is still low. There are several technical and economic problems in the recycling of plastics; which can be classified into two general categories:

- the issues on segregation and identification of plastics and
- the economics of recovering because segregation and recovery costs for plastics can be very high.

Most plastic recycling industries in Malaysia focus on plastics scraps from industries or rejects from manufacturing/ productions. Recovery of consumer plastics is rather new in Malaysia but production of plastic pellets from consumer plastics were carried out by some industries in recent years. Detailed information on such recycling activities is not

available and need to be investigated.

2.5.5 Recycled Plastic Types

2.5.5.1 PET - Polyethylene Terephthalate

PET as a thermoplastic polymer resin in the polyester family is used in producing synthetic fibers. The chemical structure of PET is shown in Figure 2.3. Glass fiber often combined with beverage, food and other liquid containers via use of thermoforming applications and engineering resins. Infect, PET is one of the most important raw materials utilized in the production of artificial fibers. PET has good barrier properties against oxygen and carbon dioxide.

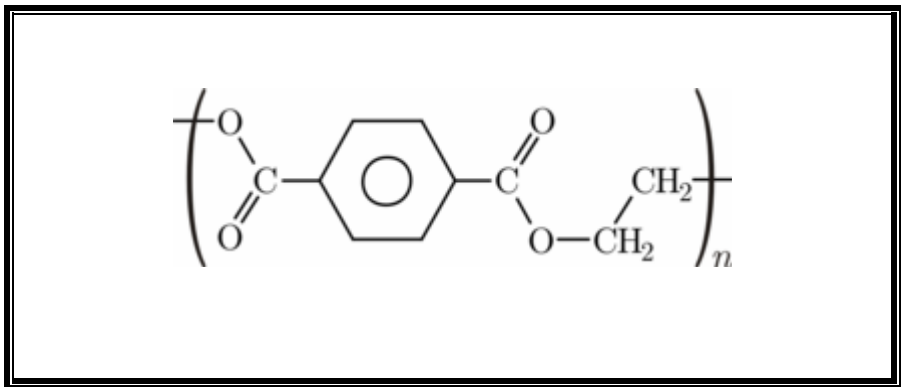


Figure 2.3: Chemical Structure of Polyethylene Terephthalate (PET)

PET molecules like other polymers are formed from long chain repetition of carbon, oxygen and hydrogen unit. Figure 2.3 shows PET structure which is the repetition of the molecular unit. Usually the number of N is 100 to 200 (Omrani, 2005).

PET are potential very resistant to mineral oils, acids and solvents but not to bases. It can be recycled several times before losing some of its quality. It is naturally colorless with high transparency and is a semi-crystalline class of thermoplastic material. PET is

a material with high insistence and low weight, large-capacity and low thickness from polyester. PET being a common consumer plastics, is used in producing various types of drinking bottles, water, oil, cosmetics, edible oils, cleanings detergents, pharmaceutical products and other food and non-foods containers (Waltera, 1991). Fast and global growth of PET bottle demands is very observable during 1990s in Europe. Thus, the rate of consumption of these bottles has increased from 300,000 tonnes to 1.5 million tonnes, and similar increase is also evident in other parts of the world (NAPCORE, 2007).

PET is used for the first time in producing synthetic fibers in 1941 (NAPCORE, 2007). The use of PET in industrial packages in 1970 started with the production of normal bottles. Nowadays, PET is mainly used for the production of bottles. PET production started from raw material of ethylene and parazylene compounds. These two materials with ethylene glycol and terephtalic acid form PET resin. This resin which is formed in small cylinders will be melted and poured inside the final mold. This mold will be in the form of bottle under pressure and will be blown. High resistance of these bottles distinguishes them from other materials. Because of molecular characteristics of PET which is formed during the blowing and resin formation, drinks with carbonic gases will easily remain in these bottles and will not undergo change due to pressure (Bisio and Xantos, 1994).

PET containers can be fully recycled. Their distinction from other materials is not only because of their recycling feature but also because of their low weight. By reducing PET containers' volume, less space in transportation will be utilized. Also their low

weight will consume less petroleum in transportation which will save energy (Saatniya, 2002).

The materials formed from PET are used in daily life. Other features of PET are its low weight and thinness in packaging industries which make contents visible. From other physical characteristics, its' well-formation feature enables the molding into different shapes (Showartez and Godman, 1999). This plastic melts at 255 C° as it is shown in Appendix E. If it is cooled quickly, it will totally become formless and its density will change (Omrani, 2005).

PET's toughness allows its broad applications. Camera film base and record tape are the main products of this process. This film can be used for a long time in projector without breaking or considerable erosion. Regarding its resistance against moisture, the film is used in packaging industry, food production and also as insulator in transformators. Also, they are used in cable covers due to their characteristics of toughness in films with low thickness.

Polyester fibers of PET have excellent elasticity and high resistance against crumpling compared to other weaving fiber. PET characteristics are better maintained when wet. Thus, pleated cloths and dresses made from this fiber will not change after washing and drying. The characteristics of this fiber make it useful in producing cloths that need no ironing.

In recent years, the productions of drinking bottles from PET are highly noticeable. PET has excellent brightness and gleams. It has high insistence against penetration of carbon

dioxide, oxygen and water while it has considerably low weight when compared with glass bottles. These are the reasons that make the production of drinking plastic bottles increase rapidly over the years. Also, the production of PET bottles is cheap. PET bottles have high strength against impact and crack such that the bottle will not break easily. When it is melted and blown, hydrocarbons can't penetrate. If there is no caution in the procedures of generating PET, staldeid will be created. This staldeid can change the taste of non-alcoholic drink. However, with the use of the best condition in injection molding (keeping it in exposed heating), concentration of generated staldeied will be very low and drinking taste will not change. In most countries, PET bottles are thrown with other domestic wastes and incinerated. It causes environmental pollution (Omrani, 2005).

2.5.5.1.1 Types of PET

There are four types of PET with different features.

A.PET

The real differences between A.PET and PET as two polymers are not obvious and somehow are same. A.PET is similar to bead or pill and structurally is crystalline. It becomes bright under formation process such as extrusion.

C.PET

This material is known as crystal Polyethylene Terephthalate. It is always turbid but in natural state it is cream in color. This material is used in the production of polystyrene

containers for microwave ovens. Formation process of this resin is similar to other polyesters but it needs more consideration to keep humidity rate lower than 0.003%. High humidity causes reduction of its stroke characteristics.

G.PET

Glycol Polyethylene Terephthalate is a polycoplyester which has more nonlinear molecule chains. This material with PVC is used in capsule packages and pills. Due to its similar characteristics and cost with some of polycarbonates and acrylic, it is used in packaging.

R.PET

Returned PET material is shown with R.PET abbreviation. Previously, before the advent of primary polymerization of monomers in chemical reactors, producers of resin use returned material in reactors. Nowadays R.PET materials are used in different ways. Weaving industry is the biggest consumer of R.PET but new markets are opening to produce consumers' products and goods at lower price. R.PET is usually prepared as non-crystal flakes or crystal pellets which is mainly sourced from drinking bottles (Waltera, 1991).

2.5.5.2 HDPE - High Density Polyethylene

Another thermoplastic made from petroleum is HDPE which is in polyethylene form. HDPE possess stronger intermolecular forces and tensile strength than lower density polyethylene. In fact, HDPE is simply the high density version of PE plastic. It is heavier, harder and stronger than LDPE, though less elastic. HDPE can be machined, molded and joined together via welding because its less dense than water. It is also very

resistant to many alkalis, solvents and acids, and possess variety of applications potentials; hence can be used in production of children's toys, plastic bags, etc (Lou *et al*., 2007).

2.5.5.3 PVC - Polyvinyl Chloride (vinyl)

PVC is a heavy, ductile, stiff and medium strong amorphous material. It has good resistance to bases and acids, but is often affected by some solvents. Soft PVC is very resistant to most chemicals and PVC is basically one of the best recyclable plastic which has similar quality to that of virgin plastic, as shown in Figure 2.4. PVC tubes do not bend and possesses good barrier properties to atmospheric gasses. Most insulators for pipes, electrical wires, etc are made in PVC form (Lou *et al*., 2007).

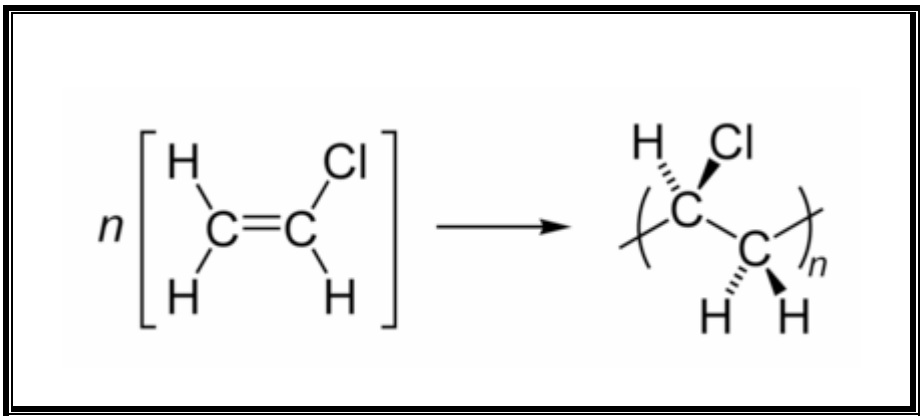


Figure 2.4: Polymerization of the Monomer Vinyl Chloride

2.5.5.4 LDPE – Low Density Polyethylene

LDPE is also a thermoplastic made from oil and just is the low density version of PE. The degree of its strength, hardness and stiffness is less when compared to HDPE, rather it possesses better ductility. It is characterized of an opaque nature and only thin foils can be transparent. LDPE also has excellent resistance to water, moisture and most organic solvents and chemicals. LDPE is commonly used in the production of various

containers, dispensing bottles, wash bottles, tubing, plastic bags for computer components, and some other molded laboratory equipment (Lou *et al*., 2007).

2.5.5.5 PP – Polypropylene

PP is another thermoplastic polymer produced by the chemical industry and used in a wide variety of applications for including food packaging, stationery, textiles, ropes, reusable containers and plastic parts. Characteristics of PP range from being low in strength, inexpensive material with reasonable outdoor performance to ductility, as shown in Figure 2.5. It possess a waxy surface, scratches easily, opaque like and white coloration though can be dyed in many colors. PP is very combustible and additives can reduce its inflammability. Like LDPE, it is also resistant to bases, water, acid, moisture and some solvents (Khoo, 2009).

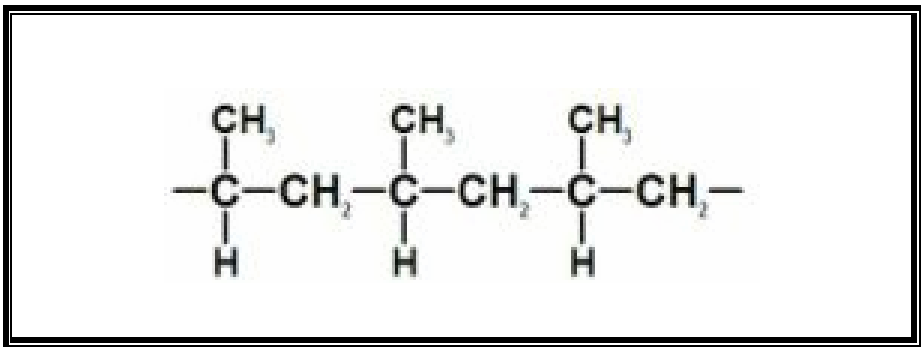


Figure 2.5: Chemical Structure of Polypropylene (PP)

2.5.5.6 PS – Polystyrene

Another form of thermoplastic which normally exists in solid state at room temperature, but melts if heated, and solidify again when cooled is PS. Styrene monomers pose serious threat to health and the structure is shown in Figure 2.6. PS is also an inexpensive amorphous thermoplastic that is vitreous, brittle and has low strength, though stiff and hard. PS in a foam form is used for packaging and insulation purposes.

It is transparent (transmits about 90% of the sunlight) and can be continuously dyed. Also resistant to acids, water, and detergents, but it generally dissolves in almost all solvents. It is used in the production of disposable drinking glass, biodegradables, razor, etc (Lou *et al*., 2007).

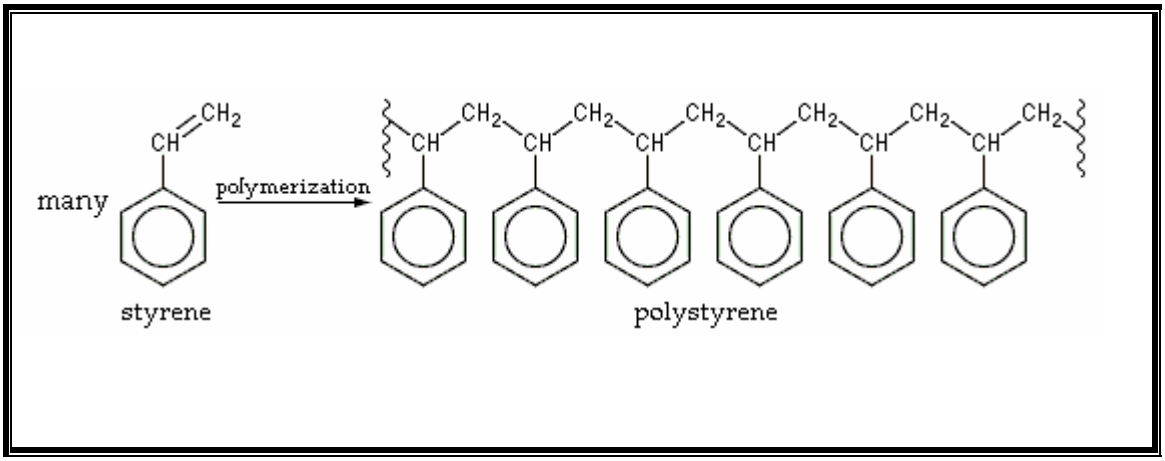


Figure 2.6: The Chemical Makeup of Polystyrene is a long Chain Hydrocarbon with every other Carbon Connected to a Phenyl Group

2.6 PET RECYCLING HISTORY

PET bottles were generated the first time by Nathaniel Vic in 1973. The first process of PET recycling is done by Saint Jude Polymers Company in 1976. Their first products from recycled PET were strap and paintbrush. This company for the first time started making consumed plastics of PET palletizing in 1977. This act is considered important pace because many companies of PET production in their processes rely on fractional plastics. With this act a variety of productions from used PET and recycled PET can be increased. The main growth in developing demand and capacity for used PET recycling happen when a plastic weave factory called Wellman began its operation. In early 1978, Wellman started recycling of PET bottles in the form of weave product for carpet and other proper weave products. Wellman increased the recycling of used PET and increased the capacity of the process as a result of market demand for PET consumption

during 1980s until 1990s. Other important event was producing the first fiber weave in 1993. It was a production of 100% of PET recyclables called Ecospon which is now the most familiar material in sport clothes. Nowadays, with the operation of many companies and that of Saint Jude and Wellman, the capacity of recycling action is totaled to more than 2 million pound recycled PET resin annually. About 1.5 million tonnes of PET is collected worldwide every year. In fact in 2007, about 1.13 million tonnes of PET bottles were collected in European alone as stated by Petcore, the European trade association that ensures collection and recycling of PET. This consists of more than 40% of the total number of bottles. With recent developments in PET recycling techniques, the access to this technology become possible in which containers and bottles and even some food packages are recycled and reused (Hurd, 2000).

2.6.1 PET Recycling

In the recycling industry, "post-consumer PET" means referred to discarding of the empty PET packaging by the consumer after use which becomes PET waste (Figure 2.7). Many local governments and waste collection agencies often collect post-consumer PET separately from other household waste. In some places, the collected post-consumer PET is taken to recycling centers also known as materials recovery facilities (MRF) for discrete sorting from other materials like metal, HDPE and PVC products, and even flexible plastics of low density polyethylene.

Figure 2.7: Cycle of PET Bottles

2.6.2 Collection Method

World over, there are four basic ways in which communities offer recycling collection services for plastic bottles and containers to their residents. In some areas the ways of collection is similar, while in other areas it is the combination of several methods. Plastic is an ideal material for recycling and can be reprocessed multiple times because the source material is available in large quantities (often as a 'mono-material').

Presently, focuses have shifted to PET bottles which are collected in dedicated collection systems (NAPCORE, 2007) or sorted from other waste streams. Some countries are planning to or have already adopted legislation to reduce packaging waste by the following approaches:

- Imposing ban on disposal of packaging waste
- Instituting collection rates
- Adoption of reuse or reprocessing quotas (WRAP, 2008).

PET bottle recycling is increasing steadily, and this effect is compounded by an overall increase in consumption and collection rates in some markets. It is expected that collection of PET bottle may double in the next five to six years on a global scale, whereas values for Asia-Pacific and Europe rim are expected to triple.

According to consultant group PCI (PET Packaging, Resin & Recycling) in 2005, about 2.5 million tonnes of PET bottles were recovered with about 70% coming from Asia Pacific and Europe. Regionally, China recovers 50% of Asia Pacific's PET bottles, with impressive reported-collection rates of 90%. Preliminary reports opined that top recyclers will remain the same: Asia Pacific (1.8 million tonnes), Europe (1.1 million tonnes), North America (721,000 tonnes), South America (231,000 tonnes) and Africa/Middle East (34,000 tonnes) (Figure 2.8) (Claudio Bertelli UOP Sinco, 2010).

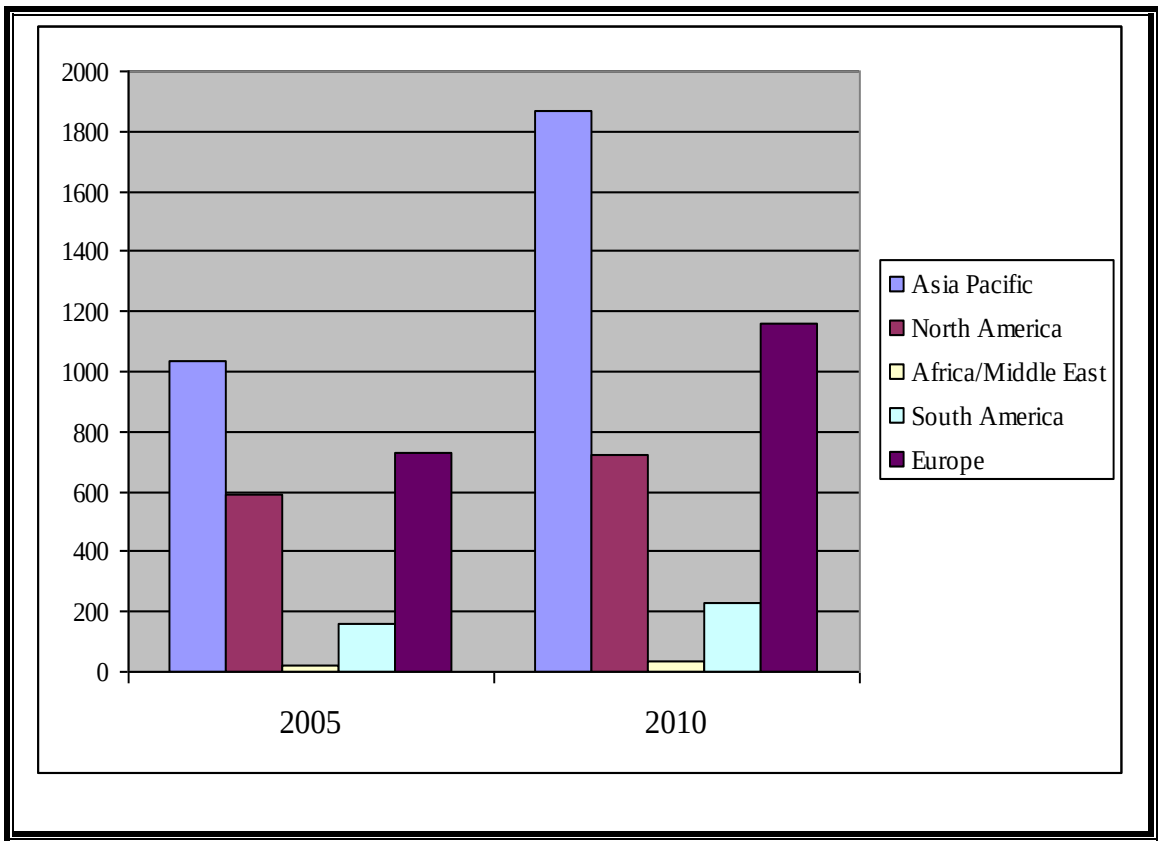


Figure 2.8: Worldwide PET bottle Consumption and Collection

Reused PET food-contact bottles is quite a small fraction of all recycled PET. In 2005, food-contact bottles accounted for only 9% of worldwide post-consumer PET. Estimates had shown that by 2014, 600,000 tonnes of PET bottles will be collected in Europe, and will be recycled back into recycled directly back into bottles—an increase of 68% from 2005 (Claudio Bertelli UOP Sinco,2010; Petcore 2004).

2.6.2.1 Drop-off Centers Method

In drop-off recycling centers, containers for designated recyclable materials are placed at centralized points like schools, churches, parking lots, and etc. The containers are properly labeled to indicate the type recyclable material to be placed in them. Residents are then required to send their recyclables to the drop-off location, where recyclables are separated by material type into their respective collection containers. Drop-off centers

need much less investment to establish unlike curbside programs, yet do not offer the convenience of curbside collection. However, drop-off collection centers work well in rural locations where curbside collection is impractical, than in urban centers. Approximately 10-15% of materials are collected with this system and if the awareness of public increases, this rate can be enhanced to 10-30%. This system of collection is so common in USA and it is also used in some countries such as France, Swiss, and Italy. It is a low cost system that can be used for every kind of recycling materials (Lisa *et al.*, 2007).

2.6.2.2 Curbside Collection Method

Curbside collection is the most widely accessible collection method and curbside recycling programs very easy for community participation, as its recovery rate is high. According to Center for Plastics Recycling Research at Rutgers University, a study showed that curbside collection gathers 70-90% of available recyclables. Similarly, estimates by the National Association for Plastic Container Recovery (NAPCOR) indicate that about 55% of all the PET plastic containers collected for recycling are generated via curbside programs. Communities that use curbside collection advise the residents to sort discrete recyclables from their household waste and to place them into designated containers, so that the municipal crews will collection them later. In this method, generally 40-60% of used materials can be recycled and it leads to the reduction of the total costs. Also public participation has much more important role in this system of collection.

