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COMPOSTING AS AN OPTION IN THE MUNICIPAL SOLID WASTE MANAGEMENT OF KATHMANDU METROPOLITAN CITY

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COMPOSTING AS AN OPTION IN THE MUNICIPAL SOLID WASTE MANAGEMENT OF KATHMANDU METROPOLITAN CITY

By

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A thesis report submitted in partial fulfillment of the requirements for the degree of Master of Science in Environmental Management

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Certification

This is to certify that the thesis entitled " **Composting as an Option in the Municipal Solid Waste Management of Kathmandu Metropolitan City**", submitted by Mr. Rupesh Udash towards the partial fulfillment of degree of Master's of Science in Environmental Management is based on the original research and study under the guidance of Dr. Shashi S. Rajbanshi. The thesis in part or full is the property of **School of Environmental Management and Sustainable Development (SchEMS)** and thereof should not be used for the purpose of awarding any academic degree in any other institution.

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Abstract

The study was conducted with the prime objective of assessing the viability and sustainability of composting as an option in the management of solid waste in the Kathmandu Metropolitan City. It focused on examining the current solid waste management system of the City, the market characteristics and demand for municipal compost in different market segments, financial requirements for operation of composting schemes, and relevant public opinion. The data and information required were collected using various tools and techniques including key informants interview, public survey, on site observations and review of literature. The field work consisted of interviews with farmers, individuals in nurseries, households in the City and officials from relevant organizations. The data collected were organized into charts, diagrams and tables and analyzed with the help of various statistical tools and software. The results from the study indicate that in the present state of affairs composting cannot be a viable and sustainable option for the management of solid waste in the City. Numerous constraints currently exist for the operation of composting schemes at the household, community and central level. The major barriers as identified by the study includes the high initial investment requirements, high operational costs, low environmental motivation among the public, public objection to operation of compost plants in residential areas, lack of space for composting facilities, competing compost products, prevalent market structure and low purchasing capacity of farmers. The viability and ultimately the sustainability of any composting schemes will depend on how these barriers are addressed.

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List of Abbreviations

CBS:	Central Bureau of Statistics
CBO:	Community Based Organization
EIA:	Environmental Impact Assessment
EPR:	Environment Protection Rules
GTZ:	Deutsche Gesselschaft Fuer Technische Zussamenarbeit
IEE:	Initial Environmental Examination
IUCN:	World Conservation Union
KMC:	Kathmandu Municipal Corporation
LNCF:	Luna Nepal and Chemical Fertilizers
MLD:	Ministry of Local Development
MSW:	Municipal Solid Waste
MSWM:	Municipal Solid Waste Management
NESS:	Nepal Environmental and Scientific Services
NGO:	Non Governmental Organization
NGSWMO:	Non Governmental Solid Waste Management Organization
SWMRMC:	Solid Waste Management and Resource Mobilization Center
UNEP:	United Nations Environment Program
UNESCAP:	Untied Nations Economic and Social Commission for the Asia and the Pacific
VDC:	Village Development Committees
WMA:	Waste Management Authority

Chapter 1

INTRODUCTION

1.1 Background

Nepal, has been witnessing a rapid urban growth in the recent decades. With the highest urban growth rate in the whole of South Asia at 6.5% per annum (UNEP, 2001) the process of urbanization is in full swing. More and more people from the rural area have been migrating towards the newly developed urban centers in the hope of a better and fulfilling life. Today almost 14% of the total population of Nepal lives in the urban areas and it is predicted that half of the country's population will be living in urban areas by 2035. The rate of urbanization in the last two decades has been staggering and it is most evident in Kathmandu Metropolitan City (or Kathmandu City).

With a population of 1,081,845 (CBS, 2001), the Kathmandu Metropolitan City is by far the largest City of Nepal. With almost all of the facilities concentrated in the City, it has attracted people from all over the country. In the last 20 years the population of the City has grown at an average annual rate of 4.82% from 422,237 in 1981 to 1,081,845 in 2001 (CBS, 2001). Today, it is the center of industrial, commercial, cultural, political and educational activities of the country. The drastic changes in the demographics, lifestyle, commercial and industrial activities in the last couple of decades have transformed Kathmandu from a predominantly agricultural area into a modern day metropolis. However, the transformation has come at a price.

The tremendous increase in the population coupled with increased industrial and commercial activities, poor planning, lack of resources and haphazard settlements has brought about various deleterious effects to the environment of the City. Air pollution, pollution of surface and ground water, noise pollution, are all beyond the tolerable limits and are on the rise. Among the multitude of environmental problems existing in the City, solid waste has become one of the most prominent problems in the recent years.

