Strategies for Optimising Domestic Solid Waste Management Systems in Urban Areas of Australia and South Korea

by

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CERTIFICATE OF AUTHORSHIP/ORIGINALITY

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Abstract

In today's world, with rapidly developing technologies and booming population, solid waste management has become a major concern. In general, awareness of this problem could lead to the development of improved pollution control technologies and rigorous policies for solid waste handling systems and disposal, in order to minimise the environmental impacts of this waste. In addition, policy-makers need to develop and implement effective municipal solid waste management strategies, taking into account all economic, technical, and environmental objectives and factors.

As the population continues to increase in both Australia and South Korea, the need for strategies to optimise municipal solid waste systems and manage waste is becoming more urgent. It is important to understand that solid waste management is a complex task, which depends as much upon organisation and cooperation between households, communities, private enterprises and government at all levels as it does upon recycling and disposal systems. A conventional view is that either private or public management is more efficient for managing municipal solid waste systems, irrespective of the nature of the resource, or the socio-economic situation of the people. However, because many local governments lack the appropriate financial, technical and human resources, they are neither able nor willing to manage these systems.

Industrialised countries such as Australia and South Korea produce millions of tonnes of municipal solid waste every year, which deplete the world's natural resources and have negative consequences for the environment. In recognition of this problematic global trend, the question of environmental protection for the world's sustainable development through solid waste management systems has been given special attention by many countries, including Australia and South Korea. This study has sought to provide the cities of Sydney and Seoul with tools that will enable them to evaluate the environmental and economic performance of the various elements of their existing or proposed waste management systems. The tools are based on the best information publicly available at the present time, with a commitment to revise this information periodically to ensure that it is up-to-date. The tools are intended as guides only; they do not prescribe the best system for each city. The determination of the best system for a community must take into account several factors, including social and political considerations.

A survey was designed and conducted with the purpose of collecting information on the attitudes of the residents of Sydney and Seoul about municipal solid waste management, how they perceive the current programs of their respective cities in terms of collection, processing and disposal, and how they believe the waste management programs of their cities could be improved in terms of decreasing the amounts of waste generated and effectively managing the collected wastes.

The researcher applied the second version of the White model, the Integrated Municipal Waste (IMW-2) model. The application of the MSW analysis to the two different cities provided an interesting comparison of economic cost, environmental cost and disposal cost. For example, the cost of disposal is quite similar between the two cities. The result does not clearly confirm the environmental superiority of the incineration over the landfill. However, if an incineration facility is introduced in Sydney, an increase of the economic cost of the system will occur. Even though these comparisons are not 100% rigorous, this analysis is still useful for giving some estimation of future MSW management strategies.

The study has used a structured focused comparison to investigate the prevailing waste management programs of Sydney and Seoul and determine the strengths, weaknesses, opportunities and threats in each, in order to develop a waste management model that can be utilised in each city. To achieve optimal results, solid waste management programs must be based on the life-cycle philosophy, filling in the gaps to assess the economic affordability of waste systems, to evaluate the environmental effects involving a product or process, to implement ways to improve or lessen these impacts, and to call for greater public participation in the solid waste management program.

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Table of Contents

List of Figures

List of Tables

List of Pictures

CHAPTER 1 INTRODUCTION

1-1 Background

Waste management strategies resulting from economic progress, increases in population and upsurges in consumption have been a prevalent subject in the waste management literature (Chertow, 1998; Shah, 2001; Furedy, 1994; White and Whitney, 1992). The need to determine a waste management program that can address waste disposal, particularly in metropolitan areas such as Seoul (Park, 1993; *Asia Travelling*, 2003; Yim, 2004) and Sydney (*The Sydney Morning Herald*, 2004; McGuirk and O'Neill, 2003) necessitates firstly developing and implementing an effective and sustainable waste management program that will be able to control and sustain cleanliness in the two cities. This study involves a structured and focused comparison in investigating the current Municipal Solid Waste (MSW) management programs of Sydney and Seoul and determining the strengths, weaknesses, opportunities and threats in order to develop a MSW management model that can be utilised in both cities.

With the onset of globalisation, the environment and sustainable development have become global concerns. Overpopulation, overconsumption and flawed environmental policies in major world cities have contributed to the alarming problem of MSW management. These industrialised cities have become what White and Whitney (1992) call "the waste economy". Indeed, the developed world's consumption levels are not sustainable.

Industrialised countries such as Australia and South Korea produce millions of tonnes of MSW, which deplete natural resources and have negative consequences on the environment. In recognition of this problematic global trend, the question of environmental protection for the world's sustainable development through solid waste management systems has been given special attention by many countries, including Australia and South Korea. In this study, the focus centres on MSW.

MSW, commonly known as trash or garbage, consists of everyday items such as product packaging, grass clippings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint, and batteries. Problems arise when these wastes are not properly managed. In order to evaluate the MSW problem, a basic understanding of a simple model of the flow of solid waste as a four-stage process is needed: (1) Generation → (2) Collection → (3) Processing → (4) Disposal.

In the first stage, the item is discarded at the site of the waste generator; it is then usually picked up by a garbage truck. During the third stage, the waste may be recycled, composted, or incinerated. Finally, the process residues from the previous stage and nonprocessed raw waste are delivered to landfills in the fourth stage. In the United States, the pressure on disposal triggered the solid waste crisis of the 1980s (Chertow, 1998).

There are several MSW management practices which aim to prevent, reduce or divert garbage from the waste streams. These practices include source reduction, recycling, and composting. Source reduction deals with the altering of the design, manufacture, or use of products and materials to reduce the amount and toxicity of what gets thrown away. Recycling, on the other hand, diverts wastes like paper, glass, plastic, and metals from the waste stream. These materials are sorted, collected, and processed and then manufactured, sold, and bought as new products. The third practice decomposes organic waste, such as food scraps and yard trimmings, with micro-organisms, producing a humus-like substance.

Other MSW management practices address those materials that require disposal. Landfills are engineered areas where waste is placed into the land. Landfills usually have liner systems and other safeguards to prevent groundwater contamination. However, there is a strong possibility that landfills can degrade the surrounding environment, not only through ground and surface water contamination, but also through the production and release of greenhouse, toxic, corrosive and odorous gases; the possible increase in noise and dust level; the loss of visual amenity; land contamination resulting in loss of land-use options including revegetation species; loss of native species and change in fauna habitat and increased hazards (pests, fire and vermin).

Combustion or incineration is another MSW management practice that has helped reduce the amount of landfill space needed. Combustion facilities burn MSW at a high temperature, reducing waste volume and generating electricity. It is inevitable that some waste will go to landfill, as it is impossible that all waste can be avoided, reduced or recycled.

In developed countries, increased waste generation per individual contributes to the MSW disposal problem. As an example, a large city like New York was chosen for the review of solid waste management. The question of what to do with 11,000 tons of waste generated each day in New York City is not quite easily resolved like any other city. In addition, the many old landfills are reaching over-capacity and regulators are closing down thousands of substandard landfills. These scenarios lead to increasing prices for waste disposal and a search for disposal alternatives, which consequently affects each of the other

stages of the process flow. To curb the problem, MSW managers resort to other approaches such as, reducing the quantity of waste at the source, collecting waste so that it can more easily be recycled or composted, processing waste more cost-effectively, and, at each stage, addressing environmental concerns.

In recent decades, Sydney and Seoul have demonstrated their prowess by accomplishing rapid economic growth. The two major cities have accomplished such astonishing economic growth that they have become a model for rapid economic development. However, Sydney's and Seoul's success, along with that of other industrialised cities, has come with the cost of the degradation of the environment.

1-2 Objectives of the Study

As the population continues to expand in urban areas of Australia and of South Korea, development and implementation strategies for optimising MSW systems and managing waste have become more urgent. It is important to understand that MSW management is a complex task, which depends as much upon the organisations and cooperation between households, communities, private enterprises and governments as it does upon recycling and disposal. From a conventional viewpoint, either private or public management can be the most efficient system, irrespective of the nature of the resource, or the socio-economic condition of the people. However, because many local governments lack the appropriate financial, technical and human resources, they are neither able nor willing to manage these systems.

In today's world, where technologies are rapidly developing and population is booming, solid waste management has become a massive concern. In general, the awareness of this problem could lead to the development of enhanced pollution control technologies and the implementation of rigorous policies on solid waste handling systems and disposal in order to minimise the environmental impacts of this waste. In addition, policy-makers should plan and implement an effective MSW management strategy, taking into account all economic, technical, and environmental objectives.

The primary objective of this research is to compare, primarily through a case study, the MSW management systems of Sydney and Seoul. Specifically, this research aims to:

1. Review literature related on the research topic
2. Develop a questionnaire for the survey
3. Discuss the institutional structures that influence MSW management in Sydney and Seoul
4. Evaluate, using LCA (Life-Cycle Assessment), the MSW management systems in Sydney and Seoul.

This research covers Sydney and Seoul and how MSWs are managed in these two cities. In this study, a number of objectives are set for increasing the sustainability of MSW management in Sydney and Seoul, and these are limited to: minimising waste; stabilising waste production; quantifying waste flows; maximising environmentally sound waste reuse and recycling; developing national programs for waste management research and practice; raising public awareness; and promoting environmentally sound waste disposal. In the study, the basis for developing MSW management systems for Sydney and Seoul lies in the review of literature, the survey conducted, and on the case study.

1-3 Background of the Two Cities

Large populations affect and put stress on the environment, and some reserachers believe that overpopulation is the major cause of environmental degradation (Shah, 2001). While populations are large in many developed countries, other stressors on the environment are the huge demands on resources and over-consumption. Consumption patterns in Australia and South Korea, similarly seen in Europe and North America, cause strain on the environment and natural resources, resulting in considerable increases in solid waste. Urbanisation and modernisation result in greater waste production (Furedy, 1994).

Some suggest that the industrialised nations need to change their consumption patterns (Shah, 2001). The choice of environmental policies on how to manage MSW and for what purposes are vital issues for both Sydney and Seoul, two major cities experiencing rapid population growth as well as enjoying tremendous economic growth.

This proposed study is not only relevant but also timely in the wake of increased urbanisation in Sydney and Seoul. According to White and Whitney (1992), urbanisation is one of the major contributors to unsustainable development, through its production of waste. In the general context of the rapid urbanisation in these two cities, some plans

proposing large investments in coordination with the urban areas, including some strategies, have been created. However, the ability of the governments to finance, implement or manage the necessary development of urban areas is highly questionable for both Sydney and Seoul.

1-3-1 Sydney

The Australian economic growth accelerated from the late 1980s, but slumped from the September quarter 1990 to the September quarter 1991; with five quarterly decreases in the trend chain volume estimates of GDP. After the recession in the 1990—1991 GDP, the economy has since enjoyed economic growth. By 1994—1995 the economy had accelerated to 4.3%. It has subsequently been above 3.5%, except for 2000—2001 when it was 2%. In 2001—2002, the GDP growth was 3.8% (Australian Bureau of Statistics, 2004).

With a population of 19.7 million in 2002, Australia's population has been growing at an average annual rate of 1.2%. Of the major cities, Sydney has a share of 4.2 million people. This stable population growth results in a better growth of employment in the country. In August 2002, total employment was at 9.34 million, 22% above the January 1993 low point. And in terms of environmental assets, according to the Australian National Accounts, the total value of environmental assets in the country was over one thousand billion dollars at 30 June 2001, of which, around 86% or $908 billion was the value of land (Australian Bureau of Statistics, 2004).

During the 1990s, exploiting the climate of national prosperity, there were significant gains in labour productivity as Australians worked longer, harder and smarter. There was a shift within manufacturing towards investment and employment in the high-value-added products and a major growth in services, a market advantage to exporters and import-competitors brought on by almost a decade of decline in the value of the Australian dollar, and the purposeful adoption across the Australian economy of the optimistic economic rhetoric of the American economy that characterised the 1990s—Sydney was developing into a global city status (McGuirk and O'Neill, 2003).

As a response to the waste problem brought about by the growing population and over-consumption of products, in 1992 the Australian and New Zealand Environment Conservation Council (ANZECC) set a national waste reduction target of 50% by the year 2000; this was followed by a number of state-level waste minimisation initiatives. In support for these initiatives, all states in the country set waste minimisation goals: a 60%

waste reduction by the 2000 target from baseline 1990 levels was set in New South Wales; a zero waste target has been set for 2010 by the Australian Capital Territory (ACT); and 50% waste reduction targets by 2000 were set by other states and territories (Newton, 2001). In Sydney, despite the increases in recycling rates, absolute waste generation rates are still high. The level of waste reduction achieved by 2000 against the 1990 baseline level was close to 18%, well below the 60% target set by the New South Wales Government (Holden, 2000).

1-3-2 Seoul

According to the Urban Management Programme (1999), South Korea had a GNP per capita of U$9,700 in 1995, with an urban population accounting for 81.3% of the national population. Seoul is the capital and the largest city in South Korea, located in the northwest of the country. The metropolitan area, in which more than a quarter of the total population of South Koreans live (Park, 1993), has grown rapidly since the mid-19th century and is now one of the ten largest in the world. Industries that provide about half the industrial employment in the country include engineering, textiles, food processing, electrical and electronic equipment, chemicals, and machinery.

The recent economic development of South Korea has been a major contributing factor to the rapid population growth of Seoul. Many migrants come to the city for employment opportunities (Chan, 1982). Presently, the city is home to over 10 million people in 25 districts and 522 villages *(Asia Travelling*, 2003). Proving to be the true hub of the South Korean economy, Seoul accounts for 48.3% of the nation's bank deposits and 50% of bank loans (Yim, 2004). At the same time, the globalisation of economic activities has rapidly appeared in Seoul (Kwon, 1993).

Seoul has encountered severe problems with housing shortages, inadequate physical infrastructure, and, most importantly, difficulties controlling growth, which particularly leads to environmental problems. In the early 1970s the government attempted to control the growth of urban centres and the population in Seoul. Decentralisation of government functions and a comprehensive national land development plan were introduced to encourage a balanced growth between urban and rural areas. In 2003, Seoul had an estimated 17,000 people per square kilometre (Korea National Statistics Office, 2004).

In terms of environmental concerns, South Korea, and specifically Seoul, has prioritised economic development over environmental protection. It is true that South

Korea has accomplished tremendous economic growth, as evidenced by its rapidly increasing annual GNP growth. However, this success came at a cost and gave rise to a number of social ills, as the South Korean government and its people were "ignorant of the deteriorating environment despite worldwide concern for pollution because they were too busy concentrating on developing the economy and meeting basic needs" (Ferris, 1993).

Plagued by industrialization, along with limited land availability and population increases, rapid urbanisation in the city made the situation much worse for the environment. Industrialisation and urbanisation have increased almost in parallel to waste generation. In particular, the problem of waste management is of significant concern. In 2003, the waste generation rate in Seoul was 1.2 kg per capita per day; the total waste generated was 12.058 tonnes per day (Environment Bureau). These figures indicate that Seoul needs to implement effective MSW management systems.

1-4 Trends toward Municipal Solid Waste (MSW) Management

Researchers have emphasised the importance of bringing together managerial, technocratic, environmental and social concerns in developing approaches to waste management. According to Furedy (1994), debates in this area are stimulated because conventional approaches to MSW management have become unsustainable in many cities, as a significant portion of wastes generated cannot be collected regularly, while dumping space is hard to acquire or is too far away. In Indonesia and the Philippines, and most Latin American countries, technical changes in MSW management are encouraging dump picking; and the direct buying of separated recyclables is declining in some countries.

Furthermore, the public is increasingly becoming aware of the risks associated with poor waste management; various types of citizens' groups are willing to take up waste issues. Another trend that encourages changes in the philosophy of solid waste management is the influence of developments in other urban services on solid waste management. Moreover, waste reduction and recycling are now internationally accepted as the basic principles in all waste management (Furedy, 1994).

According to a study on the community-based solid waste management systems in Southeast Asia (Anschutz, 1996), there is an emerging consensus that the implementation of sustainable development should be based on local-level solutions and community participation (Mwangi, 2000). Such community-based systems are critical for

environmental management programs in developing countries, because these countries are rich in communal resources; although they are often poor in financial resources (Richardson, 2003).

On the other hand, Mockler (1998) studied community-based solid waste management systems in Indonesia. She discovered that initiatives in existence since the early 1980s have been shaped and instituted primarily by various institutions, including projects by Indonesian and international institutions, government departments, municipal governments, and private companies. Her findings indicated that the scale of project initiatives varied from household-level waste separation for composting and recycling, to small- to medium-scale neighbourhoods.

In England, there is a serious problem facing future landfill as a management and disposal option for MSW. According to a report (Phillips et al., 1998), 81% of authorities will have filled their available landfill space within 15 years and 32% of companies have only 15 years of capacity remaining, according to their figures. In 1990, the Government introduced the *Environmental Protection Act*, with a recycling credit scheme, and also initiated the non-fossil fuel subsidy, Furthermore, the recent introduction of the landfill tax, supported by the National Waste Strategy, suggests that the Government is responding to the decreasing landfill availability situation.

In a study conducted by Sakai et al. (1996), the International Ash Working Group (IAWG) compiled waste data from Canada, Denmark, Germany, Japan, the Netherlands, Sweden, and the United States of America. In terms of waste avoidance and recycling initiatives, Sakai et al. noted the German Law on the Prevention and Disposal of Waste followed by the US's *Pollution Prevention Act* as good examples of an implemented hierarchy (prevention/minimisation, materials recovery, incineration, and landfill).

The success of these initiatives is based on government—industry collaboration and implementation of incentive programs. Denmark also prioritises waste minimisation, recycling, utilisation, incineration and landfill through its Government Action Plan on Waste and Recycling. Aside from these initiatives, efforts have been made to reduce the quantities of priority pollutants in the waste stream: banning the disposal of household hazardous waste.

Another international trend in MSW management is the recycling of packaging, that is, placing more responsibility on the part of producers of consumer products. Germany's Packaging Ordinance recommends that packaging materials should be manufactured from environmentally compatible materials to facilitate recycling. This move led to the

establishment of the Duales System Germany (DSD) program, which was further modified by the Closed Cycle Economy Law. Here, energy recovery was recognised as one of the methods to help meet the new targets of 80% source-separated recovery and 80% reutilisation (Sakai et al., 1996).

Likewise, the Swedish government legislated producer responsibility regarding packaging materials, targeting paper as the main material for recycling. In contrast, Japan's Package Recycling legislation believes that it is the shared responsibility of both the producers and the consumers to ensure that materials are recycled using public waste collection systems. In another development, Denmark has encouraged recycling by imposing taxes on specific types of one-way packaging, disposable tableware, CFCs and selected raw materials. In addition, recycled materials are exempt from taxes, whereas wastes processed through incinerators or sent to landfill are taxed.

In their study, Sakai et al. (1996) emphasised the importance of incineration in energy recovery. Incineration, as an alternative to landfill as the ultimate disposal option, has been used to reduce the volume and weight of society's waste, thereby protecting human health through the prevention of the spread of disease. Additionally, current innovations in incineration enable the process to recover a substantial portion of the energy inherent in the residual waste and thus supplement traditional fossil-fuel-powered systems. Also, according to a review of the environmental and health effects of MSW management published by the UK Government, there is no evidence to suggest that the current generation of MSW incinerators is likely to have an effect on human health (*Warmer Bulletin* 2004). However, there are currently no incineration facilities in Australia. The last one, located in Waterloo, Sydney's South West, was shut down in 1997 due to serious breaches of international pollution standards (Greenpeace, 2004). On the contrary, the incineration ratio in Seoul, which stood at 6% in 2000, is expected to rise up to 20% in 2005 (*Waste Management and Recycling in Seoul City*, 2001).

In most countries, bottom ash streams are deemed suitable for disposal in landfills or monofills. In many European countries, however, these streams are processed to be used in various construction applications. In Germany, Denmark and the Netherlands, bottom ash is used as a light-weight aggregate for road construction. However, the fly ash streams are considered a hazardous waste and require special handling and disposal. In the US, bottom and fly ash streams are combined prior to disposal in designated ash monofills with leachate collection systems.

Overall, the need to manage the ash stream is based on the trace-metal analytical results from regulatory leach tests compared against established regulatory limits. In response to this, the IAWG has pushed for the assessment of ash management options based on examination of the intrinsic properties of the ash rather than on the results from a single type of regulatory leach test. In conclusion, Sakai et al. (1996) have shown that most countries studied believe in the hierarchy of waste management as a tool for developing integrated strategies for managing municipal solid waste. Strategies include: waste minimisation, reuse and recycling, recycling of packaging, energy recovery, and management of incinerator residues.

1-5 Strategy of Solid Waste Management

The economic and demographic growth of Sydney and Seoul is a serious problem for urban local authorities. With uncontrolled urban population growth, an effective and efficient waste management system is required. Solid waste collection and disposal is one service that needs to be adequately provided to ensure an urban environment conducive to the well-being and productivity of residents of these two cities.

The increase in per capita income and industrial activity in Sydney and Seoul has resulted in a proportionate increase in consumption and, consequently, in the quantity and complexity of the composition of the solid waste generated. According to the Urban Management Programme (1999), urban waste generation is predicted to increase substantially during the next few years as GNP per capita increases. While Asian cities have a lower rate of waste generation than cities in the West, the quantity of waste is high, owing to Asian cities' higher levels of population and density.

Solid waste management has now become a global issue (Bulle, 1999). Many different environmental authorities have experimented with various technological options to find viable alternatives for appropriate collection and disposal of waste. These experiments have significantly established the fact that solid waste management is not just a technical issue (dalla Torre, 1992). It has socio-political and cultural dimensions that need solutions through imaginative policies, administrative reorientation, institutional and organisational arrangements and an informed population.

Damage to the environment owing to poor MSW management can be tremendous. Some researchers suggest that the waste problem can be avoided by implementing environmentally sensitive waste management techniques, involving minimisation,

composting, recycling, reuse and waste-to-energy programs. The problem of disposing of waste is international in its scope; many nations suffer from a similar fate, with serious local implications (particularly groundwater pollution from leachates, methane gas production from landfill and atmospheric pollution from incinerators).

For decades, the response of the majority of governments and waste practitioners or operators worldwide has been to burn or bury it, but such poor, and often polluting, waste management techniques are no longer necessary or acceptable. Numerous waste management techniques are currently available that, when used together, can create a truly integrated waste management system that constitutes a viable, environmentally friendly alternative to landfill disposal.

Waste is difficult to handle and often complex to recover for beneficial uses. An increasing number of communities, however, now think of waste materials as potential resources, investing in systems and infrastructure to capture the benefits waste can bring. Moreover, new technologies and management practices have been developed over the last ten years to meet the demands of this modern regard for waste (State Government of New South Wales, 2000). In Sydney, Eastern Creek UR-3R (Reduction, Recovery and Recycling) Facility, a world first, using state-of-the-art waste treatment processes for the transformation of municipal waste into valuable resources, was officially launched on September 2004 (Waste Service of New South Wales, 2004). The UR-3R process (Figure 1-1) employs a number of different proven technologies, combined in a distinctive way to develop a specific solution for Sydney's waste.

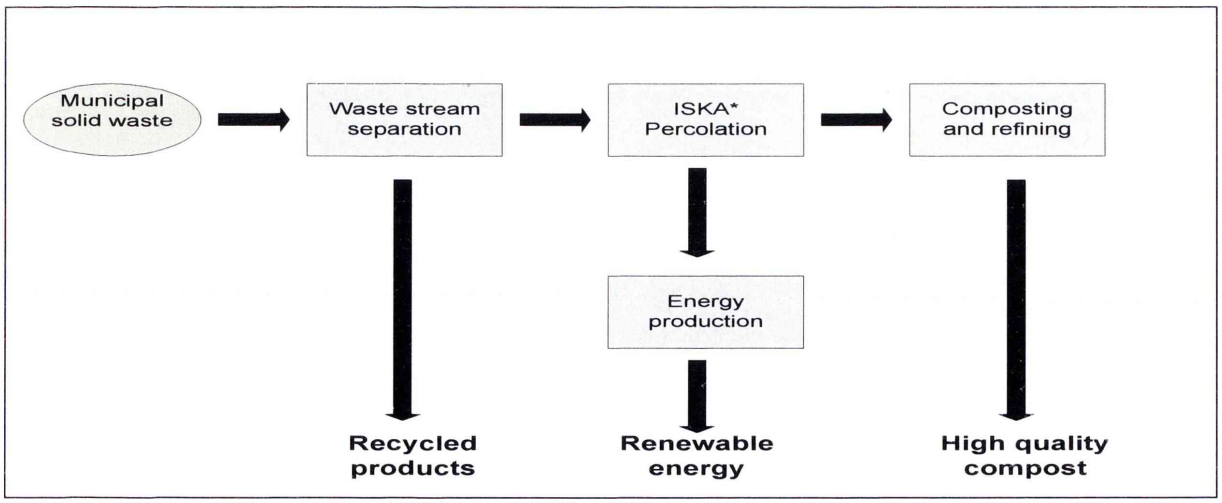

Figure 1-1 The UR-3R Process

ISKA* is a subsidiary of the German Power and Waste Management conglomerate Energie Baden Wurttemberg and is the exclusive licence holder for the ISKA Percolation patents. (http://www.minproc.com.au/index.php?c=global&article_id=317)

This study calls for sustainability, acting in a manner that will not result in poor environmental consequences for future generations. This goal of sustainability requires translation through national policy and legislation to targets that can stimulate local authorities and private waste companies in Sydney and Seoul to promote minimisation, recycling, reuse and energy recovery. The onus is currently on local authorities to implement strategies to deal effectively with their waste in a sustainable, self-sufficient and environmentally acceptable manner.

The guiding principle of this research is towards the preservation and protection of the environment against any pollutants caused by MSW; the development market; and sustainable development for the benefit of the people. In developing a MSW management system, specifically for Sydney and Seoul, the following must be considered: protection of land, air, and water quality as well as human and other animal health; usage of the LCA in evaluating integrated solid waste management to ensure efficient and effective resource management systems at the local, regional, national, and international levels.

In addition, this research places a high importance on the implementation of waste management alternatives that avoid shifting risks from one sector of society to another. For example, decisions relating to alternatives should focus on natural resource considerations and risks to human health rather than on political considerations. An additional factor to consider is public awareness. Strong public awareness and education programs must be an integral part of waste management systems. Attitude adjustment toward wastes and wasting resources should be an important part of every education program in Sydney and Seoul. Education can be used to influence public attitudes to promote source reduction, reuse, recycling, composting, and waste storage.

According to Grover and Grover (2002), there can be a few specific indicators for waste at the national level, which may include quantity of waste generated and quality of waste generated; however, at a municipal level, there are many indicators. In addition to the total quality and quantity of waste generated, indicators also include the quantity of waste being diverted away from landfill, being recycled, waste that goes to landfill, the other methods of disposal, and the cost per tonne of waste for the municipality. Further, when the indicators are developed at a micro level, such as for projects specifically for solid waste management, the number of indicators may expand to issues such as the number of public awareness events taking place and the participation rate in each on a gender basis (Grover and Grover, 2002).

With the complexity in terms of the above indicators, an MSW management strategy needs to address certain issues such as the selection of the most sound waste avoidance and minimisation program, best collection practice, best waste processing scheme, and the best disposal policy. All of these should strive to achieve the sustainable development of the environment, economy and society.

There are no simple solutions to MSW problems. Advocates of waste management using the principles of the hierarchy propose waste avoidance, minimisation, reuse, materials and energy recovery, recycling and composting as the best waste management practices. However, the waste hierarchy fails to address several issues. For example, there is a difficulty in assessing the relative merits of these practices regarding their social, economic and environmental benefits. Moreover, the waste management hierarchy is limited because of its inadequate scientific and technical basis. It also does not address costs (White, 1997).

Filling in the gap, there is one evaluation tool that can be used to develop a sound MSW management strategy. LCA is an emerging waste management strategy that is gaining support worldwide. This tool helps to assess the economic affordability of waste systems. LCA as a waste management strategy can evaluate the environmental effects involving a product or process. It can also assess the impact of environmental releases on the environment. Additionally, this management strategy can evaluate and implement ways of improving or lessening the impacts. LCA is used over the entire life-cycle of a product from the collection and processing of raw materials to the sale of the product and disposal of waste.

1-6 Research Outline

This research is composed of five major sections. The first section is the introductory chapter, which presents the statement of the problem, an overview of the study, states the rationale and the scope of the study and describes in detail what the research is setting out to demonstrate. This study works on the hypothesis that in general, MSW management systems in Sydney and Seoul lack the required management in sustainable development. This study is highly significant for policy-makers in planning and implementing effective MSW management systems.

The second section provides an extensive and critical presentation and analysis of the research that has already been conducted on MSW strategies, its problems and management. This review of related literature is divided into several parts. The first part presents a discussion of the functional elements of a MSW management system, followed by analysis of the solid waste problem and the technological and management options. The third part reviews evaluations made on these solid waste management options. The fourth and fifth parts deal with economic instruments and waste management and LCA in MSW management, respectively.

The third section discusses in detail the methodology to be used. The dissertation will employ a research method that is descriptive as well as analytic. The methodology is multi-method in focus, using both qualitative and quantitative research techniques. Surveys were conducted as part of the research. The purpose of the surveys was to assess how the residents of Sydney and Seoul perceive the MSW management systems in their respective cities. Using these surveys, MSW management in the two cities is analysed and compared. As for the case study, the current research utilises the structured and focused comparison proposed by George (1979) and Bennett and George (1997). The structured and focused comparison compares the case studies in order to draw a pattern on a certain phenomenon.

In the fourth section, the institutional structures influencing MSW management in Sydney and Seoul are discussed. Discussions include municipal responsibilities, legislation and structures, and barriers to incorporating environmental concerns. In examining MSW management in Sydney and Seoul, the background and the political objectives are also discussed, followed by a summary of the two cities' MSW projects in terms of waste-stream analysis, collection systems, processing, final disposal, and costs. Finally, this section emphasises the motivation for recycling and its importance in curbing the MSW problem. Also in this section is the presentation of the case study. A tool for evaluation of integrated MSW management aiming to determine the best management option for Sydney and Seoul is applied. In this case study, analyses are presented, focusing on economic modelling as opposed to environmental modelling.

The final chapter summarises the discussions and recommendations, provides the results, presents any significant findings, and draws conclusions. It is highly recommended that MSW management systems in Sydney and Seoul should be redeveloped to achieve sustainable development environmentally, socially, and economically. MSW management systems for both cities are then proposed.

CHAPTER 2 LITERATURE REVIEW

This chapter discusses the functional elements of MSW Management (generation, collection, processing, and disposal), and waste management practices (waste management hierarchy, integrated solid waste management, and market development). The latter are described, analysed and the related operational, environmental, social, and economic issues are identified. In addition, available solid waste treatment technologies (mechanical separation technologies, biological technologies, thermal technologies, and landfill technologies) are discussed.

This chapter also discusses how economic instruments help decision-makers in developing a MSW management system; and how the life cycle, as a perspective in analysing the waste crisis, contributes to waste management. Discussions also include the LCA and other evaluating tools.

2-1 Functional Elements of an MSW Management System

MSW management is now as much about waste generation as it is about the environmental threats from disposal. This section presents the indicators of an MSW management system according to its functional elements, such as generation, on-site storage, collection, transfer and transport, processing and resource recovery, and final disposal.

2-1-1 Generation

The ever-increasing MSW is attributed to particular demographic factors. In the US, for example, many studies attribute increases in solid waste primarily to the increase in population; the average American produces about 1,600 pounds (730kg) of solid waste per year (US Environmental Protection Agency, 1997). It was found that about 70% of the increase in household waste from 1970 to 1986 could be attributed to population increases (Franklin Associates, 1992).

Other demographic considerations that are critical for the increase in the generation of MSW include: the tremendous growth of the number of households and the size of homes (Paepke, 1993), resulting in an increase in the consumption of basic commodities (see Rifkin, 1992; Ornstein and Erlich, 1989; Kennedy, 1992). However, Cross (1993), Schor (1993), and Paepke (1993) believe that it may not be so much the increase in our

population that is producing more solid waste, but the open-ended expansion of material goods brought into the household and the increasing ratio of households in relation to the population to fill them.

Issues and debates on managing MSW are impassioned because they involve more than arguments over landfill capacity. They invoke the public's ambivalence about consumption, and raise political and economic threats to producers whose goods and packages are seen to be emblematic of over-consumption. According to Godbey, Lifset, and Robinson (1998), the waste generated is a result of what is purchased and how those purchased items are used.

Godbey, Lifset, and Robinson (1998) emphasise that criticism of packaging and other short-lived products typifies the debacles over municipal solid waste generation. In another dimension, the authors contest that it is not the environmental performance of the competing products, but the social basis of their use that is the source of the production, purchase, and use of products that swell the waste stream. Thus, to comment on the growth of the waste stream is to criticise that which is often viewed as natural, even progressive, human social change.

2-1-2 Collection

Collection is the largest cost element in most MSW management systems, accounting for 60—70% of costs in industrialised countries, and 70—90% of costs in developing and transition countries (United Nations Environment Programme, 2000).

MSW collection plays an important role in achieving a sustainable environment. According to the World Health Organization (2004), the indicators for collection and transportation are classified either as service performance indicators or as resource input indicators. Consequently, efficiency indicators such as service performance, collection frequency, and complaints can also be developed.

According to the United Nations (UN), collection, particularly the proportion of households enjoying regular solid waste collection services, is an important solid waste indicator for describing the environmental condition of an area (Macdonald, 1996). In developing countries, this can be a useful indicator for quality of life and the potential health risks associated with a lack of disposal services, whereas in most of the developed countries, this indicator is a measure simply of convenience (Macdonald, 1996). Furthermore, in studying environmental problems in cities of different sizes, Satterthwaite

(1997) states that the initial environmental problems for all urban centres are those caused by the absence of infrastructure and services, including the lack of provision for MSW collection.

2-1-3 Processing

During the processing stage of the MSW management system, the waste may be recycled, composted, or incinerated.

Recycling MSW is an attractive strategy for communities because of its potential to reduce disposal costs, conserve available landfill capacity, and contribute to national goals of energy and resource conservation. It is also a popular option among citizens (Lewis, 1989). According to Folz (1991), to realise the potential benefits of recycling, officials must successfully contend with several challenges, such as how to maximise and sustain citizen's participation in recycling. For most households and firms, recycling requires a change in waste disposal behaviour, which must be sustained by participants over time to alleviate local disposal crises.

In a paper aimed at developing sustainable MSW management, Wright (2003) believes that in order to achieve long-run sustainability, recycling must make sense both in economic and environmental terms. In New South Wales, Australia, the practice has been estimated to cost around A$300 million each year across all sectors (Wright, 2003).

Although on the consumer side, recycling has been regarded as perhaps the most astonishing trend in solid waste management, it is not always the least costly or even the cleanest alternative, largely owing to the environmental hazards of the collecting trucks that must go up and down the streets during the collection stage (Chertow, 1998). Despite this, people still demand recycling and they are participating on a grand scale.

In a study conducted by Noehammer and Byer (1997), entitled "Effect of Design Variables on Participation in Residential Curbside Recycling Programs", they concluded that when compared, people participate more in recycling when it is mandatory rather than voluntary, and mandatory programs that are accompanied by legal enforcement codes can attain even high-level participation levels. Nonetheless, well-crafted voluntary recycling programs can very well attain the same high level of participation from the greater public as mandatory programs. The study also reveals that in voluntary programs, the number of required segregations is directly proportional to the participation rate. This simply means that if the former increases, so does the participation rate. Nonetheless, the study suggested

that much must be explored to establish such a connection. In addition, data also showed that distribution of collection bags/containers free of charge has no significant effect at all on the participation rates in mandatory programs. On the other hand, the study gathered conclusive data that indicate that respondents are more eager to participate in voluntary programs, especially when collection containers are free of charge.

Moreover, in the same study data shows that respondents tend to participate more when collection is carried out on a weekly basis rather than when it is carried out every two weeks. This is true whether the programs are voluntary or mandatory. Researchers also looked at the potential impact of the provision of economic incentives among participants. Data revealed that respondents are more likely to participate when there are some rewards when they do so. However, the researchers suggest that the possible relationships between economic incentives and participation rates need a substantial research effort (Noehammer and Byer, 1997).

Ackerman (1997) tries to explain this enthusiasm for participation in recycling that goes beyond conventional economics. The author concludes that, "if our goals in life include a commitment to do the right thing for society and the environment, recycling is one of the most accessible, tangible symbols of that commitment. Participation in recycling is, in addition to its more literal purpose, a ritual of environmental belief" (p. 186).

Recycling is also the best option available for several municipalities including Seoul, where there is a debate raging over various waste issues. One of these dilemmas is concerned with the seemingly uncontrollable increasing bulk of waste that can be generated from each household. Statistics gathered in 1995 show that there were about 47,774 tonnes each day being discharged from all the households around the country, and in Seoul itself there were about 14,102 tonnes generated each day. The apparent rapid growth of household waste being generated from the whole country had sent a warning to the government officials that they must come up with immediate solutions to the problem at hand. Aside from this, South Korea is also faced with other pressing concerns, including the problems emanating from the unevenness of the country's land proportion and its growing population density, thus limiting the land sites available for final disposal of wastes. Other considerations involve the adverse attitude of the respondents toward the country's primary facilities. Incineration plants are regarded as "nuisance facilities and cannot be easily constructed" (Doh, 1996; 1). With regard to the problem of restricted final disposal sites, there is also a mounting concern over how and where these household wastes are being relocated from one place to another. Options for waste relocation are hindered

largely by several administrative restrictions relating to illegal dumping and environmental pollution. Thus, governmental authorities do not provide much leeway for accommodating household waste. In the same vein, the increase in the costs of developing and operating landfill sites also poses one of the major obstacles in effectively managing waste. Difficulties in constructing such landfill sites stem from the effect of the syndrome called NIMBY (Not In My Back Yard). In light of all these issues, the South Korean government was encouraged to resort to recycling as the best possible solution to the country's problem with its tonnes and tonnes of household wastes.

In terms of waste reduction, recycling is seen as the most efficient and reliable method. In addition, it is said that recycling one tonne of used paper is equivalent to conserving twenty living trees. Thus, reusing paper contributes to preserving the natural resources. In recycling wastes, the chances are high that there are hazardous metals such as mercury that can be recovered before they can pollute the environment. Furthermore, previous findings reveal that when recycled and used for other industrial purposes, raw materials will not pose as much an environmental burden compared to brand-new materials (Doh, 1996). Waste, when recycled, could also be convertible to energy sources.

Table 2-1 shows the recycling practices of South Korean residents as of the year 2001. The Ministry of Environment estimated that for each year, there are about 17,438,000 tonnes of household waste generated from the whole of South Korea, 13,305,000 of which were handled by the local municipalities and the remaining 4,133,000 tonnes were regenerated by the residents themselves.

Table 2-1 Situation of Collection and Recycling of Main Recyclable Materials in FY 2001

Materials	Consumption (tonnes)	Collection and Recycling (tonnes)	Collection And Recycling (%)	Others (Import) (tonnes)
Paper	6, 887	3, 662	53.2	1,283
Metal	37, 306	12, 879	34.5	5,027
Glass Bottles	788	446	56.6	-------
Plastics	3,821	539	14.1	-------

Composting is another alternative to reduce the volume of municipal solid waste being dumped in the landfills. This process has a positive effect on the environment as well as on the economy. If municipal solid wastes were allowed to rot properly, developed countries would not be facing as serious a solid waste crisis, since up to three-quarters of what people throw away is organic, readily biodegradable material (Sachs, 1993). Composting has also been regarded as an essential element in achieving municipal waste recovery targets. In the United Kingdom, targets have been set to compost at least 25% of household waste by 2005 and 30% by 2010 *(Save Water and Prosper*, 2000).

Resolving the MSW crisis depends primarily on a reduction of the trash output. But when it comes to managing the organic materials that people do discard, the obvious goal is to facilitate nature's tendency toward decay (Sachs, 1993). If instituted correctly, on a municipal level, a comprehensive composting program could address serious solid waste problems, produce cheap, safe fertiliser capable of replacing many of the chemicals now used in agriculture, and deliver a boost to both local and national economies.

Another MSW processing alternative is incineration. Despite the significant increase in the reduction, reuse, recycling, and composting practices in the management of municipal solid waste, there are still many places in which incineration continues to be an important option for the disposal and treatment of MSW. Incineration has been utilised to recover energy and reduce the volume of waste that requires landfilling. However, this process threatens people, as they believe the resulting pollutants, such as dioxin, will adversely affect their health.

In defence, proponents of incineration assert that the public concern over the health risks due to exposure to dioxins emitted by modern incinerators equipped with modern technologies is not scientifically justified (Domingo, 2002). Therefore, decisions regarding the implementation or cessation of incineration should not be primarily based on public opinion and fears of dioxin emissions.

In processing waste, whether by recycling, composting or incineration, there are times, however, when the cost of preventing pollution or closing a loop for these processes sometimes exceeds the benefits for many companies. Even when an environmental improvement shows a positive return, it may still be uncompetitive when compared with other investments a firm could make for higher returns (Greer and Sels, 1997). Such outcomes should be viewed as part of the price of pursuing the desirable goal of truly integrating environmental and business decisions.

2-1-4 Disposal

Many authors believe that solid waste disposal in landfills remains the most economic form of disposal in the vast majority of cases (Carra and Cossu, 1990). With this, landfills will continue to be the most attractive disposal route for solid waste. In fact, up to 95% of solid waste generated worldwide was disposed of in landfills in the 1990s (Gendebien et al., 1992) and about 80% in 2002 (Wright, 2003). Landfills, when carefully designed and well managed within the context of the local infrastructure and available resources, can provide safe and cost-effective disposal of a city's MSW (United Nations Environment Programme, 2004).

However, there are many problems associated with landfills. Municipal solid waste disposal through landfills generates gas and leachate, which are inevitable due to microbial decomposition, climatic conditions, refuse characteristics and landfilling operations. El-Fadel, Findikakis, and Leckie (1997) find that the migration of gas and leachate away from the landfill boundaries and their release into the surrounding environment pose threatening environmental concerns. As well as potential health hazards, other concerns include fires and explosions, vegetation damage, unpleasant odours, landfill settlement, ground water pollution, air pollution and global warming.

On the side of product manufacturers, there is a growing acceptance that waste disposal should be seen as a measure of inefficiency. According to Porter and Van der Linde (1995), in order to be more competitive, businesses must utilise all of their resources productively, regardless of whether those resources are natural and physical or human and capital. While it can be very costly to dispose of waste, some companies invest greatly in purchasing raw materials that are never turned into final products.

Literature also suggests that companies are motivated by the prospect of enhancing process efficiency, with environmental improvement being a beneficial side-effect. Florida (1997) finds that the improvement of overall performance and the response to environmental regulations are almost equal in importance as drivers of environmentally conscious manufacturing efforts. The author adds that manufacturing companies can increase quality by pursuing zero defects and optimising quantity with zero inventory, as well as setting the goal of zero emissions to maximise resource productivity.

2-2 Solid Waste Management Practices

The types of management adopted in managing discarded materials are fundamental to both protecting the environment, and using waste as a resource. In developing a municipal solid waste management system, any practice must deal with the environment-based and market-based community psyche, and be underpinned by a robust strategic policy framework. Managers must then adopt municipal solid waste management practices that lead the selection of the array of technologies employed in the solution, rather than the reverse.

In this section, major practices in managing MSW, Waste Management Hierarchy, Integrated Solid Waste Management, and Market-Development are discussed and evaluated. The current solid waste management and technological practices utilised in Sydney and Seoul are discussed in later chapters.

2-2-1 Waste Management Hierarchy

The waste management hierarchy was developed as a response to the practice of disposal-based waste management. Environmental critics argued that rather than regarding garbage as an homogenous mass that should be buried, it should be regarded as having different materials that should be treated differently. In this treatment, critics argued that some wastes should not be produced, some should be reused, some recycled or composted, some should be burnt and others buried (Schall, 1992). The waste management hierarchy is perhaps the main framework of many waste management strategies that have been generated in the past in various countries (White, 1998). Although they demonstrate many different structures all are based upon the same "order of preference; waste reduction; re-use; material recycling; composting; incineration with energy recovery; incineration without energy recovery and land filling" (White, 1998, p. 2).

Echoing the adage that prevention is better than cure, the waste management hierarchy is difficult to deconstruct. Of course, most would agree that it is more effective to avoid problems from the outset, than to invest in reactive solutions once the problem has presented itself.

The State Government of New South Wales (2000) outlines the market focus, facilitators, key drivers, and requirements for waste avoidance, product reuse support, and material recycling. The market focus of waste minimisation is geared towards the direct

reduction of virgin material usage. The facilitators and key drivers are businesses and households, and business innovation, respectively. In waste avoidance, industry responsibility and community concern are required. In terms of product reuse support, product life extension for design is the product focus; business is the facilitator; business and citizens are the key drivers; and it requires user innovation and community. In material recycling, reprocessing of products, packaging, organics, and building are the market focus; both businesses and households are the facilitators; businesses and citizens and commitment are the key drivers; and participation and support, based on sustainable quality standards and clarity of materials requirements are the requirements.

However, sceptics about the method claim that the Waste Management Hierarchy is highly limited due to the following reasons: (1) it does not possess sufficient logical findings based on systematic facts (for instance, there exist no scientific findings regarding why recycling is always preferable to landfilling); (2) the chain of preferences does not incur significant differences when it is employed with a variety of waste management options (the hierarchy falls short of overall findings as to the general impact of the whole system) and; (3) it does not provide assessment of the cost, hence making it impossible to evaluate whether the system is feasible or not, economically speaking (White, 1998). Furthermore, if the UK Waste Strategy's statement cited in Making Waste Work is to be believed, "the waste hierarchy will not always indicate the most sustainable waste management option for particular waste stream" (Department of the Environment, 1995, p. 117). A similar study which sought to determine the differences and similarities among various methods of waste management ended with the conclusion that, "the social cost-benefit of MSW management system in the European Union seems to support the conclusion that the 'waste hierarchy' is too simplistic, and that blind adherence to its tenets can lead to welfare losses (Brissons, 1997, p. 23).

Another MSW management practice is integrated waste management. In this option, the complex array of discarded material types, sources, locations, and product types from which waste arises can be handled. This practice is largely based on the overall approach idea of integrating value chain activities with waste streams, recyclable streams, treatment technologies, and markets (White, 1998; Solano et al., 2002).

In relation to waste avoidance, reduction, and recovery, the United Nations Environment Programme (2000) promotes municipally based solid waste management. Guidelines, some of which are accepted in Western Europe, North America, and Australia,

include: assessing investments in recycling, setting of quality standards, controlling collection costs, maximising participation, and other motivational techniques.

2-2-2 Market Development Options

In managing MSW, market development can be an important option. Market factors in many countries have received second-order consideration in the management of recyclables. Demand/supply equilibrium has often been assumed, possibly due to the long-term strength of markets for industrial waste materials such as steel and copper (The State Government of NSW, 2000).

One of the main thrusts in market development for MSW is the challenge to greatly increase recycling activities. In addition to the attention given to supply-side practices and technologies, recycling also requires a substantial and supportive effort to create markets and stabilise demand. Moreover, the development and expansion of markets for recycled materials requires a coalition of effort by government, business and the broader community.

In market development, it is necessary to consider conserving behaviour and recycling behaviours. While ecological concerns may encourage consumers to develop recycling behaviours as a means of energy conservation and social responsibility, economic self-interest may also be important (Richie and McDougall, 1985). As every consumer is a potential recycling agent, techniques to foster voluntary social behaviour and direct public policy initiatives need to be identified. Rather than relying exclusively on traditional methods of public regulation, social marketing techniques (Henion, 1981) hold potential for increasing recycling behaviour.

To develop a successful recycling program, and therefore to maximise the economic benefit of recycling, public acceptance is essential. In states where container and bottle deposits are mandatory, consumers have exhibited a gradual acceptance of the programs over time (Sjolander and Chen, 1989). Studies of kerbside recycling programs estimate high participation rates by community residents (Fuller and Allen, 1992). Participation and support for mandatory return systems suggest that the public may accept legislative solutions to the recycling issue. However, the potential of a market approach for stimulating recycling behaviour and its impact on consumers' dispositions may provide additional suggestions for policy-makers.

Policy choices that affect recycling behaviour include the selection of incentives, materials to be collected, and methods of collection (Milner, 1989). Although a recycling

market exists, the effectiveness of private initiatives to further encourage voluntary recycling has not been thoroughly examined. Therefore, increased marketing efforts need to be undertaken to motivate the conservation behaviour of recyclers and nonrecyclers alike.