However, some communities allow their residents to mix up the recyclables. Some communities observe daily collection of recyclables while others have scheduled days for trash collection and collection of recyclables. For better separation of materials from waste, it needs citizens' education and training (Hurd, 2000).

2.6.2.3 Buy-back Centers Method

Communities do not provide this buy-back service in the real sense. This is because most of the buy-back recycling centers are operated by private companies. Incentives are provided via legislation or loan programs in order to assist in the establishment of buy-back centers for the residents. Buy-back centers pay some amount to consumers for every recyclable materials that are brought to them. Most buy-back centers require consumers sort their recyclable materials at source before binging over for sale, and they may even be required to remove caps from the bottles. Such purchase specifications help to reduce contamination levels and enable the buy-back center to embark on immediate processing of the recyclables they purchase, while making economic incentives available for consumers to comply with the specifications.

Basically, this method is made possible due to statewide laws have passed such legislation that assigns a redemption value on carbonated beverage containers. This method of returning such containers facilitate recycling by aggregating large quantities of recyclable materials at the beverage retailers and wholesalers shop in readiness for collection by recyclers(Pakhare, 2008).

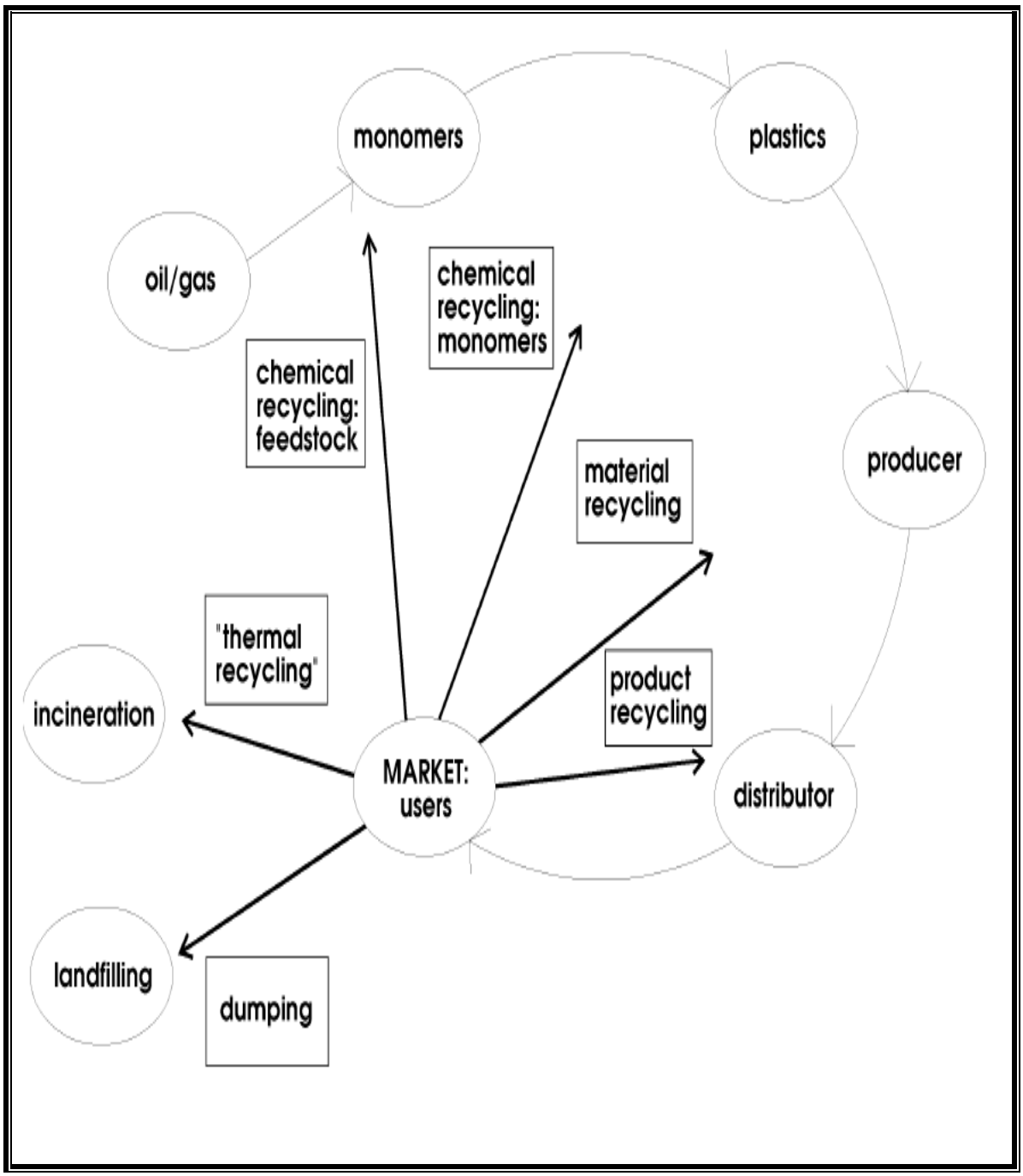
2.6.2.4 Reverse-Vending Machines Method (RVm)

This method is a kind of buy-back centers system but in small scale. The Reverse-vending machines placed at public places. Citizens are paid based on the recycling containers returned. The RVm machines are designed with some especial features in which citizens must conduct minimal source separation such as removing caps from bottles (Figure 2.9). Consideration of these characteristics can reduce the rate of pollution. Approximately 15-20% of recycled materials are collected with this method (Lisa *et al.,* 2007).

Figure 2.9: Reverse-vending Machines

2.6.3 PET Recycling Methods

The separation of the recyclable plastics into discrete resin types or fractions marks the beginning of PET recycling. It can be recycled via three methods: mechanically, chemically and energy recovery (Finger 2.10).



Finger 2.10: Plastic Life Cycle and Corresponding Recycling Options

2.6.3.1 Mechanical Recycling

Mechanical recycling of PET basically entails the shredding, granulation and melting plastics waste. Proper separation of PET materials must be sorted prior to mechanical recycling. Mechanical recycling is simply a method adopted to make new products out of unmodified plastic waste and it had been successfully practiced by recycling

companies which collect industrial scrap and reprocess them through activities of sorting, cleaning and re-pelleting using an extruder to produce uniform pellets. It is then sold to the plastics industry for production of new products (Appendix F).

After PET bottles have been sorted from household waste, they are compressed and packed by municipalities before transporting them to recycling plants, where impurities are removed, and the container is subsequently shredded, cleaned from foreign bodies and separated of non-resins. The remaining component is turned into pellets and flakes for recycling. The generated materials (recycle) are then sent to textile and sheet-making plants, and will be melted again with other processes to produce textile and sheet products.

After PET bottles are collected, it may be mixed with other bottles such as heavy polyethylene, PVC, and papers. Thus, these bottles are transferred to sorting unit. In mechanical recycling, cyclone separators are used to remove paper labels which are contaminants as the plastic is shredded or crumbed into flake forms. The process also involves washing of flakes, drying and pellet extrusion for the market; hence mechanical recycling of PET undergoes eight (8) different steps.

Step 1 - PET Collection

As it is mentioned before, PET for recycling comes from post consumer PET which has already been used earlier by people. These are the plastics obtained from plastics recycling bins and even at domestic roadside collections.

Step 2 – Sorting

Post-consumer PET must be sorted into different color fractions namely; transparent or uncolored PET, green and blue colored PET, while the remainder is classified as mixed colors fraction (Figure 2.11). The appearance of new colors (like amber for plastic beer bottles), complicates the sorting process for the recycling industry (Torres *et al.*, 2000).

Figure 2.11: Bales of Crushed PET Bottles

Therefore, the post-consumer PET waste is crushed, compressed into bale forms in readiness for sale to recycling companies. Transparent post-consumer PET attracts higher sales prices when compared to the green and blue fractions. The least valued is the mixed color fraction. PET is sorted manually or automatically.

Step 2-1: Manual Sorting

The collected PET in recycling place is usually sent for strappings where workers separate PET manually according to their features such as shape, color and etc. Sorting

PET bottles from other plastics is simple because PET bottles are brighter than other plastics such as PVC bottles and their bottom has different shape than other plastics. For example PVC has a cutting line at the end and heavy polyethylene bottles are turbid and they also have a cutting line at the end. Each worker is responsible for sorting specific type of plastic bottles.

Step 2-2: Automatic Sorting

There are different ways for automatic sorting of PET bottles which are:

- Florissant spectrum with X-rays. This method is used for separation of PET bottles from PVC bottles.
- Infrared spectrum: which recognizes the spectrum of each material and complicated sorting is possible with this method.
- Light sensors: which are used for sorting plastic bottles according to their brightness and color based on visible spectrum.

These methods can sort plastic bottles with high precision according to the color of the polymer type. In these methods all kinds of bottles are thrown over strapping before being scanned separately and their type and color distinguished according to basic information. Then air blowers fling these distinguished bottles with air pressure over strappings to sorting places and channels of the same bottles. The use of these methods needs high investment (Figure 2.12).

Figure 2.12: Separating of Plastic Types

Step 3 – Compressing

Transportation of PET bottles has low cost and its transportation to other units is easy. It needs to be compressed by a vertical and horizontal compressor. In both methods, bottles are shredded and flattened by hitting sheet. This cycle continue until a pack of fully compressed bottles is produced. This compressed bale of PET bottles is covered with metal rope. Sometimes bottles are passed through punch machine before compressing. This machine pierces bottles and releases the air inside the bottles to increase density of compressed bottles.

Step 4 – Chipping

Chipping process takes place after the sorting. This is done using the chipper; a cylinder of blades that resembles an old-fashioned lawnmower inserted in a vessel with a 10 mm

grid floor. The blades make fine cuts of the material until it is small enough pass through the grid (Drying, 2004).

Step 5 – Washing

Washing is the next stage and is very important for the removal of paper labels, glue, dirt and any remnants of the product which might still be attached on the chip. It takes about 12 minutes to wash both the "other" stream and the PET stream at around 90 C°, using an alkaline detergent wash solution in water, as it helps to removes dirt, grease and degrades protein. Finally in the process of washing, the agitator in the wash tank functions as an abrasive, grinds off the glue of the labels and reduces any paper labels to fibers. The glue paper and other dirt components are finally forced out through small holes while the plastic stays intact.

Step 6 - Floating Tank

In this step, density differences are used to separate plastics. It is done using water cyclone which is effective and of low cost. It can separate plastic or non-plastic materials from the recycling components. This process not only increases the rate of production but also takes fewer stages than other separation methods. For hydrocyclones, density is the effective factor that helps in its separation. An increased differences between materials, enables a probability of separation. The plastics are further rinsed and then separated in the PET stream based on their weight. Water cyclone is designed to separate out the given plastic from others (Figure 2.13).

Figure 2.13: PET Recycling Line- Sink-Floating Tank

Plastics such as polyethylene (PE) or PP with low density and lighter in weight will float in water while plastics such as PET which is heavier will settle at the bottom (approximately 95%). Unfortunately, PVC has same weight as PET and it settles down with PET in this stage. Thus, it is better to remove all of PVC during manual sorting (Tukker, 2002).

Step 7 - PET Flakes

The recycling firms/ industry often conduct more treatment on the post-consumer PET via shredding the material into small fragments. Such fragments may still residues from the original state, shredded paper labels and possibly the plastic caps. Different processes are used to remove the above which lead to generation of pure PET fragments, or "PET flakes" (Figure 2.14). Standardized PET flakes serve as raw material for many products that would be made of polyester (Appendix G). Polyester

fibers include strapping, PET bottles or polyester sheets. It even serves as base material used in the production of carpets, pillows and some other clothing materials (Golami, 2005).

Figure 2.14: PET Flakes

Step 8 – Pelleting

Pelleting is a process of melting the flakes and extruding them out via a fine grill in order to remove any solid dirt or metal particles. In order not to allow entangling of the extruded plastics, it is the sprayed with water immediately it comes out and subsequent by cut off by rotating knives to give small, oval pellets (Figure 2.15) (TEI and Sasaki, 2006).

Figure 2.15: Pellet of PET

2.6.3.2 Chemical Recycling

Chemical recycling involve a more complex process because the plastic polymer needs to be broken down into the monomer form before being re-polymerized. This stage/ process make the recycled product to look very similar like the virgin material. However the method is limited to certain resins especially PET. Chemical recycling of PET depends on the chemical reactions which break down the PET into small molecules. This can then be used as chemical feedstocks, either for re-polymerizing PET or for manufacturing related polymers. Two procedures, glycolysis and methanolysis, are in commercial use. Both can be used to produce PET which is chemically identical to virgin polymer. It has been approved for food –contact use (Karayannidis and Achilias, 2007).

Typical glycolysis processes produce partial depolymerization, which is followed by purification and repolymerization. Methanolysis processes provide full depolymerization, followed by purification by crystallization and then repolymerization. Glycolysis cannot remove colorants and certain impurities which can be removed by methanolysis. DuPont also operated a methanolysis facility for PET recycling. However, recently they hold discontinued the operation for economic reasons. methanolysis is the major chemical recycling production that is commonly used. However, the expenses incurred to obtain monomers via chemical recycling process is much higher that use of traditional chemistry (Sinha *et al.*, 2008).

2.6.3.3 Energy Recovery

Energy recovery is a major growing part of integrated waste management; just like using municipal waste as source of fuel to generate heat or electricity. All inorganic materials possess energy in form of carbon. Obviously, law of thermodynamics stated that energy can neither be created nor destroyed but can be transformed from one form to another. MSW is comprises of inorganic materials such as glass, metals and even organic materials such as food waste, paper and plastics. However, excluding the inorganics, all other materials have a high value that varies from one material to another. Energy recovery differs from fuel recovery because recovered fuel is mainly a manufactured product that is produced with the intention of meeting the market specifications, while energy recovery plants are designed to ensure complete burning of waste or for minimal sorting of wastes (Mastellone and Perugini, 2005). Thermal recycling also involves breaking down the chemical structure of the polymer. In this case, instead of relying on chemical reactions, the primary vehicle for reaction is heat

(Figure 2.16). In pyrolysis for example, the polymer (or mixture of polymers) is subjected to high heat in the absence of sufficient oxygen for combustion.

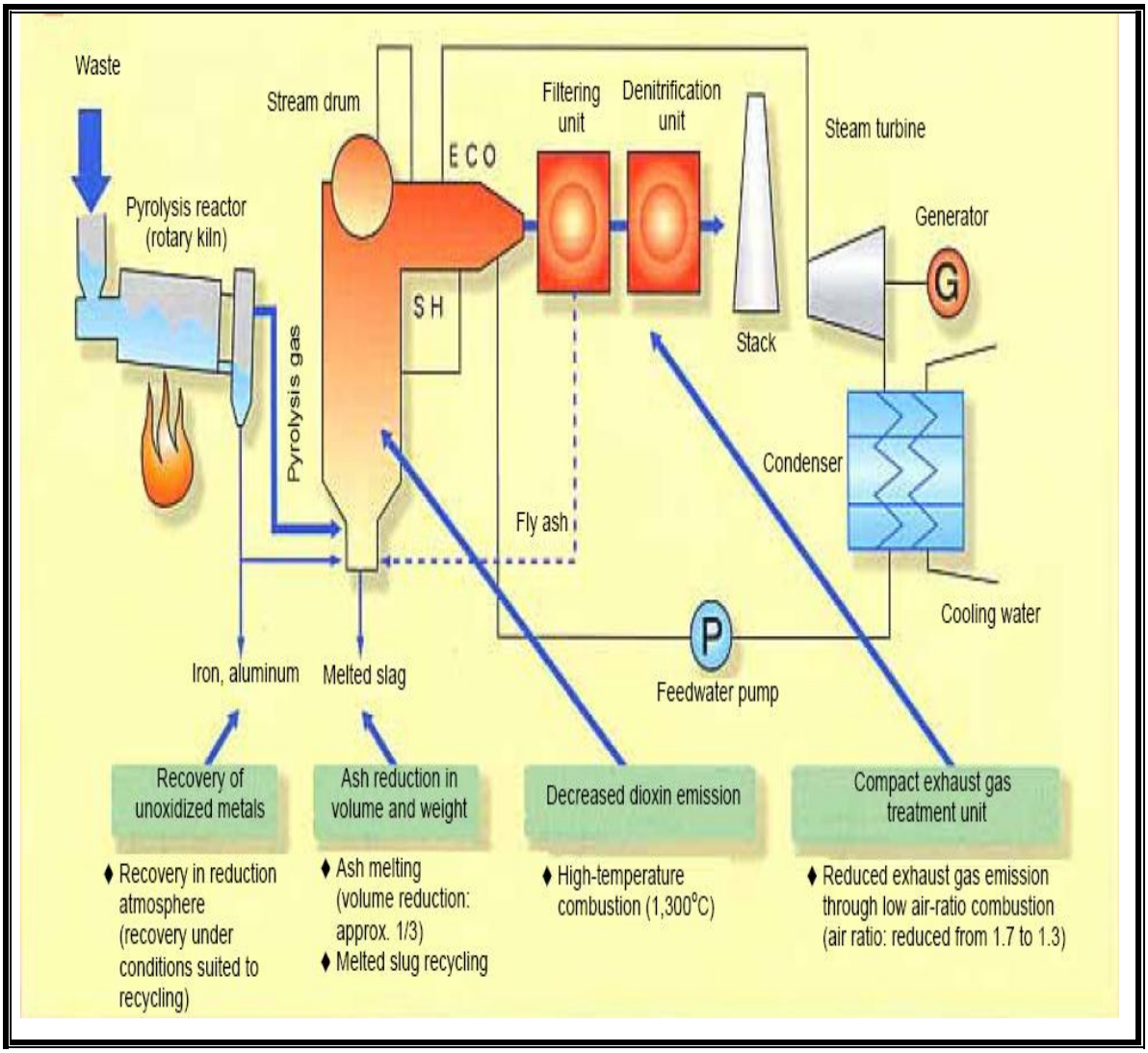


Figure 2.16: Process of Energy Recovery

2.7 PET APPLICATION AFTER RECYCLING

Sometimes recycled PET flakes are fully used or used with other new materials to reach higher quality. Generally, recycled PET flakes can be used in these materials: Fibers, A-PET sheets, bottle, and strapping. Nowadays there is high demand for PET flakes with high quality to produce the above mentioned materials in Europe, especially in Italy. The present production of flakes is not enough for this demand. Recycled PET flakes need to have special features for different usages.

2.7.1 Fiber Production Technology

For fiber production, PET pellets enter a fiber extruder machine. The extruder machine is shower-bath shaped which is installed in height with a windy channel under the shower. Materials which entered this machine are poured down towards windy channel. As it is melted, it is turned into solid by windy channel. These materials are unmonotonous fibers with low strengths. For adjustment of fibers thickness, these materials entered Unilling system where hot air stretched the fiber with monotonous speed. Therefore, the final fiber produced in this system will be with suitable thickness. At the end, a collection system is available where fibers are twisted and collected over spindles. The fiber chains have following applications:

- Clothes products, pillow, furniture filled with spinning fibers
- Cheap carpet products especially for cars
- Production of strapping, filter, inside lining and etc

2.7.2 A-PET Production Technology

In spite of excellent light features of APET, their marketing is limited because of their high production cost due to the high cost of resin. The cost of new APET is much higher than other plastics as PP and PE. The availability of PET flakes from mechanical recycling reduces its cost. It is lower than the cost of new materials. This encourages the production of APETs. Applications of APET are as follows:

Production of one-layer sheets (100% RPET)

- Internal two-layers or multi-layers inclined to a layer with new material for example a layer of PE with a layer of RPET

For the production of this sheet, complete production line consists of:

- Primary preparation of flakes, factory wastage which is produced from formed sheets, and collected wastage (approximately 30%)
- Crystallization tools for producing crystallized materials and drying dryers
- Mixtures and measuring materials
- Softening system and extrusion sheet which works as follow:

  Flat sheets of PET from extrusion process are stretched over roller where cool water is passed under. General thickness of sheets over these rollers is justified and sheets are then dried. The sheets are cut and moved to the collecting system to be twisted around the spindles. The most important usage of APET is as food package, dairy products and etc.

2.7.3 PET Bottles to PET Bottles Technology

Since PET bottles can now be reused as a PET raw material; then it implied that PET recycling is a necessity and an up-to-the-future option. PET bottles are obtained via the practice of returnable system or from collection of plastic waste. Due to the possibility of bottle-to-bottle recycling process, it is now easy to produce PET beverage containers from PET recyclate.

It is not advisable to use PET bottles as raw materials in production of soft drink bottles or liquor bottles due to unhygienic nature and associated smell. But from economic point, it is better to convert PET bottles to their state at synthesis stage rather than generality PET resin directly from petroleum. A “bottle-to-bottle” scheme as been adopted makes resin equivalent to newly made resin suitable for drinks bottles. This scheme is just a break down of the used PET bottles into their monomers (depolymerization) before turning them again into PET resin. The break down is a

combination of ethylene glycol (EG) and methanol to break waste PET resin into DMT (dimethyl terephthalate) (Christel, 2000). DMT will be utilized as a raw material used to make film and textiles. Therefore this technique decomposes waste PET bottles further from DMT to PTA (purified terephthalic acid) to make PET resin (Figure 2.17).