1.2 Statement of Problem

Rapid urbanization in Kathmandu Valley along with changing composition of waste has given rise to a serious solid waste management problem in the last few decades. Lohani and Thanh in 1978 determined that the average amount of waste generated was 0.25 kg per person per day. During the 1980's, this number increased to about 0.40 kg per person per day. By 1990, Kathmandu produced an average of 0.57 kg per person per day: a doubling in just over 10 years (Spreen, 1992 as cited by Becker, 1997). The per capita waste generation increased another 40 percent: approximately 250 tons of municipal solid waste was created everyday from the three major cities of the valley (Malla, 1994 as cited by Becker, 1997). According to the Ministry of Local Development (MLD) an estimated 122,534 tonnes of waste was generated in Kathmandu Metropolitan City in 1999 (UNEP, 2001).

The ever-increasing volume of solid waste in Kathmandu Valley is a major cause of environmental pollution. In the lack of infrastructures, resources, effective solid waste management institution, trained manpower and research backup for solid waste management, solid waste has been a mounting environmental problem. The Gokarna landfill site has been

completely filled and closed for dumping, while other landfill sites have not been developed yet. The selection of new landfill site is more problematic due to the NIMBY (not in my backyard) syndrome in the local community. The waste management authority (WMA) is using the waste as filling material for road construction along the bank of Bagmati River by ignoring the adverse effect on environment and human health (Timilsina, 2001). Almost 72% of the total waste generated is disposed off in this manner.

A major portion (67.5%) of the solid waste generated in the City is organic (UNEP, 2001) but only a fraction of it is actually composted. The current practice of dumping the waste is neither environmentally benign nor makes any economic sense. The practice is not only polluting the environment, but is also wasting a valuable resource in the form of compost, that could be derived from the organic fraction of the solid waste. Composting can help in managing the solid waste problem and in cutting down the mineral fertilizer input in the surrounding areas thus reducing the import requirements of costly fertilizers. In a country like Nepal, where resources fall short of the demand, waste management efforts should be geared to generate resources on their own. Transformation of wastes into reusable product will not only generate revenue but will also provide the basis for sustainability of the management system (Sharma and Chhetri, 1995).

Composting has long been identified as one of the options for managing the organic fraction of solid waste generated in the City. However, efforts to run a compost plant in the City have failed and operational compost plants have been shut down because of public objections. In order to develop composting as a sustainable option for the management of solid waste in the Kathmandu Metropolitan City, it is necessary that we be clear about the factors which could ultimately influence its sustainability. Some factors that will have to be considered are the infrastructural and financial requirements, market demand and market potential for the compost products, and the general public attitude towards various composting schemes. It is vital, that we analyze the various factors and establish if composting can be a viable and sustainable option for the management of organic waste in the City.

1.3 Objectives

The main objective of the study is to assess the viability and sustainability of composting as an option in the management of solid waste in the Kathmandu Metropolitan City. Specific objectives of the study are to:

a) evaluate the existing waste management system in Kathmandu Metropolitan City with special reference to organic waste management practices

b) study the market characteristics and estimate the market demand and market potential for compost derived from the municipal solid waste

c) assess the financial aspects of composting as a solid waste management option in Kathmandu Metropolitan City

d) explore public opinion on various issues of composting

e) identify the major barriers for initiating and operating composting schemes

1.4 Rationale of the Study

Solid waste is one of the most immediate and serious environmental problems facing Kathmandu City at present. Inadequate collection and disposal of waste has been posing a serious health risks to the population and is an imminent cause for environmental degradation in the City. An option to improve the current solid waste situation could consist of enhancing resource recovery.

Recycling of inorganic material, such as plastic, paper, scrap metal etc., from municipal solid waste has been effectively carried out by the informal sector in the form of waste scavengers, scrap dealers and recycling industries. However, reuse of organic waste material, which often amounts to more than 70% of the total waste, is still fairly limited despite its great recovery potential.

Organic waste recycling through composting could be an option towards sustainable management of solid waste in the City. Composting of organic matter helps to decrease disposal costs, enhances resource recovery and reduces the detrimental impact of disposal sites caused by the organics largely responsible for the leachate and methane problems.