2-3 Technological Options

2-3-1 Mechanical Separation Technologies

Waste separation is an important part of resource recovery because separation can lead to increased value of materials, and because appropriate location of separation facilities can bring advantages of scale and local market access to recovered materials. The relevance of waste-separation technologies depends on the extent to which the waste stream is prevented from mixing at source. This "unmixed" status depends upon the waste practices adopted and can vary across municipal, commercial and industrial, and construction and demolition streams. Source-separation opportunities are affected by the type of waste.

The main features of material sorting are: mature technologies; acceptance of a moderate variety of municipal and commercial dry recyclable materials; good resource conservation; the main product of recyclate for further reprocessing; and good benefit or cost position. Material-sorting technologies use both automated and manual sorting to separate mixed recyclable materials into groups of specific materials. The outputs are suitable for reuse, recycling or reprocessing. Using Material-Recovery Facilities (MRFs) as the main technology types in waste sorting, the consolidation of pre-sorted collected materials for transport to reprocessors, and sorting of incoming materials led waste streams to aggregate specific commodities (The State Government of New South Wales, 2000). In the early 1990s, MRFs had not gained a strong financial foothold, and the ability to expand their operations has been slow in developing (Naude, 1992). This resulted in increased inconvenience for consumer efforts to return recyclable materials and an overall decline in interest.

In discussing conceptual design of the collection/processing interface, Stessel (1996) deals with the issue of improving the economics of recycling from the kerbside to a MRF. Examining the shortcomings of recycling technology, the author suggests ways to reduce recyclable materials' collection costs: adoption of the wet/dry system to separate organic garbage and inorganic recyclables; design and standardisation of an automated collection vehicle that can separate light and heavy recyclable materials; a single discharge

point for the automated collection vehicle to the MRF; and conveyor systems to route loads deposited into different process trains.

Waste-separation technologies, on the other hand, involve the following as their key features: mature robust technologies; acceptance of mixed residual waste as input, the main products are specific separated resource streams for further processing; and good benefit—cost position. Waste separation can undertake a process in which the mixed waste is mechanically worked and heated; and a process in which the processed waste is segregated. Fractions recovered from the waste stream after separation are: an organic-rich fraction that can be used as a feedstock for further biological processes; a high calorific fraction consisting primarily of plastics, which can be recycled, used as a Refuse Derived Fuel (RDF) or landfilled; an inert fraction consisting of bricks, stones, glass, etc., that is landfilled; and a ferrous scrap fraction recovered using a magnetic separator.

Examples of these technologies are the German Loesche refuse mill, a rapid ball mill process adopted from mineral processing practice where friction provides the heat source; the Australian Brightstar "autoclave" process which heats and rotates waste in batches, then separates it by screening and sorting; and various tunnel systems in which the waste is fed into a rotating drum, with heat being generated through friction and biological action.

In the Wright et al., (2000) study, they discovered that among mechanical technologies, material sorting received an outstanding mark in terms of maturity. Furthermore, this method is also the least costly among other options. It only involves separation of dry recyclables, which can be subsequently converted again into new products. On the other hand, technologies for water separation received moderate scores in terms of their capability to isolate combined residual wastes.

2-3-2 Biological Treatment Technologies

The decomposition of solid wastes is carried out by physical, chemical, and biological processes (Cossu et al., 1997). Biological processes are the most significant and will control the chemical and physical processes (Ham, 1992). A variety of biological treatment technologies is now available for processing organic materials from municipal waste sources. In these processes, decomposition is achieved by microbial activity within biologically degradable wastes. In a study conducted by Wright et al., (2000) they concluded that among the technological options that are available, biological technologies

are the ones most accepted by the majority of the participants. They also generate a moderate-to high-quality soil conditioner. All biological technologies are classified as environmentally friendly, socially and economically viable.

Land Application. One type of biological treatment technology is land application. Land application is a form of bioremediation. The process involves straightforward application of macrobiotic wastes to augment the nutrient content of the soil.

Several terms are used to describe this waste management technology, which can be considered both as treatment and disposal. Optimal land application techniques balance the additions of waste against a soil's capacity to assimilate the waste constituents without destroying soil integrity, creating subsurface soil contamination problems, or causing other adverse environmental impacts (Drilling Waste Management System, 2004).

Benefits of land application include the ability to recycle organic and inorganic nutrients, enhance the physical properties of the soil while increasing plant growth, and decrease the cost to municipalities (Lindsay et al., 2000). The organics in the biosolids also increase soil fertility, pore space, organic content, and water-holding capacity (Rhyner et al., 1995). Moreover, farmers benefit from the nutrients in biosolids that can be used for crop production, generally at a lower cost than conventional fertilisers (Cornell Waste Management Institute, 1996). Sewage sludge, agricultural wastes and grease trap waste are some of the common materials used in land application.

Open windrow composting. Open windrow composting occurs under moist, oxygen-rich conditions where complex organic molecules are broken down by micro-organisms that release nutrients and energy contained in the waste. Open windrow composting technology is best suited to situations where there is a high proportion of organic material in the waste stream and markets are accessible and available (EnviroAccess, 1999; Smith, 2001). Typically, open windrow composting is a low-technology and relatively low-cost option. Operational control is accomplished through selecting and preparing a suitable waste to be composted and maintaining optimal temperature, moisture and aeration conditions in the active windrows (UNEP, 1998). Moreover, food waste and other organics may be incorporated into the process, although technology must be installed to control odours. These odour-control systems will in turn raise the costs of the operation, therefore making the technical flexibility somewhat limited.

The resulting materials are helpful in enhancing the condition of the soil. Its most uncomplicated form employs open windrows that can treat garden waste, food waste, and sewage sludge.

Enclosed Composting. This technology works in the same way as open composting. The composting process involves the provision of aerobic conditions to a concentration of organic matter in order to allow bacteria to grow and to begin the transition from waste to compost. One of the problems of enclosed composting is that it is susceptible to losing aerobic conditions, resulting in anaerobic decay, producing methane and unpleasant odours. The same environmental problems associated with open composting are encountered with enclosed composting: greenhouse gas emissions from the transport of the waste to the composting facility. The production of leachate when the moisture content of the waste is too high is another problem encountered.

Vermicomposting. Vermicomposting is a technology that, as opposed to composting, involves the breakdown of organic material through the joint action of earthworms and micro-organisms and does not involve a thermophilic stage (Dominguez et al., 1997). As the agents of turning, fragmentation and aeration, these earthworms consume organic wastes such as food waste, animal wastes and sewage sludge to produce a soil conditioner (Dominguez et al., 1997). Originally, this technology has been widely used on a small scale, such as in backyard composting and in offices and schools, but vermicomposting is now being developed on a commercial scale for processing sewage sludge/biosolids and animal wastes.

Anaerobic digestion. Anaerobic digestion (AD) involves the biological degradation of organic materials by microbial activity in the absence of oxygen. It is commonly used as a waste treatment process but also produces a methane-rich biogas, which can be used to generate heat and/or electricity. In this technology, the organic waste is broken down in the tank and up to 60% of this waste is converted into biogas (ATLAS, 2004). Apart from biogas, the process also produces a digestate which may be separated into liquid and solid components. The liquid element can be used as a fertiliser and the solid element may be used as a soil conditioner or further processed to produce a higher-value organic compost. For decades, the intrinsic characteristics of anaerobic MSW landfills have been studied,

yielding a significant volume of data regarding waste degradation processes and kinetics and the inherent products of anaerobic stabilisation.

Fermentation. Fermentation is a waste-treatment technology that yields energy from the oxidation of organic materials into various end-products. The primary input in this technology has been agriculture wastes, but recent developments are using municipal organics, including food waste and sewage sludge. Presently, yeast fermentation of organic components that contain a complex mix of waste with a high cellulose content, such as municipal solid waste, does not appear promising. The application of genetic engineering techniques combined with the genetic diversity of bacteria and fungi may result in the development of organisms that can more efficiently ferment cellulose and other waste-derived organic products for the production of alcohol and other value-added products (Rhyner et al., 1995).

2-3-3 Thermal Waste

Europe and North America have been using thermal waste treatment technologies, with incineration the most widely used thermal process. In this technology, energy recovery is usually in the form of heat and electricity. Incinerators are generally regarded as the sole treatment technology in an integrated waste management approach. However, new thermal technologies have emerged over recent decades, which do not utilise direct burning, or combustion of waste. These include pyrolysis and gasification technologies, as well as oxidisation or melting technologies.

In the same study conducted by Wright et al. (2000), incineration gains a relatively low score for its unsatisfactory performance, socially and economically speaking. Among alternatives, it also possesses the lowest resource capabilities. Meanwhile, the newest thermal technologies such as pyrolysis/gasification and waste melting received excellent reviews. These technologies, especially pyrolysis/gasification, can be applied to discrete items while waste melting is verified to be effective when carried out in mixed treatment.

Rhyner et al. (1995) identified the lack of available land to site a landfill and the high cost of energy as the two major incentives for incineration as a feasible waste disposal strategy. Benefits of incineration include the reduction of volume and weight, the destruction of certain chemicals or alteration of chemical characteristics including most hazardous chemicals, the destruction of pathogens, energy recovery, and the only

environmentally acceptable methods of disposing of some hazardous wastes (Rhyner et al., 1995). In addition, incineration reduces the volume of the combustible portion by approximately 90% and the weight by about 70%. According to Rhyner et al. (1995), air pollution and disposal of ash are the two main concerns of using incineration to process municipal solid waste. Air pollution results when heavy metals and other airborne chemicals vaporise and are emitted from the smoke stacks of incinerators (Lindsay, Zhou and Halstead, 2000).

Pyrolysis is the thermal decomposition of an organic material in the absence of oxygen or other chemical reagent. This decomposition proceeds through a complex series of chemical reactions and processes of heat and mass transfer. Pyrolysis is a step in the gasification and combustion processes. This technology involves indirect heating of carbon-rich material. The aim is to achieve thermal degradation of the material at a temperature of some 500 degrees Centigrade in the absence of oxygen and under pressure. Many pyrolysis plants concentrate on processing consistent waste streams, such as plastics or biosolids.

Gasification is a thermochemical process in which a carbonaceous matter is transformed in a fuel gas of low to medium calorific value by means of chemical reactions which occur at high temperatures and in the presence of a gasifying agent. Gasification technologies are widely considered an energy-efficient technique for reducing the volume of solid waste and for recovering energy. Some advantages of gasification are the versatility of residue appreciation, as the energy content of the residue can be used as heat, electricity or chemicals synthesis; good electrical yield, and low environmental impact.

Waste melting is a thermal technology that operates at sufficiently high temperatures to completely oxidise or reduce the waste and melt the residual or left-over material. These processes can either be used to stabilise residuals from a thermal process, or be used to process the waste directly. The outputs in this technology are heat and fuel gas, which can be used to produce energy for input into the power grid. A further product is recyclable metal. Waste melting is used around the world mainly for refining metal concentrates and metallic wastes, such as aluminium pot linings and spent nickel-cadmium batteries, and has been trialled for incinerator ash.

2-3-4 Landfill Technologies

Landfills are the primary means of disposing of solid waste in the developed nations, while recycling and composting are gaining in popularity. In the US, the reliance on landfills decreased to 61% in 1999 from 85% in 1989 (Goldstein, 1999). Landfills are a necessary component of any MSW management system. Waste recycling efforts, recycling, incineration, and composting can reduce the quantity of materials sent to a landfill, but it is impossible for these processes to prevent all waste from going to landfills (Rhyner et al., 1995).

However, landfills are continuously decreasing in number. This is attributed to: closure of older landfills that cannot meet current design and operation standards; the increasing difficulty of locating new landfill sites; the cost of the site design, construction, operation, leachate and gas monitoring and collection, leachate treatment, administration, and engineering favouring the construction of large facilities (Rhyner et al., 1995).

Landfilling of solid waste has raised concerns. According to Tchobanoglous et al. (1993, p. 370), these issues involve the uncontrolled release of landfill gases that might migrate off-site and cause odours and other potentially dangerous conditions; the impact of the uncontrolled discharge of landfill gases on the greenhouse effect in the atmosphere; the uncontrolled release of leachate that might migrate down to underlying groundwater or to surface water; the breeding and harbouring of disease vectors in improperly managed landfills; and the health and environmental impacts associated with the release of the trace gases arising from the hazardous materials that were often placed in landfills in the past.

Landfill technologies ranked moderate to high in terms of reliability, litheness, and low costs. These facets make up for the inherent weaknesses of such technologies when it comes to "resource conservation, moderate environmental risks and low social acceptability" (Wright, 2000, p. 15).

Conventional Wet and Dry Landfill. The main function of the current landfill technology is to isolate waste and the products of its decomposition from the surroundings. Landfill technology is also supposed to eliminate water from the system. The principle behind this is that waste constituents and products of their decomposition will remain captured within the waste matrix, rendering a landfill secure from the viewpoint of public health and environment (Rodić, 2000). However, when there is no water in a landfill, decomposition

processes come to a virtual halt, which implies that keeping a waste mound dry may actually only protract the period required before the site can be regarded as secure.

In the conventional wet landfill, it is assumed, in contrast to the dry landfill concept, that rain is allowed to pass through the landfilled waste, leaching out all the physically mobile and chemically active substances (Rodić, 2000). Then only inert material should remain and this will be more a disposal of waste, rather than storage, as is the case with the dry landfill concept. The major concern regarding the wet landfilling is that the leaching process is still not easy to influence and control: some substances do not leach readily; some of them take decades (Rodić, 2000). Dry landfilling technologies, being politically more desirable, have been almost exclusively pursued in practice. Technologies using dry landfills are most suitable in low precipitation climates, where minimisation of infiltration inhibits the biodegradation of waste. This reduces leachate and landfill gas formation because of the dry stable conditions.

Aerobic bioreactor landfill technology. The concept of the aerobic landfill basically involves the composting of readily and moderately degradable solid waste constituents. The waste undergoing the composting process permits gas exchange, provides its own nutrients, produces water and utilises an indigenous and diverse microbial population (Yuen et al., 1997). A study by Bernreuter and Stessel (1999) concluded that the aeration of MSW incubated in lysimeters, with moisture content sustained via leachate recycling, resulted in an increase in biomass production and greater cellulytic activity. The aerobic bioreactor landfill decreases the long-term impacts on the surrounding environment, as well as post-closure maintenance costs, and, according to Yuen et al. (1999), one would expect a significant reduction in methane production within a landfill's waste mass.

Aerobic landfill has been gaining popularity worldwide. In Germany, for example, aerobic biological pre-treatment of MSW has been carried out since the late 1970s. This pre-treatment process is used to lessen the overall waste mass, increase landfill densities, improve leachate quality and reduce the attraction of the site for birds (Leikam and Heyer, 1997). In Japan, the semi-aerobic landfill is a standard type of landfill currently in use. The Fukuoka Method that utilises the self-purifying capacity inherent in "nature" to stabilise waste materials (Hanashima, 1999) is one example of this system.

Table 2-2 summarises the various types of technologies and their input wastes and output products.

Table 2-2 Input Wastes and Output Products by Waste Technology Type
(From Wright, T et al, Report of The Alternative Waste Management Technologies and Practices Inquiry, April 2000, Office of the Minister for the Environment, p. 7).

Technology Class	Input Waste Types	Output Products
Mechanical Separation Technologies		
Material Sorting	• Mixed dry recyclables, including; paper/cardboard, packaging plastics, paper, glass, metals	• Reprocessible materials by type
Waste Separation	• Industrial dry recyclables, including; paper /cardboard, metals, plastics, glass, timber, concrete, soil • Mixed residual waste	• Reprocessible materials by type • Organic mass for biological organic processes. High calorific material (RDF) for thermal processes or reduced volume landfill. Inert materials, metals
Biological Technologies		
Land Application	• Agriculture wastes, sewage sludge, gypsum, specific organic wastes	• Soil improvement
Open Window Composting	including grease trap wastes	• Compost, soil conditioner
Vermicomposting		
Enclosed composing	• Garden waste, sewage sludge	• Compost, soil conditioner
Anaerobic Digestion	• Sewage sludge, food and garden waste	

Fermentation	• Mixed organic waste, including food, garden and preseparated waste • Mixed organic waste, including food and garden waste • Agricult. wastes, mixed organic wastes	• Biogas fuel/green energy. Digestate material for compost • Liquid fuel
Thermal Technologies		
Incineration	• Mixed residual waste. High-calorific special wastes. Special wastes including clinical and hazardous.	• Heat/steam/energy • Waste destruction
Pyrolysis/Gasification	• Sewage sludge, agriculture wastes, including food and garden waste, paper pulp and preseparated residual waste	• Pyrolysis oil or Syngas/green energy
Waste Melting	• Metal and hazardous wastes, mixed residual waste potential	• Syngas/green energy • Heat energy. Metal residue
Landfill Technologies		
Conventional Wet Landfill	• Mixed residual waste	• Methane/green energy
Conventional Dry Landfill	• Mixed residual waste	• Nil
Bioreactor Landfill	• Mixed residual waste	• Methane/green energy

2-4 Waste Management Models

According to Qureshi et al. (1999), a model is a representation of an object, system or idea in some form, other than that of reality itself. With respect to waste models, Morrissey and Browne (2004) find that most of the municipal waste management models identified in their review are decision-support models: those based on cost–benefit analysis, those based on LCA and those based on multicriteria decision-making. Rogers (2001), on the other hand, categorises models as those that use optimising methods and those that use compromising methods.

As can be seen from the comprehensive summary of waste management models provided by Berger et al., (1999) and Tanskanen (2000), optimisation models were the first solid waste management models. But these types of model are limited because they have only one time period, often ignore recyclables, and have only one generating source (Berger et al., 1999), making them unsuitable for long-term planning (Sudhir et al., 1996). In the 1980s, waste management had extended to include MSW management. Models at this time looked at the relationships between each factor in the waste management system (MacDonald, 1996). Aiming to minimise the costs of mixed waste management (Gottinger, 1988), recycling was included in some of these models (Englehardt and Lund, 1990).

Early models also dealt with the social dimension of waste management. For example, Fuertes (1974) tackled social equity issues related to the siting of facilities; Motameni and Falcone (1990) studied recycling attitudes and behaviours. Early models are limited because they only focused on waste once generated, completely excluding minimisation or prevention aspects. However, some authors contended that the reduction of wastes is the most rational and cleanest means of solid waste management (Boyle, 1989). In the last decade, models developed for the planning of MSW management included recycling and other waste management methods. Currently, most waste management models are categorised into one of three categories: those based on cost–benefit analysis, those based on life-cycle analysis and those based on the use of a multicriteria technique such as AHP or ELECTRE (Morrissey and Browne, 2004).

As described above, most waste management models consider economic and environmental aspects, but very few consider social aspects. According to Morrissey and Browne (2004), waste management models must consider environmental, economic and social aspects all at the same time for them to be sustainable. According to Nilsson-Djerf

and McDougall (2000), acceptance by the community makes a waste management system effective. Moreover, Petts (2000) strongly insists that MSW has to relate to local environmental, economic and social priorities.

2-4-1 Economic Instruments

Governments worldwide face increasing pressure to solve environmental problems. Since any policy choice inevitably has different impacts on different groups, governments have to make groups with widely divergent views and interests agree on the solutions (Harrison, 1993). Local groups can often provide ready solutions to crime, education, even health care, but many environmental problems are harder to confine.

In dealing with environmental problems, policy-makers often resort to economic instruments (Barde, 1989). These include emission taxes, trading rights to emit pollutants, and other measures that provide an economic incentive to reduce solid waste. The most important are the emission taxes in Europe and the emission-trading programs in the US that allow companies to sell emission rights. Carbon taxes and programs of tradable permits are certainly the most widely discussed on the international stage. Likewise, individual OECD countries are considering a large number of other economic instruments to deal with air and water pollution, solid waste and other environmental problems (Harrison, 1993).

In using economic instruments, theoretical arguments suggest that if environmental policy uses these devices rather than conventional command-and-control regulations, there should be substantial gains in the form of more flexibility, lower costs and increased innovation (Barde and Smith, 1997). Typically, emission taxes, if fixed at an appropriate figure, should minimise the cost of reducing pollution across polluters by moving the reduction in emissions to where marginal abatement costs are lowest; the same holds true for tradable permits.

Economic instruments have been defined in various ways. According to the OECD (1994), economic instruments have an impact on the relative prices of alternative actions relative to firms. Through this, they seek "to influence decision-making and behavior in such a way that alternatives are chosen that lead to an environmentally more desirable situation than in the absence of instrument" (p. 17). Another definition provided by the Industry Commission (1997) is that economic instruments work by using market signals, providing incentives to managers in integrating environmental concerns into their everyday

decisions (p. 10). Moreover, according to James (1997), economic instruments depend more on decentralised decision-making and market mechanisms than do direct regulations. According to the author, by creating markets for the environment, economic instruments can signal true resource scarcities to users, creating economic incentives for wiser management.

Environmental degradation through solid waste mismanagement is symptomatic of market failure. A considerable number of environmental problems are brought about by simple market failures. These may include the existence of externalities, public goods, and imperfect information. According to Grimble (1999), markets, through use of price signals, ensure sustainable resource usage, minimise wastage, ensure efficient allocation, and provide incentives for the development of reuse and recycling.

In the past few years, market-based instruments have been realised to offer scope to achieve environmental goals in more cost-effective ways, compared to the traditional command-and-control regulatory mechanisms. In addition, the use of market-based instruments also provides opportunities to achieve improved environmental outcomes where other methods have not been very effective (Bari, 2002). Broadly speaking, the use of economic instruments in environmental protection and preservation through an effective MSW management system is viewed as a practical tool to achieving sustainable development. Economic instruments aim to use market forces to encourage producers and consumers to limit pollution and avoid the degradation of natural resources. A typical approach is to put a price tag on emissions so as to discourage pollution (Barde and Opschoor, 1994).

There are several reasons for introducing economic instruments. According to Barde and Smith (1997), economic instruments are sometimes intended to provide incentives. In other situations, these instruments may have been designed to provide resources to finance specific pollution-abatement programs. With tradable permits, the primary aim may be to reduce the overall abatement cost. Although these various aims are often conjoined, it is useful to differentiate economic instruments with reference to their main or primary purpose (Barde and Smith, 1997).

The possible benefits to society from the adoption of economic instruments include lower costs to firms of meeting environmental targets. This means lower costs may be passed on to consumers. Another benefit is increased flexibility. Through this, firms have a continuing incentive to improve technologies for reducing solid waste, rather than staying locked into particular control technologies. Moreover, to the extent that economic

instruments make the costs and benefits of environmental programs more visible, they focus debate on the trade-offs between environmental protection and other government goals (Harrison, 1993).

James (1997) states that the most persuasive case for the use of economic instruments is the belief that these instruments help in attaining environmental objectives at the least cost to the community. The OECD, IMF and the World Bank are ardent supporters of relying on economic instruments and other market mechanisms to enhance environmental outcomes, and to overcome the destruction of the environment. In conclusion, economic instruments are beneficial in developing an MSW management system.

Despite these identified benefits, many critics have questioned whether economic instruments have all the advantages customarily ascribed to them. Even with the substantial incentives they can provide to reduce environmental impacts in the most economically efficient way being extensively elaborated in elegant analyses (Lloyd, 1992), critics have questioned their limited use.

The use of economic instruments was opposed by some environmentalists, officials and politicians for the reason that regulations are simpler to introduce and more precise in their implementation. They argued that economic instruments were deceptive and may not provide environmental protection, given the complexity of environmental problems. In addition, regulations were often poorly conceived, time-consuming, arbitrary and manipulated for political purposes. Further, it was possible that structural inefficiencies would exist because of information gaps at each point in the regulatory decision-making process (Harris, 1994). Other important problems in the application of economic instruments included the dealing with non-point pollutants (Segerson, 1988) as well as the spatial distribution of environmental measures.

However, despite these shortcomings, the economic logic of using economic instruments for protecting the environment in order to minimise the costs of doing so is still going strong. Empirical studies have found that the use of economic instruments in conjunction with regulatory targets can lead to substantial cost savings. Cost savings where economic instruments have been introduced have frequently been substantial. According to Harris (1996), potential savings will be much greater in the future, since the marginal costs of environmental control are likely to increase.

2-4-2 Life-Cycle Assessment (LCA)

Usually in waste management literature, consumers who generate MSW and producers who generate industrial waste are discussed separately. Waste management authors have begun to emphasise the close relations between consumers and producers in important ways. Authors such as Chertow (1998) have modified the four-stage process of generation, collection, processing, and disposal. This stems from the contention that waste generation begins most often not in the home or business, but much earlier, when products are first made. For example, if a waste consists of a plastic cup, the chain begins not when the consumer throws out the plastic, but rather when the raw material used to make the plastic is first extracted from the earth.

Chertow (1998) suggests the following model: (1) EXTRACTION → (2) MANUFACTURING → (3) DISTRIBUTION → (4) USE/DISCARD → (5) COLLECTION → (6) PROCESSING → (7) DISPOSAL. This model views the plastic cup from a life-cycle perspective. This very significant, comprehensive perspective allows policy-makers to rethink their waste management assumptions, conclusions, and proposed solutions. The advantage of this new model over the four-stage model is that it addresses the need to come up with the most suitable solid waste management practice. In the four-stage model, recycling of a plastic cup is undoubtedly likely to be better for the environment than trying to burn it or dump it in the ground in a landfill, where it would take centuries to decompose. On the other hand, the new model, applying the life-cycle perspective, provides a better solution that arises from the more comprehensive approach.

For instance, a small paper packet of dog food is sold as an alternative to canned dog food, so that the consumer has just to add water in the dog's reusable bowl. There is a high probability that there can be savings in the manufacturing process, the consumer can save room on the shelf, and the cost of recycling can be reduced or eliminated. In this case, substitute packaging will trump recycling. If the public is not ready to accept such packets, they can still choose recycling, only with a different rationale: not because recycling is better or cheaper than disposal, but because recycled metal reduces the need for extraction as well as the energy it takes to convert iron into steel (Schall, 1992).

Industrial ecology is a field based on life-cycle perspectives, paying resolute attention to materials use as it looks across factories, value chains, regions, or whole economies. The trend is based on the principle that environmental protection and economic prosperity are both desirable ends. Graedel and Allenby (1995) stated that industrial

ecology is a systems view of industrial operations "in which one seeks to optimize the total materials cycle from virgin material, to finished material, to component, to product, to obsolete product, and to ultimate disposal" (p. 9). The focus on industry leads to a consideration of the role of corporations, and more broadly, of all human activity and how it connects to the biophysical environment from which humans obtain resources and into which they place their wastes.

Industrial ecology operates on three levels pertinent to waste management. Within the firm, the drive to design out waste has evolved into design for the environment. So-called because it occurs at the beginning of the product life-cycle, it can include environmental considerations or exclude them, with a potentially dramatic effect on waste generation. Design for the environment assures that environmental issues will be considered from the start. At the second level, between and among firms, life-cycle perspectives allow us to look beyond facility boundaries across the many stages of production and use, as well as at the opportunities to share and trade waste, water, and energy.

Industrial ecologists also track the flow of materials and energy across regions, economies, and the globe. In order to understand how waste reached its current location, we must also understand where the original raw materials came from. Mass-flow analysis, often called industrial metabolism, looks at how much of a given material is produced, how much is recycled, what quantities of the material are lost directly into the environment and through which path-ways. From this base, we can determine where the greatest harms lie and target them for policy attention (Powers and Chertow, 1997).

LCA is a tool used to evaluate the environmental effects associated with a product or process including energy and material usage and environmental releases; to assess the impact of these releases on the environment; and to evaluate and implement ways to improve or lessen the impacts (Keoleian et al., 1993; Tillman et al., 1993). LCA is used over the entire life-cycle of the product from the collection and processing of raw materials to the sale of the product and disposal of waste. For example, Church and Dwight Inc. has undertaken a LCA of its product Arm & Hammer baking soda to determine its environmental impacts over its entire life from the initial mining of the soda ash ore to the disposal of baking soda down sinks, in the air and through solid waste such as cat litter (Walley et al., 1993).

LCA has mainly been applied to simple, low-design, resource-intensive products. The materials in these products may be recycled as bulk commodities or may place

excessive demands on waste disposal facilities. LCA has also been used to rate potential hazards and the impact of input substitution on the performance of products (Kirkpatrick, 1993).

Criticisms of LCA include the contention that when different methods are used to evaluate the same product, substance or material, they often give inconsistent results (Ayres, 1995). Moreover, critics have noted the failure of LCA to provide conclusive results because there are no commonly agreed-upon methods for comparing, valuing or weighting different environmental impacts. The use of LCA methods is also often limited by cost or insufficient data. Although LCA does not provide a common denominator or bottom-line comparisons of different product claims, it has been extensively used within firms to evaluate corporate progress towards policy targets (Nortel, 1996).

Nonetheless, LCA, or essentially its shortened version, the Life Cycle Inventory (LCI), is continuously being accepted among progressive countries such as the UK, France, Spain, and Canada. These countries employ the method with the aid of computer-generated models to manage their solid household waste. LCI is also seen as the answer to the long-standing paradox of sustainable development. In the paper presented at the Church House Conference Centre about Sustainable Waste Management through LCA, White (1998) explores this possibility.

Realistically speaking, there is no single tool that can effectively handle all the components of household waste in a well-organised, environment-friendly way (Aumonier and Coleman, 1997). Even LCA cannot provide such an advantage. Hence, it is a must to conduct a different environmental risk assessment. LCI is useful in this regard (Thorneloe et al., 1998). It can be relied upon specifically in determining the environmental risks of waste management (White, 1998). White further explains that, "given all the individual operations, such as composting, incineration, landfilling etc. are safe, LCI will help determine the optimal integrated combination of these options that minimises energy and raw material consumption, and the generation of air and water emissions and final inert solid wastes" (White, 1995, p. 6).

Nonetheless, he warned that such results of LCI or LCA do not necessarily yield to making a conclusive statement as to which is the most efficient waste management method. Rather, the results will present "a list of energy consumption, and emissions to air, water and land, over the whole life cycle, and will also predict the amounts of useful products that arise from waste, such as compost, secondary materials, and useful energy" (White, 1998, p. 5). As in any locality, the best method for managing waste largely depends on the

demands, requirements, and preferences of the local residents. Such needs range from the "necessity to improve the landfill condition to the need to lessen energy emissions". Hence, LCI should best be treated as only "a decision-supporting tool and not as a decision-making tool" (White, 1998, p. 5).

In countries such as Europe and Canada, LCIs are being conducted through the aid of various computer models (White, et al., 1995; Thurgood, 1998). Europe and Canada have pioneered this movement, which is indeed helpful in pinpointing what and where further information is needed. In following the lead of these two nations, the UK Environmental Agency and the US Environmental Protection Agency came up with other more highly complicated computer techniques that are guaranteed to enhance the precision and consistency of each gathered data (Environment Agency, 1998; Thorneloe et al. 1995; Powell, 2000; Barton et al., 1996). Reasons why local administrators employ such mechanisms vary across states including Gloucestershire and Hampshire in UK, Barcelona, Pamplona in Spain, London and Ontario in Canada (Steele et al. in press; Area Metropolitan de Barcelona, 1997; Wilson, 1998; Thurgood, 1998).

At present, LCI is widely used as (1) a benchmarking tool (that is, it is being employed to evaluate the existing environmental configuration of a waste management strategy; (2) a comparative planning tool (that is, it is being employed so that a wide array of "what if" dilemmas could be addressed); (3) a communication tool (that is, it is being employed as a delivery tool to provide further insights and information so as to encourage heightened awareness among the larger citizenry and; (4) a source of data (that is, it is being employed as a reliable mine for systematic and sound data regarding all facets of the existing waste management systems (White, 1998, p. 6).

2-4-3 Other Evaluating Tools

Design for the Environment. Design for Environment (DfE) was first used in the 1980s as a generic response to concerns about the scale of technology incineration and the amount of waste going to landfills. DfE deals with the potential environmental impacts of industrial processes and consumer products in a completely different way. It introduces the principles of pollution prevention into the design process before non-reversible choices have been made and while the selection of alternatives is still feasible and not cost-prohibitive. DfE has been applied to structurally complex, high-design products. These products usually contain valuable components or rare materials that are worth recovering (White, 1998).

Cleaner Production. Cleaner Production is an approach that has helped inform the development of the waste management hierarchy. In addition to Cleaner Production, other related terms and concepts such as source reduction and Pollution Prevention have also emerged. All of these approaches address the need to avoid, eliminate, prevent or significantly reduce the causes of environmental problems. This practice is opposed to managing the impacts, wastes and emissions arising further down the products or services life-cycle.

Hirschhorn et al., (1993), in explaining preventative models state: "A multitude of terms and phrases define and describe the emerging preventative environmental paradigm. These terms include pollution prevention, source reduction, and waste reduction. Waste minimisation, toxics use reduction, and clean or cleaner technology. In theory, the newer sets of terms refer to forms of preventative action that shrink the fundamental causes of environmental problems. Certainly, the newer terms are becoming increasingly more popular than the more traditional phraseology of environmental protection such as pollution control, waste management, environmental control and waste disposal. These older actions are characterised by their attempt to solve environmental problems by reacting to the effects of pollutants" (pp. 125-143).

2-5 Conclusion

In summary, this chapter has discussed the functional elements of an MSW management system, described and analysed waste management practices, presented available solid waste treatment technologies, discussed the importance of economic instruments and how a product's life-cycle, as a perspective in analysing the waste crisis, contributes to waste management.

Using the life-cycle perspective, rather than the principles of the waste management hierarchy, in developing sound MSW management addresses both consumers' interest in the preservation of the planet and business's desire to conserve for efficiency reasons. The LCA is based on the realisation that the best answer may not be found simply by looking within one facility or household. Looking beyond facility boundaries allows new opportunities to enhance product quality, reduce costs, and lower environmental impacts, whether neighbourhoods band together to make and use leaf compost or companies make products that are designed, from the start, to consider environmental concerns.

As we have seen from this chapter, the quantity of solid waste disposed of can decrease for two reasons: because less is generated or because the same or more is generated but more is reclaimed. Do arguments from sustainable development tell us which is preferable? One insight from industrial ecology is that generation numbers do not tell the whole story; primarily because it is conceivable that what would be most beneficial technically, economically, and even environmentally in some circumstances would be for waste to be generated and exchanged rather than reduced, when considering all of the life-cycle stages of several companies combined in an industrial ecosystem.

Management and technological capabilities, project financing, and economic assessments are all important when dealing with MSW management. At times, situations in which the difficulty experienced by urban managers in planning and directing concrete projects in a cost-effective way may overshadow the need for technical solutions to MSW management problems. At other times, there is a tendency for MSW management decisions to be made without sufficient planning, taking into account only some aspects of a situation, to be based on a short-term view of the situation.

Overcoming the tendencies of insufficient planning will greatly facilitate the identification of the best management and technological solutions in a particular circumstance. This study addresses these issues in the context of developing sound MSW management system for Sydney and Seoul. Importantly, this study deals with the increasing need to integrate environmental policy with economic development policy.

CHAPTER 3 METHODOLOGY

This chapter discusses the research methods used for the study, including the research design and the structured focused comparison approach in evaluating the MSW management systems of Sydney and Seoul. Likewise, the chapter presents how the research was implemented and how it came up with pertinent findings. In addition, this chapter also presents the various procedures and strategies used in identifying the sources needed for information on the identification and evaluation of MSW management in Sydney and Seoul. It specifies the research design that was followed, determination of the sample, sampling design, subject of the study, research instrument, and validation of the instrument used, data-gathering procedures, and statistical treatment.

3-1 Structure of the Methodology Section

This study seeks to illustrate a comparison between the MSW management programs of Sydney and Seoul through the life-cycle process: (1) Generation; (2) Collection; (3) Processing; and (4) Disposal. In addition, the life-cycle programs for the two cities are also illustrated. In addition, the strengths, weaknesses, threats and opportunities in both Sydney's and Seoul's program are evaluated. Next, a comparison of the MSW management program and MSW management effectiveness of the two cities is analysed. Finally, an MSW management model that can be used in both cities is proposed.

3-1-1 Research Questions

Determining the most effective and efficient MSW management program and strategy in cities such as Sydney and Seoul entails a methodological and systematic process. More particularly, this study evaluates the life-cycle processes of Sydney and Seoul. This study seeks to propose a model that will address the problems and challenges faced by Sydney and Seoul in their MSW management systems.

Specifically, the following research questions will be answered:

1. What are the components of the MSW programs of Sydney and Seoul and how are they implemented?
2. What is the level of knowledge about environmental protection and waste disposal and practices of Sydney and Seoul?

3. How do the residents of Sydney and Seoul perceive the MSW management of their city government in terms of its effectiveness in:
    a. Generation
    b. Collection
    c. Processing
    d. Disposal
    e. Recycling?
4. How satisfied are the residents of Sydney and Seoul with the cities' MSW management programs?
5. What are the strengths, weaknesses, threats and opportunities of MSW management in Sydney and Seoul?
6. What type of waste management programs and strategies will Sydney and Seoul need to implement in order to be more effective and efficient?

3-1-2 Data Collection and Research Design

This study is primarily descriptive in nature, using a structured focused comparison discussed by George (1979) and Bennett and George (1997) to illustrate the MSW management programs of Seoul and Sydney. The life-cycle process has been used as the model for evaluating the results of the data. A research onion[1] process has been followed in illustrating the case studies of MSW management in Seoul and Sydney. The result of the evaluation of the two cases has served as the framework for the analysis of the life-cycle process and the production of a proposed MSW management model that this research will be recommending for Sydney and Seoul.

The research described in this document is based fundamentally on qualitative and quantitative research methods. This permits a flexible and iterative approach. During data-gathering the choice and design of methods are constantly modified, based on ongoing analysis. This allows investigation of important new issues and questions as they arise, and allows the investigators to drop unproductive areas of research from the original research plan.

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[1] It is called the research onion process because it is composed of five layers (similar to that of an onion) of data-gathering measures, starting from the philosophy taken by the researcher until the use of data tolls and the evaluation of the results.

A mix of qualitative and quantitative data-gathering enriches evaluation; the open-ended comments provide a way to elaborate and conceptualise statistical facts.

3-2 Descriptive Method

This study has utilised a descriptive design, which focuses on the present condition of MSW management in Sydney and Seoul. The purpose of using the descriptive method is to enhance the understanding of MSW management in the two cities, discover and evaluate correlations between managing wastes and factors such as implementation, provide a more accurate formulation of the problem to be solved, and create a generalisation based on the results of the case studies.

The descriptive method has been used for the purpose of gathering information. Creswell (1994) stated that the importance of description is to determine the present condition of the two case studies as they exist at the time of study and to explore the causes of the success or failure of Sydney and Seoul in implementing their MSW management programs.

In order to come up with a MSW management model for Sydney and Seoul, the descriptive design has used a multi-method approach (multiple methods) or the combination of different research approaches and strategies. The advantages in using a multiple methods approach will be reflected in the capability of the study to back up the information gathered. The result of the survey can be verified using a critical analysis of both the waste management and the implementation process of waste management in the two cities. Moreover, as Saunders, et al. (2003) confirm, this approach will enable triangulation or the use of data collection methods within the study to ensure that the study's findings are clear, valid and reliable.

The study has gathered information through surveys, observation and a critical analysis of the MSW management programs and implementation of Sydney and Seoul. Thus, the study is both qualitative (observation and critical analysis of documents or waste management programs) and quantitative (survey) in nature. This is because the use of observation and analysis of documents enables the researcher to have an understanding and provide an in-depth evaluation of the present waste management systems of the two cities (Benjamin, 1994). Moreover, as suggested by Patton (1987), qualitative evaluation data usually refer to raw, descriptive information about programs/products and the people who

participate in/use them or are affected by them; and programs/products and the people who develop or use them. On the other hand, the quantitative approach to the survey that the researcher conducted has provided generalised information about the ideas, beliefs, and attitudes of the residents of Sydney and Seoul. Thus, the combination of the research approaches has led to a clear development of a generalisable and in-depth study on the problem and its probable solutions.

The primary source of data has come from a survey questionnaire, observation and waste management program analysis of Seoul and Sydney. A survey questionnaire was conducted on the residents of Sydney and Seoul, and the researcher has made observations through fieldwork. In addition, the documents that were gathered pertaining to waste management programs, implementation and performance appraisals have been analysed.

The secondary sources of data included published articles in waste management journals, articles, magazines, current events and news, and books relating to waste management in metropolitan areas. This has served as the basis of the researcher's assumptions and comparative data on the result of the survey. Furthermore, the researcher has used the information from the literature to clarify whether the result of the research supports, or reject assumptions and arguments presented by earlier researchers.

For this research design, the researcher has gathered data, collated published studies from different local and foreign universities and articles from management and environmental management journals, and made a content analysis of the collected documentary and verbal materials from Sydney and Seoul. The researcher subsequently summarised all the information, made a conclusion based on the analysis and developed a proposed model for waste management in Sydney and Seoul.

3-2-1 Research Process

This section presents the research onion process or the research process that has been taken by the researcher: from the perspective that will be employed in the research, the data collection and the procedure that the researcher will follow will be illustrated.

The rationale for using the research onion process is to come up with the most appropriate research approaches and research strategies for this study. Here, the researcher considered the research philosophy that will be adopted. The researcher subsequently considered the subject of the research approach that flows from the research philosophy, then examined the research strategy most applicable. The fourth layer refers to the time

horizon a researcher applies to his research, and the fifth layer represents the data collection methods to be used (Saunders et al. 2003).

Figure 3-1 shows how the research approach to be applied in this study is conceptualised in order to come up with the pertinent data needed to answer the research questions stated in the first chapter, as well as to fulfil this research undertaking's objectives.

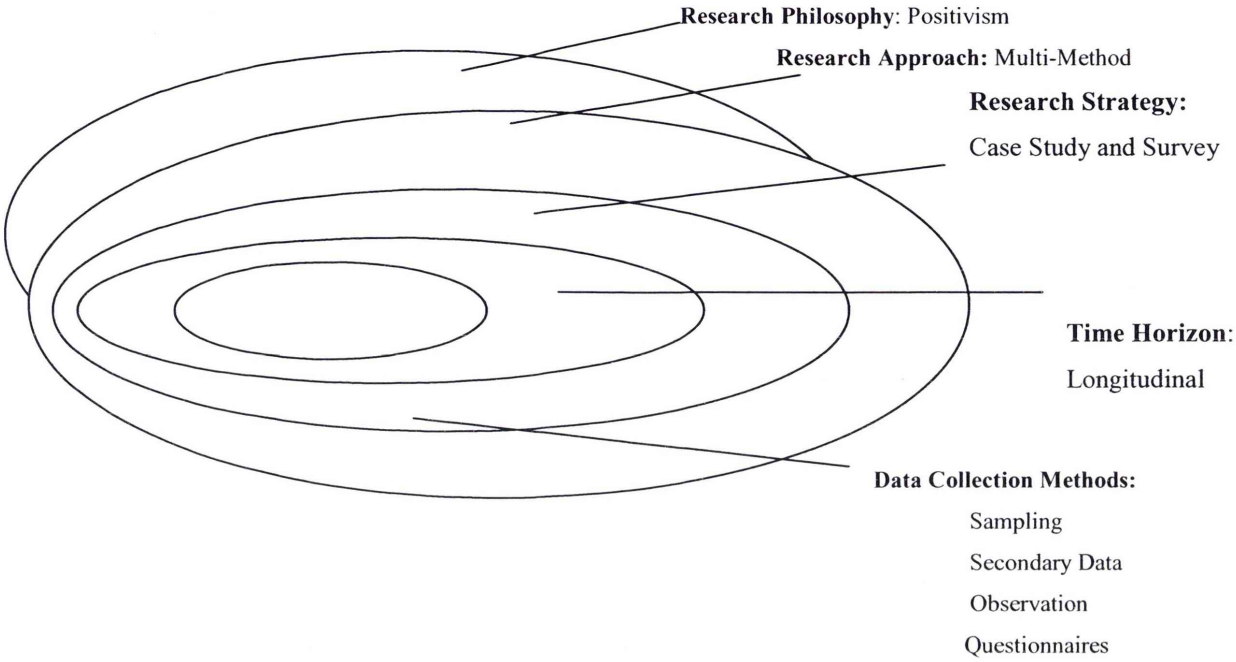


Figure 3-1 Conceptual research approach (taken from Saunders, 2003)

The research philosophy that is reflected in this study is *positivism*. With this research philosophy, a researcher prefers to work with an observable social reality in order to come up with law-like generalisations similar to those produced by the physical and natural scientists (Remenyi et al. 1998), and in this tradition, the researcher becomes an objective analyst, providing detached interpretations about those data that have been collected in an apparently value-free manner (Saunders et al. 2003). In addition, the emphasis is on a highly structured methodology to facilitate replication (Gill & Johnson, 1997) and on quantifiable observations that lend themselves to statistical analysis (Saunders et al. 2003). The assumption here is that the researcher is independent of and neither affects nor is affected by the subject of the research (Remenyi et al. 1998; Saunders et al. 2003).

3-2-2 Data-Gathering Tools

This section reflects the data procedures that the researcher used in illustrating how the data were gathered and the specific data that were gathered. The case study is the primary approach in this research. From the case study plan, three instruments, as reflected in the research onion, were utilised: (1) survey; (2) analysis of documents such as the waste management programs, implementation and performance appraisal of the waste management programs of Seoul and Sydney; and (3) critical analysis of waste management literature.

3-3 Case Study

Case studies of the waste management programs of Sydney and Seoul have been illustrated in the research. This strategy has been used in order to come up with empirical and in-depth findings on the current waste management practices of Sydney and Seoul. It answers the questions of "why," "what," and "how", and data-collection methods applicable to such an approach include questionnaires, observation, and documentary analysis (Robson, 2002; Morris & Wood, 1991; Saunders et al., 2003). A cross-sectional study has been undertaken, since a comparative study of the waste management systems of Sydney and Seoul has been conducted in order to illustrate the problems, strengths and weaknesses, and threats and opportunities in the waste management programs of the two cities.

The data-gathering tools that were used in order to illustrate the cases of waste management in Sydney and Seoul are discussed in following sections.

3-3-1 Survey

A survey (Appendix 1) measuring the life-cycle process such as the attitudes and perceptions about the environment and waste disposal practices of Sydney and Seoul residents was conducted in the study. The survey strategy is a popular and common strategy in management research, because surveys allow the collection of a large amount of data from a sizeable population in a highly economical way; data are often obtained through questionnaire and are standardised to allow for easy comparison (Saunders et al., 2003, p. 92).

The survey was designed with the purpose of collecting information on the attitudes of the residents of Sydney and Seoul about MSW disposal, their knowledge of MSW management, how they perceive the MSW management programs of their respective cities in terms of collection, processing and disposal, and how the waste management programs of their cities could be improved in terms of decreasing wastes and effectively managing the collected wastes.

The survey is composed of five sections. The first section presents the socio-demographic profile of the respondents. This is included in order to determine whether there are patterns of waste disposal and the respondent's perception of the effectiveness of waste management in their respective cities in terms of their age, the type of property they are currently living in, the number of the people in the household, their employment status, and educational attainment. Moreover, this section also allows other researchers to verify and validate the findings of the research.

The second section of the survey indicates the general view of the respondents about the environment and how they perceive the significance of the environment in their lives. In addition, it included items pertaining to the perceived effect of the environment on their individual lives. Finally, the respondents were requested to outline the important governmental issues for them.

The third section inquired into the knowledge about household waste management of the respondents. From the process of disposal until the process of recycling, the respondents were asked about the level of their knowledge about the projects of the city's waste management team. In addition, the household management practices of the respondents were evaluated. The third section illustrates their perceptions of the waste management programs of their respective cities (Sydney and Seoul). The respondents were asked to evaluate the waste management programs and the implementation process. In addition, the section also measures the respondents' perception of the effectiveness of the implementation of the waste management programs. Finally, the second section also inquired about the level of satisfaction of the respondents with the services of their city's waste management service providers.

The fourth section measures the respondents' level of knowledge about recycling methods such as kerbside recycling collections. The respondents were requested to respond about their perception of recycling and their attitudes towards recycling. They were also asked about their willingness to increase their efforts to recycle. Finally, they were asked

about their level of satisfaction with the kerbside recycling services and how these could be improved.

Finally, the fifth section determines respondents' perceptions of new ways of collection and recycling. Several ways and methods of decreasing the levels of waste and making waste management more efficient were presented. The respondents were also asked about their opinions of composting and its role in waste management. Finally, issues and problems were elicited from the respondents.

