SOLID WASTE MANAGEMENT SYSTEM IN ILOILO CITY

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Abstract---*An ever increasing problem faced by urban areas in our so-called advanced societies lies in the disposal of the residues from production and consumption processes. Although residents of Iloilo City throw away less than one-fourth of what the Australians discard, the amount generated by more than 335,000 Ilonggos also poses a big disposal problem. The average resident in the city generates about 0.52 kg of household refuse per day. In Iloilo City, about 64,000 tons of municipal solid wastes were generated for the year 1995, and this figure is currently expected to grow at an annual rate of 6%. Municipal or urban solid waste is produced by all sections in the community. It includes wastes produced in public market, commercial and industrial (63% by volume), residential (35%), and hospitals (2%). A characterization study on the waste arising in the city showed the following compositions by weight: food and kitchen wastes (51.2%), paper (20.3%), yardwaste (7.7%), plastic (6%), tin (5%), cardboard (4.7%), glass (2.7%), textile (1.3%), and rubber (1.1%). The main guiding principle adopted to dealing with the solid waste problem in Iloilo City is the hierarchy of waste management, an integrated approach which includes: waste minimization/waste prevention, recycling/re-use, materials recovery including composting, and sanitary landfill.*

INTRODUCTION

All over the world, the problem of urban solid waste is already assuming intractable dimensions. In the Philippines, much industrial growth has taken place particularly in the 1950s and the 1970s (Britannica). Many factories are licensees of foreign companies or act as subcontractors for foreign firms, turning out finished products for export from imported semifinished goods. Major manufactured goods include processed foods and beverages, petroleum products, textiles and wearing apparel, and chemicals.

The advent of high rise buildings, supermarkets, institutions, hospitals, and industries have given rise to problems in urban solid waste. Urban solid waste which includes household refuse, street litter, discards from food preparation, commercial and industrial waste, and hospital waste is a serious problem not only in Metro Manila but also in Iloilo City. Such waste has a variety of properties that make it a threat to the environment and to health if mishandled during collection, transport, and disposal.

Iloilo City, the capital of Iloilo Province is the sixth among the ten highly populated urban centers in the Philippines with a population of 309,505 people for the year 1990. (EMB,1990). It has a land area of 6,852 has. (68.52 sq. km) and is composed of six districts namely: Arevalo, City Proper, Jaro, La Paz, Mandurriao, and Molo. The city has attracted large numbers of rural people who hope to avail of better economic opportunities. However, they often end up living in slums or along the creeks, and find work as low paid unskilled laborers due to limited opportunities.

In 1995, some 64,000 tons of solid waste were disposed of in Iloilo City. Waste production has grown closely in proportion to Gross Domestic Product (GDP) of 6% per annum. Waste quantities are increasing both in total terms and on a per capita basis. It is expected that the annual waste quantities would increase to 92,944 by 2000 and 187,527 tons by 2009, if the rate of increase is allowed to continue unabated.

Landfills are the most common refuse disposal method used around the world; however, there are many drawbacks. Land is a limited and high priced resource in urban areas. As every city expands, this resource becomes more and more scarce in the vicinity of the city, thereby pushing landfills further into the countryside and increasing waste transport costs.

Additionally, leachates from landfill become a problem when the groundwater in surrounding areas is rendered useless due to contamination. Open dumping of municipal solid waste could also create

breeding grounds for pathogens leading to outbreaks of disease.

The Iloilo City government has designated a disposal site for domestic and commercial and industrial solid wastes situated in Calajunan, Mandurriao which is about 7 kilometers from Iloilo City proper, and covers an area of 20 hectares. An average of 400 cubic meters of refuse are dumped there per day. The big bulk of these , which is 63% comes from the public market and commercial and industrial establishments, 35% from the residential, and 2% from the hospitals. The method of disposal used is open dumping.

The solid waste management in Iloilo City has a limited expertise in handling and disposing of such waste, resulting in problems at facilities and during transport. The high cost of disposal also discourages some waste producers from using proper methods of disposal, and more often leads to indiscriminate dumping of wastes.