Most of the studies carried out in the past have focused on the technological aspects of composting and far less attention has been given to the study of the viability and sustainability of composting schemes in the City. It is vital that factors that can eventually influence the success and failure of composting schemes be studied in detail. Such studies will not only help in avoiding potential pitfalls but also contribute in establishing the *modus operandi* for composting schemes in the City.

1.5 Scope and Delimitations of the Study

The current study will examine the various factors related to composting in the context of its viability and sustainability as a solid waste management option in the City. The study will shed light into various aspects of composting such as the current status of composting, the market demand and potential for compost products, existing barriers for operating composting schemes and the financial aspects associated with such schemes. An assessment of compost production potential through the composting of the municipal solid waste will also be made by the study.

Because of time constraints the market analysis will be carried out only for three major market segments namely agriculture, nurseries and households. The market characteristic, market demand and potential of other sectors like hotels, institutions and commercial establishments will not be analyzed by the study. A detailed economic analysis (social cost benefit analysis) of the subject (i.e. composting as a solid waste management option) is beyond the scope of the current study. The conclusions of the study regarding the feasibility and sustainability as such will be based primarily in terms of the existing market structure, waste management system, public attitude, and financial requirements. The evaluations will not take into account the environmental and health benefits or costs associated with any potential composting schemes or other opportunity savings, hidden costs and benefits for that matter.

Chapter II

LITERATURE REVIEW

2.1 Municipal Solid Waste in Kathmandu

2.1.1 History of Solid Waste Management

Waste management in Nepal was traditionally considered to be the responsibility of untouchable castes. The history of waste management can be drawn from caste system comprising of *chyame* and *pode* (the *kuchikars* or sweepers) as early as 1768. People from these castes were hired by town administrations to collect solid wastes; most often equipped with primitive tools such as a buffalo rib to lift waste and a *kharpan* (basket slung on the shoulder) to carry and dump the collected waste in nearby open fields or on river banks (Aryal, 1986; Thapa, 1989 as cited by NPC and IUCN, 1992). In 1919, Prime Minister Chandra Shamsher introduced the *safai adda* or the Sanitation Office to handle City refuse in Kathmandu. Managing waste became responsibility of municipalities in the 1950s when the urban cores of Kathmandu, Patan and Bhaktapur were designated as municipalities. Further other traditional forms of waste management like *saaga* and *nauga* also existed.

Until a few decades ago, almost all of Kathmandu City's waste was organic and was recycled to produce compost. In the traditional system, the putriscible waste generated in households was either sold directly to farmers or placed in pits called *saaga* ('saa' means compost and 'gaa' means pit in the Newari language) which were located in the houses (Tuladhar, 1996 as cited by UNEP, 2001). The putriscibles were also disposed in *nauga* (pit under the stairs inside the house on the ground floor).

The increasing inorganic content of solid waste made the finished fertilizer from the *saagas* and *nauga* no longer suitable for agricultural use. Their use also fell out of favor as greater sensitivity developed towards sanitation, and household treatment of solid wastes was deemed inappropriate by municipal authorities. The advent of the Green Revolution in Nepal introduced a dependency on subsidized chemical fertilizers and pesticides which ultimately brought an end to the dominate practice of using local manure in the family fields of the Kathmandu Valley (Kathmandu Municipality 1994 as cited by Becker, 1997)

The former rural inhabitants no longer considered the traditional practices of self-help, which had worked well in the rural environment, adequate: now they expected help from the municipality. Industrial development brought new inorganic substance-such as metal, plastic, glass, etc-into the traditional refuse dumps. These substances are not absorbed by the natural process of waste transformation since they can neither decompose nor serve as food for stray domestic animals. As a consequence of these developments, the traditional methods of waste removal were bound to fail under the pressures of urbanization. (Spreen, 1992).

The concept of modern solid waste management evolved only in the early 70's and developed fully in the late 70's. The concept of organized solid waste management was initiated on the basis of a report (Flinthoff Report), prepared by the World Bank in December 1970 concerning waste collection in the Kathmandu Valley. Till then, besides street cleaning services, no proper waste disposal exercises had been envisaged or initiated. Waste was thrown into the streets or collected in *saagas*. There wasn't any proper mechanism and the

entire refuse removed from the streets was tipped at the nearby riverbank (KMC and World Bank, 2001).

Prof. O. Tabasaran in 1976 studied the recommendations of the Flinthoff report and prepared a report entitled "Reorganization of Waste Management in the Kathmandu Valley", revised and specified for the implementation of a definite project. On the basis of the report, a waste management concept was outlined. This outline later formed the foundation for the project agreement of 29th June 1979 between the Nepalese and German governments. As the result of the agreement, the Solid Waste Management Project (1980-1993) came into existence in 1980 (KMC and World Bank, 2001).