It was essential to obtain the respondents' cooperation, and they were therefore assured that the data gathered from them would be treated in the strictest confidence. It was hoped that this assurance would promote trust between the researcher and the respondents. This part of the study is important because the respondents would be supplying the most important data needed to fulfil the objectives of this study.

3-3-2 Sampling Design

A random sampling was used in determining the waste management practices and the opinions of the Sydney and Seoul residents about the waste management programs of their cities. I randomly selected houses/flats in the streets of the Seocho-Gu area in Seoul and the Glebe, Pyrmont, and Ultimo areas in Sydney and personally contacted the prospective respondents. The respondents were then asked if they would be willing to participate in the survey. Those who agreed were given the questionnaire while those who declined were not included in the study.

3-3-3 Respondents to the Study

The general sample size that was utilised in the study consists of 150 respondents per city or 150 respondents each from Sydney and Seoul. The determination of the sample size was based on the stratification of the area provided for by the researcher on Sydney and Seoul. The study has at least five respondents per area in Sydney and Seoul and as such, the proportionality and generalisability of the findings will be guaranteed. The general sample for the study will be 300 residents from Sydney and Seoul.

3-4 Statistical Treatment

Once the measuring instruments have been retrieved, the next activity of the researcher is to process the raw data into quantitative and qualitative forms. Data-processing involves input, throughput, and output mechanisms. Input involves the response to the measuring instrument of the subjects of the study; throughput includes the statistical procedures and techniques; and output, the results of the study, which are presented in data matrix.

Many researchers find difficulty in the statistical processing of data. It is vital that a researcher diagnoses the problem through use of the correct statistical tool in order to solve it like a physician who diagnoses the ailment of his patient to be able to prescribe the correct medicine.

For this study, the most appropriate statistical treatment used in the collated data is the following:

- Percentage. Percentage is used as descriptive statistics, which relates a part to the whole. This is used in describing some personal characteristics of the respondents of the study such as age, gender, civil status, educational attainment and employment status. The formula used in computing percentages is as follows:

$$\% = \frac{n}{N} \times 100 \quad ; \quad \begin{array}{l} n - \text{number of responses} \\ N - \text{total number of respondents} \end{array}$$

- Chi-square test. Chi-square is a family of distributions that vary with degrees of freedom. But in general, as the degrees of freedom become infinitely large, chi-square approaches normality.

Note: the expected value of each chi-square distribution (mean) is equal to the number of degrees of freedom for that curve.

This is used to determine the relationship between two variables that have a relationship. The formula for this is as follows:

$$\chi^2 = \sum \frac{(o_i - e_i)^2}{e_i}$$

where : χ^2 = chi-square value

o_i = observed frequency

e_i = expected frequency

To evaluate the information gathered, the following analysis instruments are used: percentage analysis and chi-square analysis. The chi-square value, where computed, uses the web chi-square calculator. In addition, a multiple regression analysis using ANOVA will be used in determining the level of significance of the relationships between respondents' attitudes about waste disposal and their satisfaction with the waste management program of their respective cities.

3-5 Analysis of Documents

The waste management programs of Sydney and Seoul and the pertinent documents relating to changes, implementation and evaluation have been critically analysed. Since the study's primary goal is to come up with a proposed waste management model, the components and the possible areas for improvement will be marked and compared to the result of the survey.

3-6 Analysis of the Literature

After the data was gathered from the survey, the documents on waste management in Sydney and Seoul were analysed, Comparison was made between the two case studies on the measure of an effective waste management program. The strengths and weaknesses of the waste management programs of the two cities then served as the main data for the formulation of the proposed waste management model that has been derived from the findings of the research, the analysis of the literature and the insights of the researcher.

3-7 Data-Processing

After the collection of the survey questionnaire, the researcher also collated all the data. The statistical analysis was conducted using Microsoft Excel, whereby the data was tabulated, graphed and evaluated. The testing of the level of significance was conducted using the Statistical Package for Social Sciences (SPSS) and was tabulated in the Excel files. The SPSS is the standard software used in conducting statistical analyses such as the ANOVA and the chi-square, the two correlation measures that were used in the study.

3-8 Structured Focused Comparison

From the two case studies, the researcher has been able to determine the similarities and differences in the two cities and which components and variables of their waste management program would be effective in producing a waste management model that would resolve the waste problem in their respective cities.

This section provides the framework through which the findings of the case studies in Sydney and Seoul will be compared and evaluated. Specifically, the researcher has used the structured focused comparison approach used by George (1979) and George and Benett (1997) in illustrating the similarities and differences, strengths and weaknesses and threats and opportunities in the waste management programs of the two cities. The result of the comparison between the waste management of Sydney and Seoul has provided the basis for the proposed waste management model.

George (1979) articulated that the use of structured focused comparison is actually the building block for theory development. It is a comparative study between two cases where the method is focused in that it deals with only certain aspects of the cases, that is, a selective theoretical focus guides the analysis of the cases. In this study, the focus is on the strategies of the two cities in terms of the collection, processing and disposal of wastes. The method of doing so is structured in that the same general questions are asked of each case in order to guide data collection, thereby making possible systematic comparison and accumulation of the findings of the cases.

The strategy that has been adopted in this structured focused comparison is the "most similar" strategy wherein the study posits that there are similarities in the waste problems and waste management programs of Sydney and Seoul. However, the waste management programs of the two cities still have to be improved in order to be more effective and efficient. For instance, Sydney has proved to be more effective in managing its wastes than has Seoul. Furthermore, even though two cases are almost never perfectly matched, process tracing can strengthen the comparison by helping to assess whether differences other than those on the main variable of interest might account for the differences in outcomes.

The cases of Sydney and Seoul were chosen because the researcher deemed that an effective waste management program could remedy the waste problems in these two cities,

particularly in Seoul. Four variants in the life-cycle process have been investigated through the structured focused comparison: (1) Generation; (2) Collection; (3) Processing; and (4) Disposal.

3-9 Ethical Consideration for the Study

The intended respondents were given a waiver regarding the confidentiality of their identity and the information that they did not wish to disclose.

3-10 Data Analysis

This study has followed a systematic process in analysing the life-cycle processes of Sydney and Seoul. The following steps were undertaken. First, the case study was conducted using a survey, analysis of the documents and a comparison of the literature. After the data had been gathered and filed, the researcher used the structured comparative approach in drawing comparisons. The researcher then compared the strengths, weaknesses and opportunities for the improvement of waste management systems in Sydney and Seoul.

Chapter 4 Case Study: Sydney MSW Management

4-1 Introduction

This chapter discusses the findings based on the collated information on the two case studies on MSW management. The conducting of this study aims to examine how Sydney manages its MSW. This chapter is the first of the three major parts of this study. (This chapter presents the result of the Sydney case study, Chapter 5 deals with MSW management practices in Seoul, and in Chapter 6, these two case studies are compared using a cross-sectional study. The last part aims to illustrate the problems, strengths and weaknesses, and threats and opportunities in the MSW management practices of the two cities).

This chapter is divided into several parts. The first part discusses the respondents' gender, employment status, educational attainment, the type of property they are living in, and the number of people in the household. The respondents were randomly selected in three inner suburban areas in the City of Sydney: Glebe, Pyrmont, and Ultimo. The survey was carried out door-to-door and face-to-face in the streets.

The second part involves their general view of the environment. This study aimed to learn whether the respondents in Sydney were concerned about the environment, and if they were involved or willing to be involved in any activity to help protect and preserve the environment. The next part concerned their knowledge of household waste management: how important for them household waste management is for the preservation of the environment and the conservation of natural resources; what the most important practice in waste management is; where they get most of their information on waste management.

In addition, this chapter deals with how respondents practise household waste management. The respondents were asked about the importance of reducing household waste at home, their opinions about the waste management programs in Sydney, the effectiveness and efficiency of their current household waste collection services, their reluctance to participate in waste management, and their suggestions for improving current household waste collection services.

The fourth part seeks to measure the level of knowledge of the respondents about the waste management processes such as kerbside recycling and composting. They were asked if they were fully committed to recycling, if they exerted efforts to recycle, if they

were generally satisfied with their kerbside recycling services and how to improve them. This part also determines the reasons why most of the respondents did not have compost heaps or bins/worm farms. Lastly, the fifth section presents the respondents' views on new ideas aimed at decreasing the level of waste and making waste management more efficient.

4-1-1 Socio-Demographic Profile

Gender is deemed important for this study. Similar to other concepts, the concept of "waste" is not neutral. In relation to MSW, men and women may differ in perceptions and views of what is waste and what is not, and what the different kinds of wastes are. Sometimes, in addition, men and women may have different knowledge about waste disposal places in their neighbourhoods, practices of recycling and composting, landfilling, and incineration. Figure 4-1 shows the gender distribution of Sydney respondents.

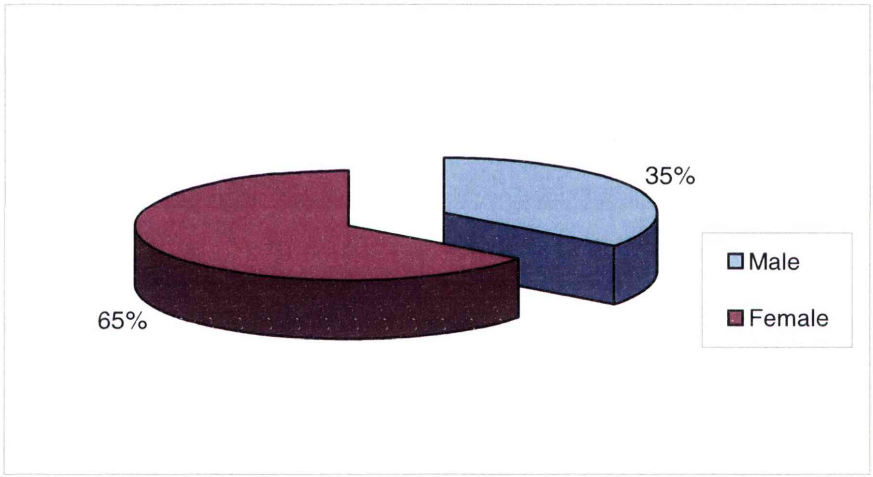


Figure 4-1 Respondents According to Gender

The figure illustrates that of the 150 respondents, 65% represents the female population, compared with 35% of male respondents. From the figure, the dominating gender among the respondents can be seen to be female. This gives an unequal footing in terms of representation of gender. This may have an effect on the outcome of the study because, as previously mentioned, in managing municipal solid waste, both men and women should be consulted and surveyed.

However, the researcher contends that the large difference between the number of male and female respondents is not significant enough to affect the result of the study. This is because of the greater role of women than men in terms of waste decisions in the

household. Women are most commonly seen as the ones who know and decide what is useful and what is to be discarded. For example, women tend to be more supportive than men of recycling, and are also more likely than men to oppose the location of potentially harmful facilities, especially if they have children (Van Liere and Dunlap, 1980).

The survey also looked at the number of people in the household. The study considered this factor because, as the literature review shows, an increase in the population results in an increase in household waste. In addition, the tremendous growth in the number of households and the size of homes are critical for the increase in the generation of MSW, because these factors increase the consumption of basic commodities. An increase in the number of people living in a household leads to the open-ended expansion of material goods brought into the household. Table 4-1 summarises the result of this particular survey.

Table 4-1 Number of People in the Household

Number of people in the Household	Frequency	Percentage
1-2 persons	42	28%
3-4 persons	94	63%
5-7 persons	9	6%
More than 7 persons	5	3%

The result shows that 63% of the respondents have three to four persons living in their households. Twenty-eight per cent have households composed of one to two persons. Six per cent of the respondents have five to seven persons in their households, and the remaining 3% of the total number of respondents have more than seven persons in the house. It can be suggested that in Sydney, at least among the respondents, waste generation is minimised because of the relatively small number of people in the household, which implies a decrease in consumption of basic products and commodities.

Furthermore, the survey also aimed to learn how the composition of the respondents' households could best be described. Table 4-2 presents the results.

Table 4-2 Description of Household

Description of household	Frequency	Percentage
A one-person household	27	18%
A couple or family	83	55%
A group household (individuals sharing)	37	25%
Others	3	2%

The above table indicates that more than half of the respondents (55%) describe their households as a couple or a family. Twenty-five percent of the respondents lived in group households wherein individuals share; a close 18% lived on their own; and the remaining 2% of the total respondents did not specify their types of households. As for the type of property the respondents were currently living in (Table 4-3), an overwhelming majority (82%) lived in a single dwelling property with garden; 17% had a flat/apartment/unit; and the other 1% did not specify their type of property.

Table 4-3 Type of Property

Type of Property	Frequency	Percentage
Single dwelling with garden	123	82%
Flat/apartment/unit	25	17%
Others	2	1%

The respondents were also asked about their employment status. This was included in the survey because socio-economic status indicators such as employment status influence waste management participation. Figure 4-2 summarises the result.

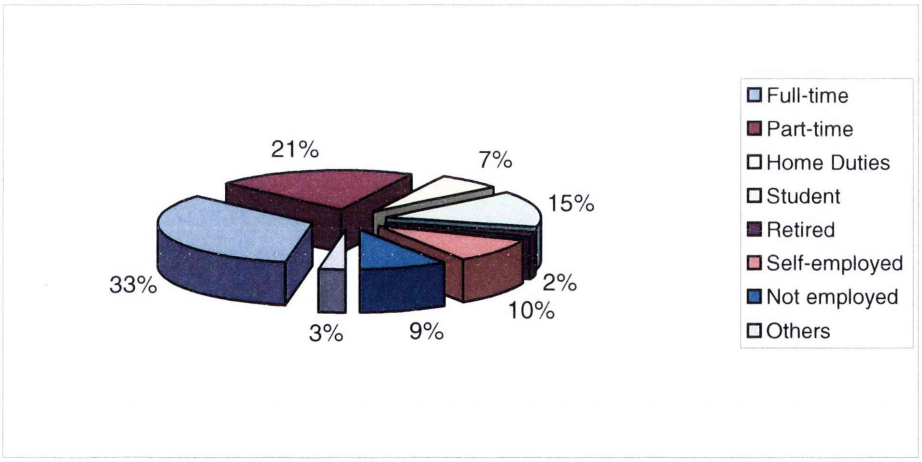


Figure 4-2 Employment Status

The figure shows that most of the respondents were employed full-time (33%), 21% were part-timers, 15% were students, 7% were engaged in home duties, 10% were self-employed, 9% were not employed, 2% were retired, and 3% did not address the survey. In addition to this, the respondents' highest educational attainment was also surveyed (see Figure 4-3). A great majority of the respondents (72%) had attained secondary education,

21% tertiary level, 4% post-graduate studies, 1% primary, and the remaining 3% did not answer the question.

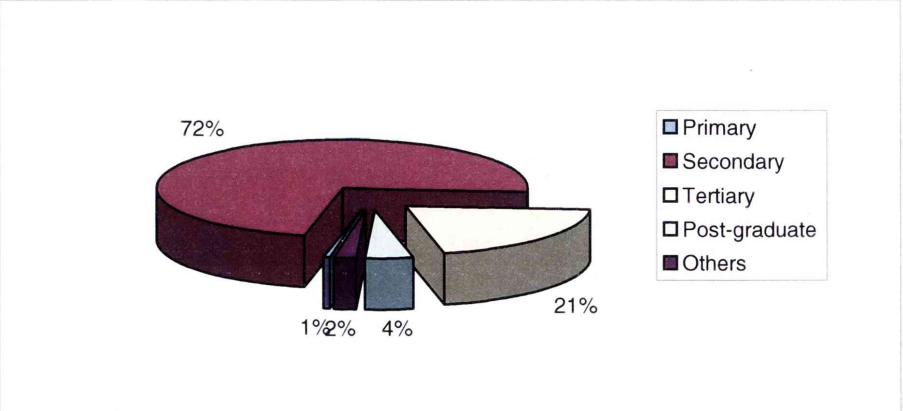


Figure 4-2 Educational Attainment

4-1-2 General View of the Environment

The respondents were asked about their concern for the environment. The result reveals that generally, respondents were fairly concerned. When asked about their concern for the environment, 74% said they were fairly concerned, 21% were very much concerned, 5% were concerned but not really, and 1% was not at all concerned about the protection and preservation of the environment. Table 4-4 shows the result.

Table 4-4. Environmental Concern

Are you concerned about the environment?	Frequency	Percentage
Yes, very much	32	21%
Yes, fairly	111	74%
Unsure	1	1%
No, not really	5	3%
No, not at all	1	1%

The study also sought to identify how the respondents perceived their capacity as an individual in helping the environment (Table 4-5). The respondents in general felt they could moderately help the environment. Fifty-seven percent of the respondents believed that they could help the environment a moderate amount, 26% stated they could help a great deal, 14% were not sure about their capacity to help, 2% answered they could

contribute to the protection and preservation of the environment a little bit, and one respondent (1%) said s/he could do nothing.

Table 4-5 Helping the Environment

How much do you think you as an individual can do to help the environment?	Frequency	Percentage
A great deal	39	26%
A moderate amount	86	57%
Not sure	21	14%
A little bit	3	2%
Nothing	1	1%

In support of the above findings, 84% of the respondents were involved or willing to be involved in any activities to help protect the environment. Only 3% had not participated in any environmental activities. Thirteen per cent were not sure if they had been involved or willing to get involved.

Table 4-6 Environmental Involvement

Have you involved or are you willing to involve any activities to help protect the environment?	Frequency	Percentage
Yes	126	84%
Not sure	19	13%
No	5	3%

Finally, when asked about the most important issues for the respondents, they pointed out that education and environment should be given more importance than other sectors. Twenty-six per cent believed that education should be emphasised, followed by the environment sector, with 24%. Natural resources ranked third with 15%, followed by waste 8%, housing, public health services and employment with 7% each, and public transport 6% (Figure 4-4).

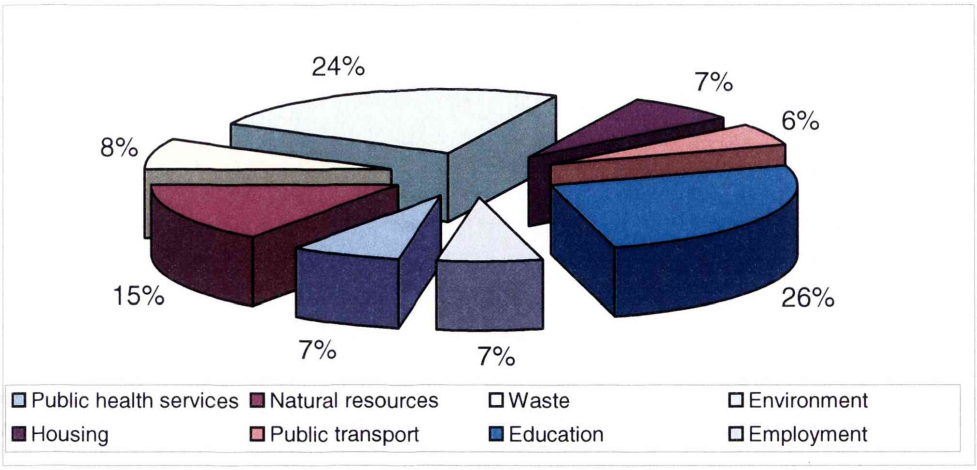


Figure 4-4 Important Issues

4-1-3 Knowledge of Household Waste Management

In terms of their knowledge about household waste management, the respondents were generally of the view that household waste management is indeed important. Sixty-one per cent of the respondents considered household waste management as important (61%). Twenty-four per cent of the respondents felt that managing household waste is very important. However, 7% of the respondents said it was not really important, and 3% said it was not important at all. Five per cent were not sure. Table 4-7 summarises the results.

Table 4-7 Importance of Household Waste Management

Importance of household waste management	Frequency	Percentage
Very important	36	24%
Important	92	61%
Not really important	10	7%
Not at all important	4	3%
Don't know	8	5%

The survey also attempted to determine how important reducing household waste at home was for the respondents. Seventy-two per cent responded that it is fairly important, 26 % agreed that reducing household waste is very important, two respondents (1%) were not sure if it is important or not. Another two respondents (1%) said reducing household waste is not at all important (Table 4-8).

Table 4-8 Reducing Household Waste at Home

Importance of reducing household waste at home	Frequency	Percentage
Very important	38	26%
Fairly important	108	72%
Not important	2	1%
Don't know	2	1%

In the survey, the respondents indicated what they were doing at the moment to try to reduce the amount of household waste being generated (Table 4-9). Most of the respondents were trying to recycle more (52%). Only 9% of the responses supported the campaign to stop the use of plastic bags at shops; 8% pointed to composting, another 8% to reducing the use of disposable products that are not recyclable; 7% of the responses considered the reduction of the amount of waste generated by preferring products with less packaging; some respondents were buying products in bulk (4%) and products with recycled content (4%).

Table 4-9 Practices to Reduce Household Waste

Current practices to reduce household waste	Frequency	Percentage n=267
Recycling more	140	52%
Composting	21	8%
Refuse plastic bags at the shop	25	9%
Select products with less packaging	18	7%
Buy products with recycled content	10	4%
Reduce the use of disposable products	21	8%
Buy products in bulk	11	4%
Nothing in particular	15	6%
Don't know	6	2%

A large number of the respondents were certainly interested in learning more about how to deal with household waste (51%). Forty-five per cent were less enthusiastic about this. Three per cent were not sure if they were interested or not, and a lone respondent (1%) was not interested at all (Table 4-10).

Table 4-10 Interest in Household Waste Management

Interested in learning more about how to deal with household waste?	Frequency	Percentage
Certainly	77	51%
Perhaps	68	45%
No	1	1%
Don't know	4	3%

As to where they obtained most of their information on waste management, 36% of all the responses pointed to the Internet as the main source of information. Fifteen per cent identified local newspapers as a major source of information, the local councils and TV/Radio each accounted for 13%, community meetings 9%, and local library and environmental groups accounted for 7% each. Figure 4-5 shows the distribution of responses.

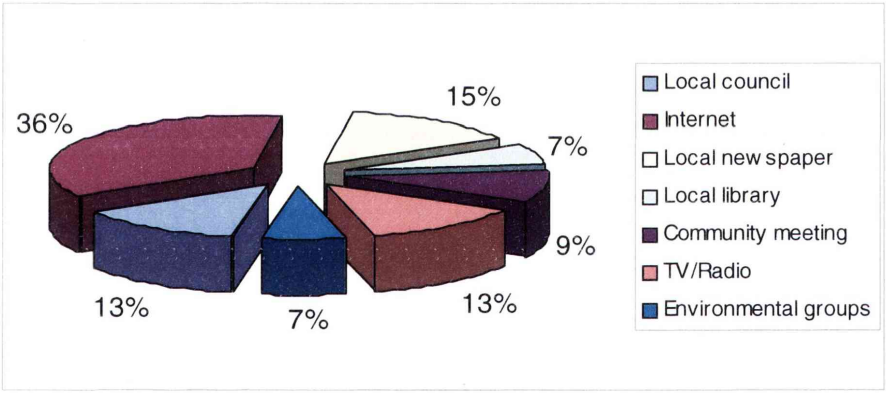


Figure 4-5 Source of Information

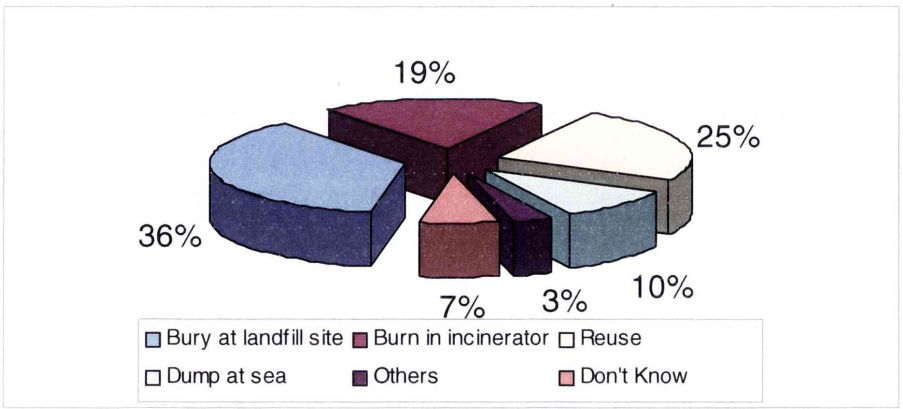


Figure 4-6 Destination of Non-recyclable Waste

The respondents were asked if they knew about the destination of household non-recyclable waste after it is taken away from the house (see Figure 4-6). The result shows that the majority of the respondents believed that landfill is the destination of most of household non-recyclable waste (36%). Twenty-five per cent thought that this type of waste is being recycled or reused after it is collected from their house. This supports the intensifying initiatives in Sydney of materials recycling. Ten per cent of the respondents said these materials are dumped at sea. From 1984 to 2003, there have been almost 300 permits issued by the Federal Government for sea dumping (Plunkett, 2003). Three per cent did not cite specifically where they thought non-recyclable materials are taken for disposal. Seven per cent did not know the destination of non-recyclable waste after it is collected. In fact, the survey shows that 19% of the respondents said that non-recyclable waste is burned in an incinerator, which is not possible because incineration is not practised in Sydney.

Furthermore, the respondents identified the most important household waste management practice. The result of the survey shows that the respondents placed high value on waste avoidance (31%). The rationale behind this is explained by the cliché "prevention is better than cure." Most of the respondents would rather avoid generating waste as much as possible rather than reusing and recycling wastes.

A close 29% identified reusing as the most important household waste management practice, followed by recycling, which garnered 26% of the respondents. Eleven per cent of the respondents believed that if wastes are properly disposed of, then landfill disposal is the best option. Despite these contentions, the remaining 3% did not know the most important household waste management practice (Figure 4-7).

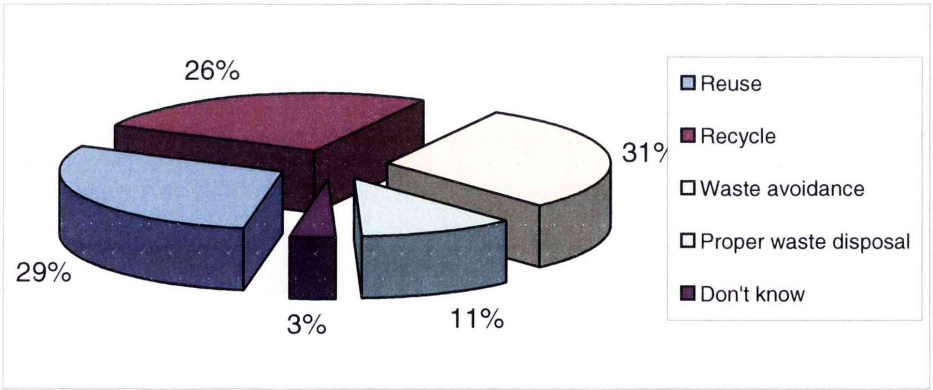


Figure 4-7 Most Important Household Waste Management Practice

The respondents also evaluated their overall performance in separating household waste (Table 4-11). The majority claimed that their performance was average (45%). Twenty-seven per cent believed they were performing fairly well, 15% thought that they performed very well in separating household waste, 7% confessed that they did not perform really well in this activity. Finally, 5% could not come up with an evaluation of their performance.

Table 4-11 Evaluation of Performance

Performance in separating household waste	Frequency	Percentage
Very well	23	15%
Fairly well	41	27%
Average	68	45%
Not really well	10	7%
Don't know	8	5%

The survey found that most of the respondents thought that their respective councils spend less. Eighty-three per cent approximated the cost of their councils in taking away and disposing their household waste each year at less than A$50 per household, while 14% of the respondents thought it cost their council A$51—A$100 annually. Each of the remaining 3% of the respondents estimated the cost at A$101—A$200, A$201—A$300, and more than A$300. Nationally, the traditional local councils spent $1.3 billion on solid waste management during 2002—2003 (Natural Resource Management, 2004).

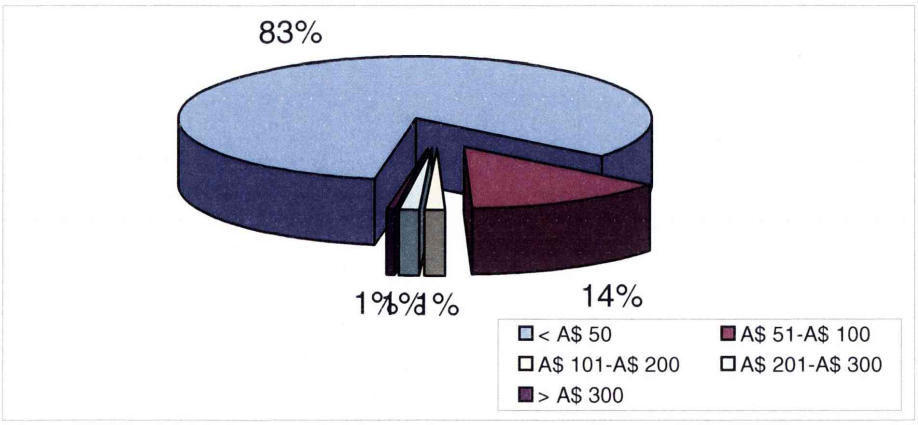


Figure 4-8 Cost of Collecting and Disposing of Household Waste

Despite the councils' generally low cost of collecting and disposing household waste, most of the respondents rated their councils' household waste management services as satisfactory (59%). Twelve per cent were very satisfied while 17% were unsatisfied with the services. Furthermore, 8% of the respondents felt very unsatisfied. The other 4% could not rate the performance of their councils with regard to their household waste management services.

Table 4-12 Satisfaction about Services

Rating of council's household waste management services	Frequency	Percentage
Very satisfactory	18	12%
Satisfactory	88	59%
Unsatisfactory	26	17%
Very unsatisfactory	12	8%
Don't know	6	4%

As the previous tables and figures show, there are some respondents who were reluctant to be fully involved in waste management practices. The survey attempted to determine the reasons for their reluctance to fully commit to household waste management with respect to collection services. In Table 4-13, it can be seen that a great bulk of the respondents pointed to the very small size of their waste bin (47%). Twenty-three per cent of the respondents felt that full involvement with household waste collection services requires too much effort. Twenty-two per cent said they just were not allowed put garden waste in household waste bin.

Nineteen per cent of the respondents identified the heaviness, bulkiness and awkwardness of the bins, while 8% said their reluctance was due to the failure of household waste services to collect a bin often enough. Seven per cent had problems with their garbage collectors who were too noisy, obnoxious and messy. Finally, 3% of the respondents could not ascertain why they were reluctant to fully commit to this type of waste management.

Table 4-13 Reluctance to Commit to Waste Management Practices

Reasons for the reluctance to fully commit to household waste collection services	Frequency	Percentage
Too much effort	35	23%
Bin is too small	70	47%
Bin not collected often enough	12	8%
Problems with collectors (too noisy, messy, etc)	11	7%

Bin is too heavy/bulky/awkward	15	19%
Can't put garden waste in household waste bin	33	22%
Other	5	3%

In line with the above reasons that hinder the success of any waste management system, it is important to also identify grounds for improvement in terms of collection services. The study found that most of the respondents (45%) believed that household waste collection services could be more efficient if collections were carried out more frequently. Eighteen per cent suggested different time frames for collection. Another 18% of the total respondents suggested bigger bins. Those who had problems with garbage collectors, 13% of the respondents, were looking for more friendly collectors. Seven per cent wanted less noise and less odour when collection takes place. Table 4-14 summarises the result.

Table 4-14 Areas for Improvement

Areas for improvement to make more efficient household waste collection service	Frequency	Percentage
Bigger bin	27	18%
More frequent collection	68	45%
Less noise/odour when collection taking place	10	7%
Different time frame for collection	27	18%
More friendly collectors	20	13%
Other	3	2%
Don't know	1	1%

4-1-4 Recycling Collection and Composting

This section seeks to measure the level of knowledge of the respondents on the waste management processes such as kerbside recycling and composting. They were asked about their commitment to recycling, their efforts in recycling, their kerbside recycling services and how to improve them. This section also determines the reasons why most of the respondents did not have compost heaps/bin/worm farms.

When asked about the items currently collected in kerbside recycling collection, glass obtained the highest number of responses (24%). Newspaper generated 23%

responses, followed by aluminium cans with 20%, milk/juice cartons 18%, cardboard and plastic bottles with 6% each, and garden wastes/clippings with 4%. Two of the total respondents identified steel cans as items currently used for kerbside recycling (Table 4-15). According to the respondents, kerbside recycling services were used most of the time (Table 4-16).

Table 4-15 Items for Kerbside Recycling Collection

Items currently collected in kerbside recycling collections	Frequency	Percentage
Glass	121	24%
Newspaper	116	23%
Cardboard	31	6%
Plastic bottles	30	6%
Aluminium cans	101	20%
Steel cans	2	0.4%
Milk/juice cartons	92	18%
Garden wastes/clippings	21	4%
Others	1	0.2%

Table 4-16 Frequency of Using Kerbside Recycling Service

Frequency of using kerbside recycling service	Frequency	Percentage
Always	37	25%
Most of the time	78	52%
Some of the time	30	20%
Hardly ever	3	2%
Not at all	1	0.7%
Don't know	1	0.7%

The survey aimed to determine how the respondents felt about recycling. A set of statements was presented to them to express their feelings about the current practice of recycling (Table 4-17). More than half the respondents (52%) answered "A lot, but not everything that can be recycled." Forty-five per cent answered "The more the better." Only 5% of the respondents chose "Don't recycle much." Finally, the remaining 1% said "Don't recycle at all."

Table 4-17 Feelings about Recycling

Statements to express feelings about recycling	Frequency	Percentage
The more the better	68	45%
A lot, but not everything that can be recycled	78	52%
Don't recycle much	8	5%
Don't recycle at all	2	1%

Earlier in this chapter, the respondents' reasons for not fully committing to household waste collection services have been presented. In addition to this, the survey also tried to ascertain their reasons for not fully committing to recycling. Forty-seven per cent of the respondents said the question was not applicable to them, while 14% said there was too much hassle in recycling. Thirteen per cent of the respondents were not sure what items could be recycled, 18% said they forgot about recycling, while 6% had no time for recycling at all. None of the respondents said recycling was unworthy. Table 4-18 summarises the results.

Table 4-18 Reluctance to Recycle

Reasons for not fully committing to recycling	Frequency	Percentage
Too much hassle	21	14%
Shortage of space	16	11%
No time for recycling	10	6%
Forget recycling	12	8%
Not worth it	0	0%
Unsure of what to recycle	19	13%
Other	2	1%
Not applicable	70	47%

When asked if they were willing or likely to increase their recycling efforts, the respondents were generally positive about it. Seventy-seven per cent were certain they could be more involved in recycling. A distant 15% said they had to think about it first, and 7% of the respondents did not care about increasing their recycling efforts (Figure 4-9).

The respondents' willingness to recycle may have something to do with their satisfaction about kerbside recycling. When asked about their level of satisfaction, more than half of the respondents (52%) felt fairly satisfied, while 29% said they were very

satisfied. On the other hand, 17% of the respondents were fairly dissatisfied with kerbside recycling. Further, 1% was very dissatisfied (Figure 4-10).

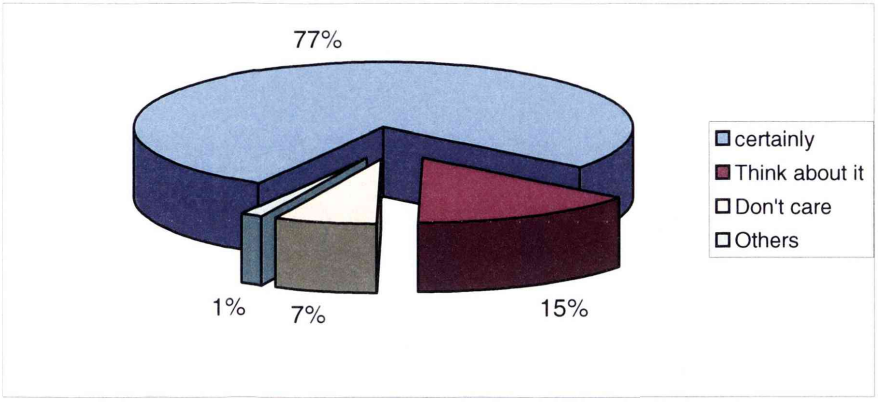


Figure 4-9 Willingness to Recycle

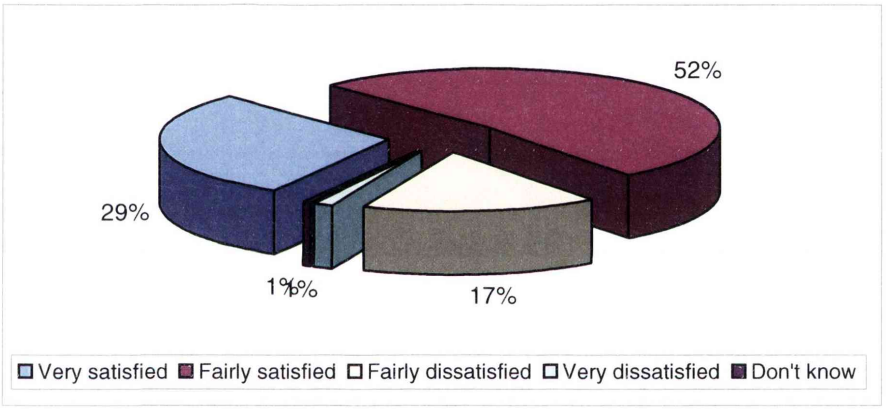


Figure 4-10 Satisfaction with Kerbside Recycling

Having known the level of the respondents' satisfaction with kerbside recycling, they were asked for their suggestions on how to improve kerbside recycling arrangements (Table 4-19). Twenty-five per cent of all respondents said there was a need for a lessened fussiness about what can be collected. Nineteen per cent said they need a more frequent service; 16% suggested a bigger split bin; 13% needed simpler and easier kerbside recycling arrangements; 9% needed a container dedicated to recycling; 7% wanted a quieter and less messy operation; and 6% called for a more reliable service.

Table 4-19 Improving Kerbside Recycling Arrangements

Areas for improvement to make better kerbside recycling arrangements	Frequency	Percentage
More frequent service	31	19%
More reliable service	10	6%
Simpler/ease of use	21	13%
Less fussy about what can be collected	40	25%
Quieter/less messy operation	11	7%
Bigger split bin	25	16%
Need a container dedicated to recycling	14	9%
None of the above	6	4%
Don't know	2	1%

This study found it necessary to determine whose responsibility it is to recycle. Specifically, it aimed at determining the role gender plays in recycling activities. According to the Urban Waste Expertise Programme (UWEP), men and women within the household have different views about waste management, particularly on discarded materials. Men and women re-value waste materials differently and see their usefulness for different purposes, such as domestic utility, saving on household expenditures, earning money, or other purposes. In short, there exists a gendered definition of "waste" and of "resources" (Muller and Schienberg, 2004), which is important to be reflected during any discussion of priorities regarding waste management in the community.

The result of the survey shows females/mothers/wives as mostly responsible for recycling in the household. Sixty-one per cent of the respondents said female members of the household, which may include mothers and wives, are responsible for recycling. Twenty-seven per cent identified male members, which may include fathers and husbands as responsible. Five percent of the respondents viewed recycling as a responsibility of teenage children.

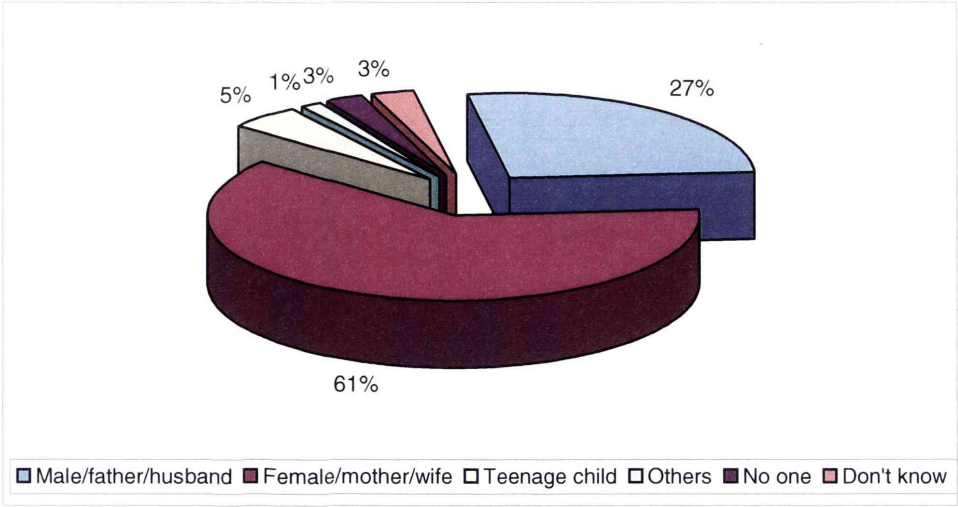


Figure 4-11 Household Responsibility

The reasons behind recycling differ. Some people initiate it on the basis of morality. Others say it is their responsibility. However, many people are driven to recycle due to practicality and other external factors. In this survey, 35% of the overall responses considered the preservation of the environment and the conservation of natural resources as the main drivers for recycling. Sixteen per-cent based their recycling efforts on its economic sensibility.

Fifteen per cent of the respondents were concerned about the limited space for landfill so they resorted to recycling. Eleven per cent said it is their moral duty to recycle, for the future of the next generation, while 10% were just plain enthusiastic about recycling. Eight per cent of the respondents said they recycle because it is their social responsibility to do so, and also for the sake of community spirit. Three per cent cited the lack of enough room in the garbage bin as a motivation for recycling. The table below summarises the result.

Table 4-20 Motivations for Recycling

Drivers and motivations for recycling	Frequency	Percentage
Preservation of the environment and the conservation of natural resources	68	35%
Limited space for landfill	30	15%
Moral (for children/future generations)	21	11%
Economically sensible to recycle	31	16%
Social (community spirit)	15	8%
Not enough room in the garbage bin	5	3%
Enthusiastic about recycling	19	10%
Other	3	2%
Don't know	5	3%

Many people throw out useful wastes, without realising that they can be recycled. This survey asked the respondents about items they had thrown away recently that could have been recycled (Figure 4-12). Twenty per cent of the total responses pointed to milk or juice cartons, 16% of the respondents disposed of glass bottles, 11% responded for aluminium cans, and another 11% for garden wastes or clippings. Nine per cent of the respondents answered newspapers, while a large number (22%) said they discarded wastes that were not in the provided list of items.

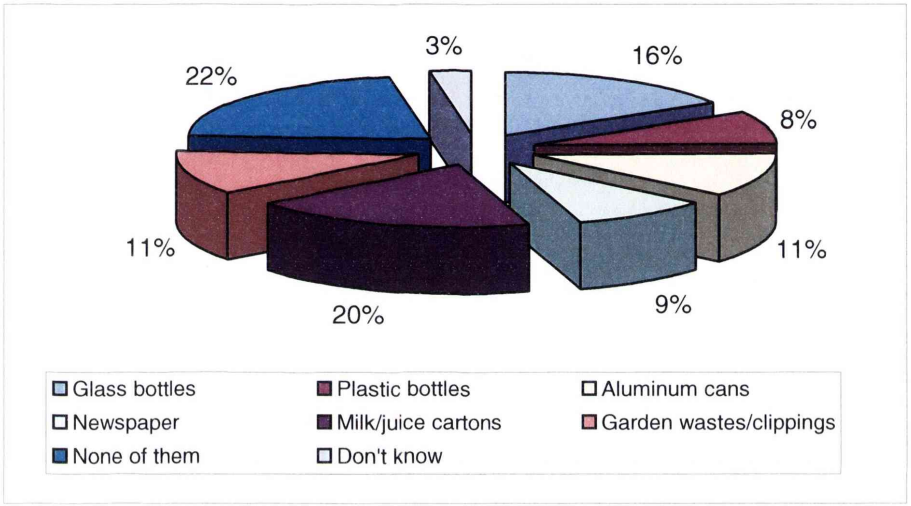


Figure 4-12 Recyclable Items Discarded As Waste

When asked for their feelings about recycled products, most of the respondents thought that products made as a result of recycling are good for the environment, for its protection and preservation. In economic terms, 26% of the respondents noted the lessened cost of buying recycled products. Four per cent of the respondents said they were likely to buy recycled items. In addition, 17% considered the enhanced quality of these products. However, 18% believed that there is not much difference between recycled and non-recycled products (Figure 4-13).

In addition to recycling practices, the respondents were also asked questions related to composting (Figure 4-14). Eighty-five per cent of the respondents had no compost heaps or bins/worm farms being used on a regular basis, 14% had been composting, while the remaining 1% was not sure.

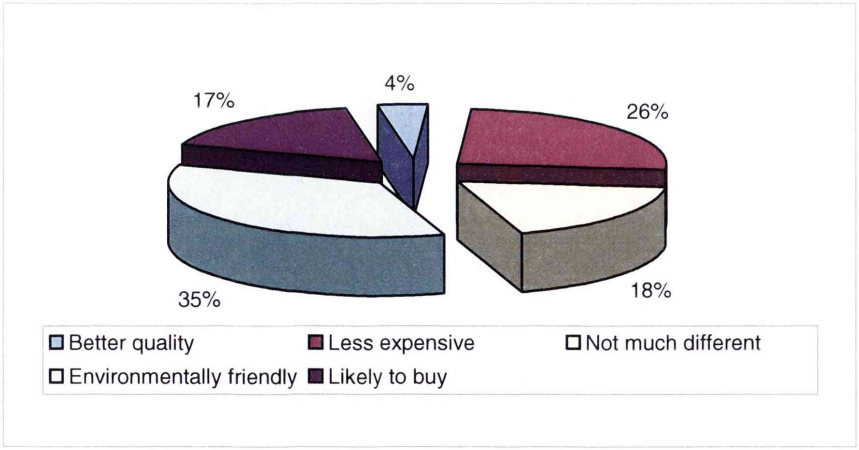


Figure 4-13 Feelings about Recycled Products

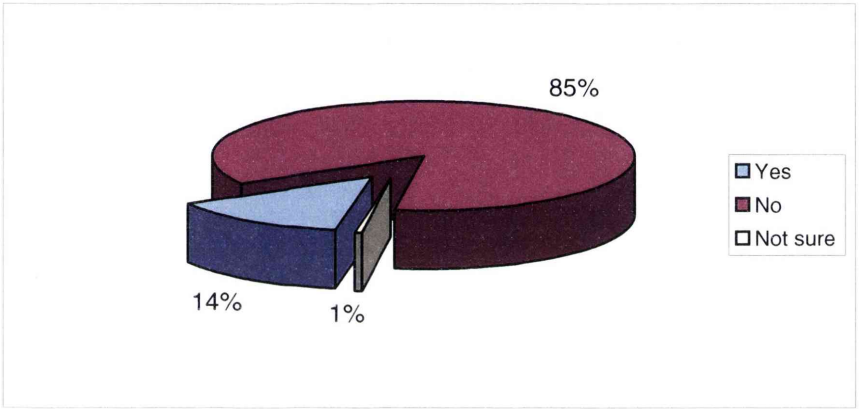


Figure 4-14 Composting

As an overwhelming number of respondents had not been practising composting, it is important to note that most of the respondents live in urban areas. As a result, reasons for not having compost heaps or bins/worm farms may be related to the type of the house and limited space. Twenty-seven per cent of the respondents were not practising composting because they were living either in flats, apartments or townhouses. In addition, 6% of the respondents had limited yard space for composting. Other reasons for not composting included: bad odour which may attract pests and vermin (10%); complicated maintenance (10%); lack of time for composting (8%); unavailability of information (8%); and the expensive cost of compost containers (8%). Some of the respondents were not generating food scraps and other kitchen waste (4%), and in some cases, if scraps and kitchen waste were generated, they were being fed to pets (4%) (Table 4-21).

Table 4-21 Reasons for not Composting

Reasons for not having a compost heap bin/worm farm	Frequency	Percentage
Live in a flat/apartment/townhouse	68	27%
No time for it	21	8%
Limited yard space	15	6%
No food scraps/kitchen waste	10	4%
Smelly-attract flies/vermin	25	10%
Scraps are fed to pets	10	4%
No information available	21	8%
Container not affordable	19	8%
Complication of maintenance	25	10%
Don't bother	10	4%
Other	5	2%
Don't know	20	8%

Composting has beneficial as well as harmful effects, in terms of environmental, economic and social concerns. The result shows that composting was viewed by the respondents more as disadvantageous (61%) than advantageous (39%) (Figure 4-15).

According to the respondents who were advocates of composting, it is generally beneficial because the resulting products are useful and profitable (46%), wastes are used in good ways (28%), and because less waste is disposed of to landfills (26%) (Figure 4-16).