The Calajunan dumpsite has been operational for 7 years now, and with the increasing volume of solid wastes dumped there everyday, the dumpsite will be filled beyond its capacity in less than 20 years, thereby forcing the government to look for a new dumpsite.

General Objective. This study seeks to attain the following general objective: To develop an efficient municipal solid waste management system for Iloilo City.

Specific Objectives. This study aims also to: 1) design a system for waste avoidance and reduction at source; 2) improve the storage, collection, transport, and disposal methods; and 3) develop a recycling system for material and energy recovery.

Significance of the Study. It is expected that this study will: 1) help increase the level of awareness of the public on the proper and efficient methods of storage, collection, transport, and disposal of municipal solid waste 2) help reduce waste entering the landfill, conserve landfill site capacity, and minimize leachates resulting in a clean and healthy environment 3) recover materials and energy and help improve economy.

PRESENT STATUS OF SOLID WASTE IN ILOILO CITY

Total urban solid waste generation rates in Iloilo City are of the order of 0.20 ton/person/yr or 0.52 kg/person /day with a daily total of 174 tons/day for the city for the year 1995. (Buensuceso,1995). Typically, in an Asian country, like the Philippines, waste is highly organic and wet with low levels of plastics, paper, glass, and tin. (Manalo, 1988). The result of a desk study on the solid waste arising in Iloilo City with a projected population of 337,220 people in 1995 is shown in Table 1.

The total waste stream for Iloilo City can be classified into three sources namely, public market, residential, and hospitals. Table 2.

Forecasts of Solid Waste Generation

For the purposes of the study, a representative population for the period 1995-2009 is required. A population of 309,505 for the year 1990 as reported by NSO(1990) is considered as the base data. The average growth rate from 1990-1995 is taken as 1.73%. It is assumed that there is a 5% increase in growth rate for the next five years and so on. A 6% growth rate in GDP (Gross Domestic Product) and 6% growth rate in waste generation rate are considered. Fig. 1 shows a comparison between waste generation at variable and constant rates over time.

In the five years from 1990-1995, the city's solid waste production grew from about 44,000 tons to 64,000 tons per year. This is expected to grow to 92,944 tons by year 2000 and to 187,527 tons by 2009. Table 3.

Storage

Based on the results of Family Income and Expenditure Survey for 1988, about 72% of the total number of households in the province are considered poor. (NSO, 1990).

Most low income families in Iloilo City do not have garbage bins or receptacles and garbage is dumped in the backyard, canals or to nearby open communal dumps, or burned. For middle to high income families, garbage is placed in various containers ranging from plastic and paper bags to native baskets (kaing), cardboard cartons, sacks, and plastic bins.

Most receptacles are unsuitable for proper storage. Because of the open nature of the container, breeding of flies and other vectors is not limited. In residential areas, it is a common practice to keep the receptacles inside the premises to avoid loss, and brought outside only during collection time.

Collection and Handling

Iloilo City has a system of solid waste collection but is not quite efficient just like Metro Manila as only 70% of the waste generated is collected and

Material Type	Composition (% by wt)	Weight (tons/day)	Weight (kg/day)	Volume (cu.m/day)	Composition (% by vol.)
Food and Kitchen Wastes	51.20	89.09	89,090	306.15	23
Paper	20.30	35.32	35,320	396.85	30
Yardwaste	7.70	13.40	13,400	132.67	10
Plastic	6.00	10.44	10,440	160.62	12
Tin	5.00	8.70	8,700	97.75	7
Cardboard	4.70	8.18	8,180	163.60	12
Glass	2.70	4.70	4,700	23.98	2
Textile	1.30	2.26	2,260	34.77	3
Rubber	1.10	1.91	1,910	14.69	1
Total	100.00	174.00	174,000	1331.08	100