Deutsche Gessellschaft fuer Technische Zusammenarbeit (GTZ), having been awarded the contract initiated the first organized solid waste management activities under the aegis of the Solid Waste Management and Resource Mobilization Center (SWMRMC), Ministry of Local Development of His Majesty's Government Nepal, in Kathmandu Valley. The project was completed in four phases and was considered successful in managing Kathmandu's waste in the 1980's and the early 90's. The project established the compost plant at Teku and the Gokarna Landfill site. However, when the project ended in 1993 the whole system established by the project collapsed because of insufficient funds (KMC and World Bank, 2001; UNEP, 2001).

Over time various political economic and social factors have contributed to MSW's changing quantity and composition in Kathmandu Valley. Since 1990, political forces have changed the formal structure of government in Nepal so that smaller, community based organizations, can now contribute to a localized, more participatory and ultimately more effective approach toward waste management (Becker, 1997). At present in accordance with the Local Self-Governance Act (1999), KMC is responsible for the management of solid waste in the Kathmandu Metropolitan City (UNEP, 2001). In the lack of effective solid waste collection and disposal services by KMC the people in some wards of Kathmandu Metropolitan City have arranged their own system of solid waste collection in the community level (Timilsina, 2001). Local communities collect waste from residential areas and transport it to public containers. These groups charge house holds from 50 to 100 NRs per month. Local youth clubs, women's organizations, consumer groups, *Tol Sudhar* (neighborhood improvement) Committees and others participate in such programs (Gautam, 2000).

2.1.2 Waste Characteristics

Kathmandu Metropolitan City comprises of residential, commercial, industrial and agricultural areas, which are sources of different types of wastes. Waste generated by the domestic sector is by far the most important and contributes nearly nine tenths of the total waste, followed by the construction activities, hospitals and manufacturing enterprises. Normally the ground floors in the houses of Kathmandu are occupied by tailoring, barbershops, restaurants, groceries and the upper floors are residential. Domestic waste in the City therefore, includes wastes from both business enterprises and residential unit (Thapa and Devkota, 1999).

Available information for 1985, 1988 and 1991 reflect a declining trend of organic waste and increasing trend of inorganic waste in recent years (table 2.1). Change in the physical composition of organic waste on dry weight basis since 1985 shows an average annual decrease of about 16% for food waste and yard waste whereas other organic waste type have

increased significantly. Average annual increment taking 1985 as base year is 3% for paper waste, 7% for plastic waste and 8% for textile. Rubber and leather and wood waste has also increased. Similarly, physical composition of inorganic waste type on dry weight basis shows over all increment averaging 7% for metals, 2% for glass and 2.5% for dust and dirt annually. (Sharma and Chhetri, 1995).

Table 2.1: Percentage of solid waste on dry weight basis 1985-1995

Components	Year			
	1985	1988	1991	1995
Food Waste & Yard Waste	67.5	57.6	59.9	26
Paper	6	6.2	6.8	9
Plastics	2.6	2	2.6	10
Textiles	2.7	2	3.8	12
Leather & Rubber	0	0.4	0.8	3
Wood	0	0.5	0.8	7
Iron &Tin	2.2	0.4	0.5	8
Glass	4	1.6	3.2	5
Dirt & Dust	15	23.3	21.6	20
Total	100	100	100	100
Source: NESS 1995 as cited by Sharma and Chettri, 1995				

But there is no uniformity between various studies on waste composition. NESS in 1995, as cited by Thapa and Devkota in 1999, in one of its study concluded that corresponding to the change in the mode of economy and lifestyle, the nature and amount of solid waste constituents are also changing, but remarkably the proportionate composition of the organic content has not changed much. Over the last two decades, organic wastes like food, paper, dirt/dust and household yard waste accounted for more than four fifths of the total weight of all kinds of domestic solid wastes. Similarly studies summarized in table 2.2 and 2.3 indicate that the organic content in the solid waste stream of the City has remained constant at around 65-70%.