On the other hand, opposition to composting is due to: the requirement of too much effort and time in maintaining a compost heap or bin (27%). Another disadvantage of composting is that it generates a bad smell (21%). Furthermore, composting requires too much space (20%), has a high cost for maintenance (13%), and attracts vermin (11%). Respondents also noted the absence of any incentives (8%) (Figure 4-17).

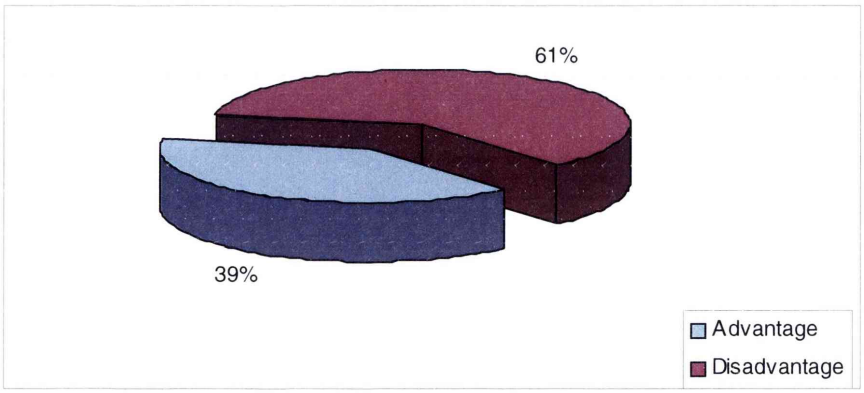


Figure 4-15 Advantages/disadvantages

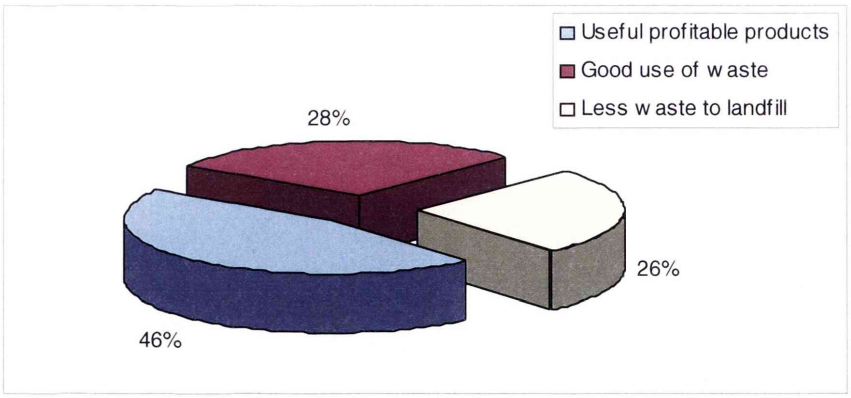


Figure 4-16 Benefits of Composting

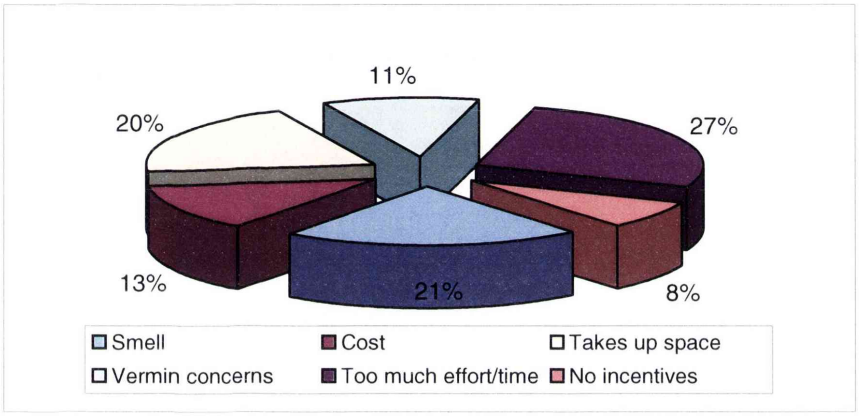


Figure 4-17 Disadvantages of Composting

4-1-5 Views on New Ideas

As the waste problem is getting out of control, many policies have been introduced to at least encourage citizens to be responsible about their household waste. This survey tried to obtain the views of the respondents regarding new ideas in curbing the waste problem.

The respondents were asked about their reaction if a volume-based waste charge system (a charge per bag/bin to encourage more recycling and less waste generation) were introduced in their respective areas (Table 4-22). Fifty-five per cent of the respondents said the move would be a fair idea for charging according to the amount of waste produced. Twenty-five per cent said this new system would result in more recycling activities, thereby reducing the amount of waste that is disposed of to landfill. However, 11% of the respondents stated that what they needed was a policy that provides financial incentives. The remaining 9% did not respond.

Table 4-22 Volume-based Waste Charge System

Volume-based waste charge system	Frequency	Percentage
Fair idea	120	55%
Results in more recycling	54	25%
Needs financial incentive	25	11%
Don't know	21	9%

The above volume-based waste charge system is just one of the possible means of managing household waste. This survey provided the respondent with a list of new ideas for household waste management. They were asked about their preparedness with regard to these schemes (Table 4-23).

Twenty-five per cent of the respondents said they were prepared for the introduction of a volume-based waste charge system in their areas. Twenty-one per cent said it would be necessary to educate the public, especially on environmentally friendly ways of shopping. In the same light, 19% saw the need for more frequent seminars, workshops and public events that would raise the level of awareness of the public about waste management. In addition, 13% saw the important role the media play in educating the public. Seventeen per cent of the respondents said they were ready to accept the introduction of composting facilities in their communities. This is despite the earlier finding of this survey that most of the respondents considered composting as generally not good for the community. Finally, 5% of the respondents were prepared for the adopting of heavy enforcements.

Table 4-23 Household Waste Management Schemes

Household waste management schemes	Frequency	Percentage
Introduction of a volume-based waste charge system	45	25%
Introduction of community composting facilities in my area	32	17%
More frequent workshops/public events about waste management	35	19%
Practical guidance on environmentally friendly ways of shopping	38	21%
Easy access to information on household waste management through media	23	13%
Adopting heavy enforcements	10	5%

As previously mentioned, respondents were calling for more responsible shopping. When asked what they thought about the discontinuation of plastic bags from shops, more than half of the respondents (51%) said implementing this scheme would be very good for the protection and preservation of the environment (Figure 4-18). Thirty-one per cent said this ban on plastic bags would be good. However, 15% were less supportive of this scheme, saying that it would cause inconvenience. Three per cent of the respondents did not care.

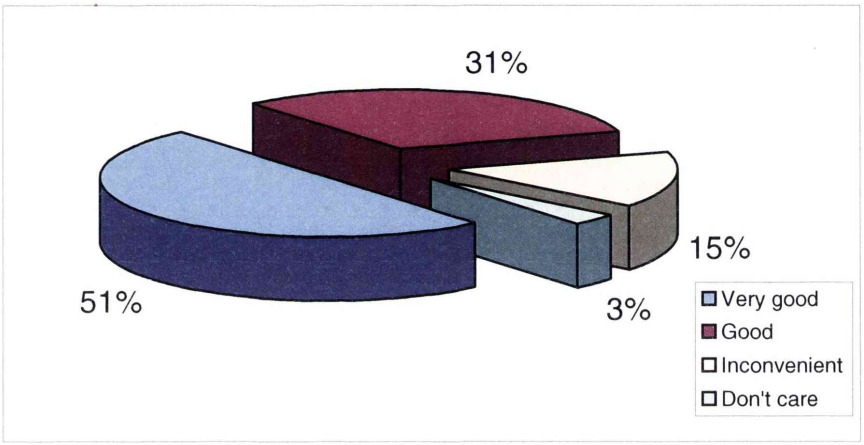


Figure 4-18 Plastic Bags Ban

When asked how likely they would be to return bottles and containers if they were given a monetary reward by local supermarkets, 49% said they would be fairly likely to return the items. Only 17% said they would be very likely to do the same. Another 17% said they would not bother returning the items even if they were offered a monetary reward. Seven per cent of the respondents did not know what they would do under such circumstance (Figure 4-19).

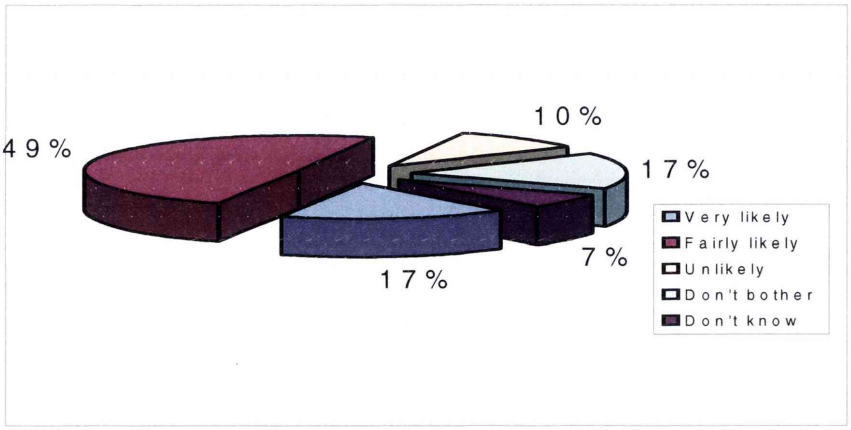


Figure 4-19 Public Response to Monetary Reward

Finally, respondents were asked about their preference for household payments for waste collection services. Sixty-seven per cent of the respondents preferred the use of smaller bins. This would mean lower payments. Twenty-five per cent said there should be an equal payment among all the households, while 7% could not make up their minds.

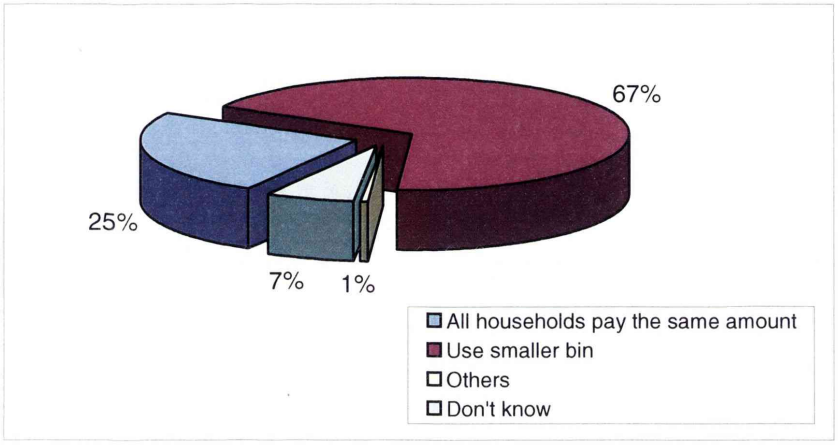


Figure 4-20 Household Payment for Waste Collection Services

4-2 Analysis

This current study included in its survey demographic profiles and socio-economic variables because they influence practically everything in the waste management domain. Gender and socio-economic status may affect one's view on waste generation, collection, processing and disposal. These factors also influence perceptions about the most developed services, how much to pay for these services, and who is responsible for finding the money to pay from within their part of the family budget. Additionally, differences in terms of these factors result in the differing preferences for policies, technologies, and approaches that affect the decisions of leaders, entrepreneurs, managers, and public authorities that in turn, affect communities, regions, companies, and municipalities.

Although most of the respondents were female, this does not significantly affect the study because, as pointed out in the Women in Development (WID) and ecofeminism literature, women are now increasingly taking part in terms of waste decisions in the household (Zein-Elabdin, 1996). In addition, the survey shows that most of the respondents live in small households, meaning that product consumption and waste generation is reduced.

Overall, the respondents are fairly concerned about the environment. However, because some were not really concerned particularly those who identified as full time employed, some intervention must be made. Citizens who do not care about the environment should be made aware of the ill effects of their withdrawal from caring. Despite this, most of the respondents are willing to help the environment by participating in many environmental activities. Citizens should be encouraged and mobilised in pursuit of environmental protection and preservation. Environmental programs should be prioritised. On a positive note, the survey found that the respondents considered the environment to be an important issue, next only to education. However, to be more effective and efficient in planning, developing, implementing and evaluation of any waste management programs, it is important to integrate concerns from different sectors.

The survey also found that household waste management is important for the respondents. With their belief in the importance of household waste management comes their increased involvement in reducing household waste at home. Those who valued household waste reduction advocated recycling more than any other reduction practices such as composting, refusing plastic bags at the supermarket, preferring products with less packaging, and reducing the use of disposable products. Recycling involves good resource conservation, minimisation of emissions, and builds strong community support and goodwill. It also leads to cleaner production and efficiency, which is the main goal of sustainability and environmental protection. However, the advantages of other household waste reduction alternatives should be studied further.

A large number of the respondents were certainly interested in learning more about how to deal with household waste. For the importance of household waste management to reach the citizens, a massive information dissemination campaign must be conducted. Due to the advancement in technology, the benefits of the Internet as a medium for communication should be exploited. Moreover, environmental groups should continue airing their concerns in the local newspapers, and on television and radio stations. Local councils and environmental groups must form positive relationships with each other. They must be one in informing and educating the public.

Information dissemination and education are all important parts of household waste management as it results in public empowerment, which in turn leads to increased environmental awareness and concern. The goal, the effective and efficient protection and preservation of the environment that addresses economic and social considerations, will then be achieved.

However there are those who consider household waste reduction as not at all important. This may mean that the respondents had in mind other schemes than this one: waste avoidance, product reuse, and proper household waste disposal. The respondents considered waste avoidance as still the most important household waste management practice, as per the old saying, "prevention is better than cure." Most of the respondents would rather avoid generating waste as much as possible rather than reusing and recycling wastes.

As for their overall performance in protecting the environment, the respondents rated themselves as average. Specifically, in separating household waste, the majority claimed that their performance was average, and a considerable number were not really involved. This has a threefold implication: (1) further environmental degradation, (2) failure to consider the economic benefits of protecting the environment, and (3) disintegration of society due to the reluctance of its citizens to get involved.

According to the Australian Bureau of Statistics, local government spending on measures to protect the environment in Australia reached $4.5 billion during 2002—2003 (Natural Resource Management, 2004). The traditional local council initiative on solid waste management, with $1.3 billion, was one of the major expenses for national environment protection. In NSW, the expenditure was $839.4 million on environmental protection, or $127 per capita (Natural Resource Management, 2004).

Along this line, this study finds that most of the respondents thought that their councils spent less in taking away and disposing their household waste each year than the actual amount. Despite this generally low cost, most of the respondents rated their councils' household waste management services as satisfactory. This implies that cost is not directly proportional to satisfaction. In planning, developing, and implementing a waste management program, therefore, cost is not the only variable to be considered.

The participation of the public and their reasons for not participating must be targeted. The survey shows that there are some respondents who were reluctant to be fully involved in household waste management with respect to collection services. Small details that are taken for granted must be emphasised. For example, the effect of the size, weight and appearance of a bin on public participation in waste management programs must be considered. In waste collection, factors to address include the effort required of the public to be involved, how often household waste services collect bins, and the behaviour of garbage collectors. Having identified the reasons that hinder the success of any waste management program, it is important to also identify grounds for improvement.

The respondents wanted to recycle a lot but not everything that can be recycled. However, others said the more the better. On the other hand, those who were not fully committed to recycling argued about the hassle of recycling and the uncertainty of what items could be recycled. But they were generally positive about it, saying they were willing to try recycling. This willingness to recycle may have something to do with their fairly satisfied attitude towards kerbside recycling. It can be recommended that to improve kerbside recycling arrangements, fussiness about what can be collected should be lessened. Moreover, the result of the survey shows that the respondents were calling for bigger split bins. However, the researcher believes that it might only encourage more waste in the bin.

As expected, the survey found that females/mothers/wives are responsible for recycling in the household. This shows that there is really a need for a wider male participation in household waste management. Household waste management should be a shared responsibility of all, regardless of gender. The results relating to the reasons behind recycling show that in waste management, some people believe it is their moral and social responsibility to protect and preserve the environment.

In summary, this case study found among the respondents: fair concern about the environment; moderate amount of help for the environment; willingness to be involved in any environmental activities; importance of household waste management; importance of waste avoidance over recycling, product reuse and disposal; their interest in learning more about how to deal with household waste; average performance in separating their household waste; and their satisfaction with their council's household waste collection service.

In addition, the respondents were recycling more to reduce the amount of household waste generated; were reluctant to fully commit to their waste household waste collection service because the bin was too small; suggested more frequent collections to produce more efficient household waste collection service; were using their kerbside recycling service most of the time; were fairly satisfied about it; suggested a lessened fussiness about what can be collected; were not fully committed to recycling because of too much hassle; and were certainly willing to increase their recycling efforts.

Respondents said female members of the household (mothers and wives) were responsible for recycling; they were motivated to recycle to preserve the environment and the conservation of natural resources, as well as to fulfil their moral and social obligation; felt that recycled products are less expensive compared with non-recycled products; were

not composting because of their type of dwelling and other inconveniences such as bad odour.

The above findings should help household waste management planners in developing sound management programs. In addition, new ideas have to be considered. As this study has found a preparedness of respondents to accept new household waste management programs such as the volume-based waste charge system, policy-makers should take advantage of this opportunity. However, the public must first be educated, mainly by environmental groups (for example EPA, Clean Up and Plant Ark., etc), before accepting any programs. Compared with other interest groups, environmental groups are primarily concerned with the preservation of the environment; while other groups are driven by economic and political motives. Therefore, independent environmental groups must be the agencies that should conduct seminars, workshops and public events.

4-3 Statistical Analysis

Statistical analysis was performed using SPSS after the data were gathered and tabulated. Prior to conducting the reliability analysis, the data were screened in respect of the issues of normality, multicollinearity and singularity. This was performed specifically in terms of the gender of the respondents, to establish the reliability of the results of the study.

4-3-1 Normality

The assumption of normality has been assessed statistically, as shown in the descriptive statistics table (Table 4-24) and graphs (Figure 4-21).

Table 4-24 Descriptive statistics

	N	Skewness	Kurtosis
	Statistic	Statistic	Statistic
Gender	150	-0.62	-1.638
Type of Property	150	2.073	3.567
Household Size	150	0.856	1.932
Household Description	150	0.194	-0.177
Employment Status	150	0.71	-0.84
Educational Attainment	150	2.003	4.362
Valid N (listwise)	150		

In order to test the normality of the data, descriptive statistics were used through SPSS. This includes the analysis of skewness and kurtosis. A skewness analysis measures the equilibrium of the data and kurtosis relates to how peaked the distribution is, either too peaked or too flat.

Variables are considered to exhibit significant skewness and/or kurtosis if the standardised scores associated with these indicators are outside the range of +/-3.3 ($p <$ .01). As a result, despite the distribution in the type of property and educational attainment, with statistics of 3.567 and 4.362 respectively, showing significant deviant kurtosis, none of the variables demonstrated significant skewness, or a significantly deviant kurtosis. The assumption of normality was met statistically. This implies that the data were normally distributed in terms of the gender, type of property, household size, household description, employment status, and educational attainment of the respondents. Therefore, the data gathered are considered to be valid in making conclusions.

In conjunction with the calculated Z-scores obtained from the Descriptive Statistics table, the frequency histograms with normal curve overlay were used to visually assess the normality of the score distributions for each variable. Figures for the type of property and educational attainment show that the variables are negatively skewed distributions; on the other hand, figures for household size and household description had slightly positively skewed distributions. Lastly, the employment status reveals a slightly negative skewness while the figure for gender has shown a positive skewness.

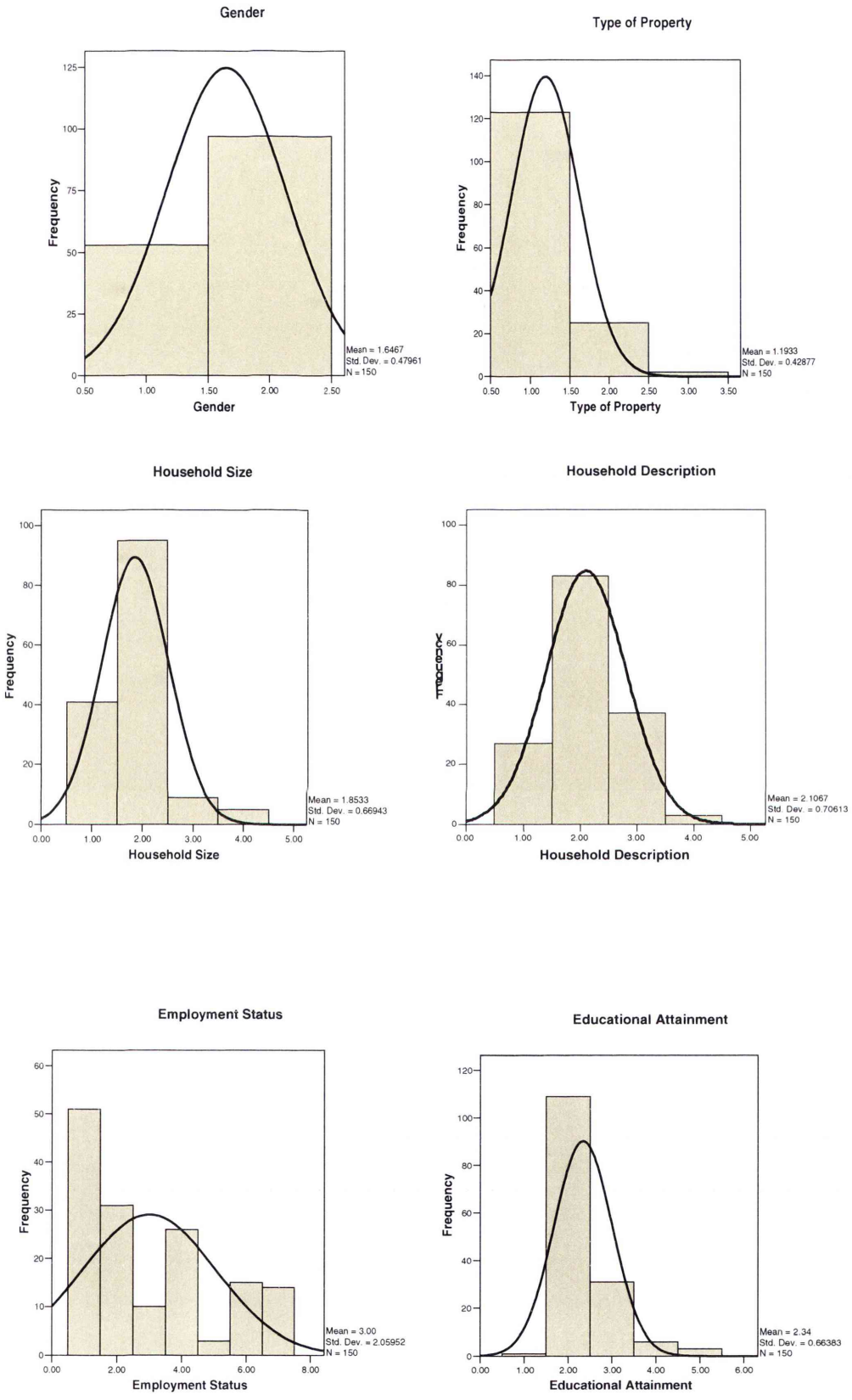


Figure 4-21 Multicollinearity and Singularity

Likewise, multicollinearity and singularity analyses were also performed on the data. Multicollinearity is the degree of correlation between variables. It is an important consideration when using multiple regressions on data that have been collected without the aid of an experiment design. On the other hand, singularity is used to obtain future perspectives of the variables generated.

Multicollinearity is present if the computed bivariate correlations exceed .90, and singularity is present if any variables in the analysis are perfectly linearly related (that is., $r = 1$). Multicollinearity among pairs of variables was firstly examined via bivariate correlations, as shown in the correlation table (Table 4-25).

An overview of the correlation matrix indicates that a high correlation is evident between the variables *type of property* and *educational attainment*, $r = 0.569$, significant at the alpha level of .01. Although the correlation is high, we would expect it to be the case that increased educational attainment tends to lead to a change in the type of property. At the alpha level of .05, each of the correlations was significant, with the exception of bivariate correlations paired with the variables, *household size* and *type of property*. This means that a variation in the household size also leads to a variation in the types of property of the respondents. The larger the household size, the better the type of property.

In contrast, it was revealed that there is no correlation between the household description and educational attainment; in addition to this, there is a weak to very weak positive and negative correlation between the household description and the rest of the variables. This implies that household description does not affect the educational attainment of the respondents, while the change in household description has an inverse relationship to other variables.

More importantly, none of the bivariate correlations are .90 or greater, the level at which statistical problems are created by singularity and multicollinearity. This justifies the validity of the data collated in this study, and the findings revealed in this study are reliable.

Table 4-25 Correlations

Correlations

		Gender	Type of Property	Household Size	Household Decsription	Employment Status	Educational Attainment
Gender	Pearson Correla	1	-.253**	.088	-.007	-.632**	-.484**
	Sig. (2-tailed)	.	.002	.282	.934	.000	.000
	N	150	150	150	150	150	150
Type of Property	Pearson Correla	-.253**	1	.123	.197*	.410**	.569**
	Sig. (2-tailed)	.002	.	.134	.015	.000	.000
	N	150	150	150	150	150	150
Household Size	Pearson Correla	.088	.123	1	-.165*	-.355**	.249**
	Sig. (2-tailed)	.282	.134	.	.043	.000	.002
	N	150	150	150	150	150	150
Household Decsrij	Pearson Correla	-.007	.197*	-.165*	1	.171*	-.006
	Sig. (2-tailed)	.934	.015	.043	.	.037	.939
	N	150	150	150	150	150	150
Employment Statu	Pearson Correla	-.632**	.410**	-.355**	.171*	1	.437**
	Sig. (2-tailed)	.000	.000	.000	.037	.	.000
	N	150	150	150	150	150	150
Educational Attain	Pearson Correla	-.484**	.569**	.249**	-.006	.437**	1
	Sig. (2-tailed)	.000	.000	.002	.939	.000	.
	N	150	150	150	150	150	150

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

4-3-2 Reliability Analysis

Reliability analysis was finally performed in this study to justify the output presented in different statistical tests of the data. This is very useful after the several analyses on a questionnaire to check the reliability of the scale. There are several ways of doing this, such as the split half method. This method randomly splits the data set into two. A score for each subject is then calculated based on each half of the scale.

If a scale is very reliable, a score should be the same on one half of the scale as on the other, and so the two halves should correlate perfectly. The correlation between the two halves is the statistic computed in the split half method, large correlations being a sign of reliability. The problem with this method is that there are a number of ways in which a set of data can be split into two and so the results might be a result of the way in which the data were split. To overcome this problem, the data can be split in two in every conceivable

way and the correlation coefficient for each split be computed. The average of these values is known as Cronbach's alpha, which is the most common measure of scale reliability.

Depending on what option was selected, a very large output could be obtained. The most important things to examine are:

• *Corrected Item-Total Correlation*: These are the correlations between each item and the total score from the questionnaire. In a reliable scale all items should correlate with the total. The aim is therefore to identify items that do not correlate with the overall score from the scale. If any of these values are less than between 0.28 this is problematic; because it means that a particular item does not correlate very well with the scale overall, the item may have to be dropped. Based on the collated data, the variables like *household size*, *household description*, and *employment status* show relatively low correlations with the scale as a whole

Table 4-26 Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if item Deleted
Gender	10.5	7.8	-0.6	0.321
Type of Property	10.9	5.1	0.585	-0.179
Household Size	10.3	6.8	-0.226	0.219
Household Description	10.0	5.5	0.136	-0.011
Employment Status	9.1	2.0	0.032	0.132
Educational Attainment	9.8	4.6	0.502	-0.28

• *Alpha If Item Is Deleted*: As mentioned before, this reflects the change in Cronbach's alpha that would be seen if a particular item were deleted. Here the aim is to identify values of alpha *greater* than the overall alpha. If the deletion of an item increases Cronbach's alpha, that means that the deletion of that item improves reliability. Therefore, any items that result in substantially greater values of alpha than the overall alpha may need to be deleted from the scale in order to improve its reliability. None of the items here would substantially affect reliability if they were deleted. The worst offender is the *gender*: deleting this question would increase the alpha. Nevertheless, this increase is not dramatic. This means that *gender* is not a reliable source of information for the findings of this study.

Dropping the *gender* as a variable in the study may lead to a more reliable output for the study.

• *Cronbach's Alpha*: To reiterate, values in the magnitude of 0.8 (or thereabouts) are being sought and identified. In this case the alpha is below the magnitude, which indicates that the most of the variables are not reliable sources of data as included in the questionnaires. This also means the variables have a neutral position with each other, meaning that there is no strong relationship in the reliability between the findings in each variable.

Table 4-27 Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
0.075	0.123	6

4-3-3 Multiple Regressions

Moreover, a multiple regression analysis will be used in determining the level of significance of the relationships between respondents' attitudes towards waste disposal and their satisfaction with the waste management program of their respective cities. The data gathered by the researcher were processed through SPSS in order to perform the specific statistical analysis.

Table 4-28 (Model Summary), displays R, R squared, adjusted R squared, and the standard error. R is the correlation between the observed and predicted values of the dependent variable. The values of R range from -1 to 1. The sign of R indicates the direction of the relationship (positive or negative). The absolute value of R indicates the strength, with larger absolute values indicating stronger relationships.

R squared is the proportion of variation in the dependent variable explained by the regression model. The values of R squared range from 0 to 1. Small values indicate that the model does not fit the data well. The sample R squared tends to optimistically estimate how well the models fit the population. Adjusted R squared attempts to correct R squared to more closely reflect the goodness of fit of the model in the population.

The logic is to use R Squared to help to determine which model is best and choose a model with a high value of R squared that does not contain too many variables. Models with too many variables are often over fit and difficult to interpret.

Table 4-28 Model Summary

Model Summary

Model	R	R Squared	Adjusted R Square	Std. Error of the Estimate
1	.919[a]	.844	.837	17.5

a. Predictors: (Constant), Educational, Household Size, Household Desc, Employment, Gender, Property

As it can be seen, the computed R of 0.919 reveals that there is a high positive relationship between the predictor variables. This implies that the respondents' attitudes towards waste disposal have a significant positive effect on their satisfaction with Sydney's waste management programs. Additionally, it was revealed in the R squared that the model fits the data very well, which indicates that the output presented is reliable.

To further justify the significant relation between respondents' attitudes towards waste disposal and their satisfaction with Sydney's waste management programs, the unstandardised coefficients were also taken. The unstandardised coefficients are the coefficients of the estimated regression model. Often the independent variables are measures in different units. The standardised coefficients or betas are an attempt to make the regression coefficients more comparable. If the data is transformed to z scores prior to the regression analysis, the beta coefficients will be obtained as the unstandardised coefficients. The t statistics can help to determine the relative importance of each variable in the model. As a guide regarding useful predictors, the logic is to look for t values well below -2 or above +2.

Table 4-29 Coefficients

Coefficients[a]

Model		Unstandardised Coefficients		Standardised Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	21.614	26.855		.805	.422
	Gender	25.017	6.506	.276	3.845	.000
	Property	30.419	8.473	.262	3.590	.000
	Household Size	-15.955	3.304	-.246	-4.829	.000
	Household Desc	-5.555	3.406	-.090	-1.631	.105
	Employment	-12.977	1.441	-.615	-9.005	.000
	Educational	2.867	4.085	.044	.702	.484

a. Dependent Variable: Respondents

Table 4-29 shows whether there is a significant difference between respondents' attitudes towards waste disposal and their satisfaction with Sydney's waste management

programs. From the analysis, the result shows that Gender, Types of Property, Household Size, and Employment Status are the variables that demonstrate a significant difference with regard to those respondents' satisfaction with Sydney's waste management programs.

4-3-4 ANOVA Analysis

The ANOVA analysis was used in the study in order to test whether the respondents' attitudes towards waste disposal have a significant effect on their satisfaction with Sydney's waste management programs.

Table 4-30 ANOVA

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	237328	6	39554	128.8	.000[a]
	Residual	43908	143	307		
	Total	281237.	149			

a. Predictors: (Constant), Educational, Household Size, Household Desc, Employment, Gender, Property

b. Dependent Variable: Respondents

The mean square is the sum of squares divided by the degrees of freedom. The F statistic is the regression mean square (MSR) divided by the residual mean square (MSE). The regression degrees of freedom are represented by the numerator df and the residual degrees of freedom are represented by the denominator df for the F statistic. The degree of freedom for the model is equal to one less than the number of categories, which has a total of 149 df. The F ratio is nothing more than the extra sum of squares principle applied to the full set of indicator variables defined by the categorical predictor variable. The total number of degrees of freedom is the number of cases minus 1. If the significance value of the F statistic is small (smaller than, say, 0.05), then the independent variables are effective in explaining the variation in the dependent variable. If the significance value of F is larger than, say, 0.05, then the independent variables do not explain the variation in the dependent variable.

Accordingly, the regression sum of squares is larger than the residual sum of squares, which indicates that the model accounts for the most of variation in the dependent variable. And since the residual sum of squares is smaller, the model was able to explain a significant proportion of the variation in the dependent variable, and we do not need to look

for additional factors that help to account for a higher proportion of the variation in the dependent variable. Furthermore, the significance value, which is less than the 0.05 level of significance, indicates that the respondents' attitudes towards waste disposal have a significant effect on their satisfaction with Sydney's waste management programs. This also shows that the respondents' profiles significantly affect their perception of Sydney's MSW management programs.

The next chapter presents the case of Seoul, followed by an analysis and cross-sectional comparison of these two case studies.

Chapter 5 Case Study: Seoul MSW management

5-1 Introduction

Chapter 4 showed the case study on the waste management practices of Sydney residents. In this Chapter, the case of Seoul is assessed. Aside from some slight variations in the survey, the core questions in the waste's life cycle were evaluated.

The following section is divided into seven parts. The first section covers the socio-economic status of the respondents considered for the study. These include their gender, type of property lived in, and number of households' members, living arrangements, employment status, and educational status. The second section tackles the respondents' general view on the environment. In this section the researcher evaluated the level of their concerns about their environment, and the level of their willingness to take part in any activities to help protect the environment. The third section assessed the respondents' knowledge of household waste management. The fourth section evaluated the actual household waste management practices of the respondents who were interviewed for the purpose of the study. Meanwhile, the process by which respondents recycled their wastes is presented in the succeeding chapter. On the other hand, their views on other systems and the process by which they manage their food waste are presented in the sixth and seventh chapters, respectively.

5-1-1 Socio-Demographic Profile

The respondents' socio-demographic profile is presented in order to accomplish three objectives. First, the demographic profile of the respondents affects their perception of household waste management and its implications for their city's waste management programs. Second, this allows for verification and thus provides the reliability and credibility of the findings of the research. Finally, it will determine significant differences compared to the Sydney case study.

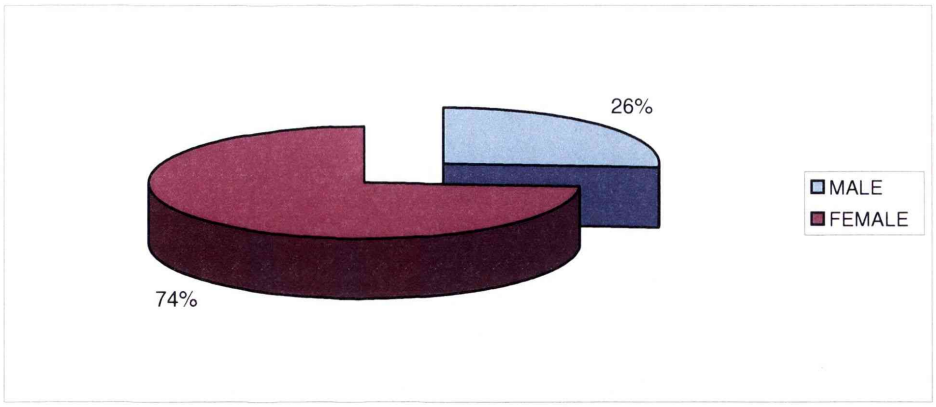


Figure 5-1 Respondents According to Gender

The researcher gathered one hundred and fifty respondents in Seoul, one hundred and eleven (74%) of whom were female, and the remaining thirty-nine (26%) respondents came from the male population (Figure 5-1).

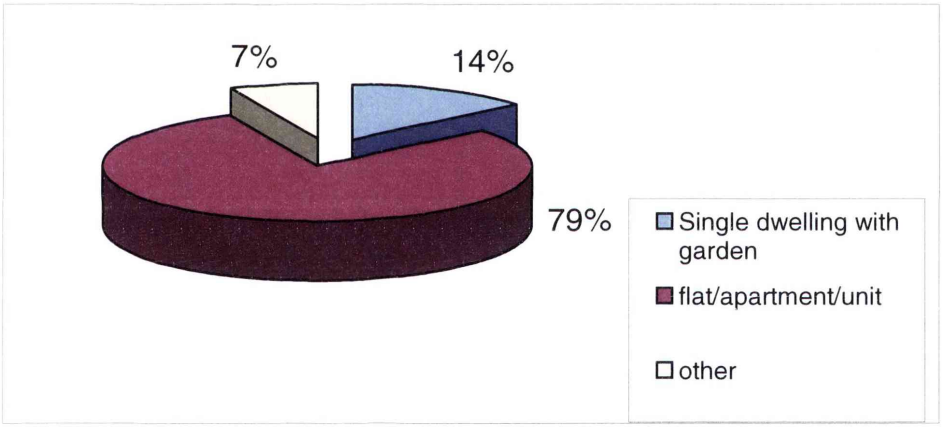


Figure 5-2 Type of Property

According to the results of the study, the majority of respondents (79%) had their own flat/apartment/unit as their place of residence. On the other hand, about 14% of them lived in a single dwelling with a garden. The remaining 7%, however, resided in other types of property, which they did not specify (Figure 5-2).

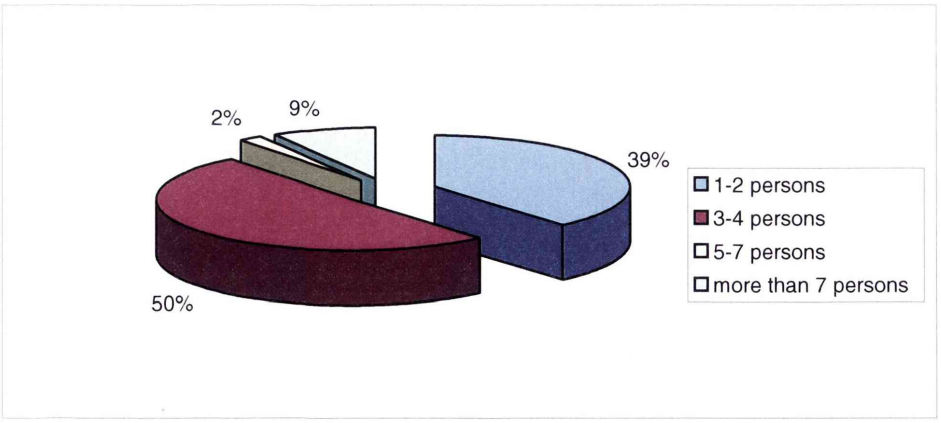


Figure 5-3 Respondents According to the Number of Households Members

Half of the one hundred and fifty respondents interviewed for the study lived with 3—4 other persons. About 39% of them, however, lived with one to two other household members. The remaining 11% shared with five and more other persons (Figure 5-3).

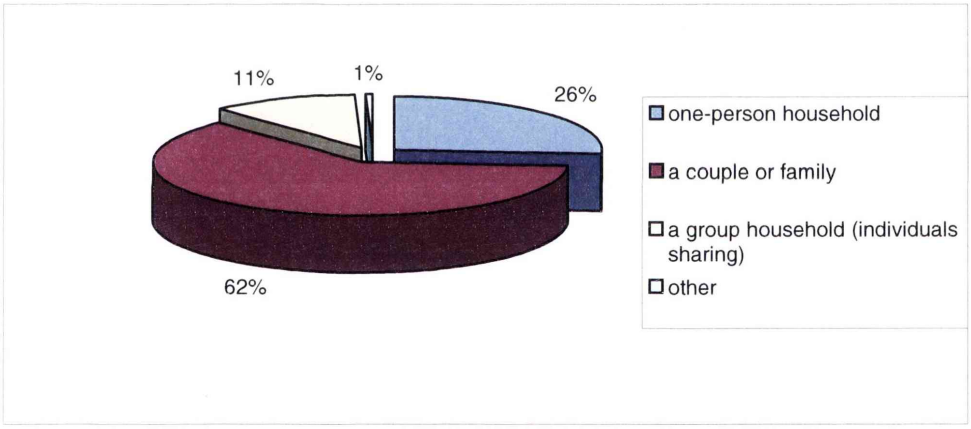


Figure 5-4 Proportion of Respondents According to Living Arrangement

About 62% of the respondents lived as part of a couple or family living arrangement. Twenty-six per cent of them lived in a one-person household and approximately 11% resided in group households. Only 1% per cent disclosed that they had other living arrangements besides the choices given (Figure 5-4).

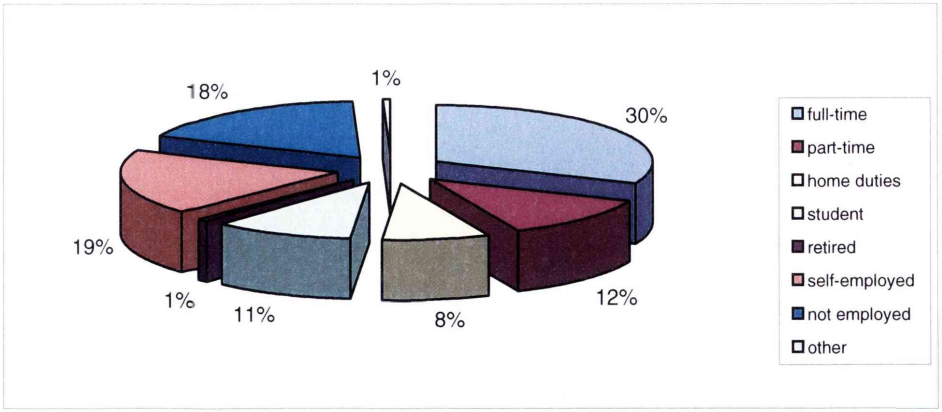


Figure 5-5 Proportion of Respondents According to Employment Status

The majority of the respondents were full-time workers. Of almost the same proportion were the self-employed (19%) and unemployed (18%) respondents. 11% of the respondents were students, 12% had a part-time job(s), and 8% were occupied with home duties. Only 1% of them had already retired from work and another 1% stated that they were doing other extra-curricular activities for a living (Figure 5-5).

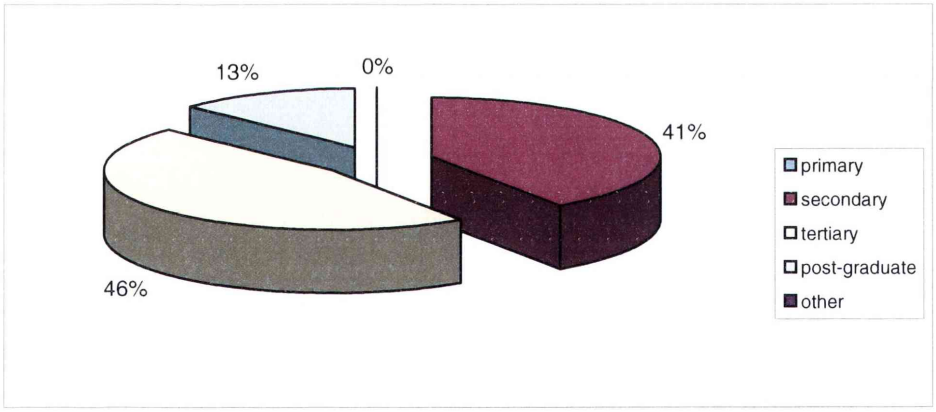


Figure 5-6 Proportion of Respondents According to Educational Attainment

All of the respondents had reached at least the secondary level of education (Figure 5-6). The majority of them had finished tertiary degree courses and about 41% had finished other degree courses. Only 13% of the respondents were post-graduate degree holders.

The demographic profile of the respondents showed the same pattern as that of Sydney. The respondents were predominantly females, they currently lived in a flat or an apartment with their respective families, were full-time employed and had a relatively high level of educational attainment.

5-1-2 General View of the Environment

The respondents' perception of the environment can be reflected in how they manage their wastes. Moreover, their level of environmental concern will also determine their household practices. This section discusses the responses that the researchers had gathered from the respondents to several questions meant to determine the level of their environmental concern, willingness to help protect the environment and the perception regarding the most important issues that they considered.

Environmental concern is an often-neglected concept among city dwellers. In addition, it serves as an important variable in the determination of their involvement in Seoul's municipal waste management programs. The result of the survey, though, reflects a very interesting point — that Seoul residents actually have a high level of concern about the environment. A significant group of 33 (22%) respondents strongly expressed their positive concern about their surroundings. Nonetheless, there was a significant portion of 21 (14%) respondents who blatantly claimed that they did not really care about their environment. Meanwhile, only three expressed their complete negligence toward the environment. Table 5-1 shows these results.

Table 5-1 Environmental Concern of the Respondents

Respondents' Concerns About Environment	Frequency	Percentage
Yes, very much	33	22%
Yes, fairly	93	62%
No, not really	21	14%
No, not at all	3	2%
Other	0	0%

People empowerment is one component of waste management. For municipal officers, the element of people thinking that they have a major role to play in waste management is often translated to action. Thus, the research inquired into whether the respondents perceived themselves to be helping in Seoul's waste management. Nearly half of the respondents (49%) asserted that an individual could help moderately in reviving the environment. Sixteen were optimistic about the difference an individual could make in helping the environment. Nonetheless, there were 31 respondents (21%) who, though

affirming that a single person could help, were still hesitant to claim that such help could have a great impact. Eighteen were not sure about what a single person could really do to help the environment. Table 5-2 summarises this information.

Table 5-2 Helping the Environment

Responses to how much an individual can do to help the environment	Frequency	Percentage
A great deal	16	11%
A moderate amount	74	49%
Not sure	18	12%
A little bit	31	21%
Nothing	11	7%

However, their affirmation of their role in helping their environment does not necessarily reflect their actual practices. Ironically, when asked about their willingness to help protect the environment, 50% of the total number of respondents expressed their disagreement with the idea. They claimed that they do not and will not involve themselves with any activities geared to help preserve the environment. On the other hand, nearly 28% of all respondents are involved and are willing to participate in any activities designed to help protect the environment.

The result shows an interesting paradox of people in relation to environmental issues: that while people may perceive the environment to be something that they should contribute to, they resist the idea of actually having to help in their individual ways. This is because they perceive the municipal waste management service providers of Seoul to be responsible for the actions. Table 5-3 shows these findings.

Table 5-3 Willingness to Help Protect the Environment

Respondents' Willingness to Help Protect Environment	Frequency	Percentage
Yes	42	28%
No	75	50%
Not Sure	33	22%

Meanwhile, respondents were also asked to choose which among seven issues is the most crucial one. Again, the respondents reaffirmed the importance of resolving environmental concerns. The result of the survey showed that they prioritise the environment to a large extent. The respondents were given the option to identify more than one issue. Next to education, environment was deemed the second most important issue, as claimed by about 23% of the total respondents. Waste ranked as the fifth most important issue to be considered, as perceived by 7% of the respondents. Employment is the fourth most important issue following, housing. 21 of the respondents (6%) chose public transport as the most important issue to be considered and 15 of them (5%) selected public health.

Table 5-4 Issues Considered as Important by Respondents

Issues Considered Important by Respondents	Frequency	Percentage
Education	78	24%
Environment	76	23%
Housing	54	17%
Employment	46	14%
Waste	24	7%
Public Transport	21	6%
Public Health	15	5%

The result showed that again, the respondents considered that the environment is an important concern for them. This came second in relation to all their social service concerns. However, an assessment of the response of the residents of Seoul results in a distinct contrast: the prioritisation of Seoul residents of environmental issues may not necessarily translate into action and actual practices. This may be reflected in their household management knowledge and practices, which will be discussed in the next section.

5-1-3 Knowledge of Household Waste Management

Wastes can be classified as municipal or domestic waste, council operational waste, commercial and industrial waste and construction and demolition waste. Predominantly, household waste management can be best managed if the level of knowledge of the Seoul residents about their own waste management is high. This section determined whether the residents had a high level of knowledge in managing their household wastes.