Total Population for 1995: 337,220 Total Waste/day: 174 tons

Table 1. Solid Waste Characterisation in Iloilo City

Material Type	Public Market, C & I		Residential		Hospitals		TOTAL
	volume (m^3/day)	weight (kg/day)	volume (m^3/day)	weight (kg/day)	volume (m^3/day)	weight (kg/day)	(kg/day)
Food and Kitchen Wastes	192.87	56,125	107.15	31,181	6.12	1,781	89,087
Paper	251.57	22,390	139.76	12,439	7.99	711	35,539
Yardwaste	83.86	8,470	46.59	4,706	2.66	269	13,444
Plastic	100.63	6,541	55.91	3,634	3.19	207	10,382
Tin	58.70	5,224	32.61	2,902	1.86	166	8,292
Cardboard	100.63	5,032	55.91	2,796	3.19	160	7,987
Glass	16.77	3,287	9.32	1,827	0.53	104	5,218
Textile	25.16	1,635	13.98	909	0.80	52	2,596
Rubber	8.39	1,091	4.66	606	0.27	35	1,732
Total	838.58	109,795	465.89	60,998	26.61	3,484	174,277

Public Market, C & I: 63% Residential: 35% Hospitals: 2%

Table 2. Solid Waste Composition by Volume

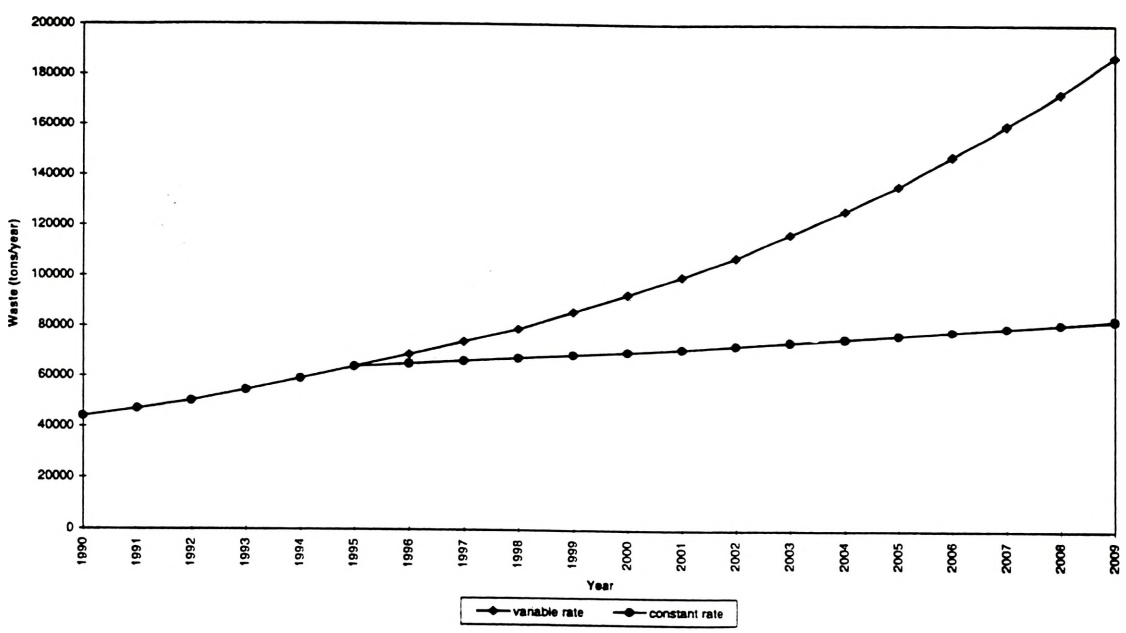

Figure 1. Iloilo City Solid Waste Generation (1990-2009)

Table 3. Solid Waste Generation Forecast in Iloilo City

Year	Popularion	kg/person/day	tons/yr
1990	309,505	0.39	44,058
1991	314,859	0.41	47,119
1992	320,301	0.43	50,272
1993	325,848	0.46	50,272
1994	331,485	0.49	59,286
1995	337,220	0.52	64,044
1996	343,357	0.55	68,929
1997	349,606	0.58	74,012
1998	355,969	0.61	79,257
1999	362,448	0.64	85,991
2000	369,044	0.69	929,44
2001	376,097	0.73	100,211
2002	383,284	0.77	107,722
2003	390,608	0.82	116,909
2004	398,073	0.87	126,408
2005	405,680	0.92	136,227
2006	413,794	0.98	148,014
2007	422,070	1.04	160,218
2008	430,511	1.10	172,850
2009	439,121	1.17	187,527