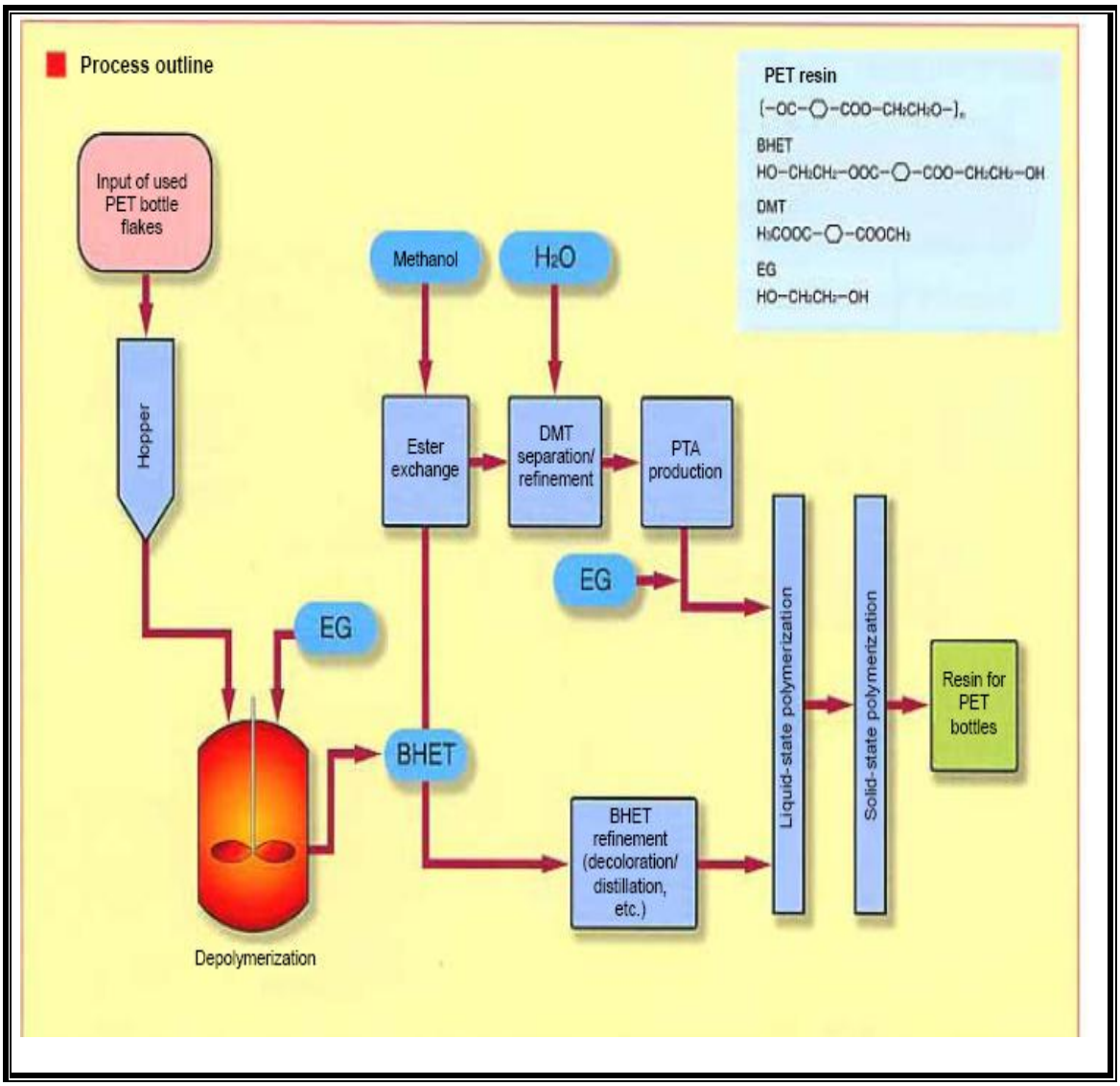


Figure2.17: PET Bottles to PET Bottles Technology

2.7.4 Strapping Production Technology

Strapping tape which has high vibration strength is made of RPET materials and it can be used in fastening different kinds of packs. Recycled flakes are not suitable because their gravity is less than usual. In most cases, regranulizing and passing of solid phase

can be used to produce strapping with low to average stretch power. PET packing strap production is a new model of packing material machine. PET packing strap is the best replacement for old packing material. Nowadays, the PET packing strap has been widely used in many industries such as paper, steel, chemical fiber, cotton, and so on (Saatniya, 2002).

To produce strapping PET pellets are injected first into the extruder system, then it moves along the horizontal chamber of the extruder where water from the shower drops on the materials and initiates cooling for proper solidification. In this system the right width and thickness of materials are achieved, based on the strength and speed of the machine and its temperature. Then the belts are twisted around different spindles (Figure 2.18). Industries of plastic recycling produce new materials in following branches:

- Polyurethane foams
- Chemical resins which can be used in producing computer pieces
- Bag and shoes production
- Geotextiles production

Figure 2.18: PET Strapping Tape

2.8 ADVANTAGE AND DISADVANTAGE OF PET RECYCLING

Advantages of plastic recycling are many. One of the major advantages is the reduction in use of non renewable fossil fuels which would have been used if one wants to produce new plastic materials. Before recycling, it needs separation and sorting of PET from other plastics properly. Thus, training of waste generators will be required, so that they can separate the wastes properly. The amount of plastic (25.2%) that reaches the landfill sites is high (Yatim and Arsha, 2010). Disposal of per tonne of plastic needs 35 m^3 spaces which is 15 times more than other waste. This can be avoided by recycling and the disposed of plastic waste to landfills will be reduced by an average of 5.4% (U.S. EPA, 2000). Thus it will reduce landfill disposal fees and minimize land pollution potential. Recycling plastics help to reduce carbon emissions. Due to the higher molecular weight of the PET polymer chains, plastic recycling tend to be more expensive than recycling other materials like metal and glass. The polymer chains that bind PET does not dissociate /dissolve under heating and this is why a complex process

is required. It seems that recycling small quantities of PETs may not be economical. However, it requires minimal processing equipment for PET recycling. It is not advisable to mix PET with different types of plastics because it reduces the quality of production (Pakhare , 2008).

Raw materials for producing PET are often imported from other countries. PET recycling can prevent importing of raw materials to produce PET containers. It also prevents the movement of currency out of the country. PET recycling can also create jobs and income in a society by collecting, sorting, other recycling processes, production and supplying new products. PET recycling not only saves the use of raw material i.e. oil but also conserves energy and helps to sustain the available natural resources that would have been used to produce new PET containers. PET containers have more insistence against decomposition because of their carbon-carbon chain. With PET recycling, the contamination of environment especially soil can be reduced. Burying waste can increase emission of greenhouse gases such as methane and carbon dioxide. PET recycling will prevent emission of these two greenhouse gases that causes global warming. Energy recovery from PET incineration in standard furnace can be saved in fossil fuels with heating value of 23 MJ per kg (Omrani, 2005).

CHAPTER 3

MATERIALS AND METHODS

3.1 RESEARCH OVERVIEW

This chapter describes the methodology that was used to determine the quantity of plastic waste generation, as well as, plastic recycling in Petaling Jaya, Malaysia. The research includes primary and secondary data collection, sampling and distribution of questionnaires. In the absence of segregated waste information, the composition of the wastes was unknown. The per capita and total waste generation capacity at source point was also not known. Therefore, a primary data collection through field survey; physical collection, segregation and wet weight measurement of the wastes and interviews with set questionnaires was initiated as per the outline of study objective; Side by side, the secondary data were collected from the relevant organizations such as Petaling Jaya City Council (MBPJ), Malaysian Plastics Manufactures Association (MPMA) and etc.

3.2 RESEARCH PROCESS

Some steps are designed in order to carry out the research which is provided below:

a) Field observation

b) Field survey and physical measurement of waste samples

c) Data collection at the source points

d) Questionnaire/ survey

e) Analysis of the data

The framework of process was provided in Figure 3.1.

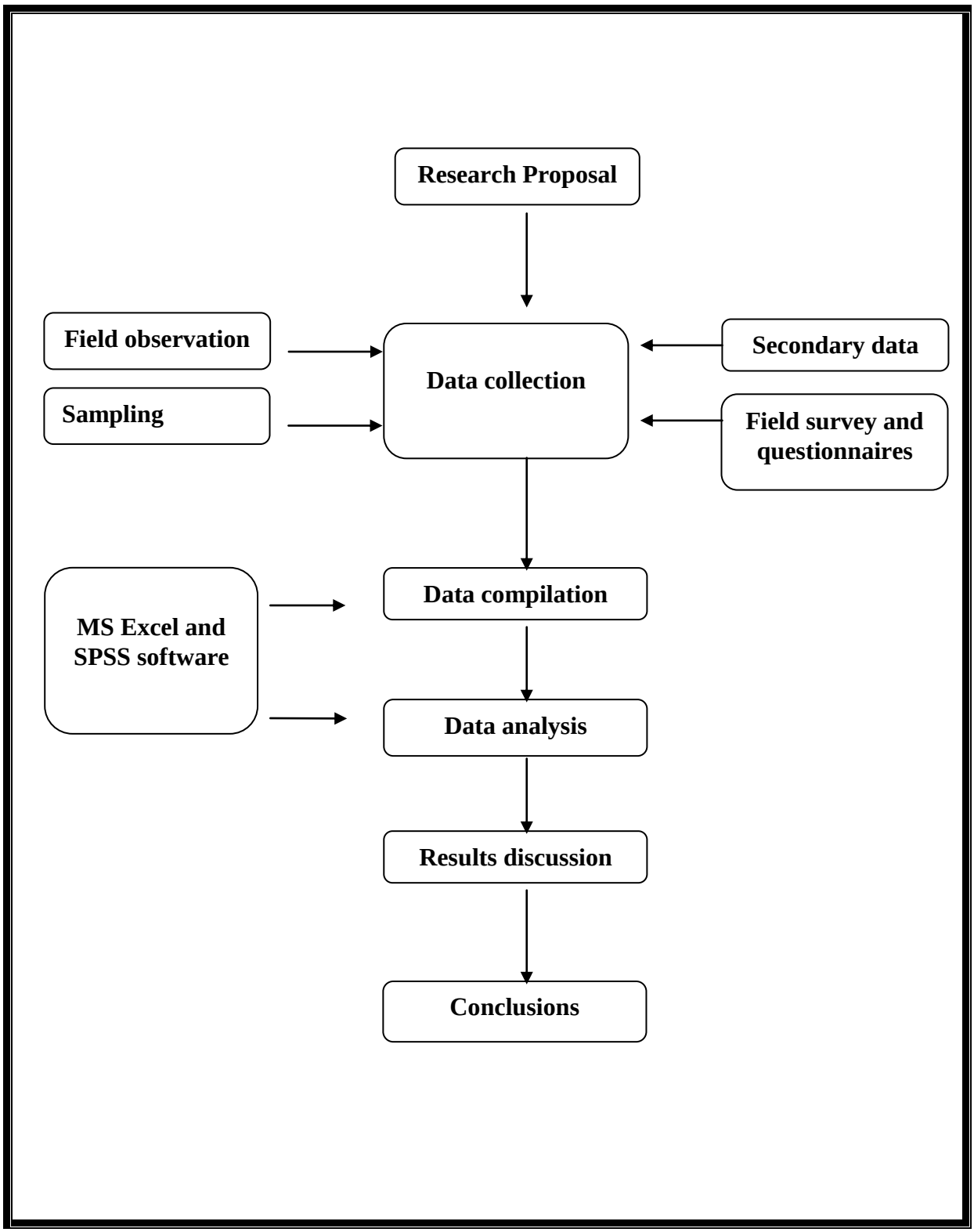


Figure 3.1: Process Flowcharts for the Research Approach

3.3 RESEARCH BASIS

In this study, information on population size and population distribution in Petaling Jaya (PJ) was collected to determine sample population for the study. The important parameters are considered in the survey were respondents' opinion on plastic recycling and quantity of plastic in waste stream.

The application of plastic recycling has direct relation to the rate of waste generated. It depends on different factors such as income and education level of citizens, lifestyle, type of residences, etc. These characteristics call for different approach in waste recycling. Segregation and measurement of waste is crucial when designing a recycling plan. In this study, PJ was selected based on the capacity of the residential area to generate high percentage of plastic waste (Yatim, and Arshad, 2010). The hospitals, commercial and industrial areas are not covered in this study since the focus is on household waste generation. Environmental, economic and social conditions will aid in identifying areas' potential for plastic recycling. Geographical location and distribution of population in Petaling Jaya was considered for sampling from residents' areas to determine the waste generated.

3.3.1 Field Observation (Visual Imaging)

Direct observation was essential during the survey. Photographs from the study areas and other places were taken to have visual observations of the sites and activities. Relevant photographs are included in the chapters where appropriate.

3.3.2 Study Area

Petaling Jaya (PJ) is located west of Kuala Lumpur (Appendix H). In 2006, PJ was granted city status. Since then, PJ has been commonly known as the most developed non-capital city in Malaysia. This place comprises mostly residential, commercial and some industrial areas. It is located in the Petaling district of Selangor with an area of approximately 97.2 km². The population in 2011 was 631,150. PJ is under the administration of the Petaling Jaya City Council or Majlis Bandaraya Petaling Jaya (MBPJ). PJ progressed rapidly due to the massive rural-urban migration. PJ also acts as one of the center hubs of Klang Valley (comprising of Petaling Jaya, Kuala Lumpur, Shah Alam, Subang Jaya and surrounding areas).

PJ is divided into several sections. These sections are subdivided into smaller neighborhoods. Some sections have their own names (SS1 as Kampung Tunku), while other sections are grouped together (SS6, SS5 as part of Kelana Jaya). The city sections are numbered as such that the older sections have no prefixes to their section number (Section1, Section 9) while later sections have prefixes such as PJU (Northern Petaling Jaya), PJS (Southern Petaling Jaya), and SS (sub-section) (Figure 3.2).

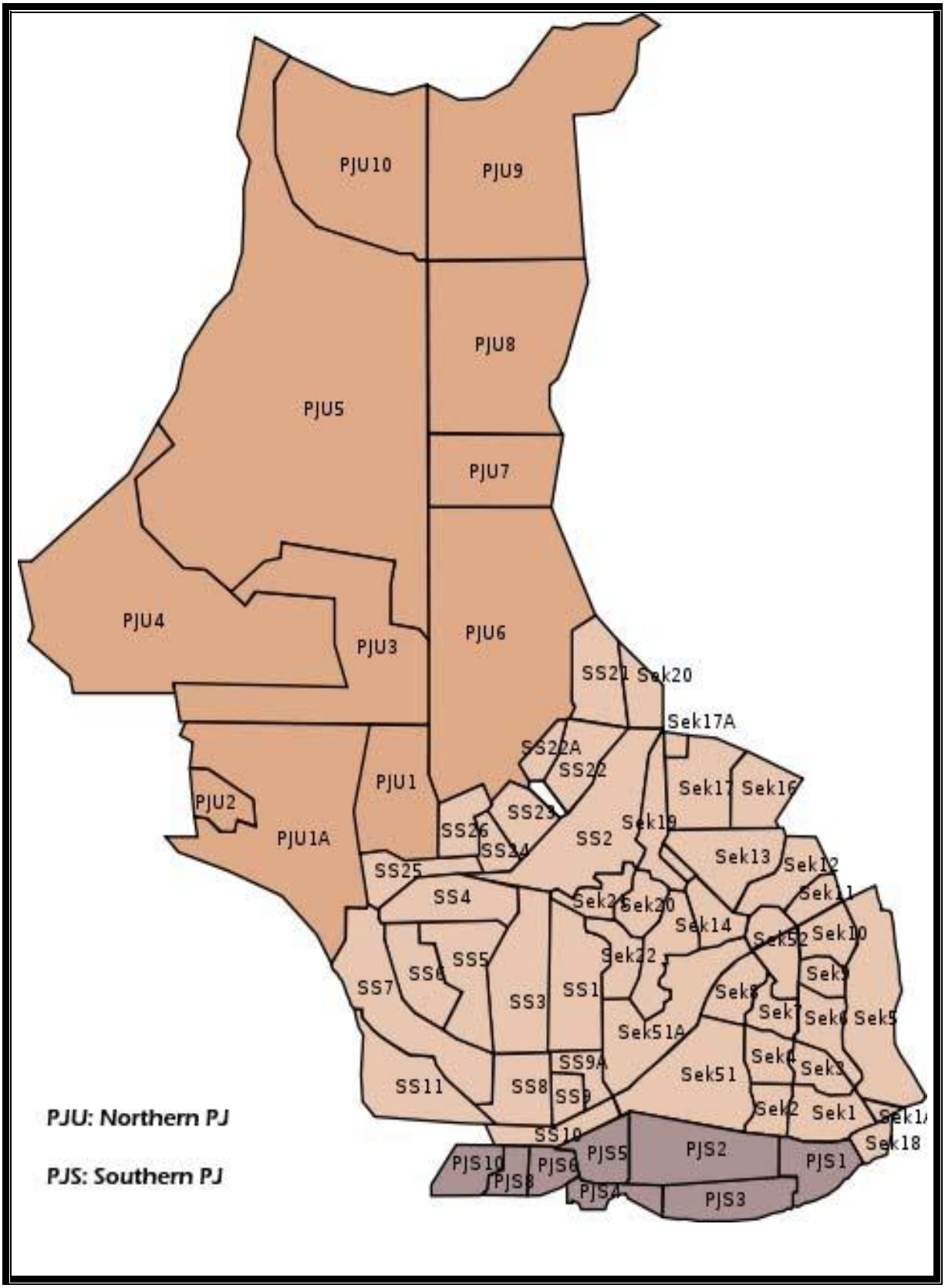


Figure 3.2: Petaling Jaya Sections

3.3.3 Sampling

The sample size was determined using the sample size formulation by Yamane, (1983) to justify the selection of samples necessary to give significant results (Appendix I). The data was obtained from MBPJ in 2011. Since the population of PJ was 631,150, it was reasonable to have 400 samples. According to Yamane (1983), the sample yields a 95 percent confidence level or a standard error of 5 percent gives a probability of less than 5 percent or $p< 0.05$. Therefore, in the results of the study, if the probability is a 0.05 or lower, the relationships can be said as significant (Aron and Aron, 1997). A sample size of 400 representatives (Table 3.1 and Appendix J) were selected based on cluster sampling from residential area of each four main parts of Petaling Jaya; by considering the sample size formulation of Yamane, (1983) and the population, 89 samples from sections, 124 samples from SS, 97 samples from PJS and 90 samples from PJU where selected, which refer to the distribution of population. According to data from MBPJ, collection of waste from these residential areas is carried out once in two days. It is basically characterized by house to house collection. In this study, wastes at the source points were collected from selected houses within PJ residential area for one week to determine daily waste quantity and the composition.

Table 3.1: Respective Sample Representation

	Source description	**Source Population**	**Sample Size (number of household)**
1	Section 1-52	140637	89
2	SS 1-26	196116	124
3	PJS 1-10	152311	97
4	PJU 1-10	142086	90
Total		**631150**	**400**

Sampling process:

Sampling from residential communities in each section of PJ was done according to the following processes:

1. Each selected house was identified with codes where sampling bags which have been labeled accordingly were provided to the households (Plate 3.1).

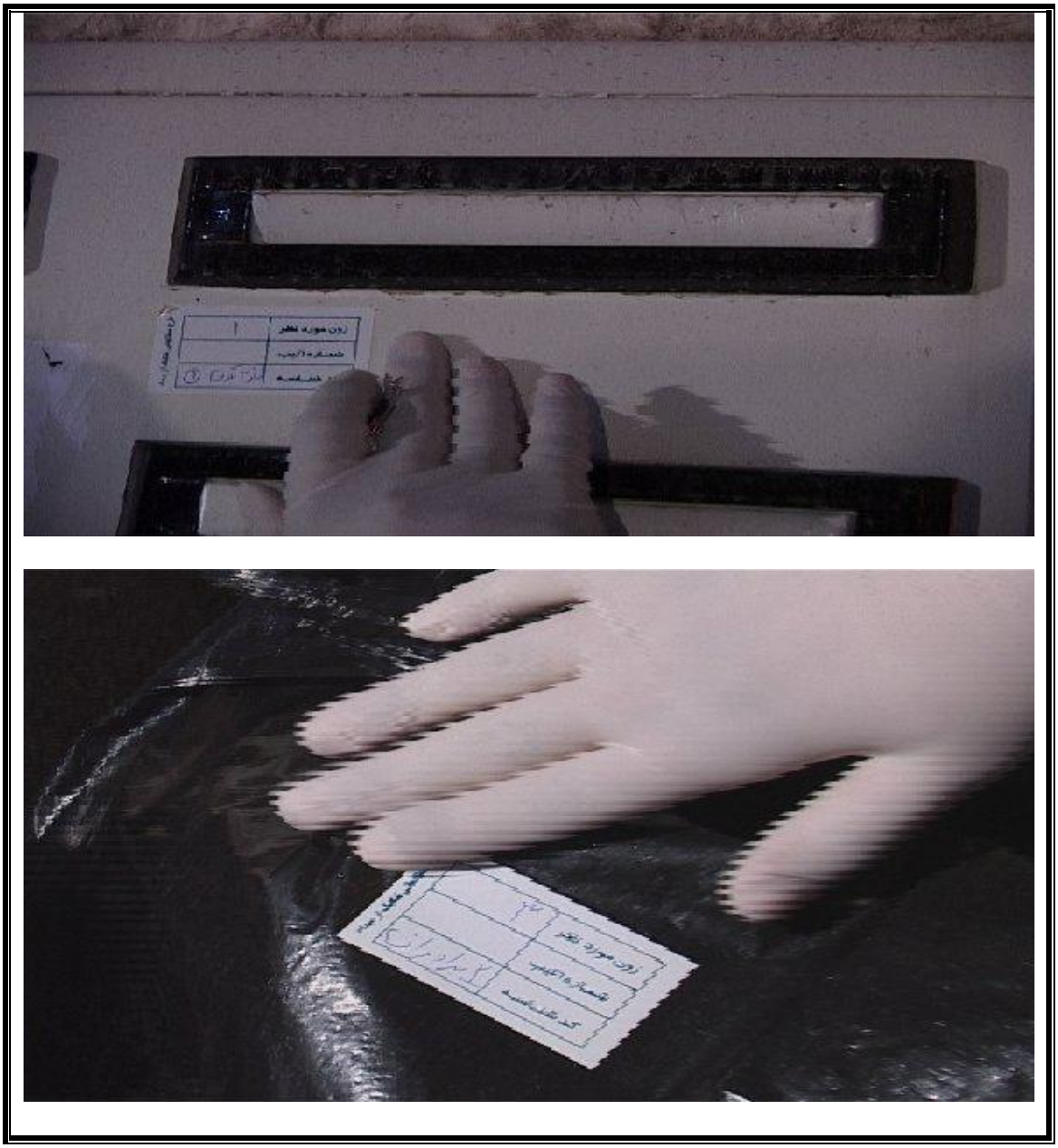


Plate 3.1: Labeling for Identifying Samples from Houses

2. The wastes were separated into two categories namely wet and dry waste by the household. Waste was collected immediately once it was placed outside the house for disposal. The time of collection was agreed earlier with the cooperation of the residents (Plate 3.2).