According to more than half of the total number of the respondents, household waste management is critical for the preservation of the environment and the conservation of natural resources. This was strongly affirmed by 14% of the respondents. On the other hand, 13% of them claimed ignorance regarding the affirmative association among household waste management, preservation of the environment and conservation of natural resources. Meanwhile, the remaining 8% of the respondents claimed that they did not consider household waste management pivotal for preserving the environment and conserving natural resources. These findings are presented in Table 5-5.

Table 5-5 Importance of Household Waste Management for the Preservation of the Environment and Natural Resources

Importance of Household Waste Management for the Preservation of the Environment and Natural Resources	Frequency	Percentage
Very Important	21	14%
Important	87	58%
Not Really Important	14	9%
Not at all Important	8	5%
Don't Know	20	13%

Table 5-6 shows the frequency of responses that the researcher gathered from respondents when asked about their knowledge about what happens to their household wastes (not recyclable) after they were taken away from their houses. About 43% of the respondents claimed that their wastes were buried at landfill sites by authorities. On the other hand, 39% of them expressed a different opinion. They believed that authorities found other uses for their wastes. They thought wastes were recycled so that they could be useful and friendly to the environment. Fourteen per cent of the respondents perceived that

after taking away their wastes authorities burned them using incinerators. Only 1.3% of them believed that wastes were being dumped into the sea. The same number of respondents claimed ignorance about the process by which their wastes were being managed after they were collected from their houses.

Table 5-6 Destination of Non-recyclable Waste

Household Waste Management	Frequency	Percentage
Bury at landfill site	65	43%
Burn in incinerator	21	14%
Recycle or re-use	59	39%
Dump at sea	2	1.3%
Other	1	0.7%
Don't know	2	1.3%

The majority of the respondents (33%) recognised that avoiding wastes is more important than others, followed by recycling, which garnered 31% of the respondents. Nearly 12% believed that reusing materials is more important compared to the others; in contrast, 24% of all respondents claimed that proper waste disposal is more important than others. Only 1 respondent professed ignorance about the issue.

Table 5-7 Most Important Household Waste Management Practice

Important Issues in Household Waste Management	Frequency	Percentage
Avoiding Waste	49	33%
Re-using Materials	18	12%
Recycling Materials	46	31%
Proper Waste Disposal	36	24%
Don't know	1	0.7%

Knowledge of household waste management precedes an interest in learning how to manage one's own household wastes. The respondents affirmed that they are predominantly interested in learning more about household waste management. Out of the one hundred and fifty respondents, 65% expressed their strong desire to learn more about

managing household waste. The remaining 35% claimed that perhaps they should learn more about it.

Table 5-8 Interest in Learning More about Managing Household Waste Management

Interest in learning more about how to manage household waste management	Frequency	Percentage
Certainly	98	65%
Perhaps	52	35%
No	0	0
Do not know	0	0

The dominance of the Internet in providing information and serving as an authority for the respondents on how to manage their household wastes is proven in the survey (Figure 5-7). This is most evident in cities where there is a high demand for broadband and Internet connections. This is reflected in the 52% of the respondents affirming that they prefer the Internet as their source of information on waste management. The preference for media such as the Internet and television is reflected in the second most popular source of information according to the responses — the media through TV and radio.

The local newspaper accounts for the third most popular response, accounting for 13% of the total responses. Concurrently, environmental groups still play a major role in information dissemination, as 10% of the respondents affirm that they obtained their information from them. In addition, community meetings received a 6% of the total responses. The local council and the local library rank sixth and seventh respectively.

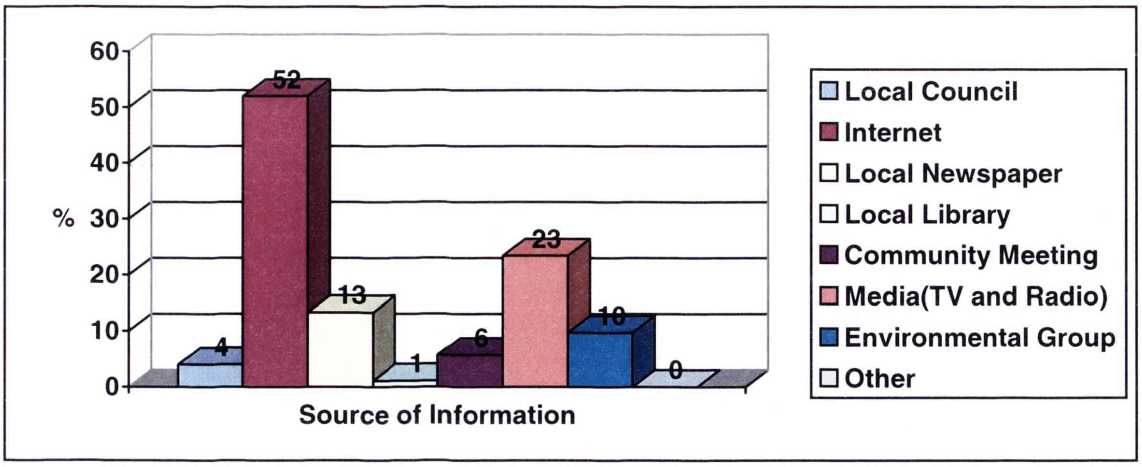


Figure 5-7 Sources of Information

The result shows an interesting pattern among Seoul residents: that waste management information comes from where it is more convenient for them to obtain it — the Internet and the media. The leaning towards getting information from the city council and their media is shown to be the least of the residents' priorities.

While the respondents asserted that they considered themselves to value their household waste practices as contributing to the municipal waste services, their responses on the issue of segregation of household waste indicated a fairly average effort to segregate. The importance of household waste management as perceived by the respondents is shown in Figure 5-8.

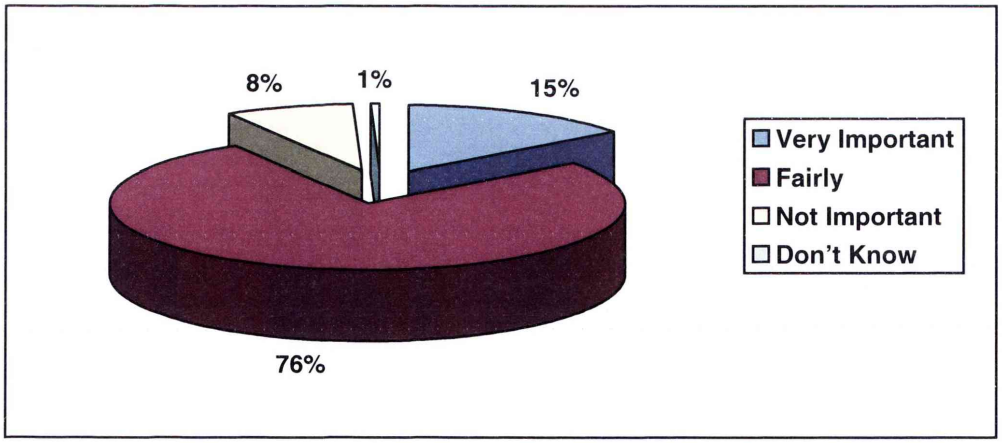


Figure 5-8 Importance of Household Waste at Home

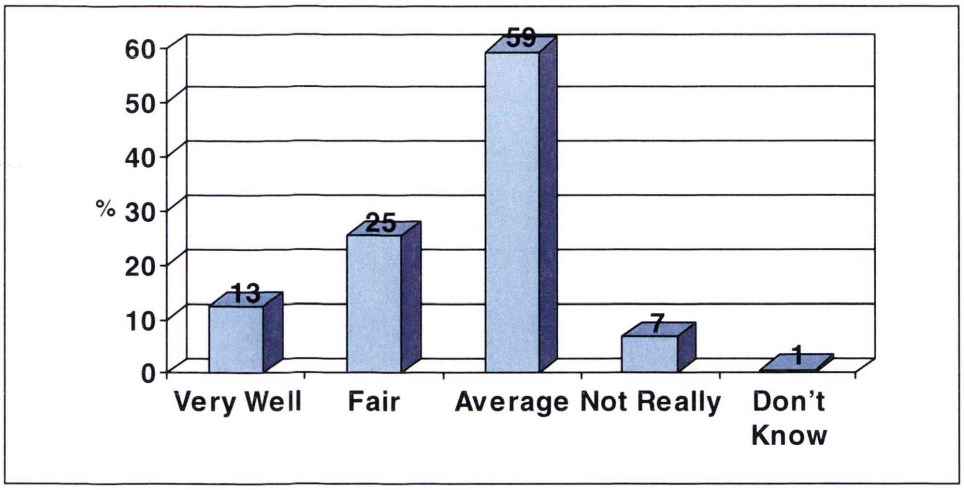


Figure 5-9 Performance in Separating Household Waste

However, their segregation practices show a contradictory output (Figure 5-9). This is illustrated in the 13% of responses suggesting that they segregate their wastes very well, compared to the 25% suggesting that they do it fairly well and average (59%).

The result suggests that while the majority of the residents practice household separation, a significant number of respondents say that they do not separate (7%) while others do not know (1%).

The respondents suggested that Seoul Council spends less than 30,000 Won or approximately U$26 per person in the disposal of their wastes every year. This is shown in the 68% of the respondents agreeing to the amount used. A further, 27% suggested that the amount is somewhere between 30,000—50,000 Won or U$ 26-43.

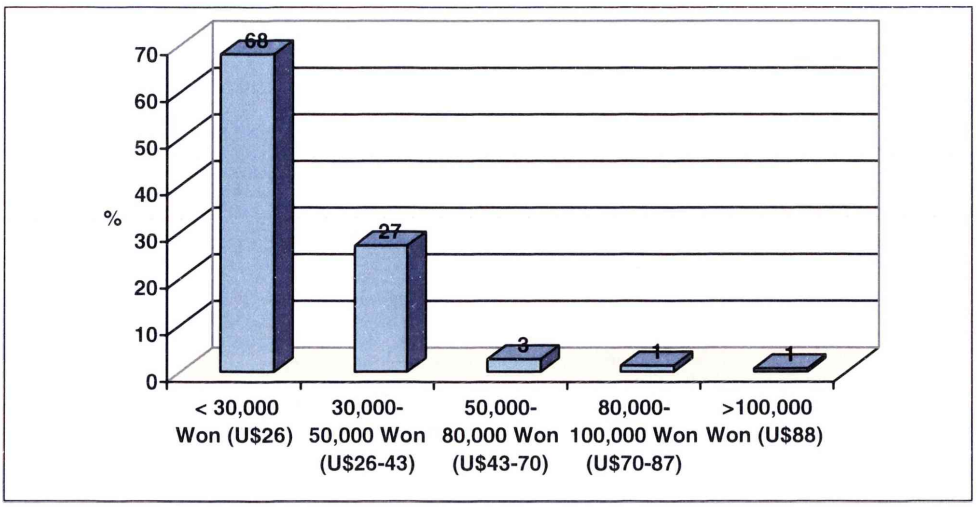


Figure 5-10 Respondents' Perceived Cost of Waste Council Services

On the other hand, only 3% responded that the council spends more than 50,000 won (U$43) on their wastes. The result suggests that the respondents considered that the council does not really spend that much for their household waste. This could suggest that because the respondents perceived the financial spending of the council on their household to be low, they contributed less in terms of separation and proper waste disposal, even though they suggested that waste management in the household is important.

Seoul residents showed a negative level of satisfaction with the services provided by their council's current household waste collection services (Figure 5-11). This is shown in the 45% of the respondents asserting that they are unsatisfied with Seoul's waste management services. Moreover, this figure is compounded by the 21% of the respondents who asserted that the council's services are very unsatisfactory.

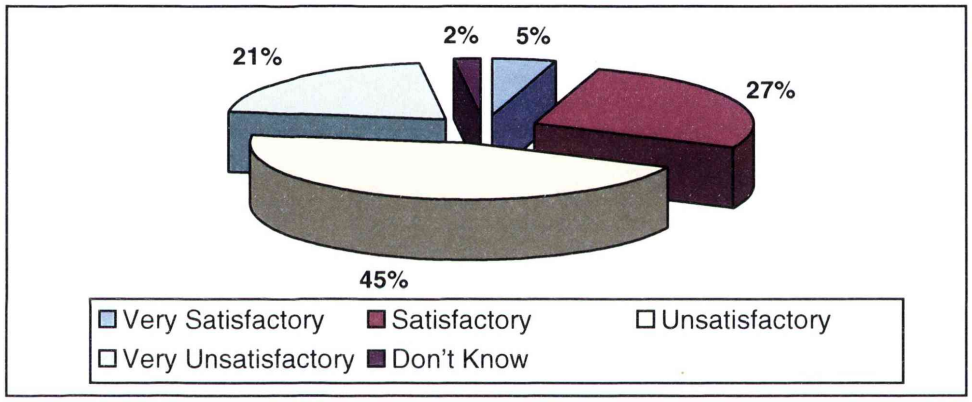


Figure 5-11 Level of Satisfaction with the Council's Waste Services

The result suggests that predominantly, the residents expect more from the Seoul Council. This also suggests that a revision and another model for waste management should be implemented in Seoul because of the level of unsatisfaction showed by the residents. The number of satisfied respondents can back up this argument. Only 5% suggested that they are very satisfied while 27% are satisfied. Comparing the two, it is evident that there are more unsatisfied residents than satisfied ones.

The result of the section suggests three patterns in the household practices of the residents in relation to Seoul Council's waste management services. First, the Seoul residents perceive household management to be important in order to reduce waste and contribute to their council. However, in practice the residents do not necessarily take action. This was shown by the lack of proper segregation practices of the respondents. Second, the residents considered that the financial expenditure for one household was cheaper than it

actually is. This may be a factor in the perception of the residents regarding their level of satisfaction. Finally, the residents are unsatisfied with Seoul Council's waste management services. This may suggest that improvements should be made in order to meet the expectations of the residents.

Table 5-9 Current Household Management Practices of the Respondents

Current Household Waste Management Practices of the Respondents	Frequency	Percentage
Recycling more	123	54%
Composting	10	4%
Refuse plastics bags at the shop	15	7%
Select products with less packaging	26	11%
Buy products with recycled content	12	5%
Reduce the use of disposable products	15	7%
Buy products in bulk	7	3%
Nothing in particular	8	3%
Don't know	11	5%

The majority of the Seoul respondents (54%) managed household wastes by recycling them (Table 5-9). Such a practice is worthwhile and at the same time environmentally friendly. A small proportion of them (11%) opted to select products with less packaging. This way they are assured of a lower amount of household waste. About 7% of respondents, when shopping, rejected using plastic bags. They instead demanded that shopping stores use paper bags for their purchased items. The same proportion of the respondents (7%) is employing some other way to lessen excessive reliance on disposable products. Approximately 4.4% of the respondents were proud to claim that they preserved household waste as fertilisers. While 5% admitted that they were careful to purchase products with recycled content, about 3% disclosed that they usually buy products in bulk. Nonetheless, nineteen residents of the Seoul respondents remained clueless about the process by which their household wastes were being managed.

Table 5-10 Reluctant to Commit to Household Waste Collection Service

Reasons for the reluctance to fully commit to household waste collection services	Frequency	Percentage
Too much effort	28	16%
Bag (for Volume-Based Waste Charge System) is not affordable	41	24%
Bag (for Volume-Based Waste Charge System) is not strong enough	33	19%
Problems with collectors (too noisy, messy, etc.)	17	10%
Bag (for Volume-Based Waste Charge System) is too heavy, bulky, awkward	30	17%
Can't put food waste in bag (for Volume-Based Waste Charge System)	21	12%
Other	2	1%

Table 5-10 shows the different reasons that hinder the Seoul respondents from fully committing themselves to the household waste collection services. The results of the study reveal that respondents are reluctant to completely involve themselves with household waste collection serviced because of: (1) expensive cost of bags (24%); (2) poor quality of bags (19%); (3) bulkiness/heaviness/awkwardness of bags (17%); (4) requires too much effort from them (16%); (5) inability of respondents to gather their food waste in the allocated bags (12%); (6) problems with the waste collector (10%), and (7) other reasons that respondents did not specify (1%).

Table 5-11 Suggestions as to How the Household Waste Management could be more effectively improved

Suggestions to Make Household Waste Management More Efficient	Frequency	Percentage
More affordable price of	49	25%

bag (for Volume-Based Waste Charge System)		
Stronger bag/ease of use (for Volume-Based Waste Charge System)	53	27%
Less noisy/smelly when collection is taking place	38	19%
Different scheme collection	25	13%
More friendly collectors	28	14%
Other	1	1%
Don't Know	1	1%

The quality of the bags was revealed as the primary consideration among Seoul respondents in relation to household waste management (Table 5-11). For 27% of them, household waste management could be further improved through the provision of stronger bags, which would in turn make the collection of food waste more convenient for both the collectors and residents. About 25% of the study's Seoul participants are more concerned about the quantity of the bags needed in collecting their waste. According to them, they are more likely to participate in household waste collection services provided that the bags they will be using are of affordable prices. These results seem to suggest that Seoul respondents put more emphasis on the quality than the quantity. Nonetheless, no conclusive data will support any claim that Seoul respondents are likely to participate if the bags are stronger but of higher cost than vice versa. On the other hand, a considerable proportion of respondents (19%) from Seoul place a high value on the behaviour of waste collectors. They indicated that they prefer collectors who are disciplined in conducting the collection. They despise collectors who perform their tasks in an undisciplined manner. Meanwhile, about 14% of Seoul respondents considered that the friendliness of the collectors would also help in encouraging the participation of many in household waste management. Others (13%) recommended that the conducting of various household waste management schemes should invite general cooperation from Seoul residents.

5-1-4 Recycling Collection

Given specific non-biodegradable items, respondents were also asked to identify which

item/s were not included in their recycling collection. Almost 24% of the respondents identified aluminium cans; 21%, however, did not segregate used newspapers. Nearly 21% of all Seoul participants did not recycle milk/juice cartons while 16% of them did not find any other uses for glass. A small proportion of the respondents (6%) of them did not set apart cardboard from other paper items for recycling processes. Plastic bottles were considered useless by a further 10% of the respondents after consumption of their contents (Table 5-12).

Table 5-12 Items that the Respondents Do Not Separate for Recycling Collection

Items that the respondents do not separate for recycling collection	Frequency	Percentage
Glass	67	16%
Newspaper	88	21%
Cardboard from other papers	26	6%
Plastic bottles	41	10%
Aluminium cans	98	24%
Steel cans	4	1%
Milk/Juice cartons	84	20%
Other	1	1%
None of them	2	1%

Nonetheless, steel cans, for the majority of Seoul respondents, are of utmost relevance in the conduct of their recycling processes, as indicated by a small proportion (1%) who stated that they did not include the item in such a process. The results also suggests that the majority of them use most of the items listed in Table 5-12 for recycling purposes, as implied by 1% of respondents who segregated none of them from the items included in their recycling purposes.

Table 5-13 Frequency of Respondents' Usage of the Recycling Services

Frequency of Respondents' Usage of the Recycling Services	Frequency	Percentage
Always	25	17%

Most of the time	63	42%
Some of the time	58	39%
Hardly ever	0	0
Not at all	2	1%
Don't know	2	1%

About 42% of the Seoul respondents disclosed that they use recycling services most of the time (Table 5-13). Meanwhile, nearly 39% of them avail themselves of the services on a regular basis, claiming that some of the time they do employ the recycling process. Only 17% of the respondents use the recycling services constantly. Nonetheless, the results suggest that the majority of the respondents exploit the recycling process, as denoted by the small portion of the respondents (1%) who disclosed that they do not avail themselves of any of the recycling services offered to them.

Table 5-14 Attitudes Towards Recycling

Attitudes Towards Recycling	Frequency	Percentage
The more the better	87	58%
A lot, but not everything that can be recycled	45	30%
Do not recycle much	16	10%
Do not recycle at all	2	1%

Table 5-14 shows that the majority of the respondents (58%) perceived that the more items that can be recycled the better for the environment and for people as well. This suggests that they are becoming more liberal about the benefits of recycling non-biodegradable items. In addition, this also means a more favourable stance towards recycling services. On the other hand, 30% of the respondents revealed the same sentiments about recycling, but they expressed some reservations, claiming that not all items could be reprocessed for other uses. A small but still significant proportion insisted that recycling is a worthwhile process but it has to be done within certain limitations. They seemed to cling to some notions that everything done in excess is harmful. Only 1% of the respondents expressed pessimistic views about recycling and its potential benefits to their lives, arguing that they do not need the process at all.

Respondents were also asked to identify the reasons why they were hesitant to thoroughly participate in recycling processes. The results are presented in Table 5-15. Based on the results, respondents were less likely to commit with recycling for the following reasons: (1) too much hassle (31%); (2) no time for recycling (25%); (3) shortage of space (14%); (4) they just forgot about it (7%); (5) unsure of what to recycle (5%); (6) not worth their time and effort. Meanwhile, a significant portion of the respondents (17%) claimed that it was not applicable to them because they were very likely to fully participate. This group of respondents and those who responded that they tended to forget about it seemed to perceive recycling as an irrelevant process, which would not yield any outcome of consequence to their lives. Nonetheless, the finding that a significant proportion of respondents viewed the recycling process rather as a very rigorous process is relevant, in that it suggests that the way to elicit considerable support from them is to devise ways to minimise the complexity of the process.

Table 5-15 Reasons Why Respondents Are Less Committed to Recycling

Reasons why respondents are less committed to recycling	Frequency	Percentage
Too much hassle	46	31%
Shortage of space	21	14%
No time for it	38	25%
Forget to do it	10	7%
Not worth it	1	1%
Unsure of what to recycle	8	5%
Other	0	0
Not applicable	26	17%

The succeeding table (Table 5-16) shows the level of the respondents' perceived willingness to conduct recycling activities in the future. More than half of them (58%) of them considered that in the near future authorities could be confident that they would undertake recycling activities. However, about 36% of them were still sceptical about the whole issue; they expressed their willingness to think about it thoroughly, instead. A small proportion (5%) nonetheless remains significant as those who do not care, much less showing any willingness to participate in recycling activities in the future.

Table 5-16 Willingness to Increase Recycling Efforts

Willingness to participate in the recycling activities in the future	Frequency	Percentage
Certainly	87	58%
Think about it	54	36%
Do not care	8	5%
Other	1	1%

Table 5-17 Items that respondents think they could have recycled but have thrown away

Items that respondents think they could have recycled but have thrown away	Frequency	Percentage
Glass bottles	44	19%
Plastic bottles	21	9%
Aluminium cans	68	29%
Newspaper	36	16%
Milk/juice cartons	32	14%
None of them	27	12%
Do not know	3	1%

The items that Seoul respondents have cited when they were asked about the things they could have recycled but had thrown away are listed in Table 5-17. Of all the given items, aluminium cans were the most frequently cited item; about 29% of respondents expressed regret about throwing them away. Although they did not specify any reason why they felt like this, it is evident that to some extent they valued whatever could be generated from them when recycled. Fourteen per cent of respondents expressed regret that they did not reuse those milk and juice cartons that they tossed aside. Other items they regretted throwing aside included glass bottles (19%), newspapers (16%) and plastic bottles (9%). A small proportion, but still of considerable value, were the respondents (12%) who regretted throwing away none of the items. They have been proud to claim that they did not throw anything away unless it virtually cannot be reused.

Table 5-18 Respondents' Satisfaction with the Recycling Services

Level of Respondents' Satisfaction with the Recycling Services	Frequency	Percentage
Very satisfied	16	11%
Fairly satisfied	91	61%
Fairly dissatisfied	36	24%
Very dissatisfied	6	4%
Do not know	1	0.7%

While there is a sizeable portion of the respondents (4%) who are very dissatisfied with the existing recycling services in their area, generally the majority of the respondents (61%) were fairly content with the current recycling service that was being offered to them (Table 5-18). However, those residents who were fairly dissatisfied with the recycling services represented also a considerable proportion. The remaining 1% expressed their ignorance as to whether they were satisfied or not about the current system.

Table 5-19 Improving Recycling Arrangements

Perceived Features That Could Enhance the Recycling Service Arrangements in the Future	Frequency	Percentage
More frequent service	123	57%
More reliable service	10	5%
Simpler/ease of use	15	7%
Less fussy about what can be collected	26	12%
Quieter/ less messy operation	12	6%
Need a container dedicated to recycling	15	7%
None of them	7	3%
Do not know	8	4%

The respondents were asked to indicate their suggestions in order to improve the recycling service arrangements for the council's services (Table 5-19). An overwhelming number of one hundred and twenty-three of the respondents indicated that the recycling service of the council would be better if they offered more reliable services. This indicates that the residents found several improvements that need to be made to the council's service. Other reasons cited include simpler features/ease of use.

When the respondents were asked about the responsible person in terms of segregating the wastes that can be used for recycling, the respondents suggested that it is most often the mother or the female of the house who takes care of those things. This is shown by an overwhelming number of the respondents who asserted that; they comprise 89% of the total respondents (Table 5-20). Aside from the mothers, a small number of fathers or male persons in the family were responsible for the recycling. This is evidenced in the 8% shown in the survey. Moreover, only a few teenage children took care of this process, as shown by the 1% who suggested that it was their teenage child who did this. Finally, a small number of 1% and 1% answered that no one attended to it and some didn't know about the issue.

Table 5-20 Person in the Household Responsible for Recycling

Person in the Household Responsible for Recycling	Frequency	Percentage
Male/Father/Husband	12	8%
Female/Mother/Wife	133	89%
Teenage Child	2	1%
Others	0	0
No One	1	1%
Don't Know	2	1%

The result suggests that, in more traditional family set-ups, women in Seoul continue to be the people responsible for the recycling of wastes. The small participation of males and the teenage children in recycling would be a setback for the waste services council of Seoul. Family participation in recycling efforts would be more ideal in order to create a culture of recycling within the family instead of relying mostly on the females in the household.

Several factors had been influential in the recycling efforts of the residents of Seoul, the foremost of which is that it served as an example for the children, especially in their moral education on responsibility for the environment. This suggests that mothers in Seoul recognise the implications of their household waste practices for the future household waste practices of their children. In addition, the respondents also suggested that preserving the environment and conservation of natural resources was also a potent factor in their decision to recycle.

The respondents also indicated that one of the reasons for their efforts to recycle is that they were personally enthusiastic to do so. This is followed by the perception of the respondents that it is economical. Moreover, it is also considered as a social responsibility, as shown in their claim that it is a community spirit activity. Concurrently, the respondents also considered the space for landfill. The consideration for the limited space shows that the respondents were also aware of the limitations of the waste facilities of Seoul. All these response are listed in Table 5-21.

Table 5-21 Factors that influence the respondents to recycle

Factors that influence the respondents to recycle	Frequency	Percentage
Preservation of the environment and the conservation of natural resources	48	21%
Limited space for landfill	26	11%
Moral (for children/future generations)	63	27%
Economically sensible to recycle	30	13%
Social (community spirit)	26	11%
Not enough room in the garbage bin	1	1%
Enthusiastic about recycling	33	14%
Other	1	1%
Don't know	4	1.7%

The result suggests that the motivation for the respondents to recycle varied greatly. However, the assertion that it is the implications of their recycling practices for their children's future that affects them the most shows a progressive view of recycling.

As mentioned in the shopping practices of the respondents, they indicated that they preferred to contribute to the waste management of the council through giving shopping tips for environmental conservation. Thus, when asked about their preference for recycled or non-recycled products, the respondents showed that they preferred the recycled products for the reasons given in Table 5-22, predominantly the respondents asserted that recycled products are less expensive than non-recycled products. Thus, aside from being economical, they were also considered as being better for the environment. This perception shows that the respondents considered the environment in their product choices. However, some respondents suggested that there was no difference between recycled and non-recycled products whereas 20 respondents (11%) showed that they were likely to buy recycled ones.

The respondents seemed to be doubtful in terms of the quality of the recycled products as shown by only three respondents (2%) agreeing with the statement.

Table 5-22 Feelings about recycled as compared to non-recycled products

Feeling about recycled as compared to non-recycled products	Frequency	Percentage
Better quality	3	2%
Less expensive	78	43%
Not much different	27	15%
Better for the environment	54	30%
Likely to buy	20	11%

5-1-5 Views about Other Systems

Waste management providers in Seoul try to tailor their services to ensure timely and effective responses to customer needs. They are strongly committed to the safe and responsible management of waste, working diligently to ensure regulatory compliance and protection of the public's health and natural resources. Thus, looking for waste management alternatives is one of the ways that will improve the services of the Seoul Council.

Aside from the recycling services in Seoul, other recycling methods were also considered as alternatives to the waste management services in Seoul. This section presents the views of the Seoul residents in relation to the effectiveness and their level of satisfaction with other alternatives to recycling and waste reduction.

The respondents were asked about their level of satisfaction on the Volume-based Waste Charge System. The respondents asserted that this method can contribute significantly to the council's waste management. This is also shown in the respondents' level of satisfaction. The result suggested that they were predominantly satisfied with the system, as 52% replied that they were satisfied and 11% suggested that they are very satisfied (Figure 5-12). However, a significant number were not satisfied with the system as exemplified in the 24% of respondents who were dissatisfied and 12% who were very unsatisfied.

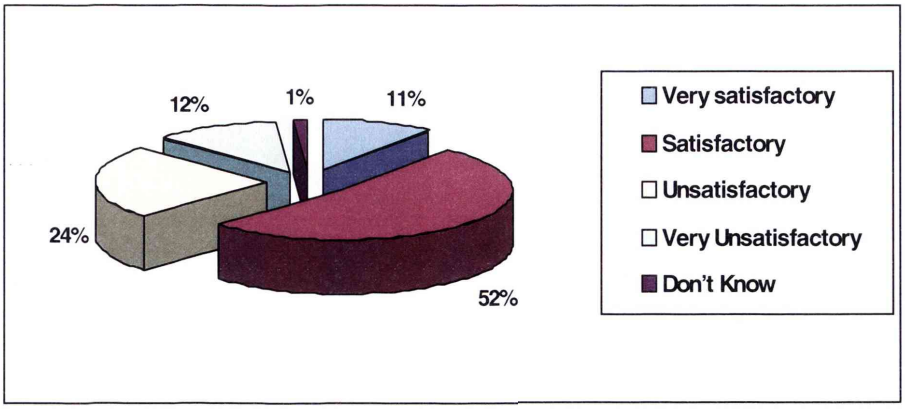


Figure 5-12 Respondents' Satisfaction with the Volume-Based Waste Charge System

The result may suggest two implications, first, that some residents are satisfied and others are not because of the effectiveness of the implementation process of the system. Second, it can be that there had been no standardised operating system in the volume-based waste charge system. Thus, a review of the framework of the system should be made and a standardised implementation process be enforced in order to attain a more uniform level of satisfaction with and effectiveness of the system.

As shown in the collection, disposal and recycling of household management, the respondents had shown rather dispersed answers. Thus, the effort to consider all of the alternatives to improve the council's waste management has been evaluated. The respondents were requested to select from several alternatives such as: (1) introduction of community organic composting facilities in their area; (2) more frequent workshops/public events about recycling, composting, etc. (3) practical guidance on environmentally friendly ways of shopping; (4) easy access to information on household waste management through media; and (5) adopting heavy enforcements.

Table 5-23 Activities that would be prepared in the respondents' area

Activities that would be presented in the respondents' area	Frequency	Percentage
Introduction of community organic composting facilities in my area	36	16%
More frequent workshops/public events about recycling, composting etc.	82	36%
Practical guidance on environmentally friendly ways of shopping	46	20%
Easy access to information on household waste management through media	40	18%
Adopting heavy enforcements	25	11%

Among the five suggested alternatives to Seoul Council's waste management services, the respondents suggested that practical guidance on environmentally friendly ways of shopping be implemented in Seoul. This assertion came from the lifestyle that Seoul residents had adopted and the result of the earlier questions suggesting that Seoul residents, while they believe that the environment is important, they do not necessarily want to practise ways to help with waste management. Thus, one of the more convenient ways to help would be their shopping, where they are not obliged to do practical work.

Second, the preference of the Seoul residents for using the media, as illustrated in the earlier part of the survey, is shown again in their preference for easier access to information on household waste management through media. This suggests that respondents consider that the media will be a big factor in improving their household waste management.

Third, the respondents suggested that the establishment of community organic composting facilities in their area would be helpful with their household waste management. This would suggest that the council would have to designate an area for composting in several locations in Seoul. Fourth on the list was the request of the respondents for more frequent workshops and public events relating to recycling, composting and other household waste management practices. Eighteen per cent of respondents agreed that this kind of practice should be implemented in their area. Finally, the respondents ranked the adoption of heavy enforcements to be the last priority on the list of alternatives for household waste management.

The result suggests that again, Seoul residents prefer alternatives where they are given the responsibility. For instance, in their preference for shopping and access to media, the respondents ranked these two alternatives as their preferred choice.

Industries, in order to contribute to the global, national and local environmentally friendly programs, had used paper bags instead of plastic bags in groceries, supermarkets and shops. The Seoul residents were asked about their opinion of the importance of discontinuation of free plastic bags from shops. The response of the respondents showed that they highly favour this move. This is shown by the 46% who suggested that this is a very good move, while 35% considered it as a good move (Figure 5-13). Only 15% responded that it is inconvenient, whereas 4% replied that they do not care.

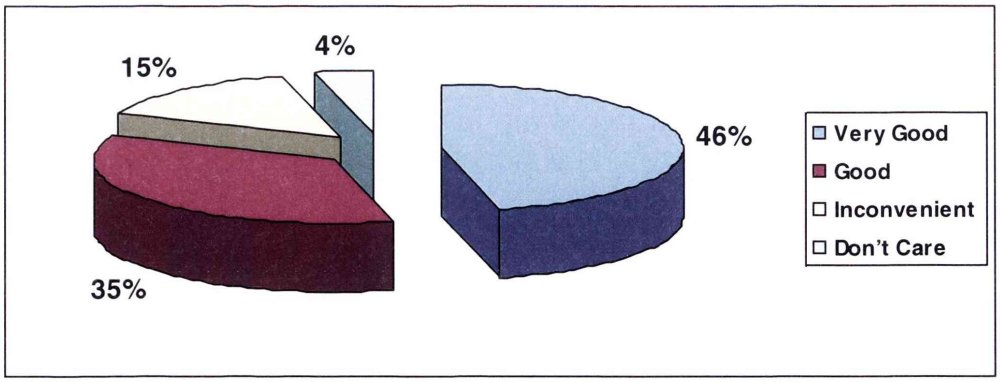


Figure 5-13 Discontinuation of free plastic bag use in shops

The result suggests that the Seoul residents in general favour the discontinuation of plastic bags in shops and instead look for viable alternatives such as paper bags. This practice can already be seen in some shops in Seoul. Most developing countries have resorted to paper bags in order to contribute to environmental protection.

Monetary rewards in order to use biodegradable and recyclable materials have been used by some countries such as the US and the UK in order to encourage consumers to use them instead of glasses, plastics and materials that do not easily decompose. This move can also be implemented in Seoul if the residents consent to this kind of plan. However, the result of the survey showed that 33.33% of the 150 respondents actually abstained from the question while only 15.33% replied with a "very likely" response, and 25.33% said it is fairly likely that they will do it.

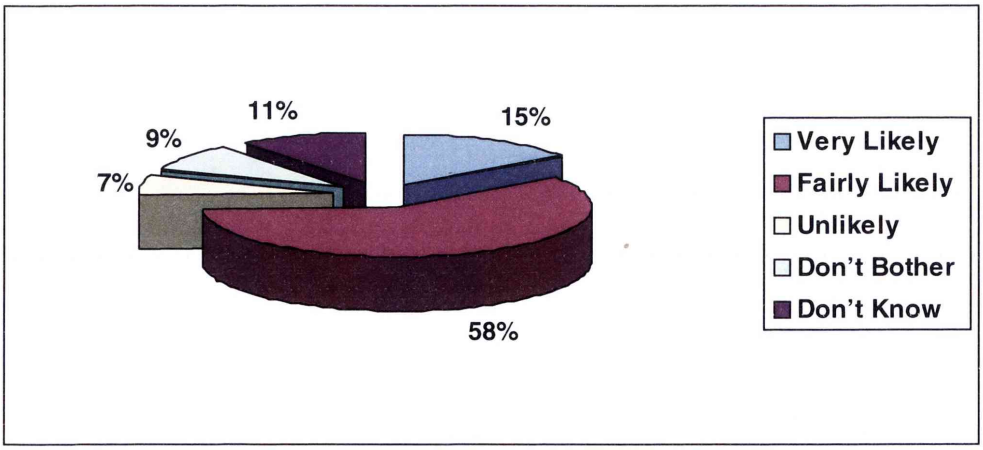


Figure 5-14 Monetary reward for returning aluminium cans/containers/milk/juice cartons

In addition, about 7% suggested that it would be unlikely and some said they would not bother. A further 11% said they did not know. The result suggests that the respondents seemed not to support the move towards the use of a monetary reward for the return of aluminium cans, containers, milk and juice cartons. While it is considered that the move seems to be a good initiative since it rewards the use of recyclable and biodegradable materials, it seems that the residents of Seoul do not necessarily support the move.

The respondents preferred that the calculation for the household payment system be made based on the volume of wastes that they have disposed of and on the materials that they used. This is evidenced by the 70% of the respondents who suggested the use of this method in collecting payments per household (Table 5-24). This is in contrast to the use of a uniform payment mode for all households, which garnered a 13% agreement. A small number, 1%, replied that other methods should be used while 15% said they did not know.

Table 5-24 Preference for Household Payment for Waste Collection Services

Preference for household payment for waste collection services	Frequency	Percentage
All household pay the same	20	13%
Use smaller bin, pay less/recycle more, pay less	105	70%
Other	2	1%
Don't know	23	15%

The result indicates a preference for the quantity-based payment. This also suggests that the respondents placed a great amount of responsibility on every household to manage its wastes.

5-1-6 Food Waste

Food wastes comprise the majority of the household wastes in Seoul. Moreover, this is a type of waste that requires time to segregate at the city level. Thus, a segregation system made within every household would be very helpful for the council's waste management. The respondents were asked about where they put their food/organic wastes; the majority responded that they put it in the normal waste bag. They comprise 47% of the total respondents (Table 5-25).

Table 5-25 Managing Food/Organic Waste Generated at Home

Managing food/organic waste generated at home	Frequency	Percentage
Separate with normal waste	46	31%
Put in normal waste bag	71	47%
Feed pets	10	7%
Don't care	21	14%
Other	2	1%

This implies that 47% did not segregate their wastes and only 31% do separate them. Some of the respondents used their organic wastes to feed their pets, as shown by 7% of the respondents who asserted this. A significant number, 14%, responded that they did not care.

The question inquiring about the reasons for not separating food and organic wastes in households indicated that the respondents did not have the time to separate their wastes. Sixty-nine of the respondents indicated such a reason (Table 5-26).

Table 5-26 Reasons for Not Separating Food/Organic Waste from Normal Household Waste

Reasons for not separating food/organic waste from normal household waste	Frequency	Percentage
No time for it	69	33%
No food scraps/organic waste	18	9%
Smelly-attract flies/vermin	35	17%
Scraps are fed to pets	11	5%
No information available	26	13%
Don't bother	37	18%
Other	2	1%
Don't know	10	5%

The second most-cited reason was that the respondents did not bother with segregation any more while others cited the smelly wastes, which attracted flies and vermin. The respondents also cited the lack of information available on how to segregate their organic wastes. Still, eighteen of the respondents stated that they did not have food scraps or organic wastes. Eleven of the respondents stated that they fed their pets with

scrap foods so they did not have organic wastes. Finally, a small number stated that they were unaware of what their households did with their wastes.

Finally, the respondents outlined the advantages and the disadvantages of the food and organic collections in relation to their household waste practices (Table 5-22). The respondents suggested that the primary advantages of this practice included: (1) good use of waste; (2) less waste for landfill; and (3) useful profitable product. The reason that food/organic collection would be a good use of waste was the primary advantage cited by the respondents, followed by less waste to landfill and the reason that it is useful for profitable products.

Table 5-27 Advantages of Food Collection

Advantages of Food Collection	Frequency
Useful profitable product	21
Good use of waste	88
Less waste to landfill	37

However, there are also setbacks for the use of food collection, which include smell, space, vermin concerns, effort and time and no incentives (Table 5-28). The respondents considered vermin concerns as the primary disadvantage of segregating organic and food wastes, as shown by forty-five of the respondents. This is followed by the amount of time and effort in doing such work; thirty-nine of the respondents cited this reason. Thirty-six cited the smell of the wastes as a disadvantage of the practice. Twenty-one cited the problem of space for the waste bags, while twenty said that the lack of incentive to carry out segregation was a disadvantage.

Table 5-28 Disadvantages of Food Collection

Disadvantages of Food Collection	Frequency
Smell	36
Takes up spaces	21
Vermin concerns	45
Too much effort/time	39
No incentives	20

The result indicates that there are always advantages and disadvantages to the segregation of food wastes. Designing a program that can make the disadvantages into advantages may resolve this problem for food segregation.

5-2 Analysis

The result showed that predominantly, the residents of Seoul regard the environment as something that they should take care of. This is shown by their perception that people in Seoul should participate in the environmental drive of the household waste service. Moreover, they showed a high degree of knowledge about household waste management and their interest in acquiring more knowledge to manage their household waste is evident in their responses. However, their concern for the environment and their knowledge of household management was not translated into action. In fact, when asked if they segregated wastes, the respondents suggested that barely one third of them do so. This is because of the inconveniences brought about by segregation.

The respondents also asserted that they were dissatisfied with the services of the local council in relation to waste management practices. In addition, the residents thought that the cost of taking care of household waste per year was cheaper than it actually was.

Recycling was one of the primary options in which the respondents showed interest. The residents complained, though, that the current recycling practices of Seoul did not meet their expectations. Thus, the respondents suggested alternative recycling techniques. The predominant reason why the respondents tended to avoid recycling is that it was perceived to take considerable time; thus it was considered as a hassle to their daily routine.

The result of the case study on Seoul showed that the residents are knowledgeable about environmental concerns and that they have a high level of knowledge about household waste management and recycling. However, the results also indicated that while they have a high level of theoretical knowledge, they did not practise proper segregation of wastes and recyclable materials.

5-3 Statistical Analysis

Likewise, statistical analysis for data collected in Seoul was also performed by means of SPSS after the data were gathered and tabulated. Similarly, before conducting the reliability analysis, the data were screened in respect of the issues of normality,

multicollinearity and singularity. Again, this was performed specifically on the gender of the respondents, to establish the reliability of the study's results.

5-3-1 Normality

In order to assess the assumption of normality descriptive statistics table and graphs were generated. The descriptive statistics table provides summary statistics for continuous, numeric variables. Summary statistics include measures of central tendency, such as the mean, and measures of distribution, such as skewness and kurtosis, which indicate how much a distribution varies from a normal distribution. Since many statistical tests assume that data are normally distributed, it is useful to check the distribution of data.

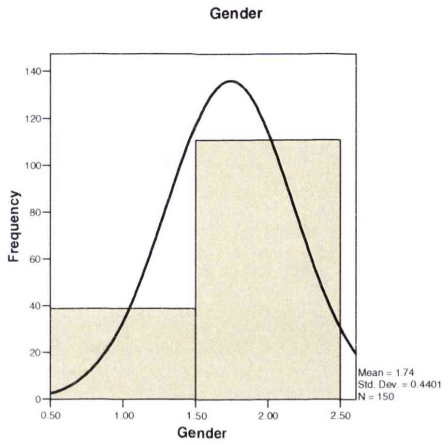
As stated earlier, variables are considered to exhibit significant skewness and/or kurtosis if the standardised scores associated with these indicators are outside the range of +/-3.3 (p <.01). Applying this, as shown in the descriptive statistics table, none of the variables demonstrated significant skewness, or a significantly deviant kurtosis. Therefore, the assumption of normality was met statistically. This indicates that the data gathered were normally distributed, thus the findings of this study are valid.

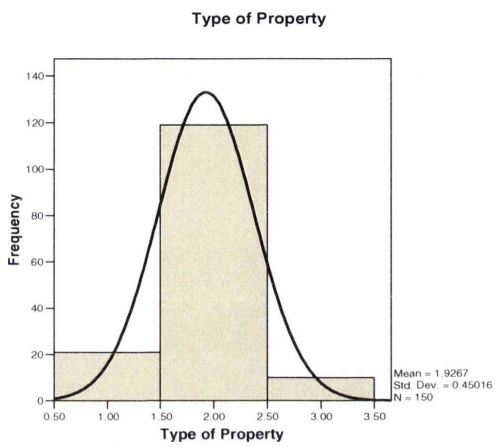
Table 5-29 Descriptive Statistics

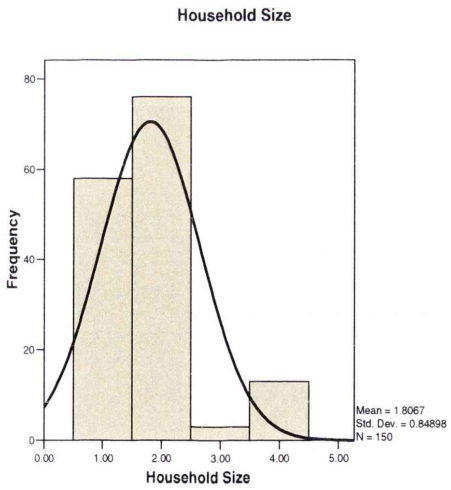
	N	Skewness	Kurtosis
	Statistic	Statistic	Statistic
Gender	150	-1.105	-0.789
Type of Property	150	-0.321	1.832
Household Size	150	1.249	1.399
Household Description	150	0.265	0.279
Employment Status	150	0.2	-1.607
Educational Attainment	150	0.409	-0.802
Valid N (listwise)	150		

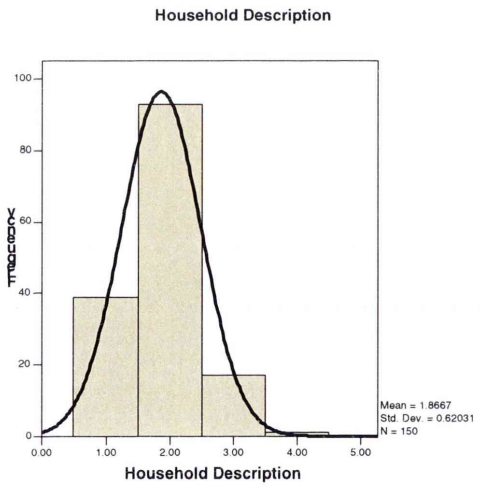
Within concurrence with calculated Z-scores obtained from the descriptive statistics table, the following frequency histograms with normal curve overlay were used to visually

assess the normality of the score distributions for each variable. It was shown that the type of property and household description clearly experienced normally distributed data. The gender of the respondents, on the other hand, demonstrated a slightly positive skewness. Furthermore, household size and educational attainment have shown slightly negative skewness. Interestingly, employment status shows that the data gathered is ill defined to those respondents; since everyone has a different employment status, there are many different measurements, with none standing out.









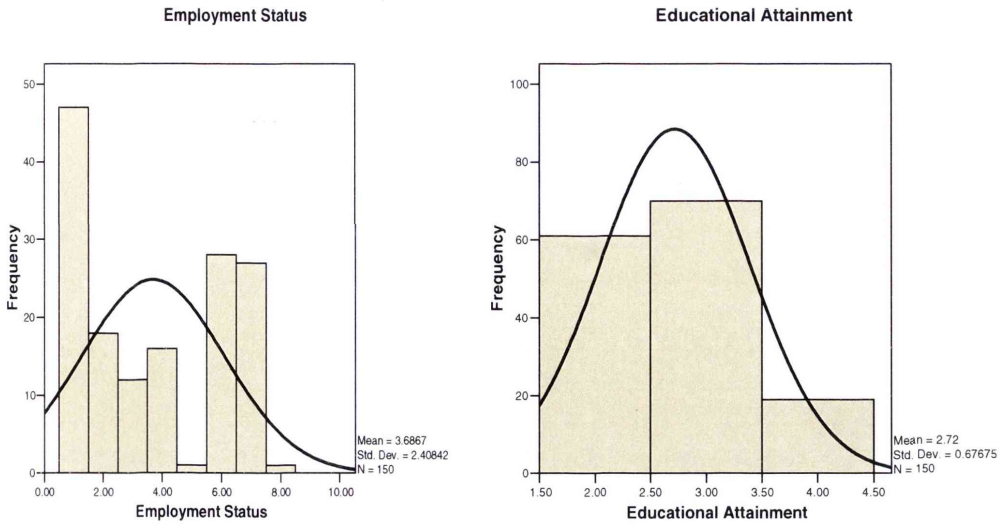


Figure 5-15 Multicollinearity and Singularity

Multicollinearity and singularity were again tested. Multicollinearity is present if bivariate correlations exceed .90, and singularity is present if any variables in the analysis are perfectly linearly related (i.e., $r = 1$). In addition, multicollinearity among pairs of variables was firstly examined via bivariate correlations, as shown in the correlation table (Table 5-30). Summarising the correlation matrix, a weak positive correlation is evident between the variables *household size* and *educational attainment*, $r = 0.263$, significant at the alpha level of .01. Although the correlation is weak, it would be expected that a higher level of education tends to lead to an "increase" in the type of property, in terms of its size/value/status. This means that there is a weak variation in the type of property when there is a change in the educational attainment of the respondents.