Notes:
Population Growth Rate:
1.73% from 1990-1995
Assuming a 5% increase in the growth rate for the next succeeding years
Waste Generation Growth rate: 6%

disposed of. (Manalo, 1988). The rest are dumped to vacant lots or to nearby creeks, burned, or composted. The primary collection and handling process involves collection from streets to wooden pushcarts or improvised wheeled carts. The rubbish is then dumped back on the ground, to be picked up by rakes and baskets and put into trucks. This results in wastage of labor and waiting time for vehicles, apart from the great health risks to which the workers are exposed because of regular skin contact with wastes during collection and loading. These wastes attract rats, dogs, and cats which are possible carriers of diseases.

Furthermore, there is also a lack of community containers or an enclosed storage place of proper design for collected street and house wastes. In most districts, community containers are not provided. Because of this, garbage is dumped everywhere possible. These dumps are invaded by scavengers and animals which scatter the waste. The rats have access to food and fly larvae can migrate and pupate in the vicinity.

Collection Systems

In Iloilo City, the collection systems basic to Asian countries are also employed. The three collection systems are communal collection, block collection, and kerbside collection.

Collection from Communal Site. In this system, the collectors just collect the waste from the communal storage or the designated dumping area which may require delivery of the wastes by the householder over a considerable distance. At the downtown area, wastes are put in plastic bags or cartons and placed at designated places usually at every corner of the street.

Block Collection. In this system, a collection vehicle travels in a regular schedule and routes, and the householders deliver the wastes to the vehicle at the time of collection.

Kerbside Collection. In this system, the residents place their bins on the footway in advance of the collection time and remove them after they are emptied. Kerbside collection is not successful in Iloilo City because: 1) the bins are sorted through by scavengers 2) the bins are stolen because the householder fails to retrieve the bins quickly 3) traffic accidents are caused by bins rolling on the road 4) the bins are sometimes turned over by animals which scatter the waste

Industrial waste, hospital waste, and building and demolition waste are not collected by the city government. A vast amount of industry exists in the province and in the city and the collection and disposal of waste is dealt with either by the industries themselves or by contractors hired to remove the waste.

The operation of collecting and hauling of garbage as well as street cleansing in the city is managed by the Office of Public Services (OPS), with an employment of 340 personnel. The OPS has established a schedule and routing of solid waste collection. The city is divided into nine(9) routes. Every route has a schedule of collection: daily (including holidays), twice daily, twice a week, and three times a week. (Buensuceso,1995). There is some two-shift working in order to accommodate late-night collections from the public markets, commercial as well as residential areas. The night shift is handled by the private collector and the day shift is handled both by the private collector and the city working for eight (8) hours per day.

Transportation

The six (6) districts of the city are served by 13 collection vehicles with a capacity of nine (9) cubic

meters each. Eight (8) of these are owned by a private contractor and five (5) are owned by the city government.

Compactor container vans are useful for the collection of soft domestic waste (i.e. food wastes, paper, plastics, etc.). These collection vehicles are equipped with internal compaction mechanisms, with enclosed top and side or rear-loading, and can carry more waste in terms of weight, thus reducing the number of conveyance tours to the disposal site. Obnoxious odors, dust and litters blown by the wind are avoided because the collection vans are closed. Unfortunately, three (3) compactor type vans are not enough to serve six (6) districts with 309,505 population.

Open dump trucks are observed to be kept uncovered and, during journeys and frequent starting and stopping, the materials tend to spill on the roads. On the other hand, these are ideal for domestic hard waste such as garden waste, tree prunings, and other bulky wastes.

Disposal

Disposal of waste in Iloilo City is through open dumping. Located in Calajunan, Mandurriao, Iloilo City, seven (7) kilometers from the city proper, the dumpsite which covers an area of 20 hectares is now seven (7) years in operation.