Plate 3.2: Label on the Sampling Bags

3. This study analyses the amount of waste generated at source by taking into considerations the actual composition. Wastes from each household are taken to a designated place and separated according to different types, namely paper, plastic, cardboards, textiles, and food organic wastes. They are weighed separately with details given more on plastic waste (Plate 3.3).

Plate 3.3: Segregation and Weight Measurement of the Wastes

3.3.4 Survey Instruments: Questionnaire

Having outlined the objectives and scope of the study, a list of questionnaires was developed accordingly (Appendix K) in both languages, i.e. Bahasa Malaysia and English to ease the process of understanding. The questionnaires consisted of 55 open-ended questions. The types of topics covered included the demographics of the respondents, as well as, public opinions on recycling, environmental issues, existing management problems, plastic recycling programs, actual recycling activities, and the weights and compositions of household wastes. The survey was conducted personally from house to house. These questions are analyzed statistically. Thus, the questionnaire covers:

- Demographic and social background of respondents in PJ such as gender, age, ethnic group, education level, occupation, income, family size and type of dwelling;
- Attitude towards awareness of environment issue such as recycling, reuse and reduction of plastic;
- Household waste management including quantity of waste, waste separation, storage facility and collection, type of waste, and knowledge and attitude of household wastes.

The attitude dimensions towards recycling are taken directly from questionnaires. The sampling and questionnaires were conducted concurrently to gain a more accurate response and a higher response rate.

3.3.5 Instrument Validity and Reliability

Since the current study is a qualitative research, it was necessary to assess the validity and reliability of the questionnaire. In qualitative research trustworthiness and understand are the main important factors. Trustworthiness is related to credibility, transferability, dependability and conformality. Understanding is related to descriptive validity, interpretive validity, theoretical validity and evaluative validity. There some strategies in order to facilitate the process of assessing trustworthiness and understanding of findings. The researcher tried to attend in research site in order to give the best perception about study. And identify pervasive qualities and atypical characteristics. The other criteria which was important in the current study was providing data and information from different sources such as (MBPJ, MPMA article, film, etc). All detailed descriptive data was provided to compare the findings of current

study with other studies which were done in different context. During the process of data collection, data analysis and interpretation external auditor with relevant background examined the whole processes.

3.3.6 Data Analysis

Analysis of data for waste compensation was manually carried out and graphical and statistical representations were based on Microsoft Excel. The Statistical Package for Social Sciences (SPSS) software was used to analyze the results of questionnaires.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 INTRODUCTION

The waste composition studies in Petaling Jaya (PJ) were conducted to determine the rate of plastic waste generation, as well as, respondents' opinion to improve plastic recycling. The analysis also focused on:

a) Waste composition especially plastic waste generated by householders

b) The respondents' attitudes and their perceptions towards recycling

c) The effects of demographics (i.e., age, race, education, family income, marital status), as well as, other explanatory variables (i.e., family size, years living in the housing unit, ownership status, and concern for recycling) on respondents' recycling activities (i.e., selling and reuse of plastic, and home separation activities) and the amounts of household wastes.

4.2 WASTE COMPOSITION IN PETALING JAYA

The result of the study indicated that the waste components in PJ include 42% organics, 24% paper, 21% plastic, 4% glass, 4% metals, 1% textile, and 4% of others (Figure 4.1).

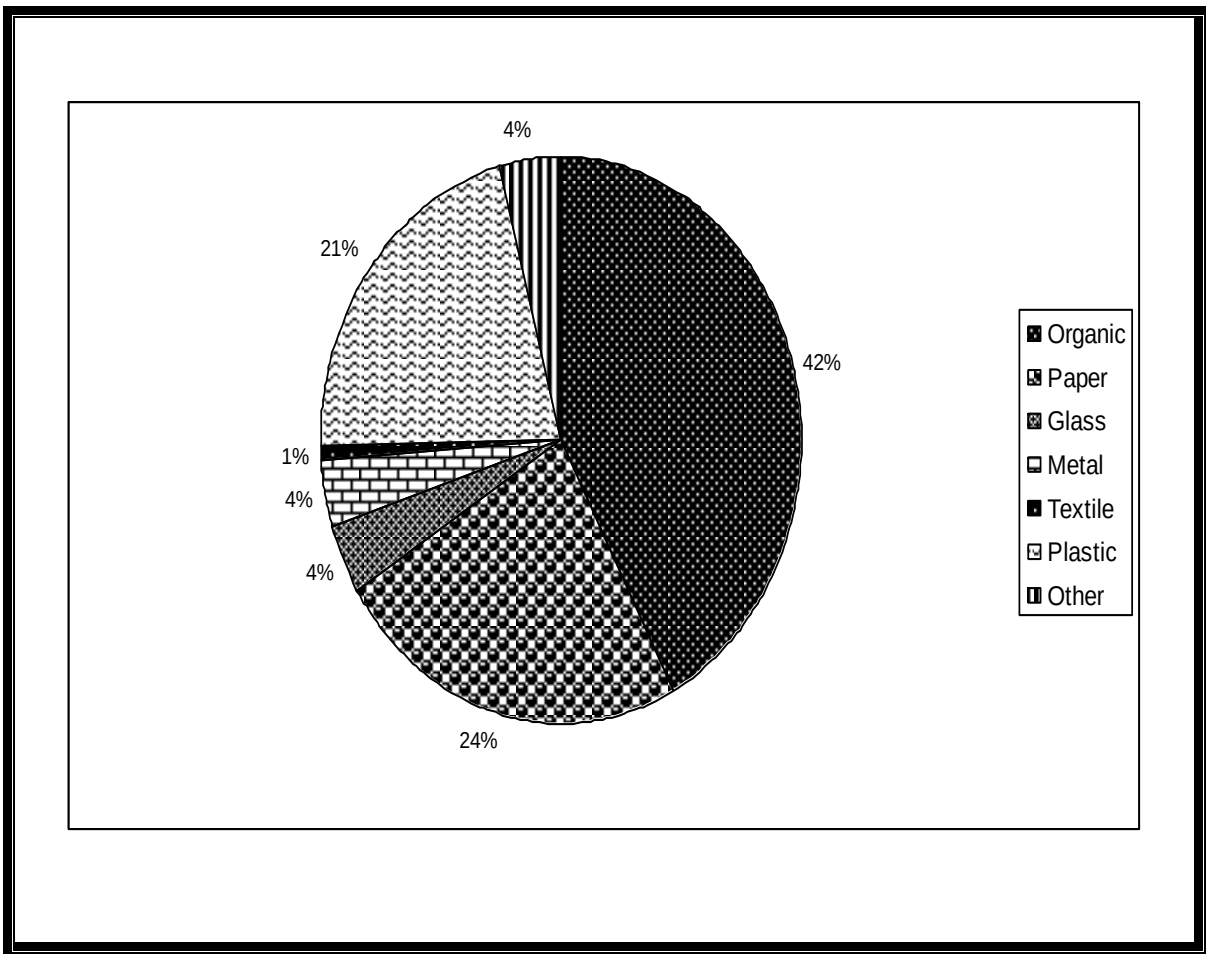


Figure 4.1: Average Waste Component in PJ (% FW)

Organic waste constitutes the highest percentage of municipal solid wastes (MSW) in PJ. This might be due to the habits of frequent cooking and quantity of left-over foods; thus, organic waste contributes nearly half of the total waste stream. The results were found to be similar to the previous findings that show that organic waste forms the highest portion of the MSW stream (Mohamad *et al*., 2009; Agamuthu *et al.,* 2004; Fauziah *et al.,* 2004; Mohd.Badruddin, 2004). Similarly, organic waste has been known to be the core of waste components in developing countries like Malaysia, Cuba, and etc. (Claudia and Mosler, 2007; Agamuthu *et al*., 2004; Fauziah *et al*., 2004). Organic component is potentially suitable for conversion to compost. In Malaysia, composting is marketable in landscaping and other agricultural sectors. Application of compost can

reduce substantial cost in waste disposal (Agamuthu *et al.,* 2004; Agamuthu, 2001; Juzhar, 2002; Mohd. Nassir, 1996).

The second highest percentage of waste generated in PJ was paper, averaged at 24%. This may be due to the purchasing power and lifestyle of people. Paper is widely used in PJ which includes newspapers, magazines, reusable cardboard packages, and food containers in fast-service restaurants. Therefore, the quantity of paper-based wastes generated was also high. This is agreeable with findings in many rapidly developing countries such as China (Ackerman, 2005). A comparison of paper-based wastes generated in PJ in 2003 (Kathirvale et al., 2003) and the one from this study in 2011 showed no significant change in quantity ratio. This might be due to the fact there were not much changes in the pattern of paper usage from 2003-2011.

Plastics were the third highest composition generated by household in PJ with 21% of the total waste stream (Figure 4.1). The result of the study in PJ showed that around 42% of plastics in MSW is PET. Through observation and sampling plastic such as soft drink and detergent bottles, food wrappings, ice cream boxes and others can be easily separated from other waste components. Among the domestic users, plastic was abundantly used because it can be obtained easily and it is cheap. As for PET usage, it is highly favored since PET bottles have high strength against impact and they will not break easily (Najafi *et al.,* 2006; Omrani, 2005). The high percentage of plastic bottles and packaging materials probably is due to its wide use in PJ area and the increasing demand. The percentage of plastic waste is considered high (21%) and is typical of a fast developing nation (Agamuthu, 2001). Though landfilling is the utmost method of waste disposal in Malaysia, sending plastic waste to landfills not only caused a loss in

the economic value but also gave negative influence to the environmental wellbeing. Therefore recycling of plastics should be encouraged as a step to improve on the existing 5% level of recycling in Malaysia to a higher percentage.

Also, there is a significant variation over the quantity of plastic wastes generated in this study (21%) when compared to quantity generated in 2003 (9%) from PJ (Figure 4.2) (Kathirvale *et al.*, 2003). This might be attributed to increased population, changes in economic status, some attitudinal variation/ lifestyle etc.

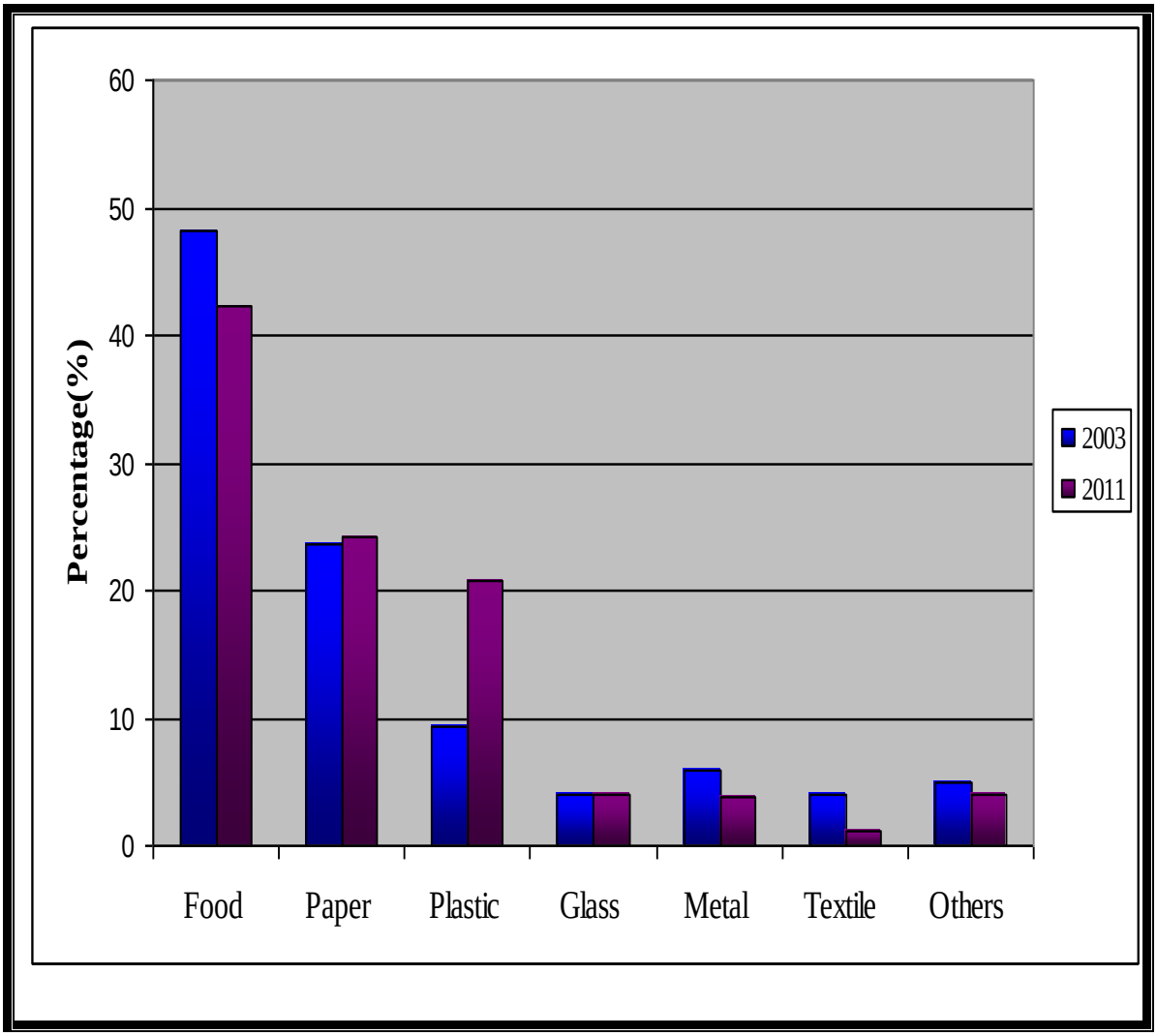


Figure 4.2: Relative Comparison of Waste Composition (% FW) in PJ.

Source: Kathirvale *et al.*, 2003.

From the waste composition study, PJ is one of the fastest developing urban areas in Malaysia. The degree of waste generation is high due to associated residential and industrial activities. The results indicated that MSW in PJ has a good recyclability potential especially for plastics waste based on the total plastic percentage which is 21% (Figure 4.1). The study indicated that though recycling activity in PJ is rising, yet significant quantity of plastics (60%) are still dumped at the landfill sites. This is due to insufficient attention from the authorities towards plastic recycling.

Basic background information of the survey respondents is discussed in the following section.

4.3 INDEPENDENT FACTOR IN SURVEY

400 respondents between 20 to 55 years of age were interviewed and this consisted of 33% male and 67% female (Table 4.1).

Table 4.1: Frequency of Respondents' Gender in PJ Area

		Frequency	Percent
Valid	Male	126	33.0
	Female	255	67.0
	Total	381	100.0
Missing	System	6	
Total		387	

They were further categorized into students, housewives and workers. Ethnical group in PJ area were 37% Malays, 43% Chinese, 17% Indian, and 3% others (Table 4.2).

Table 4.2: Frequency of Respondents' Ethnicity

		Frequency	Percent
Valid	Malay	141	37.0
	Chinese	163	43.0
	Indian	67	17.0
	Other	12	3.0
	Total	383	100.0
Missing	System	4	
Total		387	

Chinese residents formed the greater percentage of total respondents in the study area. Table 4.3 summarized the background information of the respondents in the study area based on the majority group (Appendix L).

Table 4.3: Brief Description of the Majority Group among Respondents

Area	**Age range**	**Profession**	**Income**	**Education level**
Petaling Jaya	20-55	Student Employer Housewife Employee	RM 300-2000	SPM/STPM and tertiary education

The survey indicated a strong influence between income and waste quantities in PJ area. Higher income groups tend to consume more products and thus generated more wastes (Mohd.Badruddin, *et al*, 2006; Agamuthu, 2001, 1997; Mohd.Razman and Sabarinah, 1994; Mohd Nazri, 1994; Ahmad Termizi and Fadil, 1992). This study indicated that respondents with big families and those who cooked more often at home generated more wastes. The result disagrees with Kemper and Quigley (1976) who found insignificant effect of family size on the waste amount generation. Some believe that factors such as income, age and gender, as well as, housing and ownership did not appear to be important explanatory variables in a study area (Mohd. Nazri, 1994; Ahmad Termizi and Fadil, 1992; Rahim, 1992; Richardson and Havlicek, 1978; Wertz, 1976; Kemper and Quigley, 1976).

4.3.1 Public View on Plastic Recycling Concept

Based on the question proposed in PJ area among residents when asked whether they have heard or even read about plastics recycling, 67% of the participants responded "yes" that they have read and heard about plastics recycling (Table 4.4). The positive response might be attributed to media advertisements, literacy levels of respondents and exposure to such practices from other nations. However, this is not to conclude that those that said "No" were illiterate, rather might be ignorant of their immediate environment and its associated awareness programmes/ concerns.

Table 4.4: Public's Awareness of Recycling Concept

		Frequency	Percent
Valid	No	127	33.0
	Yes	254	67.0
	Total	381	100.0
Missing	System	8	
Total		389	

With regards to the public perception and behavior towards recycling practices, this finding indicated that even though majority of the respondents in PJ knew the meaning of recycling, only 22% of respondents practiced it (Figure 4.3). This most probably was due to citizens' lack of awareness on the importance of plastic recycling (Refsgaard and Magnussen, 2009). This might also be associated to insufficiency of facilities, including collection schedule or inappropriateness in the location of recycling facilities (Agamuthu *et al.*, 2009). Continuous awareness creation programs can encourage the existing recyclers while the ignorant ones can as well be encouraged to start the recycling exercise. Recycling which serves as an income generator can also be a motivating factor to the residents (Chenayah *et al.,* 2007).

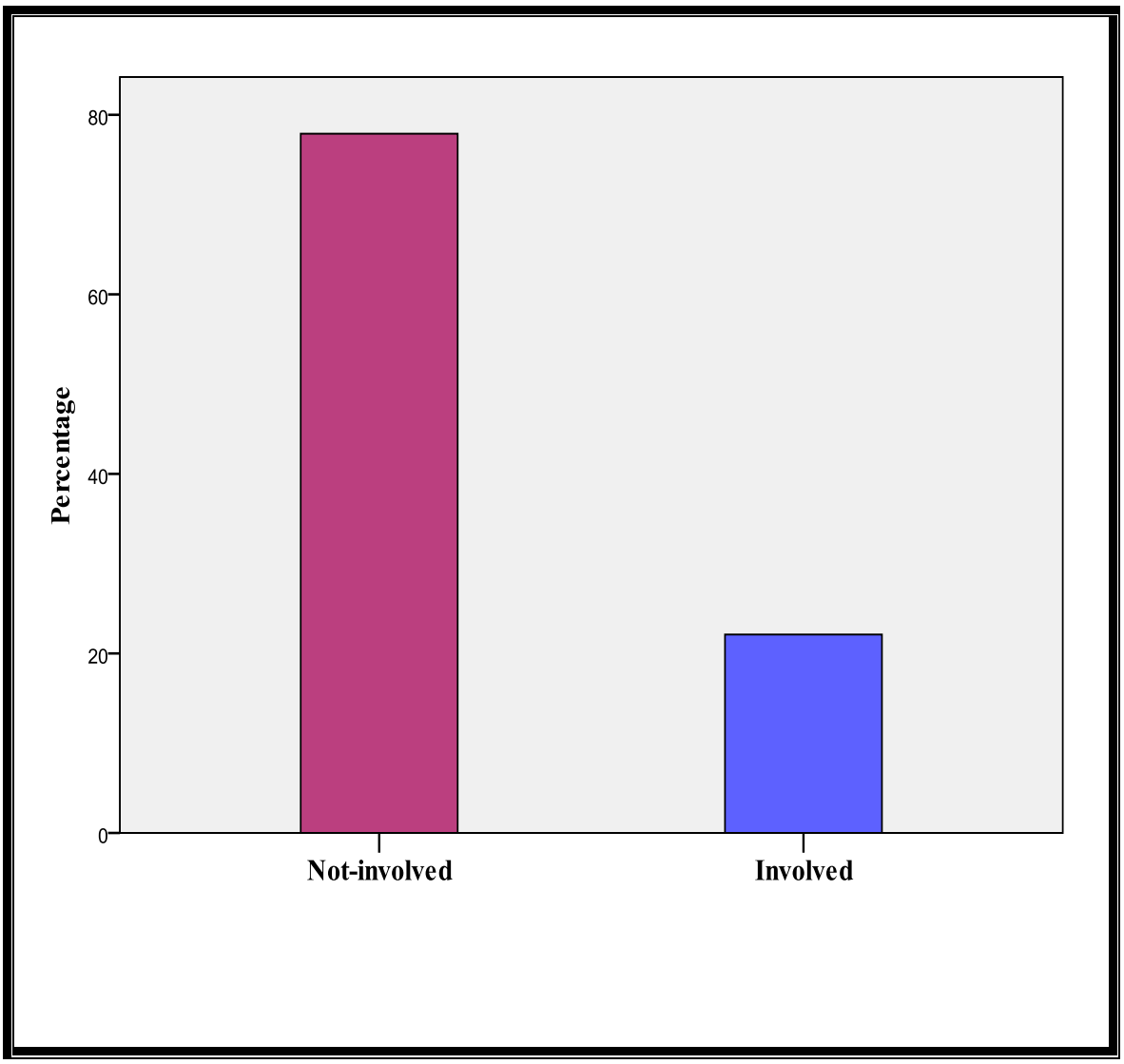


Figure 4.3: Citizens' Involvement in Plastic Recycling in PJ

In accordance with the participants that know the meaning of recycling, it can be inferred that majority had not heard or even read of plastic recycling from different sources. Hence, the findings showcased newspapers as the main source of information for about 35% of respondents. Table 4.5 detailed the respondents' various sources of obtaining information about recycling.

Table 4.5: Sources of Information on Recycling

		Frequency	Percentage
Valid	Newspapers	132	35.0
	Magazines	43	12.0
	TV	108	29.0
	Radio	50	13.0
	Leaflet drops	32	9.0
	Other	9	2.0
	Total	374	100.0
Missing	System	15	
Total		389	

The result of the study indicated that on average, 55% of respondents knew about plastic recycling through advertisements in the newspapers, magazines and leaflet drops, namely of reading material. About 42% of the respondents pointed out that television and radio advertising are the best way of getting information on plastic recycling. The rest of the respondents (2%) pointed out that they got information about recycling via billboards and advertisement in buses and LRT stations. They may be getting the information while using the public transport. Similarity, they might have gotten informed via witnessing open campaign programmes or road shows. However, integrated use of all media can increase public participation which is agreeable with Abdelnaser et al (2006a).