Table 5-30 Correlations

Correlations

		Gender	Type of Property	Household Size	Household Decsription	Employment Status	Educational Attainment
Gender	Pearson Correla	1	-.029	-.207*	-.079	-.141	.069
	Sig. (2-tailed)	.	.723	.011	.339	.086	.399
	N	150	150	150	150	150	150
Type of Property	Pearson Correla	-.029	1	.015	.085	-.096	.263**
	Sig. (2-tailed)	.723	.	.852	.301	.244	.001
	N	150	150	150	150	150	150
Household Size	Pearson Correla	-.207*	.015	1	.206*	-.141	.267**
	Sig. (2-tailed)	.011	.852	.	.012	.084	.001
	N	150	150	150	150	150	150
Household Decsri	Pearson Correla	-.079	.085	.206*	1	.084	.246**
	Sig. (2-tailed)	.339	.301	.012	.	.306	.002
	N	150	150	150	150	150	150
Employment Statu	Pearson Correla	-.141	-.096	-.141	.084	1	-.190*
	Sig. (2-tailed)	.086	.244	.084	.306	.	.020
	N	150	150	150	150	150	150
Educational Attain	Pearson Correla	.069	.263**	.267**	.246**	-.190*	1
	Sig. (2-tailed)	.399	.001	.001	.002	.020	.
	N	150	150	150	150	150	150

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Nevertheless, no variables were revealed to have a bivariate correlation greater than 0.90. However, the variables have not shown multicollinearity and so there is no problem with regard to the data collected. This implies that the data gathered were quite reliable in terms of the gender, type of property, household size, household description, employment status, and educational attainment.

5-3-2 Reliability Analysis

It is now time to proceed with the reliability analysis after performing several analyses on the questionnaire. Previously, it was stated that there are several ways of doing this, such as the split half method, which randomly splits the data set into two. Likewise, a score for each subject is then calculated based on each half of the scale. If a scale is very reliable it would be expected that a score would be the same on one half of the scale as the other, and

so the two halves should correlate perfectly, wherein the correlation between the two halves is the statistic computed in the split half method, large correlations being a sign of reliability. Then again, the problem with this method is that there are a number of ways in which a set of data can be split into two and so the results might be a result of the way in which the data were split. Therefore, to overcome this problem, the data can be split in two in every conceivable way and the correlation coefficient be computed for each split. The average of these values is known as Cronbach's alpha, which is the most common measure of scale reliability. Consequently, a value of 0.8 is seen as an acceptable value for Cronbach's alpha; values substantially lower indicate an unreliable scale.As with the data analysed from the Sydney questionnaire, it also follows that depending on what options were selected we could get a very large output. The most important things to examine are:

• *Corrected Item-Total Correlation*: In this regard, the aim is to identify items that do not correlate with the overall score from the scale. If any of these values are less than between 0.28 (this depends slightly on the sample size—with bigger samples smaller correlation coefficients are acceptable) then there is a problem because it means that a particular item does not correlate very well with the scale overall, that item may have to be dropped. Based on the collated data, the variable household description shows relatively low correlations with the scale as a whole. Therefore, the household description does not correlate with scale and hence there are problems with reliability as far as the household description is concerned. This means that the household description may be dropped, in order to increase the reliability of the data gathered.

Table 5-31 Item—Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Gender	12.0	7.4	-0.195	-0.195
Type of Property	11.8	6.9	0	-0.122
Household Size	11.9	6.6	-0.045	-0.09
Household Description	11.9	6.0	0.223	-0.28
Employment Status	10.1	2.7	-0.182	0.356
Educational Attainment	10.0	6.5	0.028	-0.147

• *Alpha If Item Is Deleted*: this reflects the change in Cronbach's alpha that would be seen if a particular item were deleted. The overall alpha is -0.114 and in this case the aim is to identify values of alpha *greater* than the overall alpha. If the deletion of an item *increases* Cronbach's alpha then this means that the deletion of that item improves reliability. Therefore, any items that result in substantially greater values of alpha than the overall alpha may need to be deleted from the scale to improve its reliability. As can be seen, none of the items here would substantially affect reliability if they were deleted. The worst offender is the *employment status*; deleting this question would increase the alpha. Nevertheless, this increase is not dramatic and both values reflect a reasonable degree of reliability.

• *Cronbach's Alpha*: LikewiseValues in the magnitude of 0.8 (or thereabouts) are being sought and identified. In this case the alpha is below 0.8; this indicates that most of the variables are unreliable, as they were included in the questionnaires. This also implies that the selected variables included in the study may also be dropped in order to gain reliability for the findings of the study.

Table 5-32 Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
-0.114	0.126	6

5-3-3 Multiple Regressions

Moreover, a multiple regression analysis will be used in determining the level of significance of the relationships between respondents' attitudes towards waste disposal and their satisfaction with Seoul's waste management programs. The data gathered by the researcher were processed through SPSS in order to perform the specific statistical analysis.

The table 5-33, Model Summary, displays R, R squared, adjusted R squared, and the standard error. R is the correlation between the observed and predicted values of the dependent variable. The values of R range from -1 to 1. The sign of R indicates the direction of the relationship (positive or negative). The absolute value of R indicates the strength, with larger absolute values indicating stronger relationships.

R squared is the proportion of variation in the dependent variable explained by the regression model. The values of R squared range from 0 to 1. Small values indicate that the model does not fit the data well. The sample R squared tends to optimistically estimate how well the models fit the population. Adjusted R squared attempts to correct R squared to more closely reflect the goodness of fit of the model in the population.

Use R Squared to help to determine which model is best and choose a model with a high value of R squared that does not contain too many variables. Models with too many variables are often over fit and difficult to interpret.

Table 5-33 Model Summary

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.895[a]	.800	.792	19.81725

a. Predictors: (Constant), Educational, Property, Employment, Gender, Household Desc, Household Size

As we can see, the computed R of 0.895 reveals that there is a high positive relationship between the predictor variables. This implies that the respondents' attitudes towards waste disposal have a significant positive effect on their satisfaction with Seoul's waste management programs. Additionally, it was revealed in the R squared that the model fits the data very well, which indicates that the output presented is reliable.

To further justify the significant relation between respondents' attitudes towards waste disposal and their satisfaction with Seoul's waste management program, the unstandardised coefficients were also taken (Table 5-34). The unstandardised coefficients are the coefficients of the estimated regression model. Often the independent variables are measures in different units. The standardised coefficients or betas are an attempt to make the regression coefficients more comparable. If the data is transformed to z scores prior to the regression analysis, the beta coefficients will be obtained as the unstandardised coefficients. The t statistics can help to determine the relative importance of each variable

in the model. As a guide regarding useful predictors, the logic is to look for t values well below -2 or above +2.

Table 5-34 Coefficients

Coefficients[a]

Model		Unstandardised Coefficients		Standardised Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-52.228	13.267		-3.937	.000
	Gender	83.349	4.184	.844	19.920	.000
	Property	-11.622	4.180	-.120	-2.781	.006
	Household Size	-5.903	4.146	-.115	-1.424	.157
	Household Desc	7.842	5.505	.112	1.425	.156
	Employment	-7.516	.787	-.417	-9.548	.000
	Educational	10.598	5.493	.165	1.929	.056

a. Dependent Variable: Respondents

The table above shows whether there is a significant difference between respondents' attitudes towards waste disposal and their satisfaction with Seoul's waste management program. From the analysis, the result shows that Gender, Types of Property, and Employment Status are the variables that have a significant difference with regard to their satisfaction on the waste management program of Seoul.

5-3-4 ANOVA Analysis

The ANOVA analysis was used in the study in order to test whether the respondents attitudes on waste disposal has a significant effect on those respondents' satisfaction with Seoul's waste management program (Table 5-35).

Table 5-35 ANOVA

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	225078	6	37513.013	95.5	.000[a]
	Residual	56159	143	392.723		
	Total	281237	149			

a. Predictors: (Constant), Educational, Property, Employment, Gender, Household Desc, Household Size

b. Dependent Variable: Respondents

The mean square is the sum of squares divided by the degrees of freedom. The F statistic is the regression mean square (MSR) divided by the residual mean square (MSE). The regression degrees of freedom are represented by the numerator df and the residual degrees of freedom are represented by the denominator df for the F statistic. The degree of freedom for the model is equal to one less than the number of categories, which has a total of 149 df. The F ratio is nothing more than the extra sum of squares principle applied to the full set of indicator variables defined by the categorical predictor variable. The total number of degrees of freedom is the number of cases minus 1. If the significance value of the F statistic is small (smaller than, say, 0.05), then the independent variables are effective in explaining the variation in the dependent variable. If the significance value of F is larger than, say, 0.05, then the independent variables do not explain the variation in the dependent variable.

Accordingly, the regression sum of squares is larger than the residual sum of squares, which indicates that the model accounts for most of the variation in the dependent variable. And since the residual sum of squares is smaller, the model was able to explain a significant proportion of the variation in the dependent variable, and we don't need to look for additional factors that help account for a higher proportion of the variation in the dependent variable. Furthermore, the significance value, which is less than the 0.05 level of significance, indicates that the respondents' attitudes towards waste disposal have a significant effect on their satisfaction with Seoul's waste management program. This also shows that the respondents' profiles significantly affect their perception of Seoul's MSW management program.

Chapter 6 Structured Focus Comparison of the case studies in Sydney and Seoul

Waste management in industrialised cities, especially in residential areas, poses a challenging task for waste management service officials in terms of: (1) enhancing the knowledge and awareness of the residents in every household on proper disposal, segregation and recycling; (2) encouraging them to act and implement their knowledge in their own households; and (3) persuading the residents to recycle their wastes.

This chapter presents a comparison of the case studies in Seoul and Sydney. The first part illustrates the similarities and differences in the perceptions of Sydney residents as opposed to that of local government and international records on household waste. The second part evaluates the similarities and the differences in the perceptions of the residents of Seoul and those of Sydney and international records on household waste and management. The third section presents the structured focused comparison between Sydney and Seoul in terms of five variables: (1) the residents' general view of the environment; (2) residents' knowledge of household waste management; (3) recycling collection; (4) views on other systems; and (5) effectiveness of the city council in collection, disposal, and recycling of wastes.

6-1 Sydney

Two significant policies have shaped the city measures implemented in Sydney: *the Waste Minimisation and Management Act* of 1995 and *the NSW Waste Avoidance and Resource Recovery Act* of 2001. These policies have, in turn, propelled the city of Sydney to effectively implement a plan that covers the residential waste collection and recycling, household clean-up service; trade waste removal and street cleaning. The breakdown of wastes provided by the Department of Environment and Conservation, State of Environment Direct, for the Inner Sydney Waste Management Region in 2000 revealed that 30% of the total waste is generated from household wastes.

Referring to the survey, the residents are correct in affirming that the city of Sydney mainly uses two strategies in waste management: landfill and recycling. This shows that the respondents are well aware of the city's disposal and recycling programs. Landfills in Sydney are located at Belrose, Eastern Creek, Jack's Gully and Lucas Heights, whereas

recyclable material is transported to a Materials Recovery Facility (MRF) where it is prepared for being reprocessed (Figure 6-1).

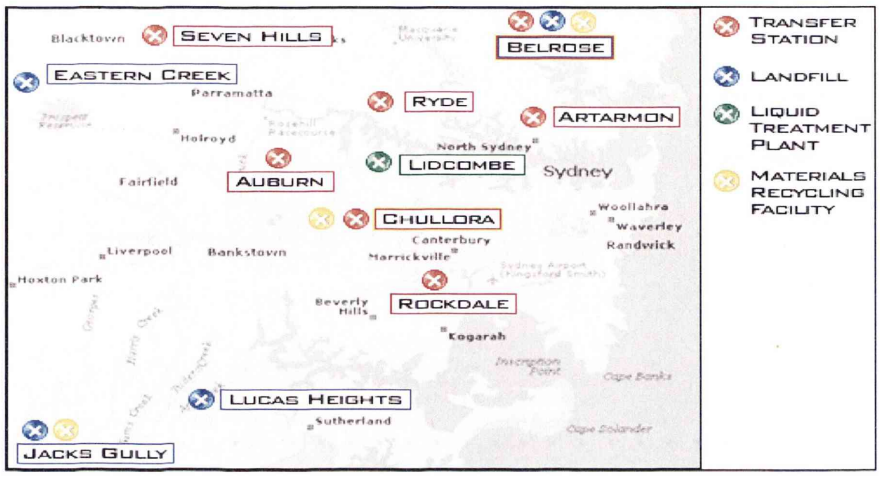


Figure 6-1 Waste Management Facilities in Sydney(taken from www.wasteservice.nsw.com.au)

The recycling efforts of Sydney, however, according to the respondents, are still not adequate. This is also recognised by the municipal waste service providers. In 2001, Sydney only recycled 26% of municipal wastes. The target had been adjusted to 66% by the year 2004 (Department of Environment and Conservation (NSW), 2004). This implies that residents of Sydney need to achieve a higher level of household waste management practices in order to help the municipal waste services attain this goal.

The need for more alternative recycling and disposal systems had been shown by the respondents in the survey suggesting other measures such as composting, heightened recycling and reuse methods. The assertion of the Sydney respondents in finding other alternatives concurs with the shortage in landfill sites. This is because four landfill sites are expected to run out of space within a few years (Sydney Olympic Park, 2004). The problem is that most rubbish is directed towards these landfills. Thus, in their absence, measures should be taken in order to look for other alternatives.

The lack of sites for disposing of the wastes in residential areas is even more heightened by the increasing population and thus, increasing wastes in Sydney. Pre-supposing these developments, the need to maintain and elevate the MSW management of Sydney is vital in order to maintain the cleanliness of the city. According to a report of the City of Sydney in 2004, 7,900 tonnes of domestic solid waste and recycling were collected in the city from July 2002 to June 2003 (Department of Environment and Conservation

(NSW), 2004). This amount of waste shows that the municipal waste services should be more vigilant in their efforts to recycle wastes such as paper, glass, aluminium, plastics, liquid-paperboard and steel cans. These are also the kinds of wastes that the residents deem necessary to segregate and recycle.

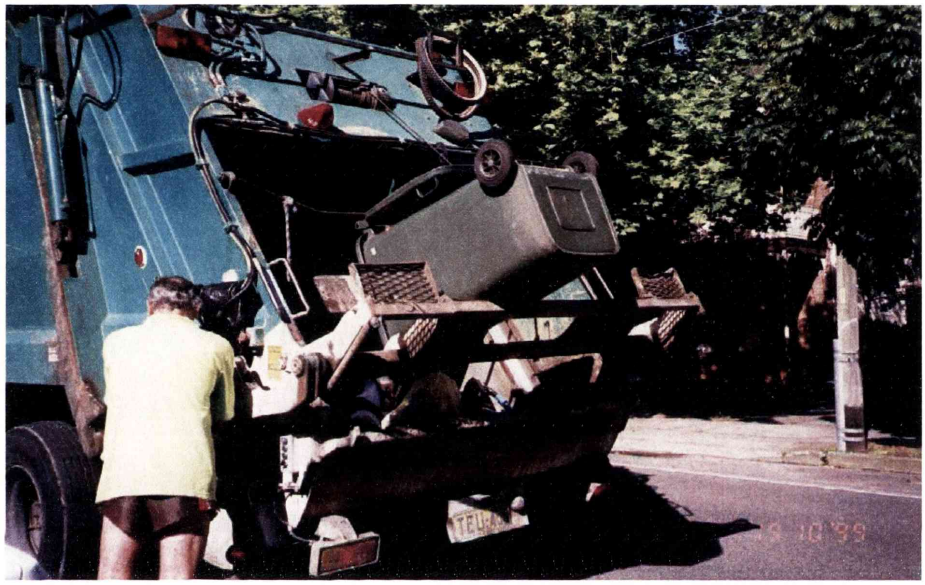
The result implies that Sydney residents recognise the future problems of the local waste services. Thus, the result of the survey, implying that they are willing to segregate and recycle more, shows that they support the municipal government's effort to lessen waste. Moreover, the fact that the City of Sydney also instituted further measures, such as the "Clean Streets are Good for the Neighbourhood", which addresses the concern raised in the survey: waste containers that are too small. Through this activity, the City of Sydney is in effect addressing this concern of the respondents. For instance, a household can request bigger container sizes from the Council, but in addition, they will be paying a higher fee per year. This move also resolves the concern among the residents that payment of waste services should be according to the quantity of wastes that they had generated instead of a uniform payment rate.

The City of Sydney had requested the residents to follow four steps in order to contribute to the city's waste management efforts: (1) reduce the amount of waste; (2) separate recyclable materials for collection; (3) use containers provided by Council; and (4) remove waste containers from the footpath on the same day as the recycling collection service (Department of Environment and Conservation, 2004; Mosman Muncipal Council, 2004; Waste Service, 2004).

In terms of waste reduction, the respondents in Sydney had primarily targeted this agenda in their cooperative efforts. They affirmed that waste reduction within their household is the most important resolution to the problem. Placing this request on the topmost agenda of the City of Sydney shows that the local governments and the residents are in agreement and thus will be expecting cooperation from each other in this area. Moreover, the second request to the residents of Sydney to separate recyclable materials for collection shows that Sydney residents still have to work on this area. Less than half of the respondents indicated that they segregate recyclable materials. This implies that more work has to be exerted by the City of Sydney in segregating. Thus, there is a need to heighten the segregation practices of the Sydney residents. This area should be focused on by the City of Sydney in its future programs.

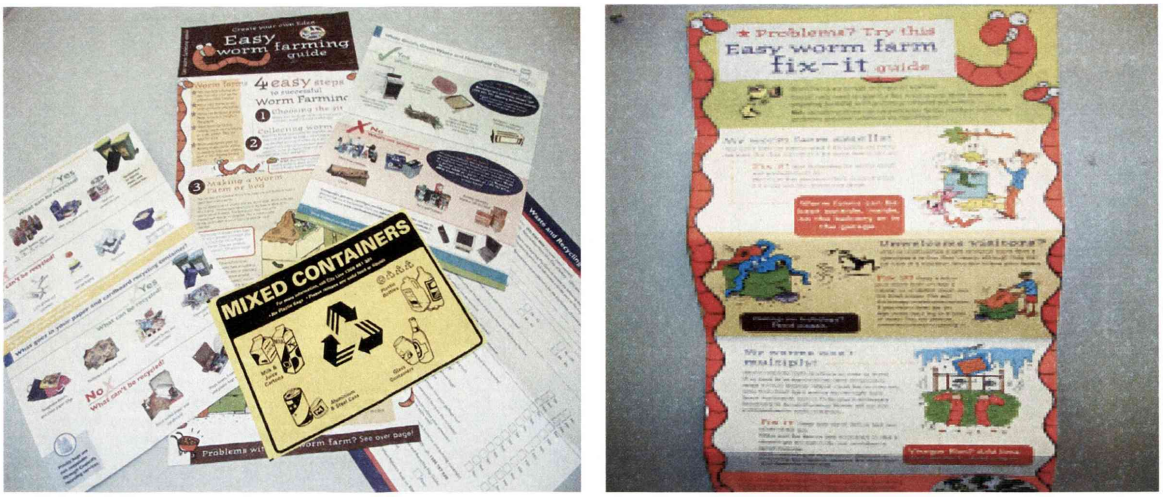
The respondents complained about the size of the containers given by the Council for waste disposal. However, this has already been addressed by the Council in

implementing a request from households for bigger containers but with different rates. The fourth agenda of the City Council, pertaining to the removal of waste containers from the footpath on the same day as the recycling collection service, also implies that residents of Sydney have to exert an effort to take note of the days on which the City Council would be collecting their wastes. The respondents of the survey indicated that they would prefer more frequent service from the council. This appeal should be taken into consideration by the Council, since food wastes that are left for a day or two usually rot.



Picture 6-1 Waste Collection in Sydney

The suggestion of the Sydney residents for the City Council to provide more frequent service proves to be valid since the City of Sydney collects household and recyclable wastes at least once a week. The City of Sydney also distributed guides for materials that are recyclable (Picture 6-2). Furthermore, the City of Sydney has also included several programs that will enhance household waste management. Some of the programs include: Implementation of the "City of Sydney's Special Events Waste Management Policy" for public events; "Clean Streets are Good for the Neighbourhood" and the current drafting of the "Domestic Waste Education Strategy".



Picture 6-2 Recycling Materials Guidelines in Sydney

The result of the comparison on the survey respondents' perception on their household waste management in relation to the City of Sydney's actual practice indicates that the Sydney residents have a high degree of awareness of their household waste management and of their role in the programs of the City Council. While we can say that there is a high degree of cooperation between residents and their City Council, there are still areas that should be improved on the part of the residents such as segregation, reduction of wastes and more efforts in recycling. On the other hand, the City Council has to find other alternatives to landfill and render more frequent services in waste collection. But this might be encouraging more waste disposal. Generally though, the cooperative efforts of the residents and the City Council are remarkable.

6-2 Seoul

The core programs of Seoul are those of minimising the use of resources, recycling waste and disposing of only non-recyclable waste. First, households are encouraged to reduce their wastes. This is consistent with the findings of the study indicating that the respondents' primary goal is to reduce household wastes. Second, concurrent with the city government, Seoul respondents indicated that recycling is their second option for managing their wastes.

Seoul's primary means of attaining these goals has focused on building environmental infrastructures. This has been achieved through the massive build-up of facilities, as the environment infrastructure of Seoul has been the primary focus of the City

Council. In 2001 alone, Korea spent US$6 billion and is expected to spend US$98 billion on environmental projects (Seoul Municipal Waste, 2003). New sewage treatment plants and waste incinerators were the primary targeted infrastructure of the city. This is in relation to the volume-based waste charge system that the Seoul Council is currently implementing.

One of the strengths of the Seoul waste management system in terms of reducing waste is its introduction of the volume-based waste charge system in 1995. In 1994, 5.7 million tonnes of waste were generated (78.9% went to landfill, 0.6% were incinerated, and 20.5% were treated for recycling). The succeeding years saw a considerable reduction of waste to 5.1 million tonnes in 1995 (70.6% for disposal, 0.5% for incineration, and 29.4% for recycling); 5 million tonnes in 1996 (68% went to landfill, 2.4% incinerated, and 30% recycled); 4.6 million tonnes in 1997 (63% disposed of, 4.3% incinerated, and 32.6% recycled); 3.9 million tonnes in 1998 (56.4% disposed of, 5.1% incinerated, and 38.5% recycled); and 4 million tonnes in 1999 (55% disposed of, 5% incinerated, and 40% recycled); and in 2000, Seoul generated approximately 4.2 million tonnes of waste, almost 1.5 million tonnes fewer, compared to the statistics from 1994. In this year, 51.2% were disposed of, 4.9% underwent thermal treatment, and 43.9% were recycled (Citizens' Committee for a Green Seoul, 2004).

This system has largely contributed to reducing waste by significantly decreasing costs, as fewer wastes are disposed of in landfills and more materials are recycled. This trend in waste management encourages Seoul residents on the one hand to organise recycling campaigns and the authority on the other hand to improve recyclable waste collecting systems. Moreover, the volume-based waste charge systems have resulted in a stricter regulation of disposable waste and the adoption of waste volume reduction machines by businesses (Citizens' Committee for a Green Seoul, 2004).

The above measures are in accordance with the policy direction waste for management in Seoul. As previously shown, the Seoul Metropolitan Government has been focusing on recycling and incineration as the primary means of disposing of wastes and is gradually decreasing the use of landfills. This strategy can be illustrated as one that seeks to limit the space that is given to waste landfills. Undeniably, the volume-based waste charge system that was introduced in 1995, as attested by the respondents, has been effective in reducing the volume of household waste generated in Seoul households. This affirmation by the respondents was also shown in the official records of Seoul City Council. In addition, the volume of waste disposed of in landfills has gradually decreased since the

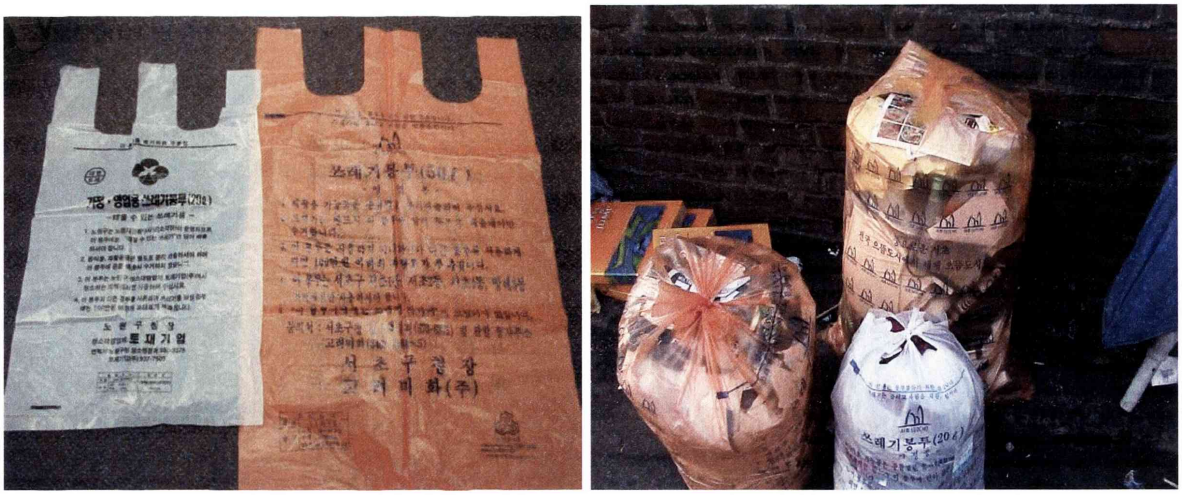
introduction of the volume-based waste charge system. In 2001, 2.1 million tonnes of waste were buried in landfills, approximately 2.3 million tonnes fewer than the total waste disposed of in landfills in 1994 when the system was not implemented (Citizens' Committee for a Green Seoul, 2004).

In Seoul, the food and organic wastes that are collected are recycled into animal feed or fertilisers. This is because organic wastes are banned from landfills because of the food separation rule that has been enforced, whereby 30% of the food collected is recycled. Moreover, as shown in the survey, the businesses of Seoul were required by the Ministry of Environment to charge customers for plastic bags to discourage their use and it was made mandatory to give deposit refunds to customers who returned their plastic bags. Thus, every Seoul resident is encouraged to bring their own baskets and bags when going to supermarkets and shops. However, in practice, the residents of Seoul indicated that they usually use plastic bags from the supermarkets because it is more convenient than bringing their own containers or paper bags.

One of the more pressing matters in Seoul is that of promotional campaigns that will encourage citizens to voluntarily take part in the reducing and recycling of waste. As indicated in the survey, Seoul respondents generally do not segregate and are not active in household waste management practices. Thus, one of the primary focuses of Seoul's program should be empowering their citizens to manage their household wastes. This may prove to be a difficulty, since the respondents indicated that are not very willing to manage their household wastes.

The Seoul waste council outsources its services to the Gu district offices and waste treatment business in order to be more efficient in collection and disposal. However, as indicated by the respondents, they are not satisfied with the services rendered to them by these agencies. Thus, the city council needs to look at the efficiency and the effectiveness of these agencies in addressing the specific concerns of the Seoul residents.

Standardised waste bags are used in Seoul (Picture 6-3). The problem with standardised waste bags, however, is that Seoul residents have to buy waste bags from supermarkets and shops, unlike in Sydney. Residents asserted that they would rather have a non-standardised payment for every household, which had been addressed by the Seoul Council through its implementation of Seoul residents buying their own bags (Seoul Municipal Waste, 2003). This is because every household has its own quantity of wastes. It is thus logical and convenient to make the residents of Seoul responsible for the size of their waste bags.



Picture 6-3 Standardised Waste Bags in Seoul

Another problem regarding standardised waste bags is that they are easily torn. Seoul residents have the option to request bigger bags for waste disposal. This is due to the thickness limit the Ministry of Environment has set for waste bags. The Ministry argues that in order to facilitate decomposition of waste, waste bags must burst easily once waste is dumped in landfills. Standardised bags are made of high-density polyethylene (HDPE) and low-density polyethylene (LDPE) which are highly adequate for incineration and landfills, respectively. Waste bags (those made of HDPE) sizes range from 26 x 46.5 cms to 71 x 113.5 cm, and the thickness ranges from 0.020 mm to 0.045 mm (Citizens' Committee for a Green Seoul, 2004).

Pictures 6-4 Waste Collection in Seoul

In another area, Seoul residents are dissatisfied with Seoul waste services. One factor is the number of days before collection is carried out. This accumulates the waste, and the residents' food waste tends to be smelly and encourages vermin, factors that prevent the respondents from segregating. In Korea, quantity of food waste is very high, accounting for 11,577 tonnes of weight generated every day or approximately 27.1% of the total municipal waste in 1999 (Korean Waste Movement Network, 2001). These statistics manifest the thriving Korean food culture that prefers a rich dining table.

One of the more admirable efforts of the Seoul Metropolitan Government is that of recycling food and organic products into fertilisers. However, separation of food scraps and organic wastes has to be practised first. The respondents of Seoul, however, showed that only one fourth of the residents segregate and that they consider segregation as too much effort and a big hassle. The Seoul Metropolitan Government needs to implement an activity that will enhance the segregation practices of the residents in order to increase the current 30% recycled food scraps of the residents and make the other 70% reusable.

Recycling by the Seoul Metropolitan Government started with five types of waste, namely paper, bottles, cans, plastic and metal scrap and now includes waste Styrofoam, clothes and quilts. The complex way of segregating these different types of wastes had hindered the Seoul residents from participating in segregation. Thus, the Metropolitan Government should devise a more friendly segregation scheme for recyclable materials for Seoul.

Prior to the introduction of the volume-based waste charge system, waste disposal charges were levied based on the amount of property tax paid. With the volume-based waste charge system, standardised waste bags are used as means of levying waste collection charges. Thus, with the system, those who discharge more waste pay more in the form of collection charges. This aims to reduce waste at its source and to promote separate discharge of recyclable items.

In terms of pricing of standardised bags, the respondents indicated that the bags are expensive and should be made more affordable by the Council. The price of the standardised waste bag is determined by the Gu district, which takes due consideration of the level of previous waste collection charges, the financial self-sufficiency of the Gu in terms of waste collection and cleaning and other local conditions. The average prices of the standardised waste bags (5-50L) are between 100 won (about US10 cents) and 1000 won (about US 90 cents). Seoul residents had been very tight regarding their financial considerations in managing their waste disposal. For instance, they indicated that per year,

for every household the government only spends 30,000 won or barely U$26 dollars. What the Seoul Metropolitan Government can do is to disseminate information and provide heightened awareness activities, showing a more transparent expenses report on the part of the government. In this way, the Seoul residents can be more aware of how much their government is spending for them.

The success of waste policy depends on reducing the generation of wastes at source. To this end, the Seoul Metropolitan Government is staging campaigns jointly with civic groups, restaurants, and other organisations. These campaigns include those for "Disposable Goods Substitution" (a campaign to discourage the use of disposable goods), "Use of Reusable Shopping Bags", and "Food Bank Donations". However, the cooperation of the residential groups and businesses has yet to be fully attained.

However, problems do exist with regard to the "face-to-face collection method" such as the inability of some households to discharge recyclable waste at the designated time, because both spouses work. Other options are being considered to resolve problems accompanying the "face-to-face collection method" and to minimise any inconvenience to residents, such as designating service stations, the Dong office or social welfare centres as discharge spots.

The Seoul Metropolitan Government recognises that residents are inconvenienced because of the diverse methods used in discharging recyclable waste. Therefore, in the mid-to-long term, the government is reviewing the plan to construct in each region recycling centres equipped with an automatic sorting system. This will eliminate the need for separate discharge of recyclable items, meaning all types of recyclable items (except paper) can be discharged and collected together. Thus, to dispose of recyclable items generated in the Seoul area in an efficient manner, companies that collect, transport and recycle the recyclable waste should operate smoothly.

Korea Zero WASTE Management Network (KZWMN), organized with more than 270 NGOs in Korea, have performed citizen movement of reducing disposables and food waste, increasing reusables, managing toxic industrial waste and hazardous household waste safety since 1997. Making effort to discourage the use of plastic bags and to bring their own cup program in public buildings are being performed.

While there have been improvements in the waste management in Seoul, there is clearly considerable room for improvement. This can be achieved at the grassroots level: the households of Seoul residents simply need to cooperate more and practise household waste management.

6-3 Sydney and Seoul

This section presents the structured focused comparison of the household waste management and practices of Seoul and Sydney in terms of the five variables in this study: (1) knowledge of the environment; (2) knowledge of household waste management; (3) household waste management; (4) recycling collection; and (5) views on other recycling systems. The result of the comparison was used in the drafting of the proposed model for the waste management systems in Seoul and Sydney.

6-3-1 General View of the Environment

Sydney residents have a slightly higher level of theoretical knowledge and a considerable difference in the level of participation in the environment and in their household waste management. In terms of their concern for the environment, Sydney and Seoul residents showed that they are generally fairly concerned about the environment, with Sydney respondents having a slight edge over Seoul respondents. Moreover, both Sydney and Seoul residents asserted that next to education, it is the environment that they prioritise next.

However, the difference became apparent in the answers of the respondents on their willingness to participate and protect the environment. The result showed that 84% of Sydney residents are willing to protect the environment while only 28% of Seoul residents affirmed their willingness. Moreover, 50% of Seoul residents actually said that they are not going to participate in environmental protection.

The result of the survey on household waste management suggests that Sydney residents are more participative than Seoul residents. The findings imply that the Seoul waste management council should first focus on information dissemination and in empowering their residents. Evidently, there is a wide gap between the perception and that of the actual participation of the Seoul residents. Making them translate their favourable perception about the environment to action will be a key concern in laying the groundwork for the waste management program.

6-3-2 Knowledge of Household Waste Management

The knowledge of household waste management in Seoul and Sydney determines their awareness of their role as well as the techniques in order to manage their household wastes. According to the results of the survey, Sydney and Seoul residents asserted that they

perceive the importance of household waste management and the relationship to that of preserving the environment and natural resources as very important. This implies that the respondents can relate their own household practices to the bigger issues of environmental protection. A clear grasp of this relationship should theoretically lead to better practice in household waste management.

Moreover, Seoul and Sydney residents also perceive the use of landfill and recycling as the two most used means of managing household wastes by their respective waste services council. This shows that predominantly, the residents are aware of their councils' waste service, since Seoul and Sydney utilise the two means in waste management. Furthermore, when the respondents were asked about what strategy they would rather employ in decreasing the volume of their wastes, they suggested that they prefer waste avoidance and the reuse of their wastes instead of implementing a household waste management system in their households. However, the result also shows that Sydney residents place more importance on this practice than do Seoul residents. In fact, a large number of Sydney residents are trying to recycle more, whereas only a few of the Seoul respondents suggested that they are trying to recycle.

However, the Seoul and Sydney residents are both generally enthusiastic in their desire to learn more about household waste management, with Seoul respondents scoring slightly higher than Sydney residents. Finally, Sydney and Seoul residents agree in affirming that their preferred source of information on household waste management is that of the Internet and newspaper in comparison to local sources and their local council. This leaning towards the media can be attributed to the lifestyle of the residents: that they would prefer ready information at the time of their convenience, something that the Internet is capable of providing.

The result of this section shows that Sydney and Seoul residents are predominantly willing to learn more about household waste management. Moreover, their responses, which generally know the information on their waste management services show that they are generally aware of the waste management system in their respective cities. However, as shown, more Sydney residents are recycling than are residents of Seoul.

6-3-3 Household waste management

The knowledge of the respondents about their household waste management shows that they have a relatively high awareness of the proper household waste management. This

section illustrates whether there is a difference in the respondents' actual practices in their own households. The result suggests that there is a high level of difference between Seoul and Sydney respondents in terms of segregating their wastes. The result showed that the majority of Sydney respondents affirm that they are doing fairly well in segregating their wastes, while only one fourth of the Seoul residents practise segregation. The result shows an interesting pattern that is consistent in the responses of Seoul residents: that while Seoul residents have a high regard for the environment and that they have a high degree of knowledge of household waste management, in practice they do not apply what they know. This is in contrast with Sydney respondents, because while there is also a gap between their knowledge and practical application, this is minor. The result from the survey on Sydney shows that the respondents try to apply what they know in terms of environmental conservation and waste management.

In terms of the amount of maintenance spent by the city councils of Seoul and Sydney on every household per year, Seoul residents pegged the council's expenses at US$9 less than that which Sydney residents perceive their council to be spending on them per year. This implies that Sydney residents have a higher estimation of the expenses and maintenance of waste services by their city council than the residents of Seoul. However, according to the records of Seoul and Sydney, the councils spend more on every household. This is because the city councils have to pay for the salaries of their employees as well as the operational expenses, for example, maintenance of equipment.

In terms of level of satisfaction/unsatisfaction with the services of the councils, the Seoul residents showed a fairly high degree of dissatisfaction with the services, whereas Sydney residents have a high level of satisfaction with their local waste services.

In the survey, Sydney and Seoul residents cited waste containers as a major concern in their household waste management efforts. However, the difference lies in their specific complaints. While Seoul residents complained about the high cost of bags for the volume-based waste charge system, Sydney residents complained about the size of the bin. To improve the quality of services by the local council, Seoul residents asserted that they would recommend the use of stronger bags because standardised waste bags are easily torn and the waste bags sold are not strong enough for heavier materials. As previously stated, waste bags inconvenience Seoul residents because of their limited thickness. The thickest bag is 0.045 mm. Respondents from both cities also complained that a high level of effort is required in doing what their respective councils require them to do. In addition, to make

more efficient household waste collection services, Sydney and Seoul residents suggested more frequent collection of the waste.

The result of the survey also suggests that Sydney residents are satisfied with their local waste services, whereas Seoul residents are not. If the expectations of the respondents can be correlated with the amount they are willing to spend, Seoul residents should have expected less from their waste services council. However, the result shows otherwise; despite the financial expectations of the residents, they also expect more and better services. Needless to say, Sydney respondents are more considerate about their local services council than are Seoul residents.

6-3-4 Recycling Collection

The identification of wastes to be recycled is critical in the segregation and thus the efficiency of the waste services to recycle. Seoul residents identified aluminium cans as the items they primarily segregate. Furthermore, they also cited glass, milk/juice cartons and newspaper as recyclable wastes. This is in contrast with Sydney residents who considered glass, newspapers and cartons to be important to segregate for the kerbside recycling.

In terms of using recycling services, Sydney residents use the recycling services more often than do Seoul residents. When asked about the reasons for not using recycling services all the time, Seoul respondents indicated that it was too much hassle and they lacked the time for recycling. On the other hand, Sydney respondents indicated that the question was not applicable to them. This is because the majority of the respondents recycle and segregate.

The result suggests that in terms of recycling practices, Sydney residents perform better than Seoul residents. Moreover, when asked about the respondents' satisfaction with recycling services, both groups of respondents indicated that they are generally satisfied. This implies that the core difference between Seoul and Sydney respondents is that more effort is made by Sydney residents in cooperating with their waste services councils in comparison with Seoul residents. Thus, considerable work is needed toward empowering the Seoul residents to improve their recycling practices.

6-3-5 Views on Other Systems

Several alternatives to recycling and use of landfill have been presented in this study. Since waste management providers in both cities are primarily considering measures to divert solid wastes from landfills, the importance of recycling, composting, incineration and other household waste processes has been emphasised in this study. The respondents had shown willingness to comply with the alternatives to waste management presented here. Although Seoul residents, for instance, prefer improvements to the volume-based waste charge system that they currently have, they consented to the empowerment of the residents in applying their knowledge. Sydney residents, on the other hand, showed optimism about composting, although they have cited problems with the possible implementation of this.

6-4 Conclusions

The result of the study indicates that in terms of household waste management, the components of Sydney and Seoul programs do not differ significantly. Although there are individual activities and projects that the two cities have been implementing, to a large extent they resemble each other. In consequence, the study concludes the following:

1. While there have been similarities in the level of knowledge in environmental and household waste practices of Sydney and Seoul, Sydney residents showed a higher level of compliance in terms of practising segregation, cooperating with their council, and in recycling.

2. Sydney residents are more satisfied with their city council's household waste management than Seoul residents: this is true even if they are paying more to their government for the services; while Seoul residents expect a lesser payment to their government, they showed a high level of dissatisfaction with the services rendered to them. This indicates that the expectations of the Seoul residents of their council's waste services are higher. However, as shown in the study, they are not likely to cooperate with their council. This is shown in their responses to the questions indicating their non-segregation practices and their tendency to avoid council-initiated measures to improve waste segregation. This gap needs to be addressed by the Seoul government. Aside from the environmental infrastructure in the city, the government has to address the

grassroots problem of waste management: solving the problem at the most basic level—the household.

3. The primary strength of the programs of Seoul is in the willingness of the metropolitan government to look for viable alternatives for waste disposal and in building a strong foundation for waste disposal and recycling. However, as stated, the weakness can be traced to their inability to gain the support of their residents.

4. Sydney on the other hand, has managed to balance the environmental infrastructure program and that of empowering its residents to practise household waste management. The residents showed a high level of knowledge about environmental issues and household practices. Moreover, this was used and applied in their household settings, where they showed high effectiveness and compliance in terms of disposal, reduction of waste, segregation and recycling. Finally, the problems posed by the respondents are manageable and can easily be remedied by slight alterations to the waste management services of Sydney.

5. The case studies presented show that enormous efforts are being made to divert solid waste from landfills. The challenge here is to look for effective and efficient diversion alternatives. For the two cities, it is clear that recycling is the option for diverting waste. This indicates that with the benefits of waste diversion, recycling and reuse of products have to be the primary means of disposing wastes.

6. For Seoul, the proposed program of this study necessitates the balancing of the infrastructure for the environment and that of assisting every household to practise waste management. The result of the survey, highlighting the dissatisfaction of residents toward waste services, suggests that Seoul has to devise sound schemes that can effectively address this problem. Seoul can, for instance, issue directives reducing the price of waste bags, or develop a scheme that charges less for households that have lower amounts of wastes and increase the charge per volume for those who consume more.

7. For Sydney, heightened awareness of the residents is still sought. This can be done through involving the males in household waste management. As shown, there is a high degree of compliance among Sydney residents; the City Council should thus exploit this opportunity in enhancing the awareness of the other members of the household in encouraging them to participate. Moreover, Sydney's City Council should also focus on addressing the issue of landfill. A massive awareness campaign and environmental education using all types of media must be conducted.

8. In line with the advent of the 21st century, Seoul and Sydney can set up a network, which provides fast and accurate information on the whole process of recycling from collection, recycling and sale of recyclable items such as paper, plastic, glass, metal and cans.

Chapter 7 Solid Waste Management Model

7-1 Introduction

In the previous chapter, it was found that, in terms of MSW management, there is no significant level of difference between the components of the programs in Sydney and Seoul. Overall, the activities and projects that the two cities have been implementing resemble each other to a large extent. However, although the result of the study suggests that Sydney and Seoul present satisfactory MSW management programs, there are still several areas that need to be resolved to enhance the waste management in the two cities.

In order to achieve the above objective, this chapter identifies the best solid waste management model that can be applied for the sustainable development of a sound waste management program in Sydney and Seoul. The decisions and assessment in the area of the MSW management are not simply very capital-intensive, but also difficult from social and environmental standpoints. There is a significant need to develop, modify and implement a simple, but reliable and consistent model that will help the decision-makers in both cities in the analysis process. The Integrated Municipal Waste model (IMW) is the tool that appears to meet all the necessary requirements (White, 1997; Bjorklund, 1998; Eriksson, 2002; Forbes et al., 2001).

However, before the presentation and discussion of the integrated waste management model that can be applied to the Sydney and Seoul settings, it is important to discuss the structure of this study. The first section of this chapter focuses on the waste management systems, descriptions of the current solid waste management systems in Sydney and Seoul. The life-cycle boundaries for recycling employed in the waste management processes evaluated by the model are described in this study, relating in particular to recycling, composting, energy recovery and landfilling. The context of LCA is also discussed in this section. This section highlights the objectives of the framework that guides the planning, development and implementation of the solid waste management program.

In the second section, the Integrated Municipal Waste model (IMW-2) is discussed, followed by the presentation and application of this model to the two cities.

In the final chapter, recommendations to better address waste problems in Sydney and Seoul will be presented. These include enhancement of waste disposal (household

waste disposal, street cleaning, disposal of construction waste, small-volume specified waste, treatment of infectious waste, penalties for illegal dumping of waste); improvement of waste disposal equipment and waste treatment facilities; implementation of a volume-based waste charge system (types and size of standardised waste bags, the price of these bags, and production and distribution of these bags) increased civic participation in waste-related problems; increased regulation on the use of disposables and violations of packaging standards; enhanced discharge separation and collection and transport of recyclables; support for the recycling industry; construction of resource-recovery facilities.

The researcher hopes that this study will be of significance not only to the academia but also to the waste industry. The researcher is also optimistic that the present study will serve as an important guideline for waste management planners and developers, as well as policy-makers.

7-2 Waste Management Systems

The primary objective of this research was to compare the MSW management systems of Seoul and Sydney and to identify a waste management model that best applies to the two cities. The economic prowess of Sydney and Seoul has been illustrated in the first chapter. However, it has been noted that the accomplishment of rapid economic growth came only at the cost of neglecting the environment. Of Australia's total population of 19.7 million in 2002, Sydney, having a global city status, had a share of 4.2 million people. In the same year, Seoul had a population of 11.2 million, accounting for 25% of the total population of South Korea. The increasing population plus the alarming growth in urbanisation have contributed to unsustainable development, through its production of waste. As a response to the waste problem, both the Australian and South Korean governments have adopted numerous waste management programs. However, the noble aim of waste management programs in the two cities is being impeded by the ignorance of their people about the deteriorating environment because they concentrate only on developing the economy and meeting basic needs.

Solid waste management as a global issue is not just a technical issue, but is also a socio-political and a cultural issue. Addressing this issue needs sound policies, administrative reorientation, institutional and organisational arrangements and an informed public. This study calls for sustainability, taking into account environmental, economic and

socio-cultural concerns. Throughout the study, it is maintained that the major goals of any municipal solid waste management system are to achieve sustainability through preservation and protection of the environment, development of markets, and furtherance of sustainable development for the benefit of the people.

These goals can only be realised using evaluating tools and waste management programs that can fully address them. It has been noted in the second chapter of this study that most of the municipal waste management models identified in the review are decision support models: those based on cost benefit analysis, those based on LCA and those based on multicriteria decision-making. This study bases its suggested waste management model on a LCA. The advantage of a lifecycle-based model is that, while considering economic and environmental aspects, it also addresses social aspects. LCA, which is used in order to evaluate the environmental impacts of the products from the cradle to grave, is progressively being applied more to the assessment of waste management strategies.

It must be remembered, however, that in designing solid waste management models and programs, it is important to evaluate the environmental and economic performance of the various elements of Sydney's and Seoul's existing waste management programs. The models and programs are primarily based on the best possible information publicly available at the present time, with commitment to and assurance of modifying this information periodically in order to ensure that it is up-to-date. The models are intended as guides only and they do not prescribe and set down the best system. The purpose of the best possible system for a community must take other aspects into account including political and social considerations.

The scope of the Integrated Municipal Waste model (IMW-2) in the study was therefore defined by the researcher to include the main components of residential waste: plastic, paper, glass, metal, textiles, organics, and yard waste. Each of these materials can possibly be managed and organised by a number of different elements within an integrated waste management system and would therefore benefit from a systematic evaluation of the management options.

7-3 Description of the Solid Waste Management Systems in Sydney and Seoul

In Seoul, South Korea, waste is generally classified into two categories and this is based on its source: municipal waste from households and industrial waste from the business sites or

large-scale factories. On one hand, industrial waste is further divided into two categories: general industrial waste which consists of ash, slag, dust, and construction waste, particular waste which consists of toxic wastes such as waste alkali, waste acid, waste oil, and waste organic solvent and so on.