Table 2.2: Percentage of various solid waste compositions on dry weight basis based on typical percent of moisture in each category composition

Component	% Wet Weight Basis	Typical Moisture %	Dry Weight	% Dry Weight Basis
Food Waste	41	70	12.30	20
Yard Waste	10	60	4.00	6
Paper	6	6	5.64	9
Plastics	6	2	5.88	10
Textiles	8	10	7.20	12
Leather & Rubber	2	10	1.80	3
Wood	5	20	4.00	6
Iron	2	2	1.96	3
Tin	3	3	2.91	5
Glass	4	2	3.92	6
Dirt & Dust	13	3	12.61	20
Total	100		62.22	100
		Organic fraction (dry)		**66**
		Inorganic fraction (dry)		**34**
Source: NESS 1995 as cited by Sharma and Chettri				

Table 2.3: Composition of waste in Kathmandu

Components	% of waste (by weight)			
	1985	1988	1995	1999
Organic Materials	67.5	58.1	65.0	67.5
Paper	6.0	6.2	4.0	8.8
Plastics	2.6	2.0	5.0	11.4
Glass	4.0	1.6	1.00	1.6
Metals	2.2	0.4	1.0	0.9
Textile	2.7	2.0	3.0	3.6
Rubber and Leather	0.0	0.4	1.0	0.3
Wood	0.0	0.5	3.0	0.6
Dust/Construction debris	15.0	28.9	17.0	5.3
				Source:UNEP, 2001

Various studies cited in the State of the Enviroment Nepal, 2001 Report (UNEP 2001) indicate that the per capita waste generation is on the increase. The average amount of waste generated in 1978 was 0.25 kg per head per day. During the 1980's, this amount increased to about 0.40 kg per head per day Kathmandu in 1990 produced an average of about 0.565 kg per head per day ,suggesting that waste generation has more than doubled in just over ten years. MLD, estimated a waste generation of 122,534 tons per year for the year 1999 based on an assumption of population growth rate of 6% taking 1991 as the base year. However, there is continuing controversy about which of these figures should be used for solid waste planning and management purposes. In practice none of the figures are used (NPC and IUCN, 1992).

2.1.3 Current Waste Management Practices

The Local Self Governance Act, 1999 makes the municipalities totally responsible for solid waste management (UNEP, 2001). KMC is the main agency responsible for managing Kathmadu's waste. Under the KMC 1317 staff members are engaged in solid waste management, of this number approximately 1200 are sweepers. In KMC the 35 ward offices are responsible for waste collection. Each ward office is assigned a tractor or a tipper and 20 to 30 sweepers. The waste at the roadside are cleaned by sweepers, loaded on to tractors or tippers, and taken to the Teku Transfer Station. The Teku Transfer Station receives approximately 250 cubic meters of waste per day. The waste is unloaded to a concrete platform where scavengers go through it to collect the recyclable waste (KMC and World Bank, 2001). From the transfer station, the loader reloads the waste into big miller or into tipper trucks which is then taken to the final disposal site (currently banks of the Bagmati River). From some wards, the waste is taken directly to the disposal site.

Residents normally deposit their waste at the roadside or in open public place. The KMC containers are picked up and taken to the disposal site. Some people however dispose their waste in vacant plots or other hidden areas. These waste dumping sites are usually in areas that are difficult to access by the KMC staffs, the result being that the waste usually does not get picked up. KMC also has an arrangement with private firms to start door to door collection of waste in wards 13, 14, 15, 18 and 5. KMC has recently started experimenting by composting waste from slaughterhouses, fruit markets, and domestic waste, on a small scale. KMC has also started scrap buying centers where people can sell recyclable scrap (KMC and World Bank, 2001). In the absence of adequate waste management services, people have begun to take action in a few communities. In most places, this is in the form of door to door

waste collection. KMC's Solid Waste Management Section has a record of 51 groups involved in waste management. Most of these groups serve a few hundred households (UNEP, 2001). A study carried out by Thapa and Devkota in 1999 revealed that around 15% of the households in the City not receiving public disposal services had made their own arrangements and paid on an average around 70 NRs for such services (table 2.4 and 2.5)

Table 2.4: Community arrangement of waste disposal in areas without public disposal service by location (in Kathmandu Metropolitan City)

Location	Yes (%)	No (%)
Core	21.6	78.4
Middle	10.6	89.4
Outer	15.3	84.7
Total	**15.4**	**84.6**
Source: Thapa and Devkota, 1999		

Table 2.5: Amount of service fee paid (under the community managed system)

Location	Amount (NRs/month)		
	Minimum	Maximum	Mean
Core	20.00	300.00	39.86
Middle	25.00	300.00	133.13
Outer	50.00	125.00	67.27
Source: Thapa and Devkota, 1999			