The liner regression was used to test and show the degree that family size, marital status and occupation can predict the getting information about plastic recycling. The summary of results is provided in Table 4.6. The analysis indicated that family size is statistically significant predictor of getting information about plastic recycling in the population (B=0.615, t = 4.343, p< 0.05, R2 Adjusted = 0.358). It means that about 39% of the variance in getting information about plastic recycling can be explained by family size in the population.

Table 4.6: Relationship between Family Size and Getting Information about Recycling

Variable			
IV	Beta	t-test	Sig
Family size	0.62	4.34	0
R2	0.38		
Adjusted R2	0.36		

Liner regression was used to test and show the degree that occupation can predict the getting information about plastic recycling. The summary of results is provided in Table 4.7. The analysis indicated that occupation is a statistically significant predictor of getting information about plastic recycling in the population, (B= 0.591, t = 4.081, p<0.05, R2 Adjusted = 0.329. About 32% of the variance in getting information about recycling can be explained by occupation in the population.

Table 4.7: Relationship between Occupation and Getting Information about Recycling

Variable			
IV	Beta	t-test	Sig
Occupation	0.591	4.081	0
R2	0.350		
Adjusted R2	0.329		

It means that residents with occupation that have big family size tend to be more interested in getting information on the recycling of plastics. The result showed that citizens with different types of occupation have different willingness to get information from different sources. Employers and students are more willing to get information from the newspaper while also housewives are more often get information from TV programmes and magazine. In contrast to mentioned group (employer, student and housewife), employees prefer to get information about plastic recycling via radio. This might be due to the nature of their job which does not give them enough time for reading or watching magazine, newspaper and TV programmes. Other parameters such as education, income and marital status have no significant effect on getting information about plastic recycling from a different source. The reason might be based on the lifestyle and behaviours of the respondents in PJ area.

4.3.2 Actual Recycling Activities

This study indicated that 38% of respondent segregate recyclable materials. Majority of respondents (62%) did not separate their wastes (Table 4.8). These respondents point

out that they do not know how to segregate waste for recycling purpose. They also do not know what they do with separated waste and where they should deliver their wastes.

Table 4.8: Waste Separation Practices among Respondents

		Frequency	Percentage
Valid	No	239	62.0
	Yes	148	38.0
	Total	387	100.0
Missing	System	2	
Total		389	

Recycling as a long-term strategy aims to transform the "throw-away" culture to that of a "conserving" one (Omran, 2008). In this regard, the MBPJ authority has implemented some programs to enhance recycling. The efficiency of a recycling program is dependent upon several requirements including adequate data on citizens' experience, understanding of recycling activities, and positive attitudes of residents about recycling. Most of these are still lacking in PJ.

On average, 37% of respondents indicated that they segregate recyclable plastics (Figure 4.4). This is a reflection of respondents' willingness to recycle plastics based on their ability to segregate. However, such response is poor considering the fact that the daily rate of utilizing recyclable plastics is high. The respondents therefore might not

have much willingness to segregate recyclable plastics due to absence of immediate market.

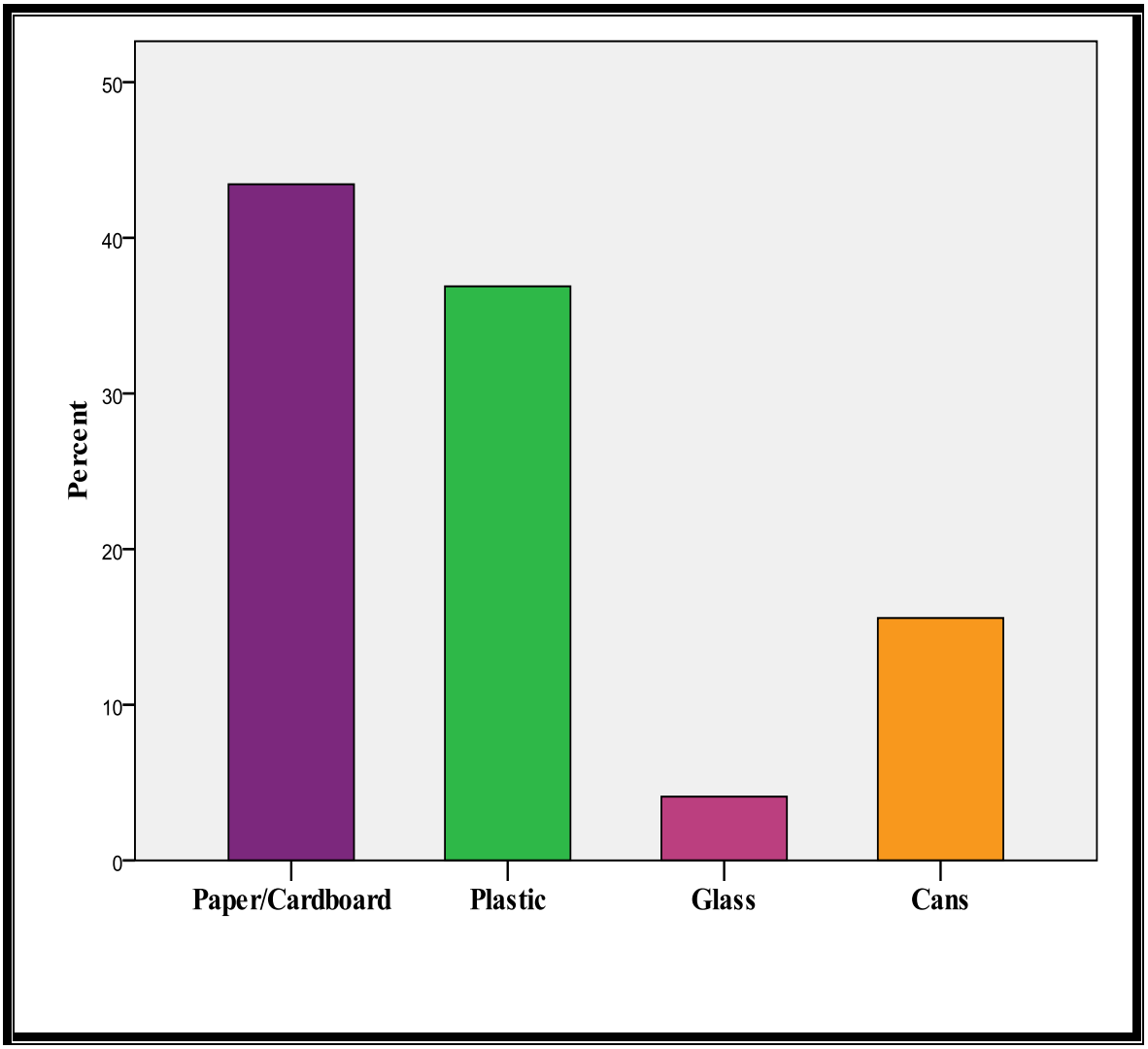


Figure 4.4: Type of Waste Being Recycled by Respondents

Based on the linear regression (Table 4.9), personal factors such as marital status (a beta value of 0.192) as well as family size (a beta value of 0.166) influence the home separation of wastes among PJ households. Married residents and those living in a big family were more involved in sorting of waste. Other parameters such as age and education do not influence the home separation activities as identified in this study.

Table 4.9: Descriptive Statistics on Home Separation of Wastes in PJ

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-0.556	.105		-5.286	.000
	Marital Status	.175	.039	.192	4.527	.000
	Family size	.115	.029	.166	3.913	.000

4.3.3 Recycling Issues and Solutions

When respondents were asked to give the best description of why citizens did not participate in recycling activities, 39% of the respondents indicated that the level of public awareness on recycling activates can be the main reason of their non-participation in plastic recycling (Table 4.10). This agrees with Imam et al. (2007) that opined that the public can play important role in promoting efficient, financially sound and technically competitive recycling activities. This is where a more active participation is required. The respondents in this study agreed that an appropriate public awareness and participation is required for the enhancement of collection and sorting of recyclable plastic.

Table 4.10: Public View on Recycling Issues

		Frequency	Percentage
Valid	Non-satisfaction from waste management service	83	22.0
	Citizens' lack of awareness on recycling activities	146	39.0
	Lack of education	136	36.0
	Other	10	3.0
	Total	375	100.0
Missing	System	14	
Total		389	

The result indicated that 36% of respondents refer to lack of education as one of the non-cooperative reasons in recycling activities. Educating individuals about what, how, and where to recycle is important. In fact, this is in accordance with Rotter (1954) that said such people believe that their participation in recycling would not make a difference. These individuals may need more persuasion to engage in recycle. Thus it is vital that individuals are aware of the reasons for recycling and the positive impact that recycling has on the environment. Thus, improving education on plastic recycling is very necessary as education allow public to know how to identify and separate types of recyclable materials; hence their ability to participate in plastic recycling activities can be improved. Therefore, public communication, awareness and education systems need to be conducted more effectively.

The remaining 22% of respondents were dissatisfied with the waste management services (WMS).

On average 78% of respondent were satisfied with the WMS. This indicated that satisfaction with WMS can be one of the factors of public cooperation in recycling plan. The citizens with high satisfaction with WMS can cooperate in recycling plan voluntarily. Citizens' lack of confidence in WMS resulted with lack of cooperation in waste collection services. It might be as a result of improper methodology in the WMS to increase public awareness over the past years. If the citizens are not satisfied with the WMS, it might be difficult to convince the public to participate in the recycling activity.

Liner regression was used to test and show the degree that education can predict the public attitude toward plastic recycling. The summary of results is provided in the Table 4.11. The analysis indicated that education statistically significant predictor of the public attitude toward plastic recycling in the population, ($B= 0.410$, $t = 2.417$, $p<0.05$, $R2$ Adjusted= 0.139. About 13% of the variance in the attitude toward recycling can be explained by education in the population.

Table 4.11: Relationship between Education and Attitude toward Recycling

Variable			
IV	Beta	t-test	Sig
Education	0.410	2.417	0.022
R2	0.168		
Adjusted R2	0.139		

Liner regression was used to test and show the degree marital status can predict the attitude toward recycling. The summary of results is provided in Table 4.12. The analysis indicated that marital status is statistically significant predictor of the attitude toward recycling in the population, (B =0.616, t = 4.216, $p<0.05$, R2 Adjusted=0.359). About 35% of the variance in the attitude toward recycling can be explained by marital status in the population.

Table 4.12: Relationship between Marital Status and the Attitude toward Recycling

Variable			
IV	Beta	t-test	Sig
Marital status	0.616	4.216	0
R2	0.380		
Adjusted R2	0.359		

It means that residents who are highly educated show more interest in plastics recycling. Thus, positive attitude towards recycling is closely related to the increased level of education. This study showed that highly educated groups can understand the necessities of certain action easily as compared to the less educated group (Irina *et al.*, 2004). Similar finding is obtained between participation in recycling and marital status, where married respondents are more positive towards recycling as compared to the not married respondents. Other parameters such as occupation, race and family size have no significant effect on the public attitude toward plastic recycling.

The respondents were also asked of their opinions on how public participation in recycling can be improved. The majority of respondents agreed that more facilities need to be provided and also monetary incentives can encourage recycling participation. In fact, recycling group should be encouraged by monetary incentives and more effort is needed to educate the people on the need and importance of recycling.

Based on the study, respondents when asked on ways to encourage the public to recycle suggested that providing more user friendly facilities can encourage public participation in recycling. Generally the perception was that recycling information is easily available and that sufficient and user friendly recycling facilities is important to make recycling a success (Agamuthu *et al.*, 2009).

When asked whether they will recycle in the future, if all facilities are provided, 86% of the respondents said that they would participate (Table 4.13).

Table 4.13: Respondents' Willingness to recycle if Recycling Facilities are provided

		Frequency	Percentage
Valid	No	52	14.0
	Yes	329	86.0
	Total	382	100.0
Missing	System	7	
Total		389	

Therefore, available facilities can increase public willingness to participate in recycling activities (Agamuthu and Fauziah, 2007). Furthermore, public opinions and attitudes have been cited to be an important part of an effective recycling program (Lokman and Fadil, 1992; Anderson, 1999). In the case of PJ, there is an urgent need for an improved public attitude. Creating public awareness will overcome problem on the general belief held by the public that it is the government's responsibility to ensure cleanliness (Gohari, 2007; Bontoux *et al*., 1996). This public participation concurs with study by Thomas (2001) which emphasized the importance of public understanding in enhancing participation rate. The planning and designing of future recycling systems may be made easier if a clear understanding of the public expectations and perceptions of institutional practices is achieved, as well as, the pattern of waste generation and composition.

When asked about the future of recycling in Malaysia, approximately 84% of the respondents generally agreed that Malaysia can achieve the recycling target of 22% by 2020 (Table 4.14).

Table 4.14: Respondent Agreement on the Achievement of 22% Recycling in 2020

		Frequency	Percentage
Valid	strongly agree	24	6.0
	Agrees	301	78.0
	Disagree	44	11.0
	Strongly disagree	18	5.0
	Total	387	100.0
Missing	System	2	
Total		389	

This is based on the perceived willingness of citizens to embank on source separation. They agreed that the level of plastic recycling in Malaysia will increase in future. Only 16% of the respondents disagreed with this perception. This small group of the respondents disagreed that the existing level of recycling in Malaysia is high and have negative view about improvement of plastic recycling in the future. They pointed out that the existing low consciousness for recycling will be the main factor, as well as, the lack of government efforts.

4.3.4 Factors that Influenced Citizen's Participation in Plastic Recycling

Participation of citizens can improve recycling activities. There are many reasons that affect citizens' non-cooperation towards plastic recycling. With regards to the survey in PJ, two main obstacles namely, government inability to provide basic facilities and the public ignorance themselves were identified. Citizens normally expect provision of

facilities from the government organizations. Thus, the frustration on the unavailable facilities can be translated into their refusal to participate in recycling activities. This hinders the progress of plastic recycling. From Table 4.15, about 31% of the respondents claimed that the lack of recycling bins is the factor that led to their non-cooperation in recycling.

Table 4.15: Issues of non-participation in Plastic Recycling

		Frequency	**Percentage**
Valid	Lack of space to collect plastic waste	80	21.0
	Lack of education	145	38.0
	Lack of recycle bins for separation	118	31.0
	Ignorance	39	10.0
	Other	2	1.0
	Total	384	100.0
Missing	System	5	
Total		389	

This group of respondents suggested that government should make recycling easier by placing more recycling bins in residential areas, particularly outside apartments' area in order to solve some of the related problems such as lack of space for collection of waste. They agreed that recycling bins need to be differentiated by colors, i.e., blue (papers), brown (glass), and orange (cans and plastics) should be better situated around

the city. When respondents who are interested in recycling have bins near to their home, they appear to be willing to recycle more fractions than when they have to walk for a longer time to drop off the waste, due to the inconvenience of carrying the large volumes of waste this type usually occupies.

The small group of respondent in PJ with 21% refers to the lack of space to accumulate waste as another factor for not recycling. Due to the lack of space in apartment residency, separation and collection of the recyclable waste is a problem. Although there is awareness of environmental issues, 10% of respondents ignore it. This group of respondents indicated that inconvenience as the reason for their non-participation. It is also interesting to note that a smaller percentage (1%) of the non-participating respondents indicated that they believed that recycling only waste time (Omran *et al.*, 2009).

With comparison between different dwelling residencies and the reasons for respondents' non-cooperation with plastic recycling, the result showed that lack of education for waste collection is one of the problems of faced by those recycling in apartment, terraces and bungalow. Similarity the respondents opined that lack of space is another obstacle that negates participation in plastic recycling. However, lack of recycle bins was also difficult to only respondents staying in terrace dwellings (Figure 4.5).

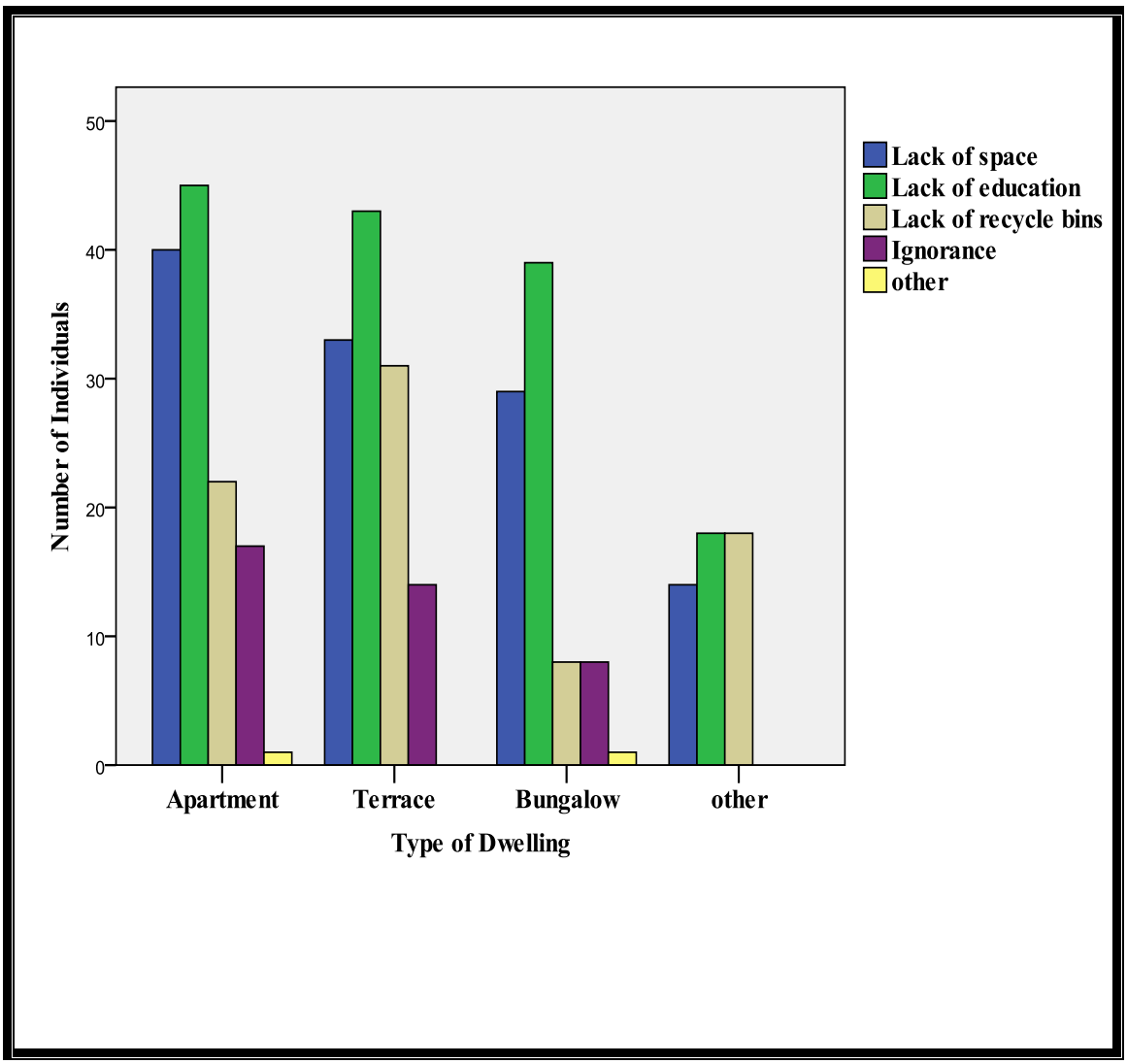


Figure 4.5: Relationship between Diverse Dwelling and Issues Related to Plastic Recycling

Length of stay has influence over residents' cooperation in recycling activities in the study areas. The result of regression linear test (Table 4.16) indicated that those who have been staying their homes for a longer period of time tend to be active cooperators in recycling, particularly in recycling of plastic and home separation of wastes. The significant level is high, in the case of selling of plastic waste among PJ residents (a beta value of -0.112), with a p value < 0.05, i.e., significant at 95 percent confidence level. Respondents with high income have more cooperation to recycle plastic. Unlike

the correlations on the length of stay and income with residents' cooperation, types of dwelling have no significant relationship with residents' cooperation.

Table 4.16: Plastic Recycling with Period of Tenure

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.849	.349		5.302	.000
	dwelling	-.059	.049	-.062	-1.205	.229
	Income	.161	.074	.111	2.155	.032
	Length of Stay	-.074	.034	-.112	-2.173	.030

The finding of this study is also supported by Read (1998) who proved that the success of a recycling scheme depends largely on the public's participation. It also availed the need to understand the respondents' frequency of plastic collection which actually buttresses the participation.

4.3.5 The Frequency of Plastic Collection

The result of the study in PJ indicated that 46% of respondents who are employees and students preferred collection of recyclables once a week (Table 4.17). Both groups (employees and students) claimed that they do not have enough time to deliver recyclable waste during the week; hence they preferred collection of recyclables once a week rather than daily collection. This might be due to the nature of their job which does not give them enough time to observe day-day recycling activity.

Table 4.17: Preference of Plastic Waste Collection Frequency

		Frequency	Percentage
Valid	Once a week	177	46.0
	Twice a week	106	28.0
	Three times a week	76	20.0
	Every day	14	4.0
	Other	9	2.0
	Total	382	100.0
Missing	System	7	
Total		389	

About 28% of respondents particularly apartment residents, housewives and those living in a big family preferred twice a week collection of plastic waste. This group of respondents pointed that keeping the recyclable waste for a long time at home is very difficult because recyclable wastes such as PET bottles take huge space. For this reason, they suggested that their recyclable waste is better to be collected as frequent as possible.

The smallest group of respondents (20%) preferred thrice a week collection. This group of respondents noted that more frequent collection tends to increase recycling intensity. They suggested that they can collect more plastic materials to get more incentives fees. However, it seems that plastic collection three times a week is difficult because of the

cost (labor and transportation). It is important to minimize the travel times and distances of the collection and transferring vehicles in order to improve cost efficiency.

The remaining respondents' (4%) preferred day to day collection of recyclable waste. Hence, this result agrees with Hormuth et al. (1993) and Zimmerman (1989) that supported provision of daily collection facilities to enhance day-to-day collection of recyclable materials which includes plastics.

Therefore, it can be deduced that recycling program may be used to reduce the cost of waste disposal. However, the revenue obtained from the implementation of recycling may fluctuate with the market price of recyclables such as plastic, paper, metal and others with high revenue generation potential (Agamuthu *et al.,* 2009).