Waste in Seoul is managed in a dual system. The local government of South Korea is responsible for the final disposal of the municipal waste, at the same time that the discharger is responsible for the final disposal of the industrial waste. The municipal waste is managed and organised by a volume-based waste charge system. This system was introduced nationwide in 1995 in an effort to encourage and motivate the citizens' voluntary reduction of the waste by charging fees in line with the amount of the waste discharged. The municipal waste management system, by means of the volume-based waste charge system is as follows:

- Municipal waste management process through the volume-based waste charge system.
- Discharge. Under this system, the discharger purchases a chosen standardised waste bag for collecting waste at stores, puts the waste inside the bag and places the bag outside for collection. In addition to this system, five recyclable products in Seoul are not to be put in the bags; these must be put aside separately, and food waste must be thrown away separately through food waste containers or bags.
- Collection Disposal. The bags filled with waste are collected and moved to the landfills or incinerators by the municipal vehicle. Another important point is that bags other than designated bags are not collected.

Recently, the South Korean government has planned to introduce the EPR (Expanded Producer Responsibility) system, imposing on the manufacturers the responsibility of collecting recyclables for reprocessing, in an attempt to efficiently and economically manage waste.

A remarkable characteristic of the municipal waste generation in Seoul is that the proportion of packaging waste and food waste is extremely high and it is expected to increase in the near future. The enormous generation of packaging waste results from the increase in consumption due to the increase in income levels. In 1999, food waste accounted for about 27.1% of the total municipal waste. The researcher considers that the large production of the food waste is primarily caused by the Korean food culture that

chooses a rich dining table. The trends in Seoul's waste generation are presented in Table 7-1 and 7-2.

Table 7-1 Trends in Seoul's Waste Generation (taken from Seoul Municipal Waste, 2003)

Unit: thousand tonnes/day

Classification		1992	1993	1994	1995	1996	1997	1998	1999
Total		114.5	141.4	147.1	148.1	180.8	194.7	188.6	219.4
Municipal Waste		75.1	62.9	58.2	47.8	49.9	47.9	44.6	45.6
Industrial Waste	Sum	69.4	78.5	88.9	100.3	130.9	146.8	144	173.8
	General	48	56	85.2	95.8	125.4	141.3	138.7	166.1
	Specified	21.4	23.4	3.7	4.5	5.5	6.1	5.3	7.7

Table 7-2 Trends in Seoul's Food Waste Generation (taken from Seoul Municipal Waste, 2003)

Unit: tonnes/day

Classification	1995	1996	1997	1998	1999
Food waste generation (tonnes/day)	15,075	14,532	13,063	11,798	11,577
Percentage of food waste in municipal waste (%)	31.6	29.1	27.3	26.5	27.1

On the other hand, in Sydney, households and industry are currently generating waste at a rate that is challenging its safe, productive cost-effective and disposal. The capacity of the ecosystems to absorb these wastes is limited, so the waste and the community's attitudes and approach to waste are the causes of major pressure on the environmental and economic sustainability. The emerging perspective for Sydney is to treat the waste as a capital resource.

In Sydney, the Western Sydney region has a large urban residential area and a considerable manufacturing sector that produce a significant percentage of the solid waste per capita of the population. In spite of the work of the Western Sydney Waste Board and the work of Western Sydney Councils, difficulties with the excess waste generated by the industry and community and ineffective recycling markets continue. Despite the new

efficiencies in Sydney, the volume of the waste is increasing due to Western Sydney's population growth.

Waste per capita, including the industrial waste for Sydney, remains at around 800 kg per annum, which is comparable to all the Western industrialised countries. In 1999–2000, domestic waste in the Western Sydney region averaged about 350 kilograms per capita per annum, below the OECD figure for Australia as a whole (400 kg per capita per annum).

There are certain issues that require consideration for sustainable waste management. These include:

- the limited lifespan of the existing landfills and inadequate potential for new landfills;
- current recycling rates are inadequate for controlling the rising volumes of waste in Sydney;
- the New South Wales State government has set an objective of reducing the amount of waste going to the landfill by 60%, an objective improbable of being achieved in the near future;
- environmental pressures from the landfill, for example, odour, noise, harbouring pests, leachate migration (pollutants leaking from the buried waste into the groundwater below); and
- rising waste generation (over-packaging, over-consumption, inefficient production processes, importing waste from the Sydney region).

Together with the most of the industrialised world, the Sydney population, with its high rate of using goods and services, creates an indefensible amount of resources to forward to landfill. In general, Australia ranks second among all the industrialised countries when it comes to waste production per head (behind the United States), for both the total of municipal waste and household waste (OECD 1999).

A comparison between the major municipal centres, in which Western Sydney is joined with the Northern and Southern waste districts, provides a breakdown of the waste stream as a whole (Table 7-3). Until the close of the twentieth century, the Western economy concentrated on only one way of making use of resources. Infrastructure and lifestyles have been geared to consuming products once and then disposing of the remaining waste to the landfill. Industry in Sydney has been geared in order to draw on

natural resources such as air, water, and minerals, as free goods. This condition is changing in Western Sydney with:

- Landfill sites becoming of greater value as real estate;
- Pollutant leakage into groundwater;
- Population and the related waste stream increasing; and
- Natural resources being accorded importance (for example, water rights and air pollution fines).

Table 7-3 Composition of Solid Waste in Major Municipal Centres

Type of Waste	Sydney Metro*	Inner Sydney	Melbourne	Average all centres
Municipal (%)	46	14	35	44
Commercial and industrial (%)	37	26	25	27
Construction and demolition (%)	17	60	40	29

**Municipal Sydney including Inner, Northern, Western and Southern waste districts*
Source: Draft National SoE Report, 2000

Moreover, the Sydney area used to be divided into waste management areas, each area under the supervision of a Regional Waste Board. A regional approach to the issues concerning waste developed in the 1970s, in the form of a Metropolitan Waste Disposal Authority (MWDA), which was established in order to develop, plan and manage infrastructure for the disposal of waste in Sydney. The *Waste Minimisation and Management Act, 1995* altered the fundamental approach from waste disposal to waste minimisation (Appendix 2).

Figure 7-1 presents the annual amount of the household waste produced per person in the City of Sydney between 1997-1998 and 2003-2004. The figure shows that with the fast rate of residential growth, and the pressures to take Sydney's waste compared to Seoul, Sydney has an increasing pattern with regards to household waste per person and per year. Sydney average of about 205.29 kg wastes per year from 1997-2003.

Figure 7-1 Trends of Sydney Municipal Waste per person per year (Kg)

7-4 System Boundaries

The life cycle of a waste starts when the product enters the waste stream and ends when a waste material has either been transformed into a resource (recovered energy or recycled material) or, when it has been finally disposed of. Recovery methods such as recycling, energy recovery and composting, which result in the production of a usable material, can be analysed as fulfilling two functions: the management of waste (the waste management function, W) and, the production of functional material or energy (the production function, P). The recovered material/energy can be used in place of conventional material/energy (for example, virgin raw materials, energy production from fossil fuel combustion, etc.). The life-cycle study of a waste material must therefore take into consideration the avoided environmental burdens, related to the production of displaced conventional material/energy. This approach enables the intrinsic environmental value of the recovered material and energy to be accounted for in a similar way to which their economic value is considered by accounting for the energy and material revenues (white et al., 1995). The life-cycle boundaries for each of the waste management processes assessed by the model are described in the study.

7-4-1 Recycling

The system boundary for recycling starts at the point at which the recyclable material is placed out at the control that is the kerbside for collection and ends when the recycled material that can be made use of as an alternative for the conventional material is produced. Energy and emissions relevant to the production of conventional materials, particularly

virgin raw materials that can possibly be substituted for by the recycled material, are taken into account and estimated for as prevented emissions. The areas within the marked boundaries in Figure 7-2 show the system boundaries for the model. It is assumed in the study that the "use" stages of the conventional and recycled material are identical, and these are therefore excluded from evaluation. The assumption is therefore made that a tonne of a recycled material will substitute for a tonne of conventional material. Nonetheless, this is not the case; the life-cycle performance of the recycling, in comparison to other waste management practices may be impacted upon considerably. For example, in a study that compared the waste management of plastic by various waste management options, it was found that if considerably less than 1 kg of plastic is substituted by recycled plastic, the recycling process may no longer have a benefit over the feedstock-recycling and energy recovery processes in terms of the environmental performance (APME, 1995).

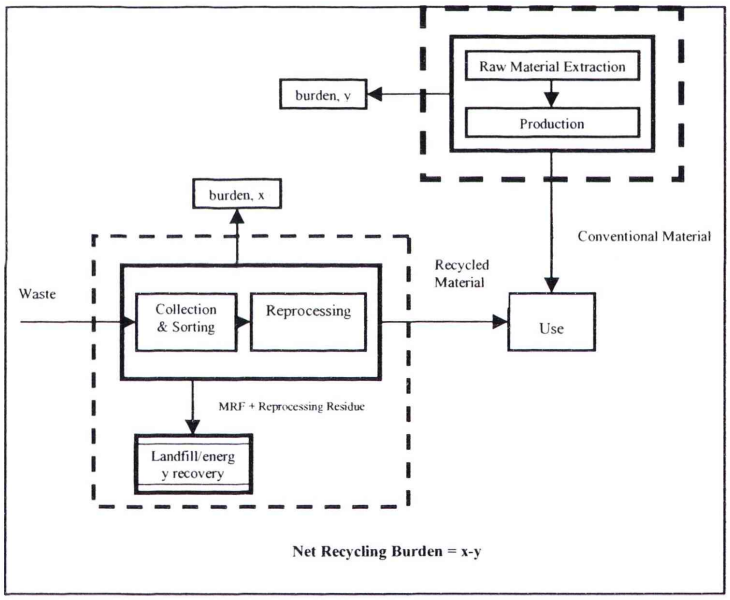


Figure 7-2 System Boundary for Recycling

7-4-2 Composting

The system boundary for the composting extends from a collection of organics at the control to the production of utilisable compost. The area within the marked boundary in Figure 7-3 illustrates the boundary used for composting. An estimation of the problems associated with the materials that can possibly be replaced by compost product, such as peat and fertiliser, is difficult, primarily due to the inadequate data on replacement rates and the life-cycle burdens imposed by replaced materials. Nevertheless, in order to

maintain consistency and reliability with other waste management options, and to identify the potential for prevented emissions of the greenhouse gases from peat or fertiliser production and application, an offset of about 10% of total CO_2 emissions from composting was allocated to this option (Sachs, 1993).

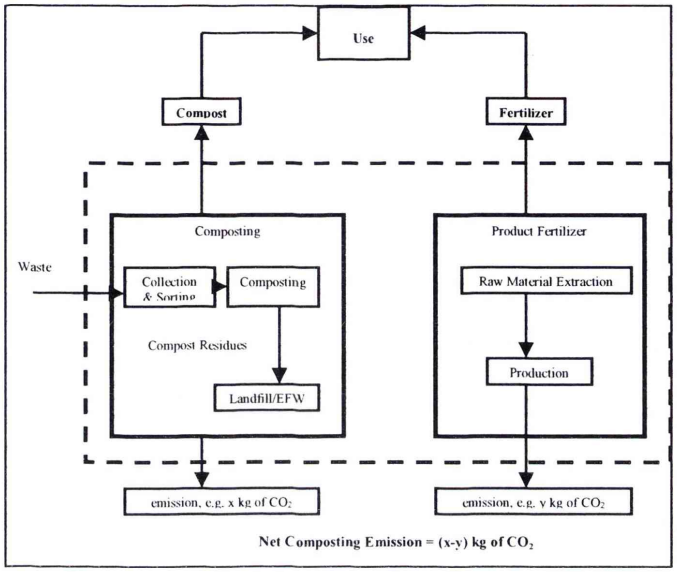


Figure 7-3 System Boundary for Composting

7-4-3 Energy Recovery

System boundaries for the energy recovery practices evaluated in this model have been drawn from the point at which the wastes are collected at the limit to the point at which energy recovered is produced (Powell, 2000). Moreover, energy and emissions related to the production of the conventional energy that can possibly be replaced by the recovered energy and material are also taken into account and estimated for as avoided emissions. The areas within the marked boundaries in Figure 7-4 show the system boundaries for the energy recovery from waste.

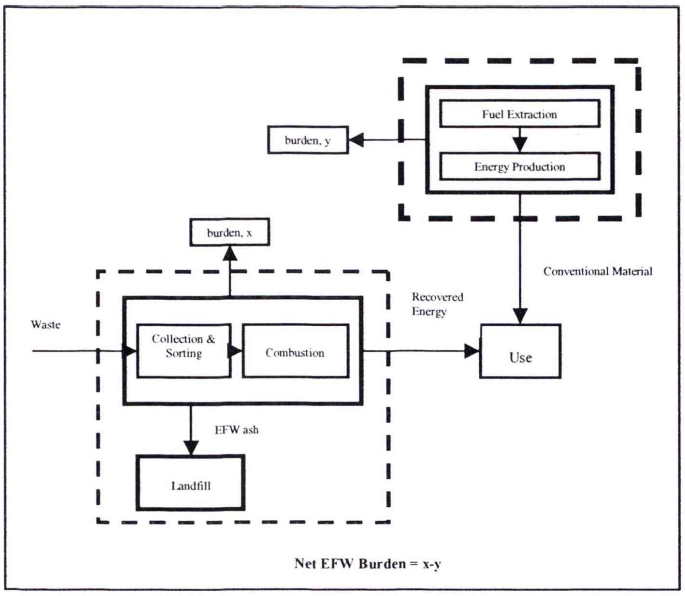


Figure 7-4 System Boundary for the Production of Energy from Waste

7-4-4 Landfilling

In contrast to emissions from other waste management practices, emissions from landfills occur over very long periods of time, spanning hundreds of years. In theory, a landfill is part of the evaluated system when it is environmentally active (producing leachate and gas), but reverts to becoming part of the environment when its active life is over. Describing the active life of a landfill is not easy. In addition, in view of the fact that landfill emissions will occur in the future, there are no indications for measuring them; they can only be estimated. Finnveden (1998) explained that two time borders are relevant in life cycle studies: the surveyable time period; and the hypothetical infinite time period. The surveyable time period corresponds to the time required for the landfill to achieve pseudo-steady state, after which changes are slower than during the initial phases. Moreover, Finnveden (1998) suggests that as an initial estimate, this time stage can be presumed to correspond to about 100 years. When evaluating emissions from landfilling with those of other waste management processes, landfill burdens (gas, leachate, etc.) are integrated over the 100-year period. After 100 years, the landfill is considered as part of the environment and waste remaining in the landfill is accounted for as remaining waste.

However, in view of the fact that the emissions during shorter time stages (decades and centuries) in various cases will be only a small fraction of the total landfilled amount, it is apparent that the option represented by looking between the shorter time period and the longer time period can be decisive and significant for the results (Sundqvist, 1998).

7-5 Life Cycle Assessment

Research into product life-cycle has generally been in the form of comparative assessments of substitutable products delivering similar functions; however, a trend towards the use of life-cycle approaches in comparing alternative production processes has emerged, including the use of LCA in comparing waste management strategies (Berkhout and Howes, 1997). LCA also provides a general overview of the product system, which can then be combined with other assessment tools, such as risk assessment, to evaluate the product or service over the entire life-cycle (Morrissey and Browne, 2003). According to Forbes et al., (2001), LCA offers a system map, setting the stage for an holistic approach and then, by comparing such system maps for different options, whether for different products or waste management systems, environmental improvements can be made.

Despite the above mentioned advantages of LCA, there are still those who criticise the tool for its use as a basis for waste management model development. Some critics argue that when different methods are used to evaluate the same product, substance or material, they often provide inconsistent results. Others point to the limitation of LCA methods in gathering sufficient data. There are limitations for the tool. Some authors state that LCA should not be used in isolation to decide such issues as which waste management treatment option is to be preferred (Finnveden and Ekvall, 1998). Another difficulty with LCA is establishing where the boundary is and the definition of the functional unit (Ekvall, 1999). The results produced by variations of LCAs also differ in practice (EEA, 2003). Moreover, lifecycle assessments are restricted to looking at environmental impacts only, although both Harrison et al.'s (2001) and Craighill and Powell's (1996) models extend the LCA methodology to incorporate an economic evaluation of the environmental impacts.

Figure 7-6 shows a highly simplified waste management system for landfill. These schematic representations illustrate system boundary considerations for waste management. Practically speaking, a waste management system usually needs to be further divided into a number of manageable components; operations for which the inputs and outputs can be identified and quantified (Aumonier and Coleman, 1997). Flow-sheets show that the entire waste management system is complex, and its analysis is greatly supported by its division into unit processes.

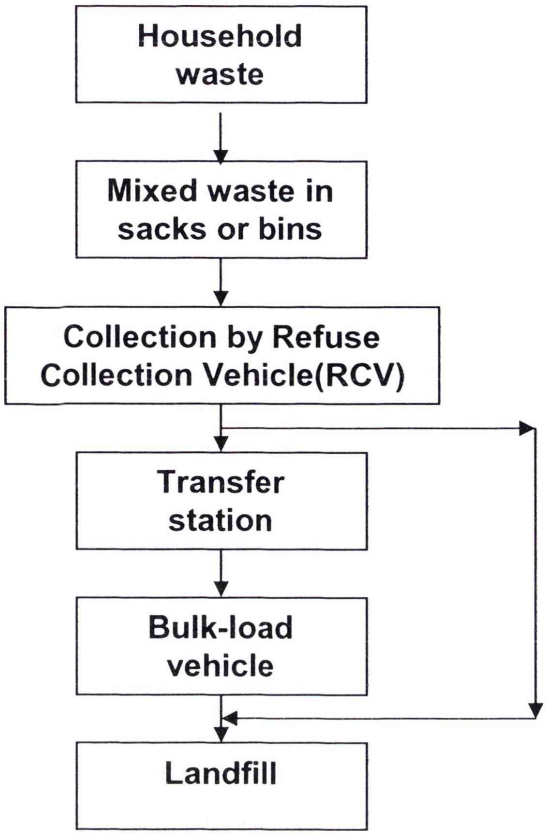


Figure 7-5 Waste Management Systems (Landfill)

7-6 The Integrated Municipal Waste (IMW-2) Model

In the literature review, a model is defined as a representation of an object, system or idea in some form, other than that of reality itself. The review identifies that most of the municipal waste management models identified are decision support models: those based on cost benefit analysis, those based on LCA and those based on multicriteria decision making.

IWM-2 was developed by Forbes, M., Peter, W., Marina, F., Peter, H., as mentioned in the reference section. This model allows the development of integrated waste management systems in practice. It is easy to use, transparent and contains a range of default data to help the modeling process. IWM -2 is not only a more widely accessible tool but also user friendly Windows style interface (stand-alone program), with significantly improved input and output features. The model is considered to be demanding because it encompasses all waste management activities, from waste generation and source reduction to home composting and kerbside recycling. For the purpose of this study, this model is applied to the cases of Sydney and Seoul.

In addition, the model must allow for any combination of the schemes, at any time, in any part of the community, and predict all standard waste management performance indicators. Furthermore, the model must allow for individual behaviours to be rationalised with regard to their likely causes, respond to any changes introduced to scheme operations, and to any management interventions to enhance performance, and be capable of predicting the environmental burdens associated with each activity. It should be extendable to economics as well.

Unlike other regions, where most local landfills have already been exhausted and waste management has become an issue of regional and national significance, Sydney's and Seoul's waste management burden still falls largely on municipal councils, in terms of implementation, operations and, most often, management. During the last decade, government bodies in Sydney and Seoul have been providing recycling services to their ratepayers, thus gradually embracing the concept of a waste management hierarchy.

Although many different formats of recycling services have been implemented, market fluctuations for recyclable materials have also directly impacted on the economic viability of local recycling contracts. This leads to questions regarding the cost-effectiveness of these recycling programs and the overall benefit of recycling. Moreover, the development in recycling services has overtaken the very essence of integrated waste management, in that the activity ignores other options that should be considered.

Aiming to identify alternative solid waste management strategies that address cost, energy, and environmental emission objectives, this integrated municipal waste management strategy is essential because of the increasing need to handle municipal wastes in a more suitable manner. Moreover, the modules of the integrated waste management system and their connections are presented in Figure 7-6 (Forbes et al., 2001). The scheme illustrates the general potentials of the MSW flow starting from the "cradle" solid waste input, and finishing at the waste "grave" landfill. The entire waste stream, or only a part thereof, can flow through several stages, creating different economic and environmental effects. The stages in the model are "sorting", "biological and thermal treatments" and, finally, landfilling.

The detailed structure of the model is far more complex. For example, the element illustrated in the scheme as the "thermal treatment" is developed in a detailed scheme into "Refuse-Derived Fuel (RDF) burning" or "mass-burning incinerator of solid waste" or burning as fuel "source-separated paper and plastic". Each of these facilities has various impacts on the society, environment, and economy. In addition, choosing one of these

options determines, to various extents, the selection of the biological treatment, together with the selection system. The various elements of the model are very much connected and the model must be seen as a unity. The detailed model of the system is shown in Figure 7-7 (Forbes et al., 2001).

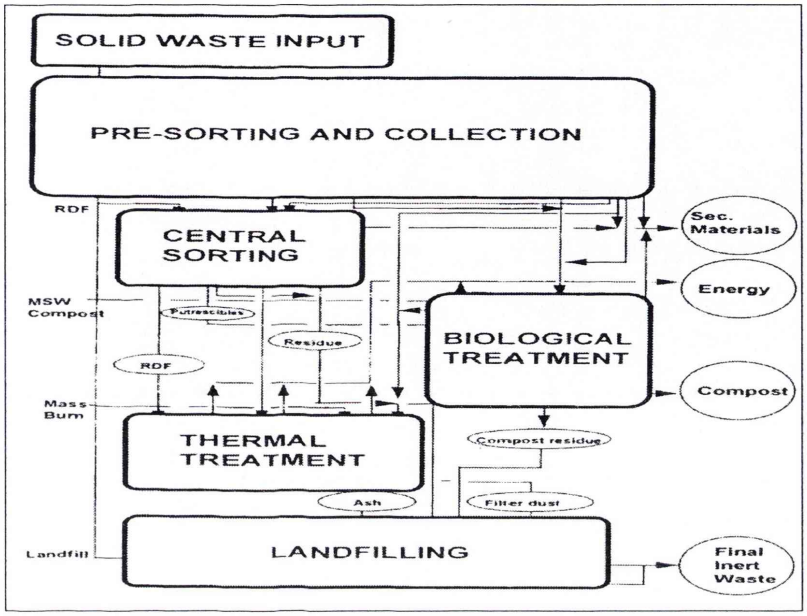


Figure 7-6 Components of Integrated Waste Management System (Forbes et al., 2001)

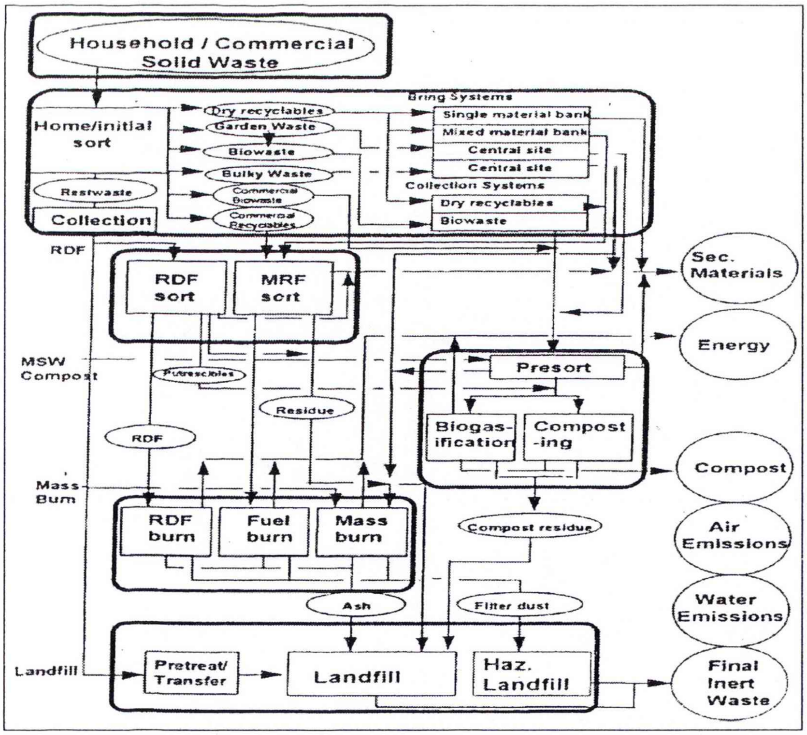


Figure 7-7 Detailed Structure of Integrated Waste Management System (Forbes et al., 2001)

Forbes et al., (2001) illustrated not only the conceptual model, but also illustrated the spreadsheet in order to calculate the economic and environmental impacts of the different waste strategies. The spreadsheet is primarily based on the average flow data. The necessary input data are the household (domestic) and commercial waste streams, calculated as the product of the unit waste steams and the number of dwellings. The waste stream is analysed in the following parts: paper, glass, metals, textiles, organic fraction and yard waste.

The list of the results presents not simply the emission of the compounds, but also the stage of the disposal method at which they are released to the environment, such as sorting, collection, thermal or biological treatment, and landfilling.

Moreover, the outcomes are accompanied by the energy balance of the entire process. The energy production and consumption are calculated not only in GJ, but also in energy media, such as oil, gas, petrol and electricity.

7-7 Application of Integrated Municipal Waste model

When applying the model it is very significant to identify the borders of the scheme, to create consistent and reliable assumptions regarding the waste definitions and to make use of reliable input data. The model is extremely difficult with regard to the amount of input data. The necessary number of data and the essential level of accuracy are extremely high. In the cases of Sydney and Seoul, consistent and reliable estimates of the composition and amounts of waste are difficult. Both industrial and MSW are produced in the cities. Both waste streams are co-disposed and mixed. This generates the problem of estimating the morphology and amount of the MSW stream avoiding the industrial component.

According to Korea Country Report, MSW is primarily defined as the waste produced by households. On the other hand, in Sydney MSW is defined as the waste generated in the community, with the exception of agricultural and industrial wastes.

As previously mentioned, the limitation of this application to the two cities points to the insufficient data. As there are few reliable data regarding the Sydney and Seoul waste stream, the amounts had to be estimated and the estimates verified by comparisons with the amounts of waste disposed of at the landfills, composting facilities and independently collected recyclables.

The comparison of the main parameters characterising the waste streams in Sydney and Seoul presents the main difference between the composition of the waste in the two cities: a higher share of the organic fraction of waste in Sydney and a higher share of paper in the waste stream in Seoul. This significant difference is very typical for the municipalities at different stages of social development (Figure 7-9 and 7-10).

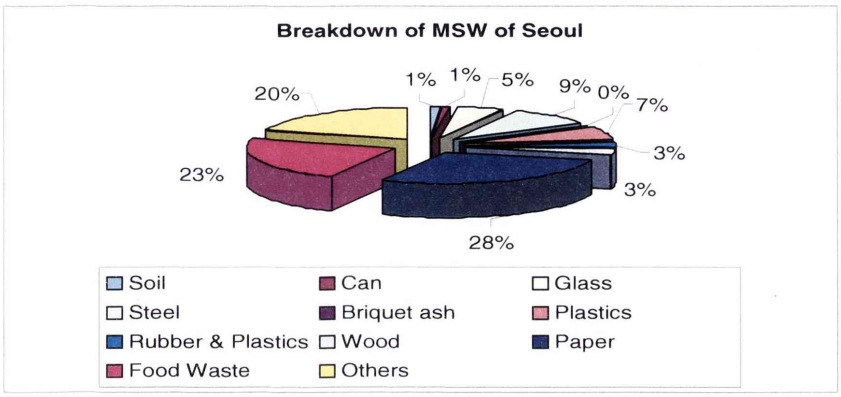


Figure 7-8 Breakdown of MSW of Seoul

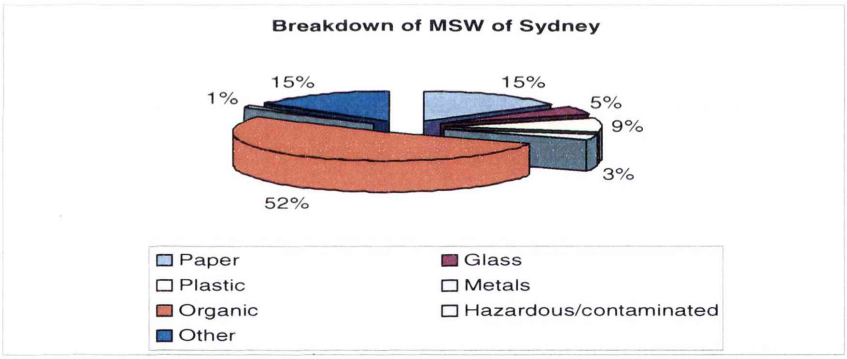


Figure 7-9 Breakdown of MSW of Sydney

7-8 Results

The application of the IMW-2 model to the two cities, Sydney and Seoul, provides results in table form, in which the number of emissions into water and air are presented. Some of the integrated indicators of a waste disposal system are also presented in the study. Table 7-4 illustrates the results of the comparison for the energy consumption, the economic cost, and the landfilled to generated waste ratio.

Table 7-4 Results of Seoul and Sydney MSW Systems Analysis with the Application of IMW-2

Stage of the process	Economic unit cost of waste disposal (U$/kg waste gen.)		Energy unit consumption (MJ/kg waste gen.)		Ratio of landfilled waste to waste generated (kg/kg of waste gen.)	
	Seoul	Sydney	Seoul	Sydney	Seoul	Sydney
Collection	0.076	0.033	0.51	0.64	-	-
Composting	-	0.009	-	0.014	-	-
Incineration	0.028	-	-9.2	-	-	-
Landfilling	0.036	0.029	-0.14	-0.83	0.6524	0.8933
Recycling	0.020	0.011	-1.91	-1.18	-0.2104	-0.2085
TOTAL	**0.160**	**0.081**	**-10.71**	**-1.36**	**0.4420**	**0.6848**

The economic unit cost of the waste disposal in Sydney (8 cents/kg) is half the cost of Seoul's (16 cents/kg) (Table 7-4). The major component leading to the higher cost for Seoul is the collection stage. There are a number of possible factors that affects the higher cost of waste disposal in Seoul. As seen in Pictures 6-1 and 6-4 it can be imagined that congested narrow streets in Seoul with manually handled sacks compared to mechanically handled bins on wide empty streets in Sydney requires more personnel and more time requirement to cope with waste management collection process in Seoul. Also fuel price for transporting the waste between two cities is more than twice. Even though wages for waste collectors in both cities were calculated based on reports from environmental groups, U$12-18/hour in Sydney and U$ 15-22/hour in Seoul, it is not representative to infer that Seoul has higher cost of living compared to Sydney. According to consultant William M. Mercer on the cost of living study released in July 2001, however, living costs in Seoul ranked the 10th in the world while Sydney ranked as 38th. The survey covered 144 cities in the world and measured the comparative costs of over 200 items in each location. These included the cost of food, housing, clothing, and household goods, together with transport and entertainment (Table 7-5). The higher cost of living in Seoul can account for the discrepancies and differences in prices and wages between the two cities. For example, it can be said that the cost of labour and equipment is higher in Seoul, directly increasing the cost of waste collection process. The presence of the cost of labour and equipment in the stage of waste collection process (total collection cost), is related to the capacity of the

equipment. The cost of collection systems in both cities, in particular, labour and equipment can be reduced if the waste collection process is scheduled by considering the complete use of volumes available in collection vehicles. Moreover, the complex issue of work ethic differs between the cities. The amount of work entrusted on each waste collector varies between each city. On the whole, the collection system is a complex and expensive system to analyse. The main reasons for this are that it involves people, equipment, levels of services, plus the possibility of numerous variations in secondary factors such as road factors, service density, climatic factors and human factors.

Table 7-5 Cost of Living

Rank 2001	Rank 2000	City	Index 2001	Index 2000
1	1	Tokyo, Japan	134	164.9
2	5	Moscow, Russia	132.4	136.1
3	3	Hong Kong	130	141.5
4	4	Beijing, China	124.4	138.3
5	2	Osaka, Japan	116.7	143.6
6	6	Shanghai, China	114.3	128
7	8	St. Petersburg, Russia	106.5	109
8	13	New York City, USA	100	100
9	9	Guangzhou, China	97.4	107.9
10	**7**	**Seoul, Korea**	**95.3**	**107.9**
11	14	Hanoi, Vietnam	94.3	94.9
12	11	Taipei, Taiwan	92.9	102.8
13	10	London, UK	92.9	106.9
14	12	Shenzhen, China	90.8	100.1
15	16	Ho Chi Minh City, Vietnam	90.4	92.7
16	15	Singapore	86.4	94.7
17	30	White Plains NY, USA	85.5	84
18	19	Tel Aviv, Israel	85	85
...	....	.....	....	...
27	28	Sydney, Australia	74.3	74.3

In addition, the unit cost of waste landfilling is high in Seoul relative to Sydney, but in the survey conducted, Sydney respondents stated that the cost of their waste services is very high. Table 7-4 as presented show the actual unit cost of the landfilling and the ratio of landfilled waste the waste generated. The amount of waste that goes to landfill is 69% in Sydney, but only 45% in Seoul. In Sydney, the process of incineration is not that advanced; the municipality has closed incinerator facilities due to pollution levels and community opposition, but Sydney is proposing a new incinerator in order to deal with waste (Greenpeace, 2003). The energy consumption by the systems in the two cities is negative. This means that the energy recovered at the landfill site in the form of the landfill gas or heat in the incinerator plus the energy saved credits to the recycling program is larger than the energy needed for processing the waste. However, Seoul city has incineration facilities (US$20-27/tonnes) in which the energy recovery rate is higher than at the landfill site.

The waste cost standard WCs is the equation used in calculating the economic cost of waste disposal for the two cities (Thomas et al., 1999):

$$WCs = (Ls + Es + Ts + Fs)*W \qquad [Eq.1]$$

Where;

WCs = total cost (U$)

Ls = estimated labour cost for collecting, composting, incineration, landfilling and Recycling (U$/tonne)

Es = equipment costs for collecting, composting, incineration, landfilling and recycling

Ts = transportation costs, including labour and equipment (U$/tonne)

Fs = dumping and disposal fees (U$/tonne)

W = weight of waste material (tonne)

To estimate the total amount of the household waste the researcher estimated and added up the waste. The total amount of household waste in Seoul is the sum of waste produced by permanent residents (10,276,968 people) plus waste generated by temporary residents (201,488 people) and by the tourists (102,882 people). The calculations were made assuming that the average citizen of Seoul generates 373.4 kg of household waste per year. That means that the permanent residents of Seoul generate about 3,837,418 tonnes of waste yearly and temporary residents 75,235 tonnes of waste. If the average tourist spends

one day in the city and generates an equivalent amount of waste as the permanent resident, that is 0.4 kg per day, the total amount of household waste generated in Seoul can be estimated:

$$3,837,418 + 75,235 + 41,153 = 3,953,806 \text{ [tonnes/year]}$$

On the other hand on Sydney, assuming that the average citizen of Sydney generates 350 kg of household waste per year, that means that the permanent residents (146,297 people) of City of Sydney generate about 51,203 tonnes of waste yearly and temporary residents (21,407 people) 7,492 tonnes of waste. If the average tourist (1,898 people) spends one day in the city and generates an equivalent amount of waste as the permanent resident, that is 0.1 kg per day, the total amount of household waste generated in the City of Sydney area can be estimated:

$$51,203 + 7,492 + 190 = 58.885 \text{ [tonnes/yr]}$$

For the entire Sydney area of about 4 million people the total of household waste is estimated to be about 1.2 million tonnes which is about one quarter of Seoul's household waste

The Seoul metropolitan government established a new waste policy direction from landfill to incineration in 1991, by which each independent local district had to create an incineration plant for the treatment of the local waste generated in their district. This system was called the "do-it-yourself-principle". Seoul, however, faced increasing opposition from local residents who lived near the potential facility sites. This particular situation resulted in the waste management policy deadlock and the war on waste in Seoul.

The national governments and Seoul metropolitan government recognised and identified the nature of the waste dilemma for the city: constructing new waste facilities cannot be the main option for managing and controlling MSW; it should be approached in a comprehensive way.

The Integrated System of Waste Management (ISWM) was introduced in order to address the problem in Seoul. The Korean national government developed legislative initiatives such as the amendment of the *Waste Management Act* in order to promote recycling (September, 1991), the volume-based waste charge system in January, 1995, and the Separate Collection scheme among others. The main goals of these measures were the

minimisation of waste generation and the promotion of resource recovery and recycling. The result of this policy appeared shortly after its implementation. The volume-based waste charge system contributed significantly in terms of lessening the waste volume and amount and promoting recycling. The policy also facilitated dynamic citizen participation in Seoul.

One of the main objectives of the waste disposal system is to minimise or reduce the waste stream that enters the landfill. Landfilling is seen as the last resort of waste disposal. The ratio of the landfilled waste to the ratio of waste generated is an indicator of how municipalities are efficient and competent with their waste disposal systems. In Sydney, this indicator is a significant 1.5 times higher than in Seoul (Table 7-4). This is primarily attributed to the application and development of the incineration technology of Seoul and the extensive application and development of recycling could have some positive effect, but it has had a marginal impact on the waste disposal ratio.

Moreover, the ISW model, or the White model, also provides information regarding the environmental emissions generated during the whole process of waste disposal. Such relevant information is too excessively fragmented to allow any effective analysis of the different disposal systems. According to the U.S Environmental Protection Agency (1995) there are 12 methods involved in distinguishing the impact of man's activities and pursuits on human health, natural resources and/or ecosystems. Not all the 12 methods can be made use of in all cases and several are more suitable for assessing particular impact categories. The method of the Environmental Standards Relation (ESR) appears to be the most appropriate for the analysed case. The underlying principle of ESR is to evaluate the chemical releases to air, water, and land based on their relative potential human and environmental impacts. The emission fee was mainly used as a media detail weighting factor. If the emission fee completely covers the external cost of the pollution, by estimating the total fee one can acquire the total cost to the environment caused by each option of the MSW disposal.

The local government of South Korea has implemented a regulation restricting dioxin emission, but it happens that if treating the utmost acceptable concentration of the pollutant in the ambient air as an indicator of the components' toxicity, the emission regulations for the different pollutants are inconsistent or unreliable with their toxicity. Presuming that the utmost allowable concentration of different pollutants is the superior indicator of the toxicity, the new, modified or customised emission regulations were calculated. For every component, the modified regulations emission has been set, but the utmost limit is too high, and it is still questionable whether the regulations will be followed.

Such a method leads to one indicator for the environmental impact of the entire waste disposal system. Moreover, in applying such a method, both environmental and economic impacts are in very similar monetary units, and that fact enables the direct comparison of the systems. The comparison and assessment of the MSW disposal systems of the two cities is presented in Table 7-6. The present and future MSW systems in Sydney are compared with the present system in Seoul. The future system in Sydney was analysed presuming it is processing the current amount of waste. However, the future stage in Sydney is the stage of the municipal waste disposal upgrade and improvement program with assumption that there is a program of incineration facilities in Sydney.

Table 7-6 Comparison of Sydney and Seoul MSW disposal system

	Sydney present stage	Sydney future stage	Seoul present stage
1. Waste stream (kg)	1,200,000,000	1,200,000,000	3,952,806,000
2. Economic cost of waste disposal on application of IMW model (U$)	14,472,089	28,721,101	39,612,258
3. Economic unit cost (U$/kg)[2÷1]	0.012	0.024	0.01
4. Environmental unit cost (per kg of waste)(U$/kg)	-0.000038	0.00019	0.00009
5. Total disposal cost per kg of waste (U$/kg)[3+4]	0.012	0.024	0.010

The present cost of one kilogram of disposal waste in Sydney is quite similar with the cost of Seoul's, but if the system in Sydney is modified and the proposed incinerator is built, the costs in the two cities will be quite different. It is a theoretical prediction of the cost of incineration in the future. The cost is high as the incineration process involves several distinct stages: the burning process, energy recovery, emission control and treatment of solid residues. In the case of landfill, the cost involves transport of the waste from the source and cost of dumping. However, in the case of incineration, there are transport costs, cost of incineration and also cost of transport of remaining solid waste generated from incineration (though comparatively much less than the initial amount of waste). But, incineration technologies are very efficient alternatives to cope with environmental needs, if operated properly. The requirements of rigorous mandatory

emission control and concerns from the public necessitate continuous development of advanced technologies and renovated facilities. Updated equipments and running incineration facilities could be one of the main factors of increasing economic cost of disposal of waste in Sydney in the future. Also, a huge public education cost to convince the public for accepting the facilities will also be involved.

The present environmental impact of the Sydney system is negative. That means that the avoided emission, attributed to the recycling, is greater than the emission caused by the residual waste disposal and collection treatment. The positive effect will be eliminated if the new system or model is introduced in the municipality of Sydney; the environmental cost of the residual waste treatment in the detailed structure will be greater than the environmental advantages from the recycling process. The emissions in Sydney and in Seoul will be comparable (Appendix 3), but the emissions in Sydney will be greater primarily due to the lower efficiency of the waste recycling programs. Moreover, the environmental impact, expressed in economic terms, is insignificant or irrelevant to the economic cost of the disposal of waste. The environmental cost is not greater than 1% of the economic cost and the economic cost alone seems to be the indicator of the waste disposal system.

7-9 Conclusion

This chapter has demonstrated an application of the integrated MSW analysis model developed by White, in particular to the IMW-2 model. The model is applied to the Sydney and Seoul areas and analyses and compares the MSW disposal strategies. The essence of the MSW management approach is to deal with the impacts generated by the waste collection, composting, incineration, landfill and recycling.

The application of the MSW analysis to the two different cities provided an interesting comparison of economic cost, environmental cost and disposal cost. For example, the cost of disposal is quite similar between the two cities. The result does not clearly confirm the environmental superiority of the incineration over the landfill. However, if an incineration facility is introduced in Sydney, an increase of the economic cost of the system will occur. Even though these comparisons are not 100% rigorous, this analysis is still useful for giving some estimation of future MSW management strategies.

Through this, planners will be able to predict and evaluate the likely economic and environmental benefits of any integrated waste management system. On the periphery is the concept that, while IMW-2 model focus on economic and environmental concerns, they also consider some social concerns. As mentioned in Chapters 4, 5 and 6 public participation strengthens the planning profession by increasing the visibility and value of planning in the public's eye.

Chapter 8 Conclusion and Recommendations

The previous chapters have shown that it is not sufficient to rely on the waste management hierarchy in designing sound solid waste management systems. In global cities like Sydney and Seoul, and to some extent cities from developing countries, what is needed is an integrated waste management system that addresses not only socio-cultural and socio-political concerns, but also cost and environmental issues. To achieve this, MSW management programs must be based on the life-cycle philosophy, filling in the gap to assess the economic affordability of waste systems, to evaluate the environmental effects involving a product or process, to implement ways to improve or lessen these impacts, and to call for greater public participation in the MSW management program.

This study acknowledges that MSW management is not a simple task. To understand the complexity of MSW, the study attempted to compare, primarily through a case study, the MSW management systems of Sydney and Seoul. This study covered Sydney and Seoul and how MSW are managed in these two cities. To achieve this, a number of objectives were set for increasing the sustainability of MSW management in Sydney and Seoul. These were limited to: minimising waste; stabilising waste production; quantifying waste flows; maximising environmentally sound waste reuse and recycling; developing national programs for waste management research and practice; raising public awareness; and promoting environmentally sound waste disposal. MSW management planners, developers, and policy-makers should plan and implement an effective MSW management strategy, taking into account all the economic, technical, and environmental objectives.

The conclusions derived from this study are divided into two topic areas, one which determines the attitude of the public toward household waste management in two cities and the second which analyse and compares the MSW management systems in two cities.

8-1 Survey Results

To meet the objectives of this study, a survey was conducted. The primary aim of this survey was to determine the attitude of the public toward household waste management in Sydney and Seoul. There were 150 respondents each for the two cities. The survey included the respondents' gender, employment status, educational attainment, the type of property in which they were living, and the number of people in the household. The survey

also wanted to establish whether the respondents in the two cities were concerned about the environment, if they were involved or willing to be involved in any activity to help protect and preserve the environment, how important household waste management is for the preservation of the environment and the conservation of natural resources, and the most important practices in waste management. Moreover, the respondents were also asked how they practised household waste management, and about their reluctance to participate in waste management.

The result of the survey shows that, to some extent, MSW management systems in Sydney and Seoul do not differ significantly. Through a structured, focused comparison of the household waste management and practices of the two cities, it was found that, in terms of their knowledge about the environment, respondents from Sydney are slightly more concerned with the environment than their counterparts in Seoul. It was also found that respondents from both cities prioritise education second only to the environment. Furthermore, Sydney residents are more willing to protect the environment. It can therefore be concluded that Sydney residents are more participative than Seoul residents.

In relation to the knowledge of household management in the two cities, the result showed that Sydney and Seoul residents value the importance of household waste management in preserving the environment and natural resources. They also stated that their respective waste services councils manage household waste through the use of landfill and recycling, showing their awareness of the services. Respondents from Sydney were more ready than their Seoul counterparts to practise waste avoidance and material reuse generation and reuse material rather than undertaking further waste management practices in their households. In addition, more Sydney respondents are involved in recycling, and Seoul respondents are more enthusiastic in learning more about household waste management, preferring the Internet and newspapers as their sources of information. It is concluded that, based on their fast-paced lifestyle, residents from Sydney and Seoul would prefer ready information at a time that is convenient for them.

With regard to household waste management, the survey suggests that there is a high level of difference between Seoul and Sydney respondents in terms of segregating their wastes. Although Seoul respondents have a high regard for the environment and are knowledgeable about household waste management, in practice they do not apply what they know, in sharp contrast to Sydney respondents. This shows that Sydney respondents take an active role in protecting the environment through waste management. Moreover,

the result shows that, in terms of the respondents' estimation, the cost of waste services provided by the Sydney respondents' councils are higher than waste services in Seoul.

Compared to Sydney residents, Seoul residents are less satisfied with their waste services; Sydney respondents are more satisfied with their local waste services; Seoul residents are more dissatisfied with the high cost of bags for the volume-based waste charge system; Sydney residents, on the other hand, are less satisfied with the size of their bins. Seoul residents suggest the use of stronger bags, whereas Sydney residents call for more frequent collection of the waste services. Generally, the study does not suggest that Seoul residents are not satisfied with their local waste services, rather they are less satisfied with their local services councils compared to Sydney respondents.

Seoul residents do not consider glasses, milk/juice cartons and newspaper as recyclable wastes; Sydney residents consider these items as important to segregate for the kerbside recycling; Sydney residents use their recycling services more often; Seoul respondents do not recycle all the time because of too much inconvenience and lack of time; Sydney respondents recycle and segregate most of the time. This is consistent with the finding that Sydney residents are better at recycling compared to Seoul residents. This can be attributed to the greater effort expended by the Sydney residents in cooperating with their waste services councils than that of Seoul residents.

8-2 Application of IMW-2 Model on Sydney and Seoul

When applying and modifying the model it is very significant to define the borders of the systems to create reliable assumptions regarding the waste definitions and to make use of reliable input data. The model is very challenging in terms of the amount of input data that will be considered. The necessary number of data and the required level of accuracy are very high. In the cases of Sydney and Seoul many assumptions have been made as it is very difficult to obtain reliable and consistent data.

The IMW-2 model illustrates the results of the analysis of the application. The amount of information is extremely great, but it does not provide a comprehensive answer regarding the position of the options. The costs of the different options in the application of IMW-2 model are presented both as the total costs and also with boundaries on various stages of the waste disposal process. Making the system or the method more complex increases the cost. The first stage of waste management is the collection process, which is

the most expensive stage of the process. The cost of this stage is approximately 50% of the total cost of the system.

Application of the IMW-2 for comparison of the Sydney and Seoul MSW systems has led to some conclusions. Some of the conclusions are of broad character and some are more specific:

- The data for the comparison studies is very difficult to obtain, because in the different systems there are various definitions of MSW and there are various statistical methods employed in the analysis;
- The economic comparison of MSW management systems in the two cities brings further uncertainty and improbability, making the international comparisons more difficult;
- Social impacts of the MSW management is not taken into consideration in this analysis;
- Introduction of incineration facilities and advanced recycling schemes more than doubles the economic cost of the system;
- Both in Sydney and in Seoul, the environmental impact of the system will be measured as the cost of the emissions, which is insignificant or irrelevant in comparison with the economic cost of waste disposal.