Only 40% of the total cost of waste management is spent on collection, transportation, and disposal services by the city. The total cost of collection and disposal is P 150/ton (US$ 6/ton) daily. The remaining 60% is spent on Administration and Overhead Expenses and Equipment Purchases.

Landfill Site Management

Financed by World Bank, the proposed method of disposal for the Calajunan site is sanitary landfill, using an earth covering of 100 millimeters thick. Of late, it is observed that during the rainy months, waste is just dumped near the entrance of the site. The dumptrucks could not drive through because the way is slippery and muddy. There are no earth excavations that can be seen and sanitary landfilling is no longer practised.

The standard of operation of a landfill determines to a large extent its impact on the environment. Regrettably, Iloilo City has a poor standard of site management for Calajunan dumpsite and this leads to environmental and public health problems such as: 1) water pollution from leachates; 2) rats, flies, and mosquitoes infestations; 3) spontaneous fires and associated toxic emissions; 4) serious odor problems; 5) litter problems; and 6) the number of scavengers living and working in the dumpsite is increasing.

About 40% of the Calajunan dumpsite area is already full. It is calculated that with the current waste generation trends, the existing disposal site facility would be exhausted by the year 2005. To date, no abandonment plan has been made as to what should be done with the site after it is fully closed.

EVALUATION OF PREFERRED SYSTEM FOR ILOILO CITY

The strategic plan for managing Iloilo City's solid waste is based on a mix of options which can be considered practical and appropriate for the city. These options are firstly to reduce to a minimum the quantity of waste requiring disposal by: 1) encouragement of waste minimization/waste prevention; 2) optimizing separation at source for recycling/re-use; 3) development of materials recovery including composting. The option then available for disposing of the remaining waste quantities is by sanitary landfill.

The waste reduction/waste prevention and disposal options and their potential to improve the existing system in Iloilo City are discussed in the following: 1) waste minimization, and 2) source reduction.

Solid waste reduction can be achieved in two ways: 1) Primary Reduction: reducing the amount of waste created with consumer demands playing a key role; and 2) Secondary Reduction: turning potential waste into something of positive value through re-use, composting, or placing material out for collection by others.

Primary Reduction - Consumer Choice!

Reducing Waste Through Consumers' Choice (Hirschhorn and Oldenburg,1991)

Unpackaged Products (e.g. fruit and vegetable)

1. Buy less (buy more frequently)
2. Buy things that last
3. Buy small
4. Favor over packaged products

Packaged Products (e.g. cereals, detergents)

5. Buy large economy sizes
6. Buy concentrated products
7. Buy products with the fewest layers of packaging Products for packaging purposes (e.g. carry bags, wrapping paper)
8. Say no - take your own bag

9. Buy packaging that can be re-used
10. Consolidate

Secondary Waste Reduction - Waste is a Resource!

Even if consumers buy more environmentally friendly products, generation of waste is still unavoidable. It is therefore important for consumers to: 1) reduce organic waste leaving the household 2) separate waste for re-use by others (e.g. donate used clothing to charity) 3) re-use products (e.g. buy a re-usable electric razor than a disposable one) 4) repair products rather than throw away broken ones.

Waste minimization, or avoiding the generation of waste by changes to manufacturing procedures or in other ways, has been applied with some success to industries producing liquid waste and intractable waste. Waste minimization is taken to include waste avoidance/elimination, waste areduction (quantity or toxicity), re-use and recycling.(Moore, 1995).

In the Guangzhon Chemical Works in the People's Republic of China, there is a Chlor-Alkali plant which was built over twenty years ago. Unlike most such plant in the world, it does not pollute. All the waste chlorine streams are collected and used to make bleaching powder which is then sold. The sludge from the electrolysis cells is sold as filler to a local rubber factory, and there is no mercury pollution because since its inception the plant has used diaphragm cells.(Royston,1990).

In Malaysia, old tin mine sites have been converted into recreational areas, and in the Philippines, site of the Second World Recycle Conference, examples of success stories of turning waste to profit abound, particularly in the conversion of forest wastes and special fast growing trees into energy. (Royston,1990).