The demand for recyclable wastes has lured private entrepreneurs into waste collection and trading. Itinerant traders in Kathmandu go from house to house to buy waste paper, jute bags, scrap metal and glass bottles. Likewise, scavengers collect reusable wastes, like plastic bags of low density polyethylene, packaging materials of polypropylene, insulating materials of polystyrene, footwear of polyvinyl chloride and food bottles or toiletries of polyethylene terepthalate and sell to the wholesale traders. The price of each scrap item depends on its cleanliness and grade. For instance milk pouches are sold at 6-10 NRs/kg, polyethylene bags 1-15 NRs/kg. The scrap dealers sell these materials to plastic recycling factories. Some scrap materials, which cannot be recycled in Nepal, are being exported to India. Textile wastes are being used for cushions and other items. A recently established bone crusher plant has provided opportunity for bone recycling. Nevertheless, majority of butchers in Kathmandu have a tendency to dump bones into waste containers and rivers (Thapa and Devkota, 1999). Kathmandu Metropolitan City is currently operating a few small composting units. Although this is a positive step, their contribution is negligible as they handle less than one percent of total waste (UNEP, 2001).

"Out of Sight, out of mind" is the most common response to the problem of solid waste management. The attitude of most people as well as of the authorities is to sweep the streets and dump the garbage in an area where no one will complain. Waste is often treated as a nuisance rather than a resource, and the long term implication of poorly managed waste in not considered seriously. The country has formulated some policies on waste management, but implementation of these policies is clearly lacking. In recent years, the waste management crisis in Kathmandu has prompted local community groups and the municipalities to make some improvements. There is now an urgent need to build on these efforts and coordinate the activities of the government, municipality and local communities (UNEP 2001).

2.1.4 Composting in Solid Waste Management

Traditionally, a considerable proportion of organic waste was converted into useful compost through two methods i.e. *Nauga and Saaga*. In Newari, *Nauga* is compost made in small pit dug under the staircase on the ground floor in which ash from fuel wood and husk is collected. At night the pit was also used for urinating until the people shifted to the use of toilets. Organic waste collected in this way would then be changed into good quality compost after a couple of months. Normally the settlers emptied the pit every six months and applied compost to their farmlands. This type of practice does not exist nowadays (Thapa and Devkota, 1999).

Saaga is a Newari word for compost made from organic wastes dumped in a pit dug on the courtyard called *chowk*. Surrounded by houses, pits were places for collection of kitchen wastes, which was converted into good quality compost after a few months. Settlers emptied pits three or four times a year and used compost for fertilizing their fields on a rotational basis. This practice has also vanished from the municipal area, but still exists in some villages (Thapa and Devkota, 1999).

In 1980 the Solid Waste Management Project was initiated in Kathmandu. Under the project compost production based on aerobic methodology started in 1984-85. The first year of operation produced 146 tons of compost and the amount reached 2,418 tons in 1988-89. The plant was shut down in 1991 due to public complaints about its location in the City. Since the closure of composting plant of SWMRMC, it can be said that composting at municipal level has stopped. Rehabilitation of the plant is not possible anymore. Some Non Governmental Organization's (NGO) activities connected with the small scale production of compost exist in the valley.

The people in the Valley are willing to pay for the efficient management of solid waste. To some extent, the people are paying service charge for door to door collection, provided by some NGO's and private organizations. Now, the government and WMA have realized that the public and private sector's involvement is essential for the efficient management of solid waste in the Valley. In this regard the government has taken initiation to mobilize private companies in the field of solid waste management, especially for the establishment of compost plant (Timilsina, 2001).

2.2 Legislation and Policies relevant to Municipal Solid Waste Management in Nepal

The Constitution of the Kingdom of Nepal, 2047 (1991):

The Constitution of the Kingdom of Nepal, 2047 has made a notable provision in the field of environmental protection. Article 26(4) of the Constitution states that the state shall give priority to the protection of the environment and also to the protection of its further damage due to physical development activities by increasing the awareness of the general public about environmental cleanliness. Article 26 (4) imposes substantial political obligations upon the State in the sense that environmentally concerned citizens and interest groups can utilize this provision to command public attention on the environmental performance of the national government.