8-3 Recommendations

The result of the IMW-2 model is a set of the total emissions of the different components to water and air as well as the statistics regarding the energy consumption and the volume of solid waste disposed of. The economic information concerning the system is also considered.

Moreover, this study has shown that Sydney and Seoul are taking pro-active steps in managing MSW. However, there are areas that need improvements to fully develop sound MSW management systems in the two cities. In line with addressing the attitude of the public toward household waste management in the two cities and the application of the IMW-2 model, the researcher recommends that:

1. Citizens should take an active role in the establishment of waste-related policies from the very first stage. This can be completely successful if the governments

in Sydney and Seoul implement promotional campaigns and educational programs for their citizens.

2. More co-production partnership between the citizens and their local governments is necessary as the key issue in helping to solve issues of local concern, such as optimizing household waste management strategies.
3. Recycling activities in the household or in the community in both cities should be encouraged by providing incentives. To be able to treat recyclable items in an efficient manner, the recycling industry should be supported by the government.
4. There should be more reliable and accurate data in regards to waste management available to the public as there may be some reluctance to provide such data due to the fear of releasing commercially sensitive information.
5. Developing an optimal waste management system for any given region should in part, depend on local needs and priorities. In this case, compromise is inevitable.
6. A further study comparing cities from underdeveloped countries, developing countries, and different groups within a country in terms of their perception of MSW management should be conducted.

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Appendix 1

A sample of survey

OUR ATTITUDE TOWARD HOUSEHOLD WASTE MANAGEMENT IN SYDNEY URBAN AREA

CLASSIFICATIONS

1. Are you male or female?

1-1 ( ) Male
1-2 ( ) Female

2. What type of property are you living in? (Tick one)

2-1 ( ) Single dwelling with garden
2-2 ( ) Flat/apartment/unit
2-3 ( ) Other

3. How many people live in your household? (Tick one)

3-1 ( ) 1 – 2 persons
3-2 ( ) 3 – 4 persons
3-3 ( ) 5 – 7 persons
3-4 ( ) more than 7 persons

4. Which of the following best describes your household? (Tick one)

4-1 ( ) A one person household
4-2 ( ) A couple or family
4-3 ( ) A group household (individuals sharing)
4-4 ( ) Other

5. What is your employment status at the moment? (Tick one)

5-1 ( ) Full-time
5-2 ( ) Part-time
5-3 ( ) Home duties
5-4 ( ) Student
5-5 ( ) Retired
5-6 ( ) Self employed
5-7 ( ) Not employed
5-8 ( ) Other

6. What is the highest educational qualification obtained? (Tick one)

6-1 ( ) Primary
6-2 ( ) Secondary
6-3 ( ) Tertiary
6-4 ( ) Post-Graduate
6-5 ( ) Other

GENERAL VIEW OF THE ENVIRONMENT

7. Are you concerned about the environment? (Tick one)

7-1 ( ) Yes, very much
7-2 ( ) Yes, fairly
7-3 ( ) No, not really
7-4 ( ) No, not at all
7-5 ( ) Other

8. How much do you think you as an individual can do to help the environment? (Tick one)

8-1 ( ) A great deal
8-2 ( ) A moderate amount
8-3 ( ) Not sure
8-4 ( ) A little bit
8-5 ( ) Nothing

9. Have you involved or are you willing to involve any activities to help protect the environment? (Tick one)

9-1 ( ) Yes
9-2 ( ) No
9-3 ( ) Not sure

10. Please, indicate what are the most important issues to you. (Tick one or more than one)

10-1 ( ) Public health services
10-2 ( ) Natural resources
10-3 ( ) Waste

10-4 ( ) Environment
10-5 ( ) Housing
10-6 ( ) Public transport
10-7 ( ) Education
10-8 ( ) Employment

KNOWLEDGE OF HOUSEHOLD WASTE MANAGEMENT

11. How important is the household waste management to the preservation of the environment and the conservation of our natural resources? (Tick one)

11-1 ( ) Very important
11-2 ( ) Important
11-3 ( ) Not really important
11-4 ( ) Not at all important
11-5 ( ) Don't know

12. What do you think happen to household waste (not recyclable) after it is taken away from your house? (Tick one)

12-1 ( ) Bury at landfill site
12-2 ( ) Burn in incinerator
12-3 ( ) Recycle or re-use
12-4 ( ) Dump at sea
12-5 ( ) Other
12-6 ( ) Don't know

13. Please indicate which one is more important than others in regard to household waste management.(Tick one)

13-1 ( ) Avoiding waste
13-2 ( ) Re-using materials
13-3 ( ) Recycling materials
13-4 ( ) Proper waste disposal
13-5 ( ) Don't know

14. Would you be interested in learning more about how to deal with your household waste? (Tick one)

14-1 ( ) Certainly
14-2 ( ) Perhaps
14-3 ( ) No

14-4 ( ) Don't know

15. Which of the following would you prefer to get most of information on waste management from? (Tick one or more than one)

15-1 ( ) Local council
15-2 ( ) Internet
15-3 ( ) Local newspaper
15-4 ( ) Local library
15-5 ( ) Community meeting
15-6 ( ) Media (TV/radio)
15-7 ( ) Environmental group
15-8 ( ) Other

HOUSEHOLD WASTE MANAGEMENT

16. How important do think it is reducing household waste at home? (Tick one)

16-1 ( ) Very important
16-2 ( ) Fairly important
16-3 ( ) Not important
16-4 ( ) Don't know

17. How well do you thing in general you separate your household waste? (Tick one)

17-1 ( ) Very well
17-2 ( ) Fairly well
17-3 ( ) Average
17-4 ( ) Not really
17-5 ( ) Don't know

18. How much approximately do you think it costs your council to take away and dispose of your household waste each year? (Tick one)

18-1 ( ) < A$ 50
18-2 ( ) A$ 50 – A$ 100
18-3 ( ) A$100 – A$ 200
18-4 ( ) A$ 200 – A$ 300
18-5 ( ) > A$300

19. How do you rate your council's current household waste collection service? (Tick one)

19-1 ( ) Very satisfactory
19-2 ( ) Satisfactory
19-3 ( ) Unsatisfactory
19-4 ( ) Very unsatisfactory
19-5 ( ) Don't know

20. Please indicate what you are currently doing at the moment to try to reduce the amount of household waste generated. (Tick one or more than one)

20-1 ( ) Recycling more
20-2 ( ) Composting
20-3 ( ) Refuse plastic bags at the shop
20-4 ( ) Select products with less packaging
20-5 ( ) Buy products with recycled content
20-6 ( ) Reduce the use of disposable products
20-7 ( ) Buy products in bulk
20-8 ( ) Nothing in particular
20-9 ( ) Don't know

21. Do the following reasons make you reluctant to fully commit with household waste collection service? (Tick one or more than one)

21-1 ( ) Too much effort
21-2 ( ) Bin is too small
21-3 ( ) Bin not collected often enough
21-4 ( ) Problems with collectors (too noisy, messy, etc)
21-5 ( ) Bin is too heavy/bulky/awkward
21-6 ( ) Can't put garden waste in household waste bin
21-7 ( ) Other

22. Please indicate what you would like to see to make more efficient household waste collection service in your area. (Tick one or more than one)

22-1 ( ) Bigger bin
22-2 ( ) More frequent collection
22-3 ( ) Less noisy/smelly when collection taking place
22-4 ( ) Different time scheme collection
22-5 ( ) More friendly collectors
22-6 ( ) Other
22-7 ( ) Don't know

RECYCLING COLLECTION

23. Which items below do you currently separate for kerbside recycling collection? (Tick one or more than one)

23-1 ( ) Glass
23-2 ( ) Newspapers
23-3 ( ) Cardboard or other papers
23-4 ( ) Plastic bottles
23-5 ( ) Aluminum cans
23-6 ( ) Steel cans
23-7 ( ) Milk/juice cartons
23-8 ( ) Garden waste/clippings
23-9 ( ) Other
23-10 ( ) None of them

24. How often use the kerbside recycling service? (Tick one)

24-1 ( ) Always
24-2 ( ) Most of the time
24-3 ( ) Some of the time
24-4 ( ) Hardly ever
24-5 ( ) Not at all
24-6 ( ) Don't know

25. Which of the following statements come closest to how you feel about recycling? (Tick one)

25-1 ( ) The more the better
25-2 ( ) A lot, but not everything that can be recycled
25-3 ( ) Don't recycle much
25-4 ( ) Don't recycle at all

26. If you are not fully committed to recycling, why? (Tick one)

26-1 ( ) Too much hassle
26-2 ( ) Shortage of spaces
26-3 ( ) No time for that
26-4 ( ) Forget that
26-5 ( ) Not worth

26-6 ( ) Unsure of what to recycle
26-7 ( ) Other
26-8 ( ) Not applicable

27. In the near future, are you willing/likely to increase your recycling efforts? (Tick one)

27-1 ( ) Certainly
27-2 ( ) Think about it
27-3 ( ) Don't care
27-4 ( ) Other

28. Please indicate which of following items you have thrown away recently that could have been recycled. (Tick one or more than one)

28-1 ( ) Glass bottles
28-2 ( ) Plastic bottles
28-3 ( ) Aluminium cans
28-4 ( ) Newspaper
28-5 ( ) Milk/juice cartons
28-6 ( ) Garden waste/clippings
28-7 ( ) None of them
28-8 ( ) Don't know

29. How satisfied are you with your kerbside recycling service? (Tick one)

29-1 ( ) Very satisfied
29-2 ( ) Fairly satisfied
29-3 ( ) Fairly dissatisfied
29-4 ( ) Very dissatisfied
29-5 ( ) Don't know

30. Please indicate what makes better in kerbside recycling arrangement in the future. (Tick one or more than one)

30-1 ( ) More frequent service
30-2 ( ) More reliable service
30-3 ( ) Simpler/ease of use
30-4 ( ) Less fussy about what can be collected
30-5 ( ) Quieter/less messy operation
30-6 ( ) Bigger split bin
30-7 ( ) Need a container dedicated to recycling

30-8 ( ) None of them
30-9 ( ) Don't know

31. Who in your household is responsible for recycling? (Tick one)

31-1 ( ) Male/father/husband
31-2 ( ) Female/mother/wife
31-3 ( ) Teenage child
31-4 ( ) Other
31-5 ( ) No one
31-6 ( ) Don't know

32. To what extent do the following influence you to recycle? (Tick one or more than one)

32-1 ( ) Preservation of the environment and the conservation of natural resources
32-2 ( ) limited space for landfill
32-3 ( ) Moral (for children/future generations)
32-4 ( ) Economically sensible to recycle
32-5 ( ) Social (community spirit)
32-6 ( ) Not enough room in the garbage bin
32-7 ( ) Enthusiastic about recycling
32-8 ( ) Other
32-9 ( ) Don't know

33. How do you feel about recycled products compared with non-recycled products? (Tick one or more than one)

33-1 ( ) Better quality
33-2 ( ) Less expensive
33-3 ( ) Not much different
33-4 ( ) Better for the environment
33-5 ( ) Likely to buy

VIEWS ON NEW IDEAS

34. What do you think if volume-based waste charge system (charged per bag/bin to encourage recycle more and generate less waste) is introduced in your area?(Tick one or more than one)

34-1 ( ) Fair idea for charging according to the amount of waste produced

34-2 ( ) Resulting more recycling
34-3 ( ) Financial incentive needed
34-4 ( ) Don't know

35. Which following activities in regard to household waste management would be prepared to take place in your area? (Tick one or more than one)

35-1 ( ) Introduction of the volume-based waste charge system
35-2 ( ) Introduction of community composting facilities in my area
35-3 ( ) More frequent workshops/public events about recycling, composting etc
35-4 ( ) Practical guidance on environmentally friendly way for shopping
35-5 ( ) Easy access to information on household waste management through media
35-6 ( ) Adopting heavy enforcement

36. Do you think the discontinuation of plastic bags from shops to be? (Tick one)

36-1 ( ) Very good
36-2 ( ) Good
36-3 ( ) inconvenient
36-4 ( ) Don't care

37. If local supermarkets gave money reward, how likely would you be to return bottles and containers? (Tick one)

37-1 ( ) Very likely
37-2 ( ) Fairly likely
37-3 ( ) Unlikely
37-4 ( ) Don't brother
37-5 ( ) Don't know

38. Please indicate preference for household payment for waste collection services? (Tick one)

38-1 ( ) All household pay the same
38-2 ( ) Use smaller bin, pay less/Recycle more, pay less
38-3 ( ) Other
38-4 ( ) Don't know

COMPOSTING

39. Do you have a compost heap or worm farm being used on regular base? (Tick one)

39-1 ( ) Yes
39-2 ( ) No
39-3 ( ) Not sure

40. What is the reason for not having a compost heap/worm farm? (Tick one or more than one)

40-1 ( ) Live in a flat/apartment/townhouse
40-2 ( ) No time for it
40-3 ( ) Limited yard space
40-4 ( ) No food scraps/kitchen waste
40-5 ( ) Smelly- attract flies/vermin
40-6 ( ) Scraps are fed to pets
40-7 ( ) No information available
40-8 ( ) Not affordable of container
40-9 ( ) Complication of maintenance
40-10 ( ) Don't bother
40-11 ( ) Other
40-12 ( ) Don't know

41. What do you think the advantages/disadvantages of the composting would be? (Tick one or more than one)

Advantages
41-1 ( ) Useful profitable product
41-2 ( ) Good use of waste
41-3 ( ) Less waste to landfill

Disadvantages
41-4 ( ) Smell
41-5 ( ) Cost
41-6 ( ) Takes up spaces
41-7 ( ) Vermin concerns
41-8 ( ) Too much effort/time
41-9 ( ) No incentives

Appendix 2

Waste Minimisation and Management Act 1995

WASTE MINIMISATION AND MANAGEMENT ACT 1995 No 102

UPDATED 17 APRIL 2000

NO AMENDMENTS (SINCE REPRINT No 1 OF 4.4.2000)

DOES NOT INCLUDE AMENDMENTS BY:
Pollution Control Amendment (Load-based Licensing) Act 1997 No 146 (not commenced)

REPRINT HISTORY:
Reprint No 14 April 2000

Reprinted as at 4 April 2000

[STATE ARMS]

New South Wales

Waste Minimisation and Management Act 1995 No 102

Contents

Scenario: SYDNEY
Results: Air Emissions

	Units	Collection	Sorting	Biological	Thermal	Landfill	Recycling	Total
Particulates	g	5.532E+08	3.587E+06	Zero	Zero	Zero	3.969E+07	5.965E+08
CO	g	9.456E+07	4.230E+05	Zero	Zero	2.576E+06	-3.600E+08	-2.624E+08
CO2	g	4.792E+11	3.011E+09	Zero	Zero	1.822E+11	-4.947E+10	6.149E+11
CH4	g	1.064E+09	7.128E+06	Zero	n/a	8.096E+10	-1.471E+08	8.188E+10
NOx	g	1.267E+09	6.461E+06	Zero	Zero	Zero	-1.188E+08	1.154E+09
GWP	g	5.036E+11	3.170E+09	Zero	Zero	1.882E+12	-5.215E+10	2.337E+12
N2O	g	6.632E+06	2.907E+04	Zero	n/a	Zero	1.321E+06	7.982E+06
SOx	g	2.586E+09	1.585E+07	Zero	Zero	Zero	-3.476E+08	2.254E+09
HCl	g	7.177E+07	5.345E+05	Zero	Zero	1.339E+07	6.008E+05	8.630E+07
HF	g	6.944E+06	5.253E+04	Zero	n/a	2.679E+06	9.640E+05	1.064E+07
H2S	g	Zero	Zero	Zero	n/a	4.122E+07	1.865E+05	4.140E+07
TotalHC	g	4.348E+08	Zero	Zero	n/a	4.122E+08	Zero	8.470E+08
ChlorinatedHC	g	2.859E+02	2.174E+00	Zero	n/a	7.213E+06	Zero	7.213E+06
Dioxins/Furans	g	Zero	Zero	Zero	Zero	Zero	Zero	Zero
Ammonia	g	1.166E+06	8.494E+03	Zero	n/a	Zero	1.198E+07	1.316E+07
Arsenic	g	Zero	Zero	Zero	Zero	Zero	-2.605E+06	-2.605E+06
Cadmium	g	8.922E+03	6.277E+01	Zero	Zero	1.154E+03	-2.366E+03	7.772E+03
Chromium	g	Zero	Zero	Zero	Zero	1.360E+02	1.166E+03	1.302E+03
Copper	g	Zero	Zero	Zero	Zero	Zero	6.299E+03	6.299E+03
Lead	g	8.794E+04	6.440E+02	Zero	Zero	1.051E+03	2.106E+06	2.196E+06
Manganese	g	3.748E+04	2.774E+02	Zero	n/a	Zero	Zero	3.775E+04
Mercury	g	1.199E+04	8.469E+01	Zero	Zero	8.449E+00	5.621E+02	1.264E+04
Nickel	g	5.633E+05	4.013E+03	Zero	Zero	Zero	-2.250E+04	5.448E+05
Zinc	g	1.373E+05	9.257E+02	Zero	Zero	1.546E+04	1.673E+03	1.554E+05

Scenario: SYDNEY
Results: Water Emissions

	Units	Collection	Sorting	Biological	Thermal	Landfill	Recycling	Total
BOD	g	2.326E+06	7.045E+02	Zero	n/a	3.916E+08	4.345E+07	4.374E+08
COD	g	1.671E+07	1.404E+04	Zero	n/a	3.916E+08	-6.277E+09	-5.868E+09
SuspendedSolids	g	1.363E+08	9.799E+05	Zero	n/a	1.817E+05	1.002E+08	2.377E+08
TOC	g	4.014E+07	2.203E+05	Zero	n/a	3.635E+05	3.871E+08	4.279E+08
AOX	g	7.793E+03	3.809E+01	Zero	n/a	3.635E+05	-6.359E+07	-6.322E+07
ChlorinatedHC	g	2.308E+03	1.163E+01	Zero	n/a	1.872E+05	1.168E+04	2.012E+05
Dioxins/Furans	g	Zero	Zero	Zero	n/a	5.820E-02	Zero	5.820E-02
Phenols	g	2.111E+05	1.605E+03	Zero	n/a	6.906E+04	2.244E+04	3.042E+05
Aluminium	g	1.674E+08	1.273E+06	Zero	n/a	Zero	-3.181E+07	1.369E+08
Ammonium	g	3.235E+06	2.461E+04	Zero	n/a	3.817E+06	5.105E+05	7.587E+06
Arsenic	g	3.442E+05	2.544E+03	Zero	n/a	2.544E+03	-6.475E+04	2.846E+05
Barium	g	1.676E+07	1.275E+05	Zero	n/a	Zero	-2.278E+06	1.461E+07
Cadmium	g	1.193E+04	8.286E+01	Zero	n/a	2.544E+03	-4.433E+03	1.013E+04
Chloride	g	1.874E+09	1.402E+07	Zero	n/a	1.072E+07	1.701E+09	3.599E+09
Chromium	g	1.717E+06	1.267E+04	Zero	n/a	1.090E+04	-3.247E+05	1.416E+06
Copper	g	8.474E+05	6.261E+03	Zero	n/a	9.814E+03	-1.557E+05	7.073E+05
Cyanide	g	1.101E+04	8.372E+01	Zero	n/a	Zero	-1.765E+08	-1.765E+08
Fluoride	g	4.956E+04	Zero	Zero	n/a	7.088E+04	Zero	1.204E+05
Iron	g	2.305E+08	1.705E+06	Zero	n/a	1.727E+07	-2.147E+05	2.492E+08
Lead	g	3.165E+06	7.695E+03	Zero	n/a	1.145E+04	-1.519E+05	3.032E+06
Mercury	g	3.465E+02	2.268E+00	Zero	n/a	1.090E+02	2.754E+01	4.853E+02
Nickel	g	8.621E+05	6.367E+03	Zero	n/a	3.090E+04	-1.562E+05	7.431E+05
Nitrate	g	5.700E+06	3.733E+04	Zero	n/a	Zero	1.100E+08	1.158E+08
Phosphate	g	1.035E+07	7.493E+04	Zero	n/a	Zero	7.308E+05	1.116E+07
Sulphate	g	1.952E+09	1.437E+07	Zero	n/a	Zero	9.233E+08	2.890E+09
Sulphide	g	7.210E+04	3.761E+02	Zero	n/a	Zero	4.240E+03	7.671E+04

Scenario: SEOUL
Results: Air Emissions

	Units	Collection	Sorting	Biological	Thermal	Landfill	Recycling	Total
Particulates	g	8.351E+05	Zero	Zero	1.714E+06	2.567E+05	-1.024E+06	1.782E+06
CO	g	7.487E+06	Zero	Zero	2.019E+05	3.939E+06	-5.183E+07	-4.021E+07
CO2	g	1.592E+09	Zero	Zero	5.038E+10	3.750E+10	-6.877E+09	8.260E+10
CH4	g	2.450E+06	Zero	Zero	n/a	1.639E+10	-3.248E+07	1.636E+10
NOx	g	2.506E+07	Zero	Zero	3.471E+06	1.121E+07	-1.035E+07	2.939E+07
GWP	g	1.645E+09	Zero	Zero	5.038E+10	3.817E+11	-7.565E+09	4.262E+11
N2O	g	2.182E+03	Zero	Zero	n/a	1.504E+01	-1.847E+04	-1.628E+04
SOx	g	2.962E+06	Zero	Zero	4.769E+06	9.385E+05	-1.280E+07	-4.133E+06
HCl	g	4.596E+04	Zero	Zero	2.870E+05	2.713E+06	1.595E+05	3.206E+06
HF	g	4.614E+03	Zero	Zero	n/a	5.424E+05	1.390E+04	5.609E+05
H2S	g	Zero	Zero	Zero	n/a	8.345E+06	-3.621E+04	8.309E+06
TotalHC	g	4.233E+04	Zero	Zero	n/a	8.345E+07	Zero	8.349E+07
ChlorinatedHC	g	2.780E-01	Zero	Zero	n/a	1.460E+06	Zero	1.460E+06
Dioxins/Furans	g	Zero	Zero	Zero	2.600E-03	Zero	Zero	2.600E-03
Ammonia	g	1.566E+03	Zero	Zero	n/a	1.690E-02	-5.853E+02	9.806E+02
Arsenic	g	Zero	Zero	Zero	4.398E+01	Zero	Zero	4.398E+01
Cadmium	g	3.509E+00	Zero	Zero	1.757E+02	2.337E+02	-3.695E+02	4.341E+01
Chromium	g	Zero	Zero	Zero	2.919E+02	2.754E+01	1.829E+02	5.023E+02
Copper	g	Zero	Zero	Zero	1.634E+03	Zero	9.877E+02	2.622E+03
Lead	g	3.864E+01	Zero	Zero	1.107E+03	2.128E+02	1.785E+04	1.921E+04
Manganese	g	1.880E+01	Zero	Zero	n/a	5.000E-04	Zero	1.880E+01
Mercury	g	6.909E+00	Zero	Zero	2.522E+03	1.711E+00	1.463E+01	2.545E+03
Nickel	g	1.831E+02	Zero	Zero	1.709E+03	3.001E-01	-5.670E+03	-3.778E+03
Zinc	g	7.427E+01	Zero	Zero	7.176E+03	3.130E+03	-3.658E+02	1.001E+04

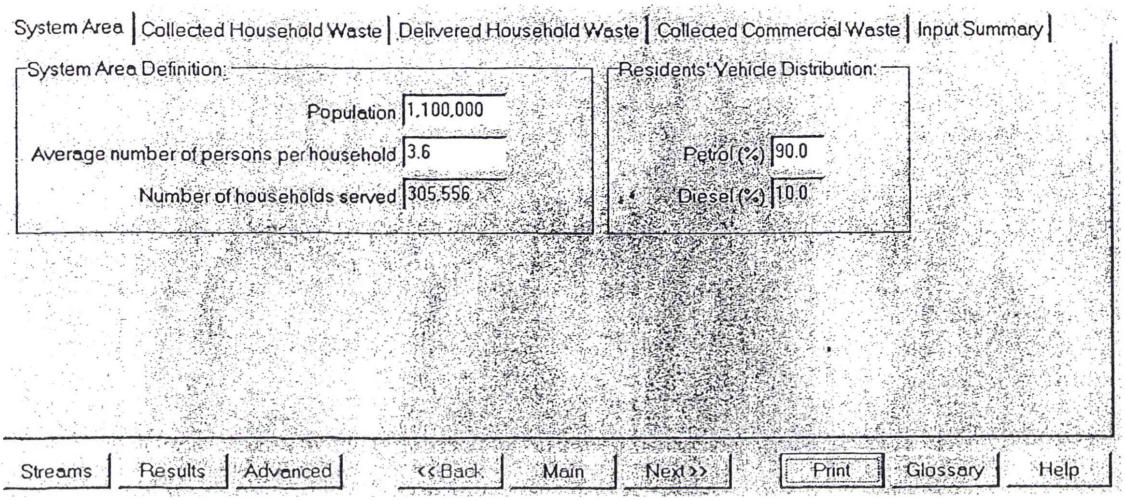
Scenario: SEOUL
Results: Water Emissions

	Units	Collection	Sorting	Biological	Thermal	Landfill	Recycling	Total
BOD	g	2.779E+05	Zero	Zero	n/a	7.935E+07	Zero	7.963E+07
COD	g	9.626E+05	Zero	Zero	n/a	7.935E+07	-1.829E+04	8.030E+07
SuspendedSolids	g	1.459E+06	Zero	Zero	n/a	5.932E+05	-8.048E+05	1.248E+06
TOC	g	2.643E+04	Zero	Zero	n/a	9.832E+04	-8.413E+04	4.062E+04
AOX	g	4.242E+01	Zero	Zero	n/a	9.821E+04	-1.897E+03	9.635E+04
ChlorinatedHC	g	7.312E-01	Zero	Zero	n/a	5.059E+04	1.789E+03	5.238E+04
Dioxins/Furans	g	Zero	Zero	Zero	n/a	1.580E-02	Zero	1.580E-02
Phenols	g	6.983E+01	Zero	Zero	n/a	1.867E+04	-2.085E+03	1.665E+04
Aluminium	g	1.499E+05	Zero	Zero	n/a	2.082E+01	-5.981E+06	-5.831E+06
Ammonium	g	7.821E+03	Zero	Zero	n/a	1.034E+06	-1.961E+04	1.022E+06
Arsenic	g	2.998E+02	Zero	Zero	n/a	6.901E+02	-1.200E+04	-1.101E+04
Barium	g	1.244E+04	Zero	Zero	n/a	2.394E+01	-5.180E+05	-5.055E+05
Cadmium	g	8.992E+00	Zero	Zero	n/a	6.878E+02	-3.043E+02	3.924E+02
Chloride	g	1.226E+07	Zero	Zero	n/a	8.173E+06	-3.548E+05	2.007E+07
Chromium	g	1.489E+03	Zero	Zero	n/a	2.976E+03	-6.021E+04	-5.575E+04
Copper	g	7.372E+02	Zero	Zero	n/a	2.820E+03	-2.890E+04	-2.534E+04
Cyanide	g	7.718E+00	Zero	Zero	n/a	Zero	-8.633E+01	-7.861E+01
Fluoride	g	Zero	Zero	Zero	n/a	2.038E+04	Zero	2.038E+04
Iron	g	5.970E+04	Zero	Zero	n/a	4.669E+06	-8.157E+05	3.913E+06
Lead	g	9.309E+02	Zero	Zero	n/a	3.095E+03	-2.959E+04	-2.557E+04
Mercury	g	2.755E-01	Zero	Zero	n/a	3.227E+01	Zero	3.255E+01
Nickel	g	7.494E+02	Zero	Zero	n/a	8.366E+03	-2.912E+04	-2.000E+04
Nitrate	g	1.037E+04	Zero	Zero	n/a	6.245E+00	3.475E+03	1.385E+04
Phosphate	g	8.833E+03	Zero	Zero	n/a	2.463E-01	-3.588E+05	-3.500E+05
Sulphate	g	1.851E+06	Zero	Zero	n/a	1.787E+05	-2.187E+07	-1.984E+07
Sulphide	g	2.062E+01	Zero	Zero	n/a	3.000E-04	-4.755E+02	-4.549E+02
Zinc	g	1.503E+03	Zero	Zero	n/a	3.346E+04	-6.054E+04	-2.557E+04

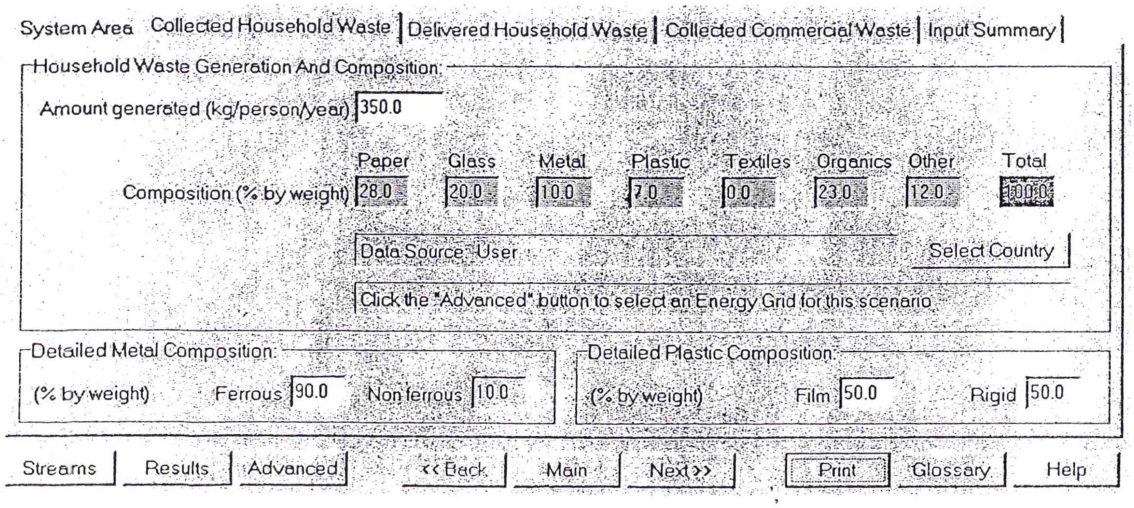
Appendix 3

Some sample of the IWM-2

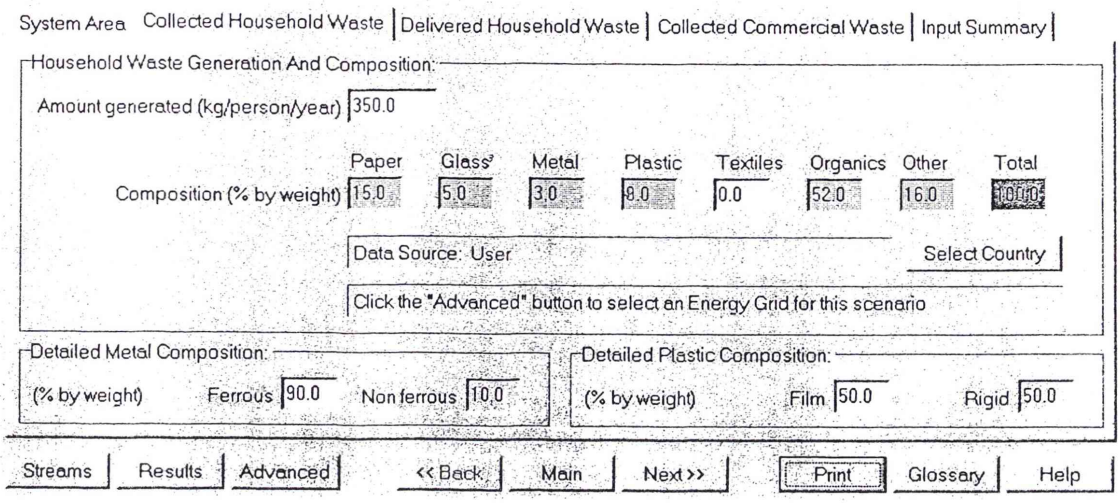
Scenario: SEOUL
Screen Shot: Waste Inputs Input Screen



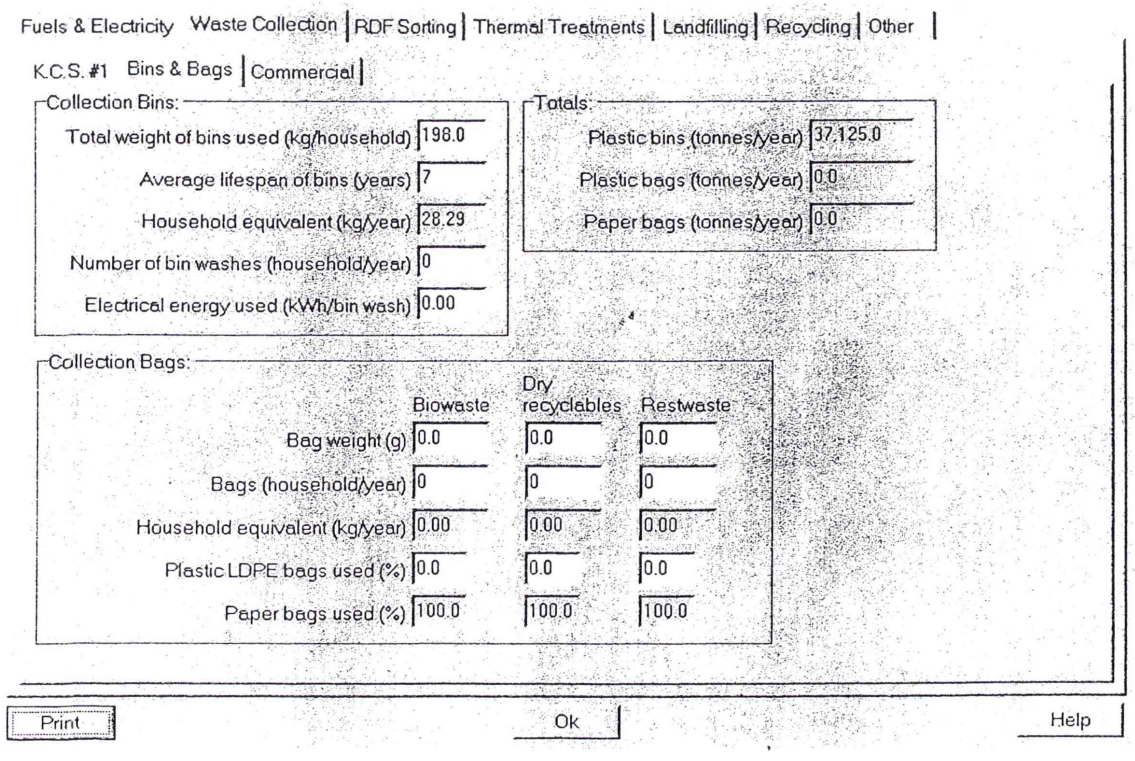
Scenario: SEOUL
Screen Shot: Waste Inputs Input Screen



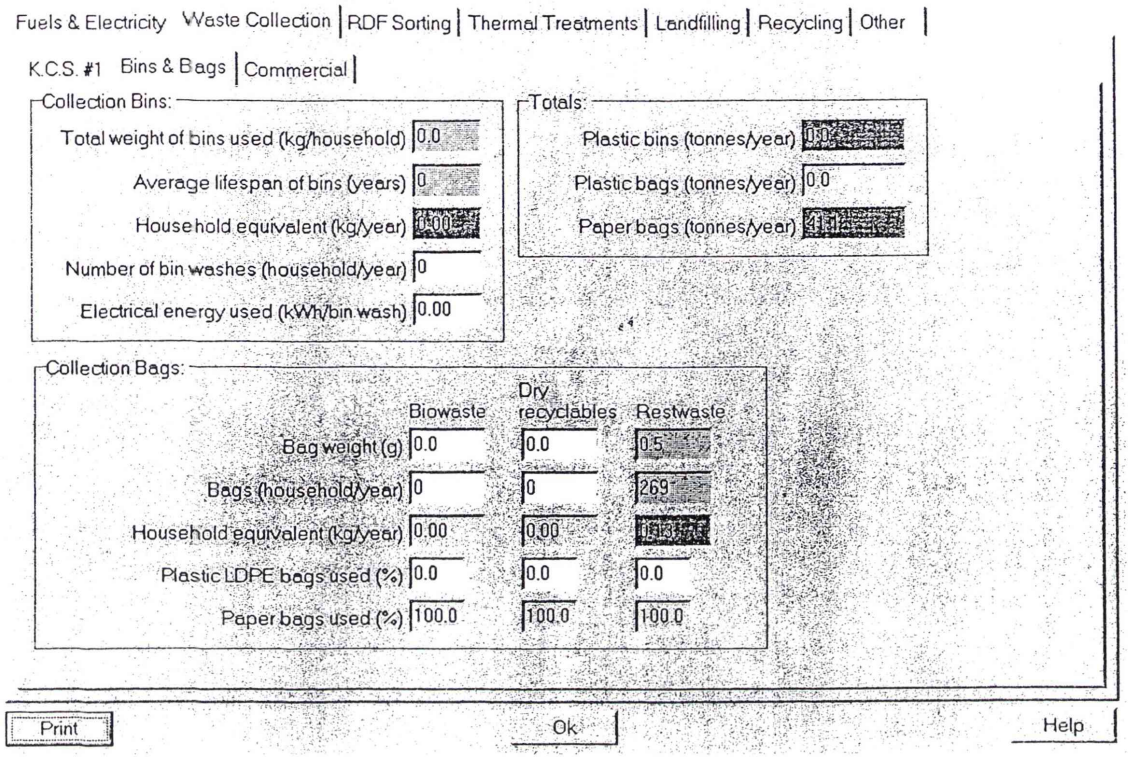
Scenario: SYDNEY
Screen Shot: Waste Inputs Input Screen



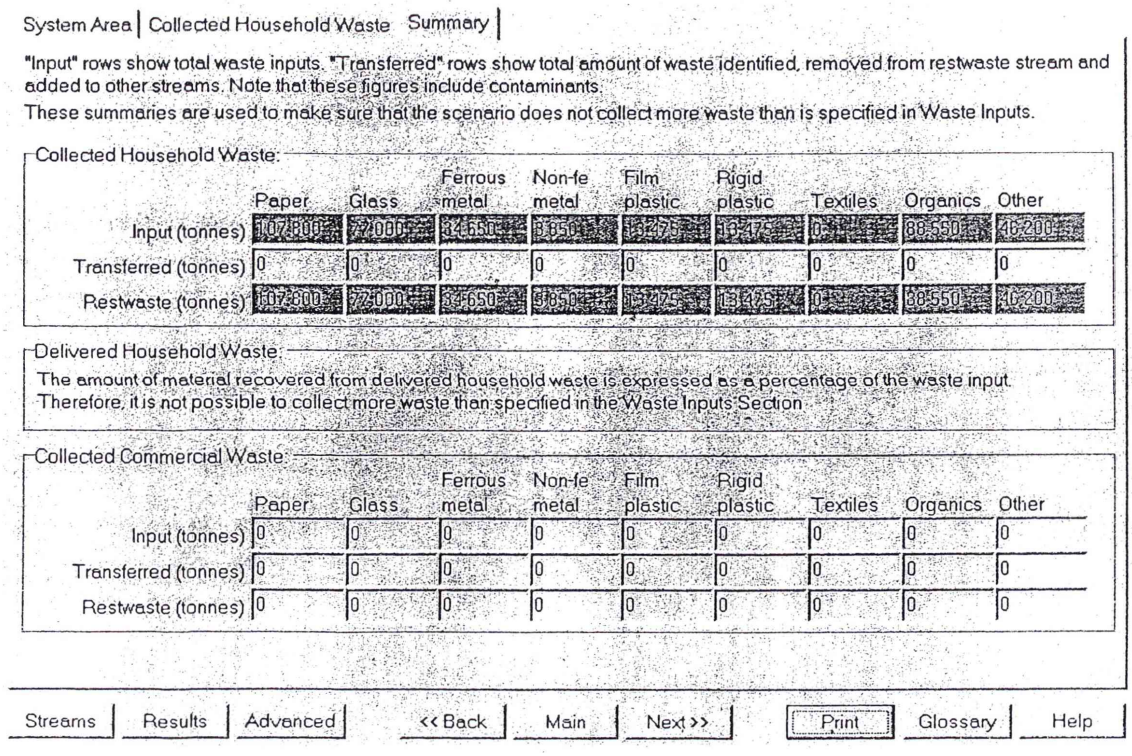
Scenario: SYDNEY
Screen Shot: Advanced Variables Input Screen



Scenario: SEOUL
Screen Shot: Advanced Variables Input Screen



Scenario: SEOUL
Screen Shot: Waste Collection Input Screen



Scenario: SEOUL
Screen Shot: Advanced Variables Input Screen

Fuels & Electricity | Waste Collection | RDF Sorting | Thermal Treatments | Landfilling | Recycling | Other

Incineration Process #1 | Incineration Process #2 | Incineration Emissions | RDF Burning | PPDF Burning

Energy Inputs:

	Paper	Glass	Ferrous metal	Non-fe metal	Film plastic	Rigid plastic	Textiles	Organics	Other	Compost
Nat. gas (m3/tonne)	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Electricity (kWh/tonne)	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00

Energy Outputs:

	Paper	Glass	Ferrous metal	Non-fe metal	Film plastic	Rigid plastic	Textiles	Organics	Other	Compost
Cal value (GJ/tonne)	10.5	-0.5	-0.5	-0.5	25.0	28.0	13.5	3.7	4.0	7.4

Solid Residues:

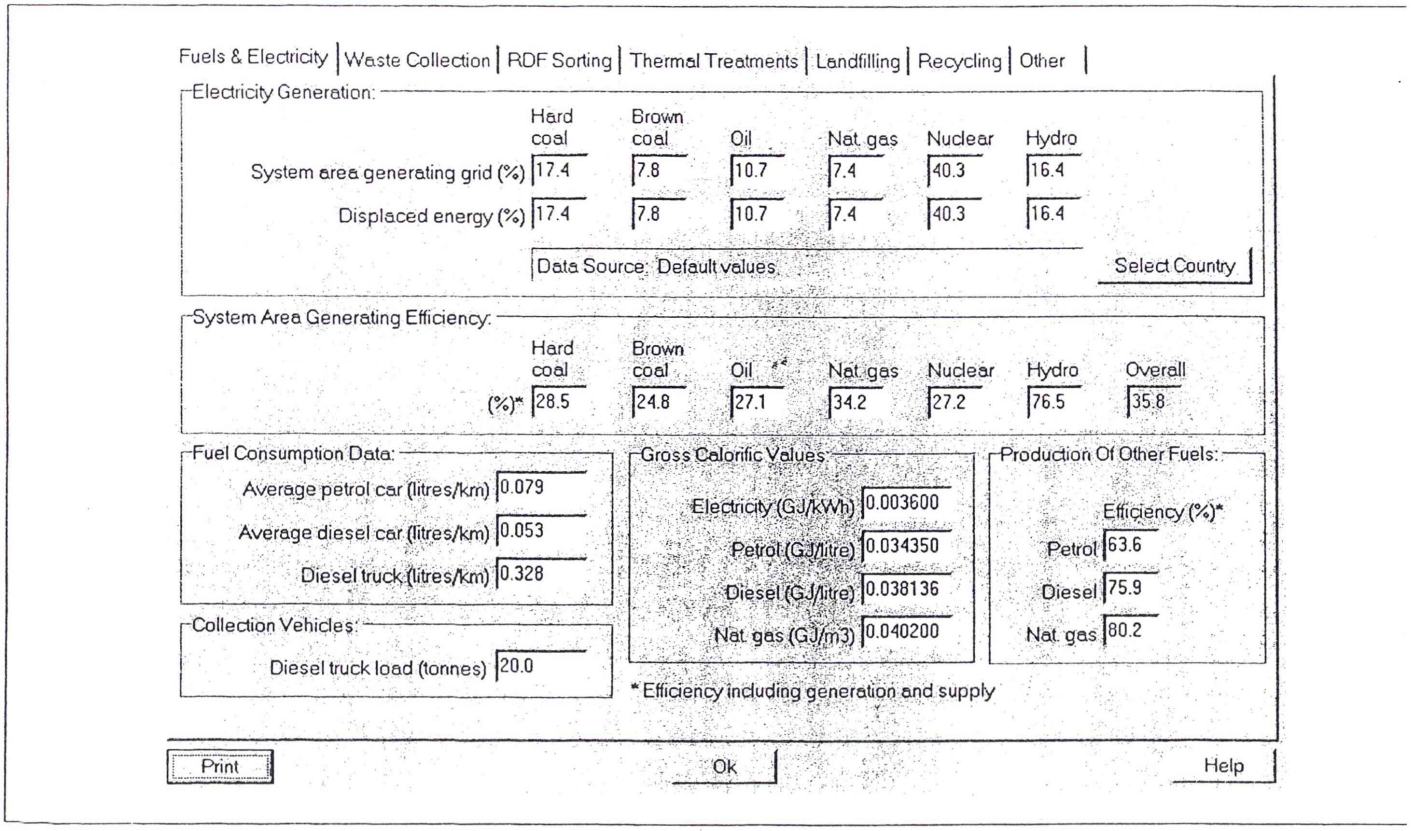
(tonnes/tonne input)	Paper	Glass	Ferrous metal	Non-fe metal	Film plastic	Rigid plastic	Textiles	Organics	Other	Compost
Hazardous*	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320
Non-hazardous**	0.0840	0.9000	0.8500	0.9000	0.0900	0.0600	0.0750	0.0770	0.4200	0.1540

* Fly ash, filter dust and gas cleaning residues

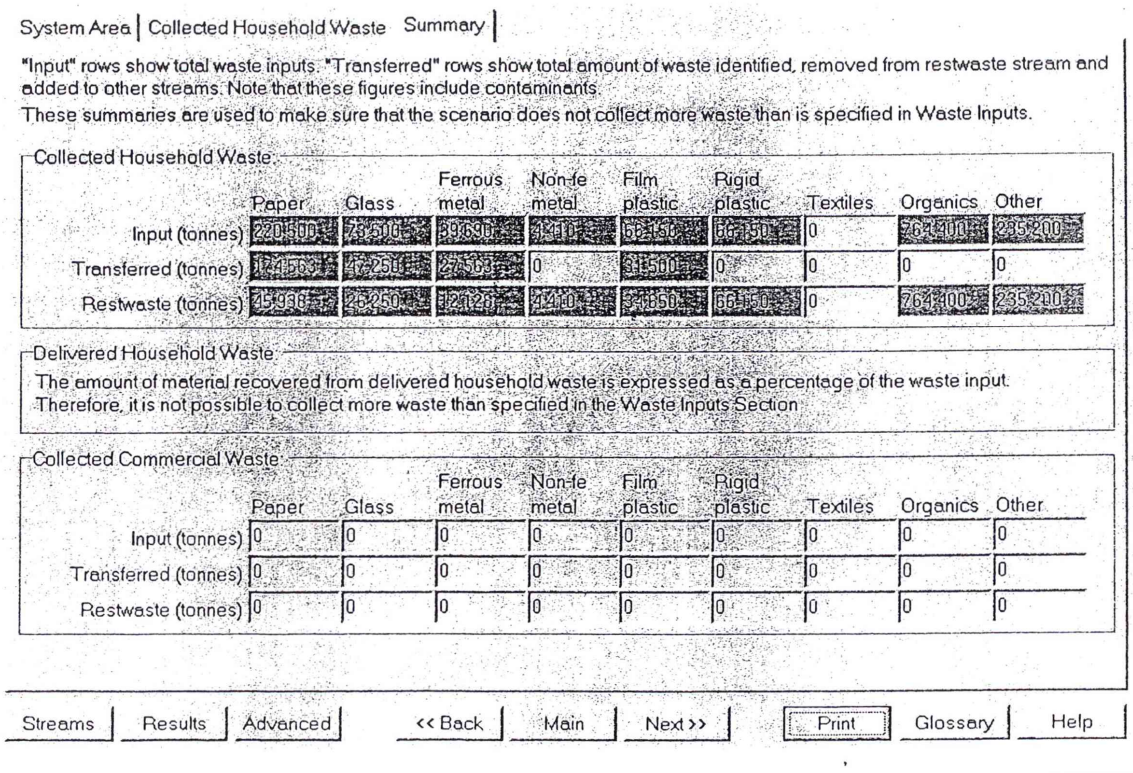
** Bottom ash

Print | Ok | Help

Scenario: SYDNEY
Screen Shot: Advanced Variables Input Screen



Scenario: SYDNEY
Screen Shot: Waste Collection Input Screen



Scenario: SYDNEY
Screen Shot: Advanced Variables Input Screen