Waste Minimization Program

There are a number of waste minimization projects that are implemented in the Philippines to provide assistance to industrial and agri-business firms in solving their environmental pollution problems related with industrial and agricultural operations.

The Industrial Environmental Management Project (IEMP) is a project launched by the Department of Environment and Natural Resources (DENR) and funded by the United States Agency for International Development (USAID). It aims to create a broadly-based partnership between sectors which include: government, business, and non-government organizations (NGOs). (EMB,1992). The objectives of this project are to: 1) encourage sustained growth in the industry 2) reduce pollution from industrial activities 3) improve human health and the environment

Another economical scheme which is being promoted by the national government is the Integrated Food Processing System (IFPS). (Manalo,1988). It is designed to maximize utilization of the raw materials. The main features of the system are 100% utilization of raw materials and diversification into multi-product line hence reducing problems of food wastage and waste disposal.

An example of this is when applied to fully ripe fruits, whose major products are jams, jellies, bottled preserves in syrup, dehydrated glazed fruits or juice. The by-products from the seeds, peelings, and trimmings can be utilized as wine, or vinegar, animal feeds or fertilizer.

Recycling/Re-use

Re-use and recycling of materials represent a way of indirectly recovering the energy content of municipal solid waste and slowing down the rate of depletion of natural resources. In the Philippines, old newspapers, magazines, or other kinds of paper are sold by the kilogram and recycled as additional pulp for the paper industry. Catsup and mayonnaise bottles are sold to oil, vinegar, or soy sauce local entrepreneurs who cannot afford to buy new ones. Old fluorescent lamps are recycled and sold at lower prices. This is a new livelihood source at Smokey Mountain launched by the Department of Labor and Employment (DOLE) in coordination with the Institute for the Protection of Children. (Manalo,1988).

Tires aside from being converted into slippers, flowerpots and doormats are now being made into artificial reefs, a safe haven for marine life. Most coral reefs in the Philippines have been damaged due to illegal dynamite fishing method called "Muro-Ami".

In Sydney, the Metropolitan Waste Disposal Authority (MWDA), encourages recycling by directing the public to recycling centers at its regional landfills and transfer stations and to other facilities and services offered by private and public organizations. Recycling is best undertaken at the source by encouraging householders and other generators to separate wastes for collection or to deliver the component products to receival points.

(van den Broek, 1987).

Recycling is actively practiced at most stages in the solid waste management system in Iloilo City,just like in many cities in developing countries. Source separation has to a certain extent occured effectively in the city by the scavengers going from door to door and buying reusable items.

Composting

Composting is very compatible with recycling. While composting is the biological decomposition of the organic components in the waste stream, it is recycling that will help improve the product by removing undesirable material such as glass, metal, and plastics. Composting is by far the most responsible technical solution for many developing cities, especially where the climate is arid and the soil is in serious need of organic supplements. (Holmes,1984).

Cellulolytic fungi can hasten the process of composting by immediate increase in temperature of piles and by rapidly increasing populations of active decomposers.

In the Philippines, a compost activator called genus Trichoderma is used in the National Program on Rapid Composting. This fungus is currently mass produced in all regions of the country by the provincial or regional centers of Department of Science and Technology (DOST), Department of Agriculture (DA) and State Colleges and Universities, and sold at P7.50-P12.00 (US$0.30-US$0.50) per kg activator. (Cuevas,1992).

Landfills

According to Williams (1991), landfills are the one form of waste management that nobody wants but everybody needs. There are simply no combinations of waste management techniques that don't require landfilling to make them work. Of the four basic management options (composting, incineration, sanitary landfill, refuse-derived fuel),landfills are the only management technique that is both necessary and sufficient. Although landfill is the final step in all waste treament, it is by far the cheapest and most widespread method of waste disposal. (Barbiroli,1994).