4.3.6 The Control of Plastic Waste Generation

The public needs complete and clear information regarding the trends in waste generation, as well as, benefits and effects of source reduction, recycling and reuse. Recycling behaviors and household waste generating behaviors are necessary for designing and planning an effective plastic material reduction from MSW in the near future.

People's participation in 3Rs initiative is anticipated to function in an integrated manner. The result of the study on waste generation control in PJ indicated that majority of respondents (60%) preferred to throw away their waste. However, in PJ, 13% of respondents reuse their products, whereas 19% of respondents recycled their wastes. Only 8% of them prefer reduction (Table 4.18).

Table 4.18: Method of Waste Disposal Practice among Respondents

		Frequency	Percentage
Valid	Throw/Dispose	230	60.0
	Reduction	30	8.0
	Reuse	50	13.0
	Recycle	71	19.0
	Total	381	100.0
Missing	System	8	
Total		389	

Majority of respondents (60%) who throw away their waste rarely think about what happens after they toss their plastic bottle in a trash can instead of the recycling. This group of respondents in fact does not have enough information on 3Rs benefits. When asked why they are unwilling to recycle plastic, some of them claimed that they do not know the location of the nearest collection centers. Others pointed out that location of collection centers is too far away, and so it is easier to throw the recyclables away than to bring them to a collection centers. Thus, there is a strong need to increase the facilities in PJ to encourage public recycling ability. Therefore, a fair distribution of facilities can lead to higher recycling percentage if the facilities are easily accessible to the public (Agamuthu *et al.*, 2009).

When asked whether they knew the location of the nearest collection center for their area, 29% indicated that know some recycling centers at PJ area such as in SS2 (Table 4.19). Yet, this group complained that the collection centers could not be easily located. Without doubt, the farther the location of the collection point, the more discouraged will the householders be. Similarly, Robinson and Read (2005) found that a contributing factor for those who were not recycling was a high lack of awareness of the location of the nearest facility.

Table 4.19: Respondents Awareness on the Location of Recycling Center

		Frequency	**Percentage**
Valid	No	273	71.0
	Yes	112	29.0
	Total	385	100.0
Missing	System	4	
Total		389	

Price is another limiting factor. The result showed that most of the respondents were quite aware of the location of recycling centers but were not encouraged by the unit price of recyclable plastics when compared to unit price of metals, paper etc. These recycling centers pay only RM 0.12 per kg of plastic bottle but RM 2.50 per kg for aluminum cans. As a consequence, residents do not show any willingness to segregate plastic wastes.

Increased in price of recyclable plastics can help the council (MBPJ) to encourage waste management contractors to collect plastics from the plastic stream for recycling purpose. Apart from this, residents will be able to obtain a sizeable supplementary income by selling recyclable items to MBPJ. MBPJ should not only focus on providing facilities but also on awareness creation too. However, awareness creation without easy accessibility to the facilities is not rational. Therefore, a rational strategy should involve increase in the number of recycling facilities, as well as, simultaneous awareness creation.

The respondents were also asked of their opinions on how the situation could be improved. The majority of respondents (76%) suggested citing of local collection centers which are within the reach for each community or housing area. Some opined that if the number of these centers, as well as, payment for plastic increases, it can prompt the residents to easily deliver their plastic materials. Majority of respondents with 80 % pointed out that they were not aware of the existences of recycling centers. The result agrees with whose of Nyamwange (1996) which stated that making recycling more convenient could be an effective motivator. About 19% of the respondents prefer recycling to control waste generation.

The respondents believed that segregation at point source can increase the percentage of recyclable waste. Definitely, they might have believed and experienced that once the waste are segregated at the point generation, it makes collection of recyclable plastics easier. This help to extract all the plastics that are sent to landfills when waste is not segregated. Waste separation is the key activity in any successful 3R initiative. It is also worthy to note the importance of recycling industries or buyers in recycling wastes.

Findings indicated that the best management option for solid waste in PJ area is the integration of all options in waste management hierarchy but with strong emphasis on recycling. This option not only will reduce the waste management cost but will also serve as revenue generator from the marketable products (Chenayah *et al.,* 2007). Similar study had shown that plastic recycling application reduce the cost of plastic waste disposal (Agamuthu *et al.,* 2009).

Approximately 13% of the respondents agreed that reuse option can reduce waste generation. This group of respondents suggested that the best possible way of reducing waste is through reuse of products. Citizens should be aware of the dangers of abundant plastic waste to the environment. Therefore, reuse is preferable since plastic bottles can be kept for their own use such as to be refilled with self-made juice and other drinks. When long lasting goods are reused times and again, it offsets the production of new or same products. This saves new resources and reduces waste generation.

Another group of respondents (8%) preferred reduction of waste as one of the methods of waste generation control. Purchase and careful use of resources can reduce the pace of consumption of resources and energy (Shimizu, 2006). However, 28% of total respondents recommended that the best way of reducing plastic is by using high quality products (Table 4.20). Thus, it can be concluded that reuse of plastic materials and the use of high quality products can reduce waste generation. Some of the respondents believed that giving up past habits of unnecessary purchasing (the more purchasing as the sign of high culture) can help to reduce waste generation.

Table 4.20: Respondents' Opinion on Best Solution to Reduce Plastic Waste Generation

		Frequency	Percentage
Valid	Use of high quality products	109	28.0
	Reuse of products	189	49.0
	Giving up past habits	47	12.0
	Not wasting	20	5.0
	Other	22	6.0
	Total	387	100.0
Missing	System	2	
Total		389	

When asked whether they use their own recycled bags for shopping in market, about 37% of the respondents indicated that they use their own baskets in market when they go for shopping. Since they are aware of the importance of recycling of plastic, they prefer to carry their own basket in order to reduce the rate of the plastic bags in environment. Also, they believed that everyone should be responsible to protect the environment.

In contrast with the above mentioned group, another 63% of the respondents did not use their own basket while shopping (Table 4.21). They pointed out some reasons for not using of their own baskets. Some of them pointed out that they want to use their own

baskets but often forget to carry it. However, some of them felt that plastic bags are cheap and readily available; hence, they do not need paying for plastic shopping bags.

Table 4.21: Frequency of Respondents Who Use their Own Basket When Shopping

		Frequency	**Percentage**
Valid	No	242	63.0
	Yes	140	37.0
	Total	382	100.0
Missing	System	7	
Total		389	

The results from linear regression test showed that race (a beta value of 0.106) has a significant factor in relation to the use of own basket in market (Table 4.22). It was found that Chinese residents show more interest in using their own basket while shopping as compared to that of other ethnic groups. Other parameters such as occupation and marital status have no significant effect on the use of the own basket in market.

Table 4.22: Dependent Variable and Use of own Basket in Market

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.414	.110		12.912	.000
	Race	.063	.031	.106	2.042	.042
	Marital status	-.045	.039	-.060	-1.153	.250
	Occupation	-.022	.021	-.055	-1.056	.291

Similarly, the respondents were asked whether they have the idea that old plastic bag can be reused for shopping. About 42% of the respondent agreed that such bag can be reused whereas 58% were of different opinion (Table 4.23).

Table 4.23: Opinion of Respondent about Reuse of same bag for Shopping Time

		Frequency	**Percentage**
Valid	No	223	58.0
	Yes	161	42.0
	Total	384	100.0
Missing	System	5	
Total		389	

It might be argued that majority did not look at this issue from just the economic (loss price) point of view but may have considered the inconvenience associated to keeping the already use bag for a next- time use and having to bring it all the way to the shopping center. However the majority may have considered the degree of waste generation that will arise from incessant disposal of such plastics. Hence, they opted to reuse the bags in order to ensure the reduction of plastic waste from the total waste stream.

A chi-square test was used to show if there is any statistically significant difference between ethnical factors and income towards recycling of plastic. The racial background factor appears to be in significant than income variable in determining the recycling behavior. The Chinese and Malay respondents were found to be active recyclers only in the activity of selling of plastic in the PJ area. This ethnic variation in response may be as a result of culture and social heritage of the Malays and Chinese that allows to get involve into plastic recycling. Unlike ethnical background, income was significant with $p < 0.05$ on plastic recycling (Table 4.24). The result showed that both reselling and plastic recycling activities are familiar amongst those of lower income groups in PJ area.

Table 4.24: Effect of Ethnical Factors and Income on Recycling Behavior

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	21.613[a]	8	.006
Likelihood Ratio	22.974	8	.003
Linear-by-Linear Association	3.643	1	.056
N of Valid Cases	380		

a. 3 cells (20.0%) have expected count less than 5. The minimum expected count is .40.

Based on "waste hierarchy", the result of PJ study indicated that residents' dealing with their plastic wastes, is in the disposed process toward least favoured option. In fact, most of PJ residents (60%) are not aware of 3Rs that the majority of plastic waste is still being disposed off into the landfills. Therefore, creating awareness and encouragement of citizens toward 3Rs are crucial in preventing plastic waste from going to the landfill. Indeed, recycling can be one of the best methods to help use resources better and reduce the environmental impacts associated with disposing of waste.

4.3.7 Educational Programs for Public' Pre-cycling Behavior

The result of the study on educational programs in pre-recycling activities in PJ indicated that 50% of respondents obtained training in schools, 34% via media, 8% through educational CD, and 6% from handouts and pamphlets (Figure 4.6).

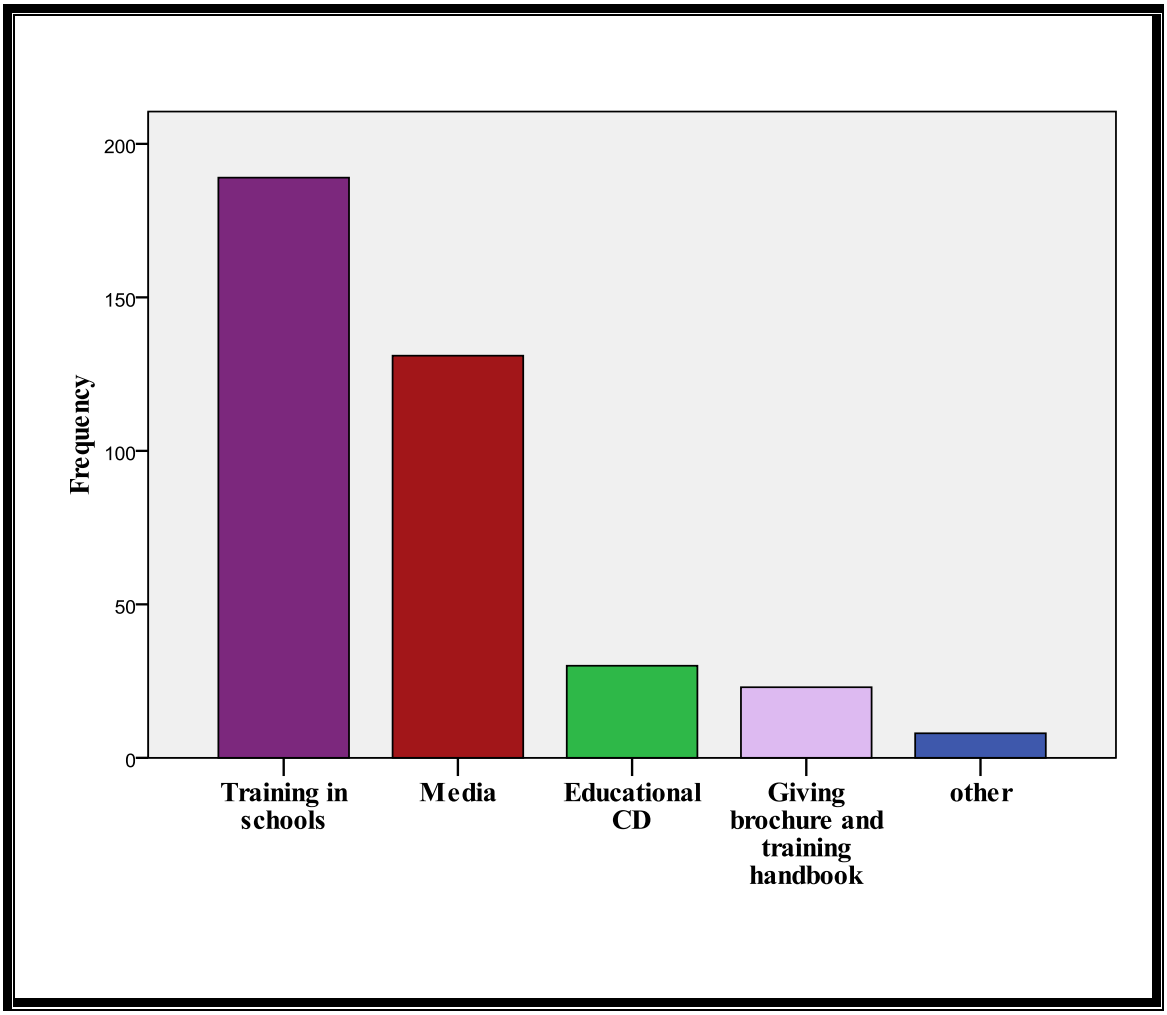


Figure 4.6: Citizen's Preference in Improving Recycling Participation in PJ

Creating awareness and motivation for the public will increase their participation in activities such as waste reduction, waste segregation at source and recycling. There are different ways to encourage citizens to cooperate in plastic recycling program. Training for residents can create awareness for them to participate in plastic recycling. Training can be conducted at school, public hall and some other places, while the importance of plastic recycling can be disseminated via educational CD, handouts and pamphlets or through media. The identification of encouraging factors can increase the efficiency of plastic recycling program.

Based on linear regression test, the income, race, age, and education factors seem to be insignificant in training methods (Table 4.25), except for the recycling of plastic amongst PJ residents.

Table 4.25: Dependent Variable with Method of Training

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.304	.381		3.422	.001
	Income	.091	.076	.063	1.192	.234
	Race	-.073	.063	-.061	-1.171	.242
	Education	.060	.058	.055	1.037	.300
	Age	.027	.046	.031	.582	.561

About 50% of the respondents agreed that creating awareness and giving training on plastic recycling in schools is the most effective method to improve plastic recycling. Awareness of recycling and concern for the environment should be inculcated from early age. Unfortunately, there is no formal subject dedicated to achieving this purpose in the present education system at primary and secondary level in Malaysia.

About 34% of the respondents recognized media as the means of creating public awareness. This group pointed out that getting information on plastic recycling through media is worldwide and broad. The effect of media particularly TV programs to public regardless of their age and education is very important. The regional media to introduce

recycling activities especially separation of plastic bottles from other waste can be an effective option to encourage public to participate in plastic recycling activities. This finding was supported by Abdelnaser et al. (2006b) who claimed that integrated use of all media can increase public participation.

About 8% of respondents in this study agreed that educational CD can enhance citizens' awareness on recycling program. This group of respondents with the majority being students suggested that education through CD serve a better way of introducing the processes of plastic recycling to citizens. They believed that citizens can get clear understanding of the recycling programs via CDs. The small group of respondents (6%) felt that handouts and pamphlets distribution in public places, shopping malls, and resident areas are effective in increasing citizens' awareness on plastic recycling. They can exchange their knowledge on plastic recycling and improve their understanding. The smallest group of respondents in PJ (2%) suggested that public awareness can be enhanced via website and e-mail news. The finding of the study showed that training at school and through media are the best ways for creating public awareness.

Authorities' initiative is needed to generate the appropriate condition for education of the citizens on the importance of recycling through exhibitions, forum, and numerous campaigns through the media (TV, internet, etc). Creating public awareness should be an on-going process by utilizing educational aspects including printed material, as well as, other electronic media. Education plays an important role in creating awareness and enhances public participation in plastic recycling activities. Educational programs to be introduced to communities should be made more aggressive with 'hands-on' approach. Educational programs can be used to enhance cooperation and contribution of the

citizens to the success of plastic recycling (Clarke, 1994). Hence, a study of household pre-cycling behavior allows a better understanding on how to develop future public educational programs along with recycling policies (Davio, 2001; Uche, 1998; Park, 1998).

4.3.8 Benefits of Plastic Recycling

In this survey, four reasons for plastic recycling were listed: the improvement of public health, the reduction in environmental pollutions, economic benefit with direct and indirect effect, and the increase in city's aesthetic condition. Respondents were asked to give the best description of why they recycled. About 43% of respondents believed that public health will increase with proper recycling, whereas, 35% claimed that pollution will be reduced if citizens show adequate cooperation in recycling. On the other hand, 14% of respondents suggested that economic benefit is the main reason for recycling while the remaining 6% takes the aesthetic aspects of a city as the reason for recycling (Figure 4.7).

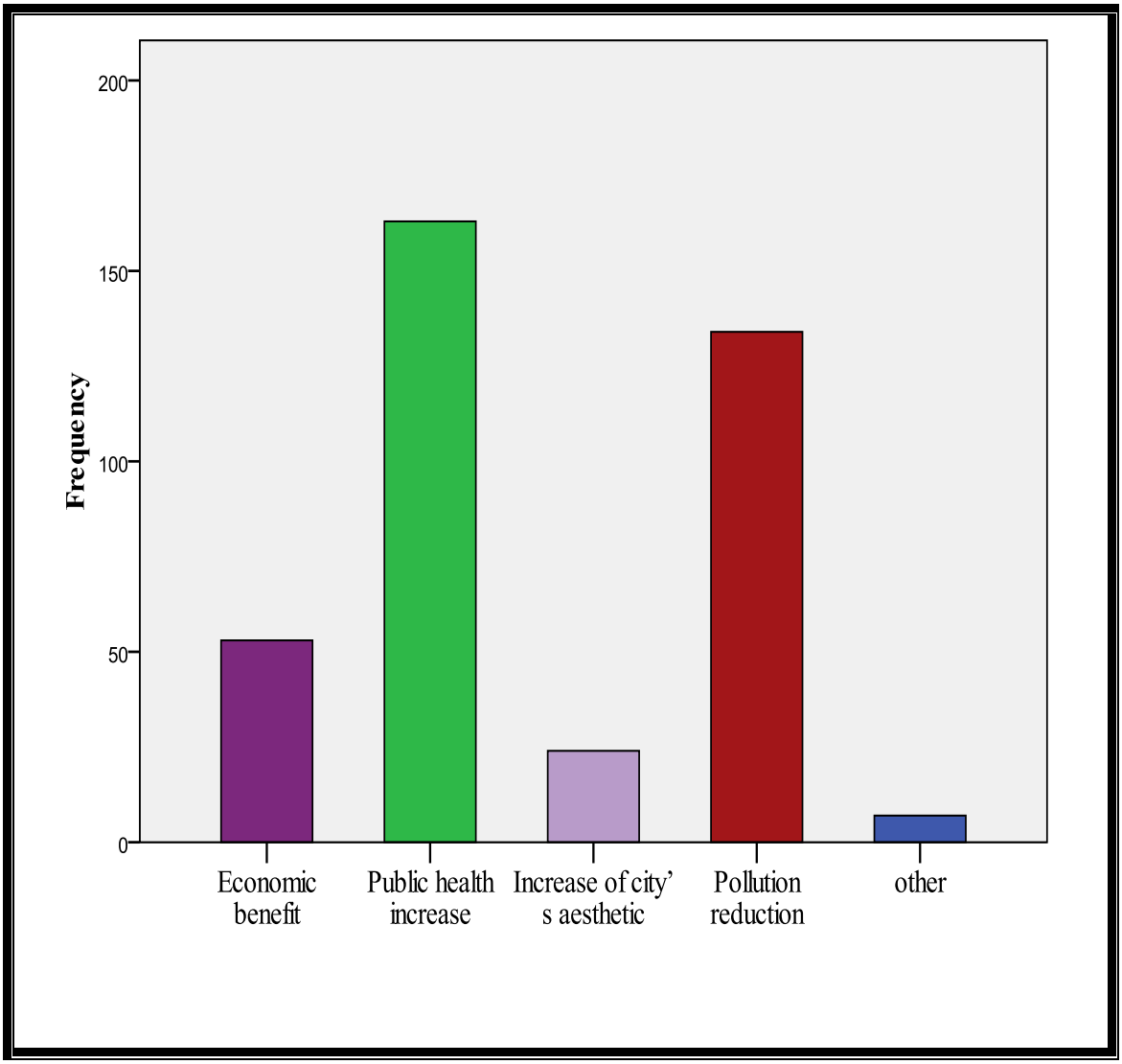


Figure 4.7: Respondent View on the Reasons to Recycle Plastic in PJ

The highest percentage of the respondents (43%) who live in their own house with high income believed that recycling has indirect effects on public health. They thought that the issue of increasing recycling wastes has been importantly linked to the most crucial aspect of health. Due to the strong direct or indirect link between recycling and health issues, some respondents are interested in recycling activities. Therefore, identifying benefits of plastic recycling can increase the efficiency of plastic recycling activities. Implementation of plastic recycling plan in developing countries such as Malaysia is

closely linked to the public for it is considered as an essential part of proper public health and environmental control (Azman, 1995; Mohd.Razman and Sabarinah, 1994).

The linear regression test results showed that income factor (a beta value of – 0.012) and ownership (a beta value of – 0.2) were significant in the need to inculcate the benefits of recycling (Table 4.26). It means that residents with ownership and high income tend to be more involved in the recycling of plastics. Other parameters such as length of stay, occupation and education have no significant effect on recycling benefits. The reason might be based on the fact that some think there is no professional reason to make someone have the quest to recycle; hence occupation and education were neglected. Length of stay may not really be significant since every individual intends to maximize profit at any give opportunity.

Table 4.26: Dependent Variable with Recycling Benefits

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.410	.481		7.089	.000
	Income	-.021	.090	-.012	-.228	.020
	Length of Stay	-.090	.114	-.065	-1.233	.219
	Ownership	-.351	.073	-.200	-3.806	.000
	Occupation	-.017	.049	-.018	-.338	.736
	Education	.039	.067	.031	.587	.558

The second largest respondents (35%) pointed out that recycling can reduce environmental pollution. They referred to frightening fact of pollution levels and they suggested that an immediate action on a global basis can be achieved via recycling activities. For them, the reduction of pollution is the reason why plastic need to be recycled. They stated that plastic recycling has close relationship to environmental degradation. Recycling plastic may be aimed to reduce pollution to the environment, slow down exhaustion of primary resources or simply because it is economically profitable (Isa *et al.*, 2005; Visvanathan *et al.*, 2004; Broek *et al.*, 1998). People who believed that their government was making a reasonable effort to protect the environment were more inclined to adopt environmental-friendly behavior. Therefore, participation of the public in plastic recycling might help in achieving clean environment.