Environment Protection Act, 2053 (1997):

Although no direct provisions relating to the Solid Waste Management exists in the Environmental Protection Act, 2053, it has provisions relevant to the management of solid waste. In section 3 and 4 of the act, there are provisions for carrying out of Environmental Impact Assessment (EIA) or Initial Environmental Examination (IEE) and prohibition on Implementation of proposal requiring IEE or EIA without approval. This is particularly significant for the operation of new facilities like land fill sites, dumping sites etc. Section 7 of the act emphasizes the prevention and control of pollution. In accordance to the provisions of sub section under the section 7 nobody shall create pollution in such a manner as to cause significant adverse impacts on the environment or likely to be hazardous to public life and people's health. In case any person commits, any acts under the act or the rules or guidelines framer under the act, the prescribed authority can close down such acts immediately and punish the offender according to the degree of offence, with a fine up to fifty thousand rupees.

Environment Protection Rules, 2054 (1997):

The Environment Protection Rules (EPR) is framed on the grounds of the power conferred by Section 24 of the Environment Protection Act, 2054. The rules prescribed in the EPR also have significance in the management of solid waste. According to rule 3 of the EPR a proponent (of a project) is required to carry out an IEE of the proposals mentioned in Schedule 1 and an EIA of the proposals mentioned in Schedule 2. The proposals related to municipal solid waste management in Schedule 1 and 2 of the EPR are given below.

Schedule 1:

1. Waste Management activities to be undertaken with the objective of providing services to a population ranging between 2,000 and 10,000

2. Following activities relating to waste emitted form households and residential areas:

   a) Filling of land with 100 to 1000 tons of waste a year

   b) Activities relating to transfer stations and resource recovery areas spread over not more than 3 hectares

   c) Selecting, picking, disposing and recycling waste through chemical, mechanical or biological techniques in an area of not more than 2 hectares

   d) Activities relating to compost plants in an area ranging between 1 and 5 hectares

Schedule 2:

1. Waste Management activities to be undertaken with the objective of providing services to a population of more than 10,000

2. Following activities relating to waste emitted form households and residential areas:

   a) Filling of land with more than 1000 tons of waste per year

b) Activities relating to transfer stations and resource recovery areas spread over more than 3 hectares

c) Selecting, picking, disposing and recycling waste through chemical, mechanical or biological techniques in an area spread over more than 2 hectares

d) Activities relating to compost plants spread over an area of more than 5 hectares

Solid Waste Management National Policy, 2053 (1996):

Solid Waste Management National Policy is another important legal document concerned with the solid waste sector. The policy has the following objectives

- To make management work of the solid wastes simple and effective
- To mobilize the solid waste as resources
- To minimize environmental pollution caused by the solid wastes and adverse effect thereof to the public health
- To privatize the management work of the solid wastes
- To obtain public support by increasing public awareness in sanitation works

The strategy adopted by the policy for achieving its objectives is the promotion of public participation, technology, resource mobilization and privatization. The policy points out national and local level institutions responsible for the management of solid waste and describes the responsibilities and legal authority of these institutions. According to the policy a national level institution should be formed by His Majesty's Government Nepal for the management of solid waste. In case of local institutions the policy mentions the *Mahanagarpalika, Upa Mahanagar Palika, Nagarpalika*, and Village Development Committees (VDCs) as responsible for the management of solid waste and related activities.

Local Self Governance Act, 2055 (1999):

The Local Self Governance Act in section 96 subsection C under the heading of Functions Duties and Power of Municipality and Relating to Water Resources, Environment and Sanitation authorizes and makes the municipality responsible to carry out or cause to be carried out and manage the acts of collection, transportation, and disposal of garbage and solid wastes.

2.3 Operational Definition of Terms

Chemical Fertilizer:

Refers to nitrogen, phosphorous or phosphate fertilizers manufactured from virgin raw material feed stock

Compost:

A soil amendment derived from aerobic decomposition of organic wastes. Valuable in agriculture, horticulture, and land reclamation because it improves the ability of soil to retain moisture and chemical fertilizers and to resist erosion, can also be used as a feedstock in aquaculture and as intermediate cover in MSW landfills to reduce the volume of waste and prevent waste from attracting pests or blowing away into residential neighborhoods.

Composting:

Biological decomposition of the biodegradable organic matter under aerobic conditions. End product, which looks like soil, is high in carbon and nitrogen and is an excellent medium for growing plants. Apart from being clean, cheap, and safe, composting can significantly reduce the amount of disposable garbage.