CONCLUSIONS AND RECOMMENDATIONS

Solid waste management encompasses many interrelated elements that must be well orchestrated to be effective. Appropriate solutions exist that can be afforded by the city government. However, there is no universal solution to the problem of refuse disposal; there is no single best method. Any of the existing methods or a combination of them can be used but the methods adopted must be related to local social and cultural conditions. For an efficient municipal solid waste management system in Iloilo City, the following hierarchy of waste management, Fig. 2, and an integrated approach to waste management, Fig. 3, are recommended.

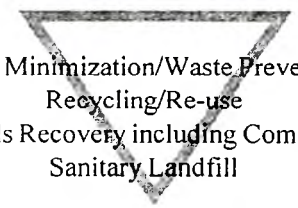

Figure 2. Hierarchy of Waste Management

To further improve the existing system, the following elements must be considered:

Storage. In order to have sanitary and effective storage of refuse in house premises, the following steps must be taken:

* All household units must have standard garbage bins. The garbage bins must have tight-fitting lids, must be water tight, durable, and resistant to corrosion.
* Surveys must be carried out to establish the house population density and also to gauge public interest in and support for the system about their attitudes toward waste disposal and recycling issues.
* The capacities of the garbage bins must be related to house population density and the frequencies with which the garbage bins are likely to be emptied.
* The city in care of the Office of Public Services (OPS) must provide the garbage bins and sell to those who may wish to buy them.
* There must be regular health education of the people on the proper use of the garbage bins.
* The Mayor's office shall pass a decree setting out, in detail, the conditions of household refuse collection with regard to the receptacles to be used, pick-up frequency, and the various steps required for recovering and treating the solid wastes.

Separate Collection. In order to facilitate the recovery of certain wastes, the city by means of a city ordinance may require that certain wastes be sorted (paper and board, glass, plastic) and brought

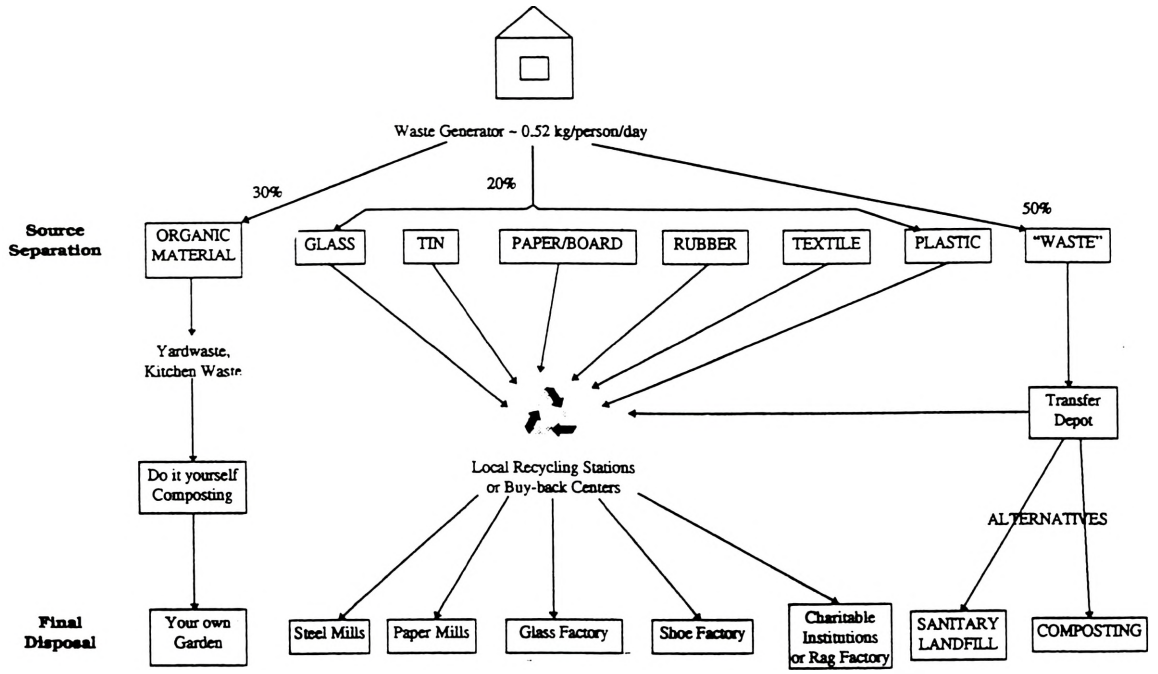

Figure 3. Integrated Solid Waste Management Scheme for Iloilo City

to local recycling stations or buy-back centers, provided by the city. Organic waste must be separated from inorganic at the household level so that the compostable materials may be collected and brought directly to the composting plant.