The third group of respondents (14%) with low income pointed out that plastic recycling can bring economic benefit both to the government, as well as, to themselves.

This group opined that economic factors can influence public recycling behavior in terms of cooperating with private sectors. In regards to economic benefits, the recovery of secondary materials is necessary to reduce dependency on other countries. Whereas in industrialized countries, government and WMS play a large role in providing infrastructure and partly subsidizing recycling materials, the developing countries such as Malaysia, do not provide any financial resources to support recycling (Omran *et al.*, 2009).

The fourth reason for public to be involved in plastic recycling is due to aesthetic reason. The remaining 6% of the respondents pointed out that plastic recycling can improve the aesthetic condition. They expressed the need for a clean and unpolluted place to live. They suggested that government should encourage proper placing of recycling bins particularly in public areas. This is because most of recycling waste is generated in public places, schools, and shopping malls (Anon, 2001). They agreed that Malaysia as a country that receives tourists should pay more attention to the aesthetic aspects of the country. Currently, tourism is one of the largest sources of income in Malaysia. This group of respondents noted that PET bottle disposal on streets eventually will clog drains or streams which are unfavorable for tourism. With the reduction of plastic waste, the environment will be cleaner.

CHAPTER 5

CONCLUSION

5.1 CONCLUSION

This study was aimed at determining the factors that influence plastic recycling in PJ in relation to the adopted recycling procedures and encountered problems. In view of the above, this study therefore concludes that waste in PJ is mainly composed of organic components. Among other components of MSW in PJ were paper waste, metal scraps, textile, plastics etc. The concentration of plastics obtained in the waste stream is approximately 21%.

Also, after estimation of respondents' level of plastic recycling awareness, the study concludes that even though majority of the respondents with 67% in PJ knew the meaning of recycling, only 22% of respondents practiced it. This most probably was due to citizens' lack of awareness on the importance of plastic recycling.

However, the research identified a number of problems that hinder efficient recycling of plastic is PJ. Such problems ranged from lack of awareness (39%), level of literacy (36%) to unavailability of recycling facilities (31%). From the survey, it was concluded that 60% of plastic waste from PJ area is still being disposed off at landfills. With regards to this finding, the residents' awareness of 3Rs is low (81%).

Finally, suitable approaches to improve plastic recycling in the studied area must include, increase in number of recycling centers, provision of more recycling facilities, and increasing the unit price of recyclable plastics to encourage recyclers.

5.2 RECOMMENDATIONS

Finding from the study identified the following issues as problem in plastic recycling in PJ:

a. The most important issue in plastic recycling is the lack of effective and coherent programs in creating recycling culture in PJ. Citizens have an important role in the success and the development of recycling activities. Therefore, without establishing a recycling culture, achieving the objective is impossible. Proper training methods are necessary in PJ to increase the motivation of the citizens towards recycling. Training at school and through media proved to be the best and the most effective solution to this problem. In addition to these cases, it is suggested that other programs such as distributing brochures in all areas of cities, performing musical programs for kids in parks, holding exhibitions on recycling products in different places such as mosques and parks, holding seminars on recycling in universities and governmental and private organizations, performing educational programs for students in schools, introducing recycling centers in exhibitions and stadiums, and having educational programs for restaurant workers, are also necessary.

b. The second issue is the lack of unique and arranged educational program. Recycling activities and programs are done through several companies and each

one has different educational program objectives. Due to these differences designing a unique advertising plan for public media becomes difficult.

c. Another issue in the recycling plan is the lack of confidence among the citizens to participate in the recycling program. Recycling is a long term plan. Unfortunately, due to short period of management in most municipalities, most of the recycling plans are incomplete. This problem caused distrust among citizens. It is recommended that new management followed the incomplete recycling plan with application of new methods. Also, advertisement and manipulation of recycling plans should be done continuously and parallel to this action.

d. The next issue is the collection method. Collection of waste in PJ is done with curbside method. Due to high cost of transportation this method is not suitable. It is recommended that drop off collection method is adopted. As it is mentioned in Chapter Two, citizens carry plastic waste to drop off centers and this causes reduction of transportation costs.

e. For the improvement of plastic recycling plan, it also is recommended that manufactures are encouraged to produce high quality products.

f. Insufficient facilities or lack of appropriate facility also staggered plastic recycling. There is no acceptable and enough equipment in transfer stations where tools such as washing conveyors, cutting machine, packing machine, and pressing machines are needed. Transfer stations equipped with press and cutting

machines reduces the costs of transportation by compacting plastic bottles. In Malaysia, most of the separation activities are done manually. In this case, some recycling materials were disposed due to workers' mistake in plastic waste separation. Thus, it is recommended that mechanical method be used in separation centers.

g. Another issue in recycling plan is the presence of many groups of scavengers. This group causes dissatisfaction among citizens due to the scattering of waste. They also create pollution and destroy aesthetic condition of a city. These groups collect recyclables illegally and unhealthily, and mixed them with other wastes. To solve this problem, it is recommended that municipality and relevant organizations control the activities of the scavengers. Educational training and facilities should be provided to encourage them to be an active player in recycling programs. In general, municipality should supervise these groups and use their capacity.

h. One of the biggest difficulties in plastic recycling is non-participation and lack of support from municipality and governmental organizations. Municipality can give factories standard bottles with low contamination to reduce the costs of production line. To encourage plastic recycling towards environmental preservation, municipalities and relevant organizations should provide financial assistance and loans to private sectors as financial and economic support.

i. Another issue in plastic recycling plan is illegal and unorganized plants. In these factories, production of flakes creates high pollution. As a result, value and price of flakes of low quality will plunge causing fluctuation in the market. Hence, municipality needs to create suitable marketing for these flakes.

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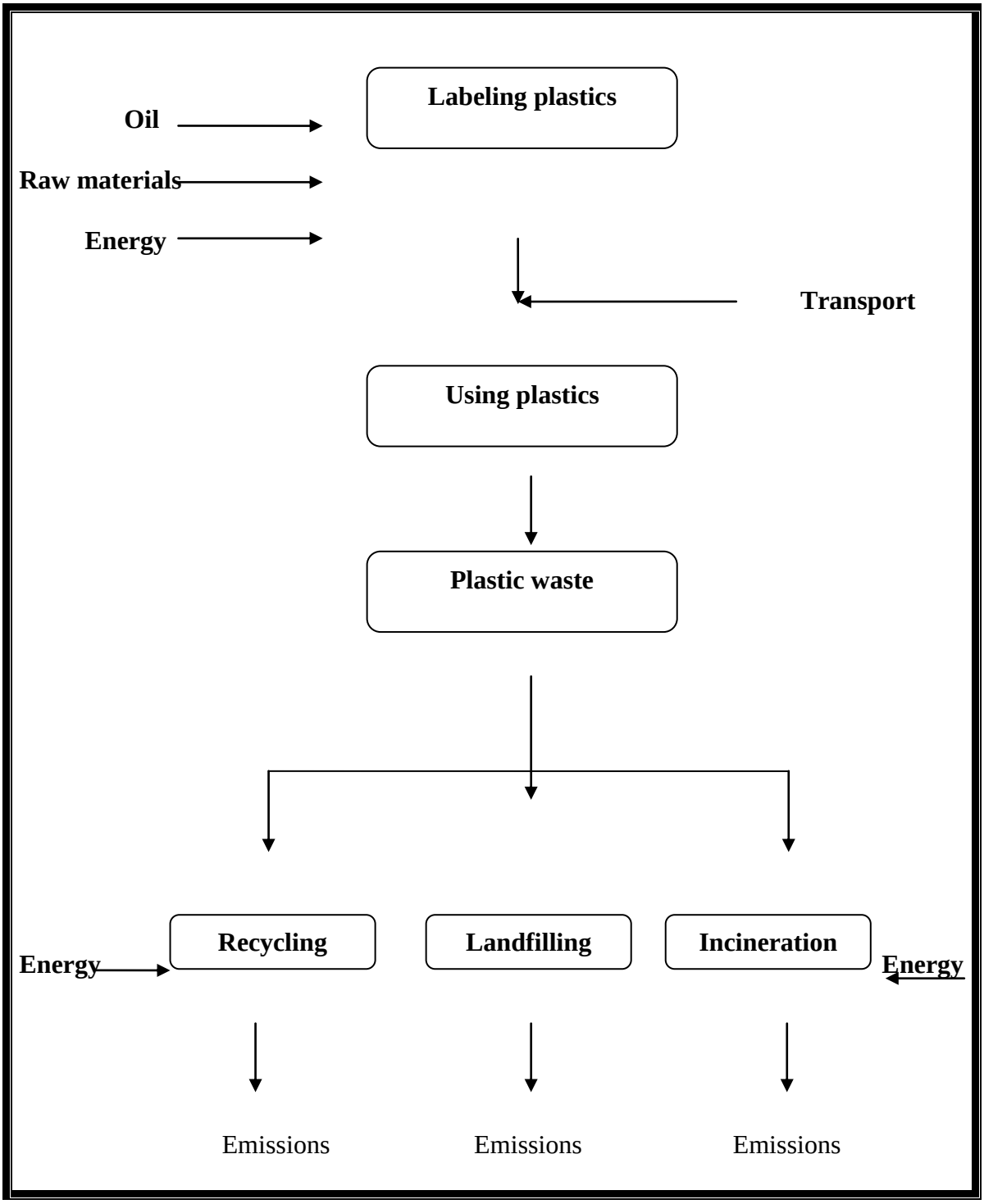
APPENDIX A: Properties of Plastics and Their Advantages

Property	**Examples**
Low cost	Can be cheaper than natural materials, for example, PET replacing further down.
Lightweight	Plastics are lighter than many conventional materials. For example, a paper bag weighs roughly six times as much as a plastic bag. A liter of plastic bottle of oil weighs only 7% of the equivalent glass bottle. This leads to reduced fuel consumption and transportation costs.
Durability	Greater durability of plastics in some applications compared with other materials such as metal, wood and glass is often a consequence of factors such as greater resistance to corrosion strength and impermeability to water.
High strength	Greater strength-to-weight ratio of many plastics compared to other materials means that less material is required. For example, use of polyamides in bullet-proof vests.
Manufacturing versatility	Different plastic component parts can be integrated easily within a single product, which reduces processing and assembling costs. For example, one-piece PVC windows frame.
Color	Color can be varied easily at the processing stage.
Good thermal insulator	Polystyrene in building insulation.
Low permeability to oxygen	PVC wraps to protect food, such as red meat, from exposure to the air.
Impermeability to water	PVC waterproof flooring and coverings.
Heat resistance	Polypropylene containers are lightweight and low-cost alternative to glass. For example, the use in microwaves.
Electrical resistance	PVC and polypropylene are used for wire and cable insulation.
Corrosion resistance	Use of plastics in the building industry and car manufacturing.

Source: RAPRA Technology Limited and Building Research Establishment, 1994

APPENDIX B

Simplified life cycle of plastics



Source: Environmental Agency, 2001.

APPENDIX C

Uses of Plastics

Type of plastic	**Main applications**
Thermoplastics	
High-density polyethylene	Containers, toys, housewares, industrial wrapping and film, gas pipes
Low-density polyethylene	Film, bags, toys, coatings, containers, pipes, cable insulation
PET	Bottles, film, food packaging, synthetic insulation
Polypropylene	Film, battery cases, microwave containers, crates, car parts, electrical components
Polystyrene	Electrical appliances, thermal insulation, tape cassettes, cups, plates
PVC	Window frames, pipes, flooring, wallpaper, bottles, cling film, toys, guttering, cable insulation, credit cards, medical products
Polymethyl methacrylate	General appliance moldings
Polyamide	Films for packaging of foods such as oil, cheese and boil-in-the-bag products and for high temperature engineering applications
ABS/SAN	Transparent all-weather sheet, electrical insulators, domestic appliances
Thermosetting plastics	
Epoxy resins	Adhesives, car components, sports equipment, boats
Polyurethane	Adhesives, appliances, car parts, electrical components, trainer soles, furniture foam
Phenolics	Adhesives, appliances, car parts, electrical components

Source: Richardson, 1997.

APPENDIX D

Plastic Identification Code

Symbol	Acronym	Full name and uses
	PET	Polyethylene terephthalate - Fizzy drink bottles and frozen ready meal packages.
	HDPE	High-density polyethylene - Milk and washing-up liquid bottles
	PVC	Polyvinyl chloride - Food trays, cling film, bottles for squash, mineral water and shampoo.
	LDPE	Low density polyethylene - Carrier bags and bin liners.
	PP	Polypropylene - Margarine tubs, microwave-able meal trays.
	PS	Polystyrene - Yoghurt pots, foam meat or fish trays, hamburger boxes and egg cartons, vending cups, plastic cutlery, protective packaging for electronic goods and toys.
	Other	Any other plastics that do not fall into any of the above categories. For example melamine, often used in plastic plates and cups.

Source: www.vikoz.com

APPENDIX E

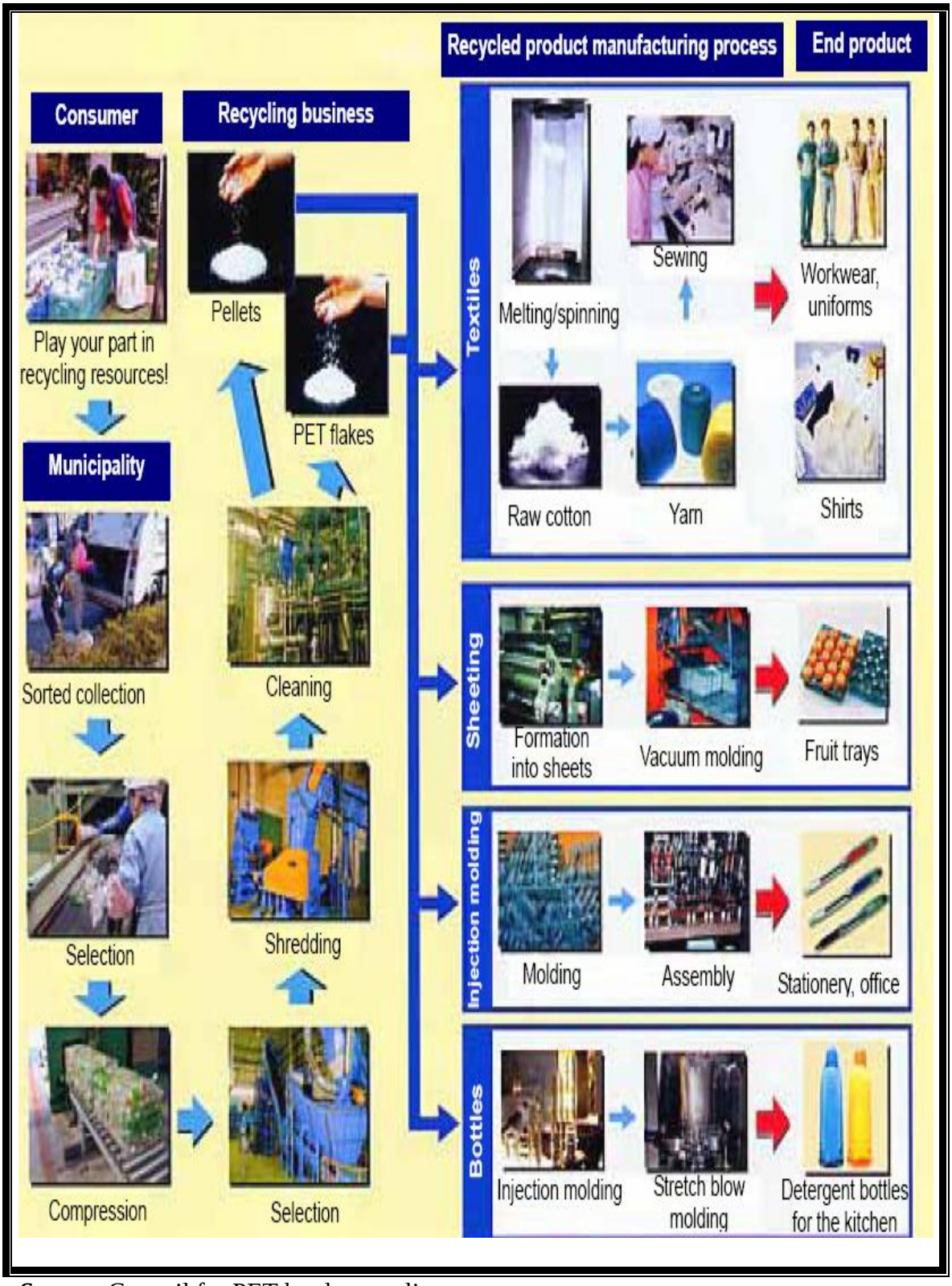
Characteristics of PET

Density	1.33 g.cm³
Stroke Strength	1.5 to 3.5 kg.m²
Melting Temperature	255 c°
Heat Insistence	-40 to 200 c°
Maximum temperature	70 c°
Molding Quality	Excellent
Water Absorption (24 hours)	%2
Combustion Speed	Slow
Effect of Sunlight	Slightly dim
Acids' effects	Attackable by Oxidation acids
Alkenes' effects	Attackable
Solutions' effects	Attackable by Halogen Hydrocarbon
Light Quality	Bright to turbid
Stretch Insistence Mpa	59 to 72
Pressure Insistence Mpa	76 to 128

Source: Showartez and Godman, 1999.

APPENDIX F

Mechanical Recycling Process



Source: Council for PET bottle recycling.

APPENDIX G

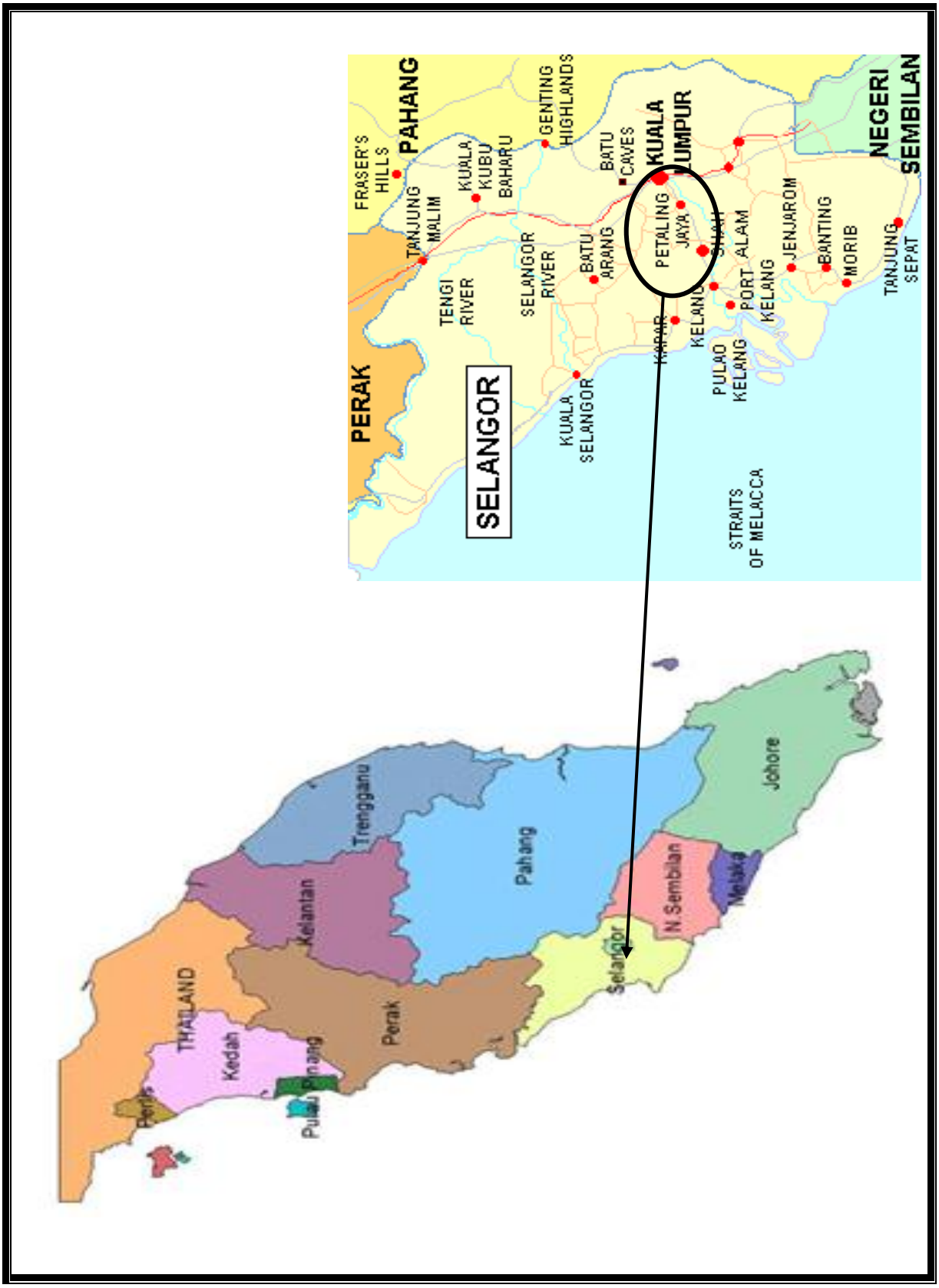
Standard Parameters in Quality of PET Flakes

Innate Viscosity (IV)	0.82±0.02 dl.g
Flake size	10-12 mm
Colour	Colorless ,blue ,green
Melting point	250 ± 5° G
The rate of pollution to P.V.C Max.	20 ppm
The rate of pollution to Paper Max.	15 ppm
The rate of pollution to PE, PP Max.	100 ppm
The rate of Humidity Max.	1 %
Volume density	350-550 kg.m^3
The rate of dust Max.	150 ppm
The rate of pollution to glue Max.	50 ppm

Source: Golami, 2005.