Organized/Controlled Scavenging. The idea is to hire as many of those currently engaged in scavenging. They will make the rounds of households and be authorized to buy at pre-determined prices those recyclables which have been previously sorted by the household. The materials will be redeemed at redemption centers or buy-back centers owned by the city at about 20% to 25% more than what they paid for them, and where the materials can later be sold to junk dealers.

Primary Collection. Picking up of wastes once only could be applied using simple indigeneous equipment such as pushcarts or pedal tricycles working in conjunction with dumptrucks and compactor-type vehicles.

The expansion of primary collection through the introduction of low cost locally-made pedal tricycles ("tri-sikad") and an optimal number of simple short-range dumping stations or transfer depots, would substantially reduce the cost of collection and transportation. Depending on the density of the population, one transfer-point may cover 4,000-6,000 population. This will help reduce the requirement of vehicles and fuel.

Collection from Central Points Only. The idea is that the people bring their wastes themselves (or via a person responsible for handling the waste) to a central strategically located collection point. These points should be within some walking distance from the houses. The collection point may be: An open space surrounded with concrete walls, or trailers. Wastes must be placed inside plastic bags and sealed to prevent emission of odors and leachates.

Street Cleansing. The success of street cleansing depends on two main elements: 1)sufficient garbage/ litter bins are frequently emptied; and 2) cooperation of the population.

Promotion campaigns can improve people's motivation but they will only have a lasting effect if the garbage bins are really emptied everyday.

Public Education, Participation, and Awareness. The system needs the active co-operation and participation of citizens. This can be achieved only when the citizens become aware of the ill-effects of the existing systems and the advantages of using proper methods. Environmental education of the population should cover all segments of the population, from school-going children to senior citizens.

The education program must reach into the school, the university, the office, the restaurant, the public market, and must seek to have an effect on the daily lives of the citizens through the process of motivation.

Sanitary Landfill. The area method of

landfilling is a solution for superficial or shallow ground-water table. It is recommended that a final cover material (earth or compost from municipal solid waste) one (1) meter thick will be spread over each layer of waste, two (2) meters thick.

Several precautions will be undertaken at the landfill site against pollution of the environment, which include: the areas filled up with refuse must be regularly covered with fresh earth, and other precautions, like spraying of insecticides for fly, and rodents control; and fences will be erected to prevent garbage and paper from blowing away from the site. Any refuse scattered inside the site ground or spilled during vehicle entry and exit will be collected.

Leachate Control. So that water does not percolate laterally into the side of a cell, a liner is used, or the fill area is situated so that the gravity does not take percolating run off towards the cells. This is recommended for the area or trench method. As stated by Tchobanoglous (1993), compost from yardwaste and municipal solid waste, the geosynthetic clay liner, and clay are effective in limiting the entry of surface water into the landfill.

For treatment of leachate, biological processes such as aerated lagoons or activated sludge plants are recommended. The treated leachate may then be disposed of to the nearby creek.

Landfill Gas Control. It is suggested that landfill gas monitoring and extraction systems need to be installed at the site after closure to minimize malodors and to prevent any damage to future vegetative rehabilitation at the site and ensure that the site is compatible with its planned recreational end uses.

ACKNOWLEDGMENT

This paper is an output of a six-month research study in the University of New South Wales, Sydney, Australia, supported by DOST-ESEP. The author wishes to thank her adviser, Prof. Stephen J. Moore, for his helpful guidance and Engr. Benjamin O. Cuales, Jr., for sending the needed data.

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