APPENDIX H

Geographic Location of the Petaling Jaya



APPENDIX I

Sampling Requirement by Size of Population

Size of population	Sample size (n) for precision (e) of					
	=1%	=2%	=3%	=4%	=5%	=10%
500					286	91
1 000				385	286	91
1 500			628	441	316	94
2 000			714	476	333	96
2 500		1 250	769	500	345	96
3 000		1 364	811	517	353	97
3 500		1 458	843	530	359	97
4 000		1 538	870	541	364	97
4 500		1 607	891	549	370	98
5 000		1 667	909	556	370	98
6 000		1 765	938	566	375	98
7 000		1 842	976	574	381	99
8 000		1 905	976	580	383	99
9 000		1 957	989	584	383	99
10 000	5 000	2 000	1 000	588	385	99
15 000	6 000	2 143	1 034	600	390	99
20 000	6 667	2 222	1 053	606	392	100
25 000	7 143	2 273	1 064	610	394	100
50 000	8 333	2 381	1 087	617	397	100
100 000	9 091	2 439	1 099	621	398	100
> 100 000	10 000	2 500	1 111	625	**400**	100

Source: Yamane, 1983.

Note: For the population of more than 100,000 (urban communities) and with 95 percent confident level (5 % precision), the appropriate samples are 400.

APPENDIX J

Distribution of Population in Petaling Jaya

	Area	Population	Number Sample
1	Section 1	5117	3
2	Section 1A	1181	1
3	Section 2	2391	2
4	Section 3	3728	2
5	Section 4	7175	5
6	Section 5	13689	9
7	Section 6	3798	2
8	Section 7	2293	1
9	Section 8	4643	3
10	Section 9	872	1
11	Section 10	1857	1
12	Section 11	3461	2
13	Section 12	5965	4
14	Section 13	168	0
15	Section 14	13141	8
16	Section16	7386	5
17	Section 17	19514	12
18	Section 17A	2138	1

(Cont'd)

	Area	Population	Number Sample
19	Section 18	1716	1
20	Section 19	9384	6
21	Section 20	5036	3
22	Section 21	9581	6
23	Section 22	4305	3
24	Section 51	534	0
25	Section 51A	10664	7
26	Section 52	900	1
Total		**140637**	**89**

	Area	Population	Number Sample
1	PJS 1	14637	9
2	PJS 2	44323	28
3	PJS 3	12611	8
4	PJS 4	7509	5
5	PJS 5	22649	14
6	PJS 6	19286	12
7	PJS 8	5483	3
8	PJS 10	25813	16
Total		**152311**	**97**

(Cont'd)

	Area	Population	Number Sample
1	SS 1	11767	7
2	SS 2	30280	19
3	SS 3	17984	11
4	SS 4	11787	7
5	SS 5	15533	10
6	SS 6	5295	3
7	SS 7	15474	10
8	SS 8	7943	5
9	SS 9	2275	1
10	SS 9A	15532	10
11	SS 10	3412	2
12	SS 11	745	0
13	SS 20	6119	4
14	SS 21	12198	8
15	SS 22	12787	8
16	SS 23	8060	5
17	SS 24	5393	3
18	SS 25	7786	5
19	SS 26	5746	4
Total		**196116**	**124**

(Cont'd)

	Area	Population	Number Sample
1	PJU 1	12802	8
2	PJU 2	1037	1
3	PJU 3	1790	1
4	PJU 4	753	0
5	PJU 5	22521	14
6	PJU 6	47627	30
7	PJU 7	1648	1
8	PJU 8	9662	6
9	PJU 9	39102	25
10	PJU 10	5144	3
Total		**142086**	**90**

APPENDIX K

Questionnaire

A. Demographics/ Socio-economic Background and Housing Characteristics

A1. Gender/Jantina

1. Male/Lelaki
2. Female/Perempuan

A2. Age (yrs.)/ *Umur (thn)*

1. 20-25
2. 26-35
3. 36-55
4. Above 55/ 55 *ke atas*

A3. Race/*Keturunan*

1. Malay/Melayu
2. Chinese/ Cina
3. Indian/ India
4. Others/ lain-lain

A4. Marital Status/ *Taraf perkahwinan*

1. Single/ *belum berkahwin*
2. Married/ *sudah berkahwin*
3. Others/ *lain-lain*

A5. Family size/ *saiz keluarga*

1. 1-3 people/ *orang*
2. 4-6
3. 7-9
4. 10 – more/ *10-lebih*

A6. Type of dwelling /*Jenis tempat kediaman*

1. Apartment
2. Terrace/Teres
3. Bungalow/Banglo
4. others/Lain-lain

A7. Ownership/ *milik sendiri atau sewa*

1. Own/ *kepunyaan sendiri*
2. Rent/ *disewa*
3. Others (e.g. stay with relative, etc.)/ *Lain-lain (tinggal dengan ahli keluarga,dll.)*

A8. Length of Stay/ *Jangkamasa menetap*

1. 1 year or less/ *Kurang 1 tahun*
2. 1-2 years/ *thn.*
3. 2-3 years/*thn.*
4. 3-5 years/*thn.*
5. 5 or more/ *5 thn. atau lebih*

A9. Occupation*/ Pekerjaan*:

1. Student/*Pelajar*
2. Employer/*Majikan*
3. Housewife/ *Suri Rumah*
4. Employee /*Pekerja*
5. Others/*Lain-lain*

A10. Education/ *Pendidikan*

1. High school/ *sekolah menengah*
2. College/Institute/ *Diploma*
3. University Degree/ *Ijazah Sarjana Muda*
4. Graduate/Post-graduate/ *lepasan ijazah*
5. Other */lian-lian*

A11. Family Income levels (per month)/ *pendapatan (sebulan)*

1. RM 0-300
2. RM 301-500
3. RM 501-1500
4. RM 1501-2000
5. Above 2000/ lebih RM 2 000

B. Concept of plastic recycling / *konsep kitar semula*

B12. Are you familiar with the concept of "plastic recycling?"

Adakah anda mengetahui dengan konsep "kitar semula plastik? "

1. No /*Tidak*
2. Yes, explain/*Ya, jelaskan*.....

B13. Do you know the types of plastic that can be recycled?

Adakah anda tahu jenis plastik yang boleh dikitar semula?

1. No /*Tidak*
2. Yes, explain/*Ya, jelaskan*.....

B14. How many are such types of recyclable plastics?

Berapa jenis plastik boleh dikitar semula?

1. 3
2. 4
3. 5
4. 7

B15. Which type of plastic you know?

(Antara berikut, yang manakah jenis plastik yang anda tahu?)

1. PET
2. PVC
3. HDPE
4. HLPE
5. PP
6. PS

B16. Do you know how to identify the types of plastic for recycling?

Adakah anda tahu cara mengenalpasti jenis plastik untuk dikitar semula?

1. No /*Tidak*
2. Yes, explain/*Ya, jelaskan*.....

B17. Do you know what is "coding system" for plastics?

Adakah anda tahu maksud "pengekodan sistem" untuk plastik?

1. No /*Tidak*
2. Yes, explain/*Ya, jelaskan*.....

C. Actual Recycling Activities

C18. Do you separate your garbage according to different categories before throwing?

Adakah anda mengasingkan sampah sarap mengikut jenis sebelum dibuang?

1. No (refer Q 21) /*Tidak* (terus menjawab soalan 21)
2. Yes/*Ya*

C19. What items are these?

Apakah jenis barangan berkenaan?

1. Paper/Cardboard (Kertas / kadbod)
2. Plastic/Plastik
3. Glass/Kaca
4. Cans/tin
5. Other (Please State)/ Lain-lain (Sila nyatakan)

C20. Do you have any experience of plastic waste separation at home?

Adakah anda mengamalkan pengasingan sisa plastik di rumah?

1. No /*Tidak*
2. Yes, explain/*Ya, jelaskan*.....

C21. How much effort does it takes to recycle a particular item at home?

Berapa banyak usaha yang diperlukan untuk mengitar semula barang tertentu di rumah?

1. Easy/ *mudah*
2. Somewhat easy/*Agak mudah*
3. Neutral
4. Somewhat difficult /*Agak sukar*
5. Difficult/*Sukar*
6. Not applicable/ *Tidak diamalkan*

C22. Do you think your neighbor does recycling?

Menurut anda, adakah jiran anda menjalankan kitar semula?

1. No /*Tidak*
2. Yes/*Ya*

C23. Do you suggest recycling plastic to your neighbor?

Adakah anda menyarankan kitar semula plastik untuk jiran anda?

1. No /*Tidak*
2. Yes/*Ya*

C24. If plastic recycling is to be implemented how you do think the public will respond?

Pada pendapat anda, apakah respon orang awam sekiranya kitar semula plastik dilakukan?

1. Agree/*Setuju*
2. Disagree/*Tidak bersetnju*

D. Citizen awareness on recycling center

D25. From where do you get the information about plastic recycling? (Multiple answers)

Daripada mana anda mendapatkan maklumat tentang kitar semula plastik?(beberapa jawapan)

1. Newspapers/*Akhbar*

2. Magazines/*majalah*
3. TV/*Televisyen*
4. Radio
5. Leaflet drops
6. Other/ *Lain-lain*

D26. Do you know where is the nearest recycling center?

Tahukah anda dimanakah letaknya pusat kitar semula yang terdekat?

1. No/*Tidak*
2. Yes, specify where/*Ya, tentukan di mana*

D27. Have you ever sent any things for recycling?

Pernahkah anda menghantar barang-barang untuk dikitar semula?

1. No /*Tidak*
2. Yes, explain/*Ya, jelaskan*.....

D28. How much plastic do you recycle weekly?

Berapa jumlah plastik yang anda kitar semula dalam seminggu?

1. Less than 1 kg/*Kurang 1 kg*
2. 1kg
3. More than 1 kg/*Lebih 1 kg*
4. None/*Tiada*
5. Other/ Lain-lain

D29. How much do the plastic recyclers pay you for every kilogram of recyclable plastics you supply them? _____

Berapakah bayaran yang diberikan oleh pembeli barangah kitar semula untuk setiap kilogram barangan yang anda bekalkan? _____

D30. How often do these procedures take place? *(Berapakah kekerapan untuk menjalankan prosedur ini?)*

1. Weekly/*Mingguan*
2. One a fortnight/*Setiap dua minggu*
3. Monthly/*Bulanan*

4. Longer/ *Tidak menentu*

D31. What recycling procedures take place in your area?

Apakah prosedur kitar semula yang dilakukan di kawasan anda?

1. Recycling bin collection/ *Tong sampah kitar semula*
2. Bottle collection/ *koleksi botol*
3. Furniture collection/ *koleksi perabot*
4. None/*Tidak ada*
5. Other (Please State)/ *Lain-lain (Sila nyatakan)*

D32. Are you happy with the recycling procedures that are in place in your area?

Adakah anda suka dengan prosedur kitar semula yang dijalankan di tempat di kawasan anda?

1. No /*Tidak*
2. Yes, explain/*Ya, jelaskan*.....

E. Concept of 3R

E33. Which method applies to your plastic waste?

Apakah kaedah yang anda lakukan untuk sampah plastik anda?

1. Throw/dispose (*Buang/Lupus*)
2. Reduction/*Pengurangan*
3. Reuse/*Guna semula*
4. Recycle/*Kitar semula*
5. Other/*Lain-lain*

E34. Are you aware that we can reuse the same bags instead of accepting new plastic bags while shopping?

Adakah anda sedar bahawa kita boleh menggunakan semula beg plastik yang sama dan bukannya menerima beg plastik setiap kali berbelanja?

1. No /*Tidak*
2. Yes/*Ya*

E35. Do you bring your own basket when you go to market to reduce the use of plastic bag?

Adakah anda membawa bakul sendiri ketika anda pergi ke pasar untuk mengurangkan penggunaan beg plastik?

1. No /*Tidak*
2. Yes/*Ya*

F. Opinions on Existing Problems and solution

F36. In your opinion, what is the main reason of residents' non-cooperation with plastic waste separation program?

Pada pendapat anda, apakan alasan utama penduduk tidak bekerjasama dengan program pengasingan sampah plastik?

1. Non-satisfaction from waste management service/*Tidak berpuas hati terhadap perkhidmatan pengurusan sisa*
2. Citizens' lack of awareness on program/ *kurang peka dengan maklumat tentang program*
3. Lack of education/ *Kurangnya pendidikan*
4. Other (Please State)/ *Lain-lain (Sila nyatakan)*

F37. What is the main problem of apartment's residents with plastic waste recycling?

Apakah masalah utama kepada warga apartmen tentang kitar semula sampah plastik?

1. Lack of space to collect plastic waste /*Kurangnya ruang untuk mengumpul sampah plastik*
2. Lack of education/*Kurang pendidikan*
3. Lack of recycle bins for separation /*Kurangnya tong sampah kitar semula untuk pengasingan*
4. Ignorance/*Tidak prihatin*
5. Other/ *Lain-lain*

F38. What are the problems facing plastic recycling in Malaysia?

Apakah masalah kitar semula plastik yang dihadapi di Malaysia?

1. People are ignorant /*Sikap tidak prihatin*

2. Lack of proper public awareness/*Kurang kesedaran oleh masyarakat*
3. Insufficient technology/*teknologi tidak mencukupi*
4. Lack of incentives from recyclers/ *kurangnya insentif dari pengitar semula*

F39. How do you think such problems can be solved?

Bagaimanakah masalah tersebut dapat diselesaikan?

1. Education/*Pendidikan*
2. Government participation/*Penyertaan kerajaan*
3. Providing incentives to plastic consumers/*Memberikan insentif kepada pelanggan plastik*
4. Adoption of advanced recycling technologies/ *Adaptasi teknologi kitar semula*

F40. What is the best solution to reduce plastic waste generation by household?

Apakah penyelesaian terbaik untuk mengurangkan penghasilan plastik sampah oleh surirumah tangga?

1. Use of high quality products/*Menggunakan produk-produk berkualiti tinggi*
2. Reuse of products/*Guna semula produk*
3. Giving up past habits; the more waste generation is the sign of high culture/ *Meningkatkan gaya hidup; lebih banyak sisa yang dihasilkan lebih banyak perubahan budaya*
4. Not wasting */tidak membazir*
5. other/*Lain-lain*

F41. Which is the most suitable method to increase plastic waste recycling?

Yang manakah kaedah yang paling sesuai untuk meningkatkan kitar semula plastik sampah?

1. Training families/*Latihan keluarga*
2. Offer gift for people that recycle/*Penawaran hadiah untuk orang-orang yang mengitar semula*
3. Increase public cooperation in this program/*Meningkatkan kerjasama awam dalam program ini*
4. Other/ *Lain-lain*

F42. Will you recycle if containers are provided to collect plastic waste for recycling in your area?

Adakah anda akan mengitar semula jika bekas disediakan untuk mengumpul sampah plastik untuk dikitar semula di kawasan anda?

1. No /*Tidak*
2. Yes/*Ya*

F43. How frequent should plastic waste be collected?

B*erapakah kekerapan untuk mengumpul plastik sampah?*

1. Once a week/ *sekali seminggu*
2. Twice a week/ *dua kali seminggu*
3. Three times a week/ *tiga kali seminggu*
4. Every day/ *setiap hari*
5. Other/*Lain-lain*

G. Educational Programs

G44. Which would provide the most efficient result for recycling program?

Yang manakah akan memberikan hasil yang paling efisien untuk program kitar semula?

1. Training in schools/*Latihan di sekolah*
2. Media
3. Educational CD/ CD Pendidikan
4. Giving brochure and training handbook/ Memberikan risalah dan buku latihan panduan
5. Other/ *Lain-lain*

G45. What is the most suitable age to educate the public about plastic recycling?

Apakah usia yang paling sesuai untuk mendidik orang awam tentang kitar semula plastik?

1. 7-17
2. 18-28
3. 29-39
4. 40 above/*40 ke atas*

G46. Do you support recycling exhibition to inform the process and application of plastic recycling to the public?

Adakah anda menyokong pameran kitar semula untuk memberitahu proses dan pelaksanaan kitar semula plastik untuk orang awam?

1. No /*Tidak*
2. Yes, explain/*Ya, jelaskan*.....

H. Opinions on Policies

H47. Who (group of people) should take the responsibility of reuse and recycling plastic?

Siapakah (golongan) yang bertanggungjawab untuk menggunakan semula dan kitar semula plastik?

1. Student/*Pelajar*
2. Professions/*Profesional*
3. Housewives/*Suri rumah*
4. All/*Semua*
5. Other / *Lain-lain*

H48. Are you aware of any project/ activity/campaign conducted by local authority or any non profit organization about plastic recycling in your area?

Adakah anda menyedari setiap projek / aktiviti / kempen yang dilakukan oleh pihak berkuasa tempatan atau organisasi bukan kerajaan tentang kitar semula plastik di kawasan anda?

1. No /*Tidak*
2. Yes, explain/*Ya, jelaskan*.....

I. Environmental Issues

I49. Why we need to recycle plastic?

Mengapa kita perlu mengitar semula plastik?

1. Economic benefit/*Manfaat Ekonomi*
2. Public health increase/*Peningkatan kesihatan masyarakat*
3. Increase of city's aesthetic/*Peningkatan estetika penduduk bandar*
4. Pollution reduction/*Pengurangan pencemaran*

5. Other/ *Lain-lain*

I50. Do you think that you yourself play an important role in protecting the environment?

Pada pandangan anda, adakah anda memainkan peranan yang penting dalam pemeliharaan alam sekitar?

1. No /*Tidak*
2. Yes/*Ya*

I51. Please select the statement that best describes yourself?

Sila pilih pernyataan yang paling sesuai untuk menggambarkan diri anda?

1. I am very environmentally conscious/*Saya sangat sedar kepentingan persekitaran.*
2. I am somewhat environmentally conscious/*Saya agak sedar kepentingan persekitaran.*
3. I am neutral about the environment/*Saya neutral tentang alam sekitar.*
4. I am not too bothered about the environment/ *Saya tidak terlalu peduli tentang persekitaran.*
5. I am not concerned for the environment at all/*Saya tidak peduli tentang persekitaran sama sekali.*

J. Economic concept

J52. Do you think that plastic recycling is worth doing in Malaysia?

Adakah anda berfikir bahawa plastik kitar semula sesuai dilakukan di Malaysia?

1. No /*Tidak*
2. Yes, explain/*Ya, jelaskan*.....

J53. In your opinion, to what level is plastic recycling practiced in Malaysia?

Menurut pendapat anda, apakah tahap kitar semula plastik yang dipraktikkan di Malaysia?

1. High/*Tinggi*
2. Medium/*Sederhana*
3. low/*Rendah*

J54. In your opinion, which kind of item for recycling has economic worth?

Menurut pendapat anda, yang manakah jenis barangan untuk kitar semula yang mempunyai nilai ekonomi?

1. Paper/Cardboard (*Kertas / kadbod*)
2. Plastic/*Plastik*
3. Glass/*Kaca*
4. Cans/*tin*
5. Other (Please State)/ *Lain-lain (Sila nyatakan)*

J55. What is your view on future of recycling industry in Malaysia?

Apakah pandangan anda tentang masa depan industri kitar semula di Malaysia?

1. Very good/*sangat baik*
2. Good/*baik*
3. Weak / *lemah*
4. Very weak/*sangat lemah*
5. Other/ *Lain-lain*

Thanks you very much for your participation in this survey. The result of this survey will be treated with strict confidentiality.

Terima kasih di atas pandangan anda. Semua pendapat anda ada lah terpelihara dan sulit.

APPENDIX L

Raw Data of Demographic

Gender		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	126	32.6	33.1	33.1
	Female	255	65.9	66.9	100.0
	Total	381	98.4	100.0	
Missing	System	6	1.6		
Total		387	100.0		
Age					
Valid	20-25	63	16.3	16.4	16.4
	26-35	117	30.2	30.5	
	36-55	68	17.6	17.8	47.0
	55<	135	34.9	35.2	64.8
	Total	383	99.0	100.0	
Missing	System	4	1.0		
Total		387	100.0		
Race					
Valid	Malay	141	36.4	36.8	36.8
	Chinese	163	42.1	42.6	79.4
	Indian	67	17.3	17.5	96.9
	other	12	3.1	3.1	100.0
	Total	383	99.0	100.0	
Missing	System	4	1.0		
Total		387	100.0		
Marital Status					
Valid	Single	107	27.6	28.0	28.0
	Married	213	55.0	55.8	83.8
	other	62	16.0	16.2	100.0
	Total	382	98.7	100.0	
Missing	System	5	1.3		
Total		387	100.0		

(Cont'd)

Family size		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-3 people	88	22.7	22.9	22.9
	4-6	175	45.2	45.6	68.5
	7-9	90	23.3	23.4	91.9
	10 – more	31	8.0	8.1	100.0
	Total	384	99.2	100.0	
Missing	System	3	.8		
Total		387	100.0		
dwelling					
Valid	Apartment	126	32.6	32.8	32.8
	Terrace	122	31.5	31.8	64.6
	Bungalow	86	22.2	22.4	87.0
	other	50	12.9	13.0	100.0
	Total	384	99.2	100.0	32.8
Missing	System	3	.8		
Total		387	100.0		
Ownership					
Valid	Own	237	61.2	62.0	62.0
	Rent	113	29.2	29.6	91.6
	other	32	8.3	8.4	100.0
	Total	382	98.7	100.0	
Missing	System	5	1.3		
Total		387	100.0		
Length of Stay					
Valid	1 year or less	36	9.3	9.4	9.4
	1-2 years	88	22.7	23.0	32.4
	2-3 years	40	10.3	10.4	42.8
	3-5 years	44	11.4	11.5	54.3
	5 or more	175	45.2	45.7	100.0
	Total	383	99.0	100.0	
Missing	System	4	1.0		
Total		387	100.0		

(Cont'd)

Occupation		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Student	43	11.1	11.2	11.2
	Employer	70	18.1	18.3	29.5
	Housewife	93	24.0	24.3	53.8
	Employee	118	30.5	30.8	84.6
	other	59	15.2	15.4	100.0
	Total	383	99.0	100.0	
Missing	System	4	1.0		
Total		387	100.0		
Education					
Valid	High school	95	24.5	24.9	24.9
	College/Institute/ Diploma	171	44.2	44.9	69.8
	University Degree	95	24.5	24.9	94.8
	Graduate/Post-graduate	12	3.1	3.1	97.9
	other	8	2.1	2.1	100.0
	Total	381	98.4	100.0	
Missing	System	6	1.6		
Total		387	100.0		
	Income				
Valid	RM 501-1500	54	14.0	14.0	14.0
	RM 1501-2000	191	49.4	49.6	63.6
	RM 2000<	140	36.2	36.4	100.0
	Total	385	99.5	100.0	
Missing	System	2	.5		
Total		387	100.0		