Integrated Solid Waste Management:

Combination of a number of alternative waste control methods in a complementary manner, in a way, that best meets local needs. Philosophy behind the concept is that no single approach is capable of solving the solid waste problem due to the diversity of waste stream components

Municipal Solid Waste:

All solid wastes generated in a community except for industrial and agricultural wastes. Generally includes discarded durable and non durable goods, containers, and packaging, food scraps, yard trimmings, and miscellaneous inorganic debris, including household hazardous wastes and often construction and demolition debris and sludge and ash generated by sewage treatment plants and MSW incinerators.

Recycling:

Act of gathering and refining the by products of production or consumption activities for use as inputs for production activities.

Reuse:

Use of a product more than once, either for the same purpose or for a different purpose. Reusing, when possible, is preferable to recycling because the item does not need to be reprocessed before it can be used again.

Sanitary Landfill:

Method of disposing of MSW to minimize effects on human health and the environment. Generally consists of a pit lined with clay and plastic to prevent leachate from seeping into groundwater, drainage pipes to draw off leachate for treatment, deposits of MSW in thin layers that are frequently covered with soil or other material to keep out water and prevent waste from blowing away or attracting pests, and a system to collect methane to prevent explosions.

Solid Waste Management:

Discipline associated with the control of generation, storage, collection, transfer and transport, processing, and disposal of solid wastes in a manner that is in accord with the best principles of public health, economics, engineering, conservation, aesthetics, and other environmental considerations, and that is also responsive to public attitudes.

Source Reduction:

Any practice that reduces the quantity and/or toxicity of pollutants entering a waste stream prior to recycling, treatment, or disposal. Source reduction is also called waste prevention.

Transfer Station:

A facility where MSW from collection vehicles is consolidated into larger loads that are transported by tractor trailers, railroad, barges, or other means to processing facilities or landfills

Waste Collection:

Gathering MSW from where it is generated and transporting it to a transfer station, processing facility, or landfill to safeguard public health, limit congestion, and preclude unpleasant odors and offensive sights.

Waste Disposal:

Isolation and containment of the residual waste left after processing

Windrows:

Piles of aerobically composting materials that are formed into rows and turned periodically to expose the materials to oxygen and to control the temperature to promote biodegradation

Chapter III

MATERIALS AND METHODS

3.1 Study Area

The major part of the study was carried out in Kathmandu Metropolitan City. Some part of the study was conducted out of the City within the Kathmandu Valley. The study included visits to households, nurseries and waste management organizations in the City. The sites covered by the study also included the Teku Transfer Station situated in the premises of Kathmandu Municipal Corporation and the final disposal site at Balkhu on the banks of Bagmati River. Part of the study, particularly concerned with the compost use in the farming area was carried out in Kirtipur (Kathmandu District), Harisiddhi (Patan District) and Madhyapur Thimi (Bhaktapur District).

3.2 Tools for Data Collection

In order to obtain the information relevant to the study following tools for data collection were employed:

Review of Literature:

Available literatures in the form of research reports, thesis, journals, conference proceedings, and others were reviewed to extract information related to the study. Similarly other published and unpublished materials, relevant environmental standards, acts, legislation, rules and regulations were collected from the concerned agencies and public libraries. The information on the finances of solid waste management, the present waste generation, composition and current practices were obtained primarily from the KMC.

Household Survey:

For the information related to the public opinion on composting like the willingness for source separation of waste, willingness to pay for waste collection services, their preferences residents of the KMC were surveyed with the help of a standard set of schedule (Schedule I: Appendix A). Five different sampling area namely Chabahil, Minbhawan, Teku, Dillibazar and Nayabazar were selected and twenty households in each of the area were interviewed with the help of a structured schedule. At every location the respondents were randomly selected and interviewed.

Key Informants Interview:

For the information relating to the present waste management practices, current issues and constraints officials of the KMC were interviewed based on semi structured schedules. The non governmental organizations involved in solid waste management of the City were interviewed with the help of a standard set of schedule (Schedule II: Appendix A). The information on market demand for the compost products and the market potential was obtained by interviewing individuals involved in producing, selling and using compost derived products. It included interviews with households, farmers and individuals of nurseries through structured schedules (Schedule I and III: Appendix A). Altogether fifty farmers in

three different locations namely Harisiddhi, Kirtipur and Madhyapur Thimi were interviewed. In Harisiddhi and Kirtipur fifteen farmers each were interviewed. In Madhyapur Thimi twenty farmers were interviewed. Additionally ten nurseries were interviewed at different locations within the Kathmandu City.

On Site Observations:

On site observations were carried out to find out the current practices related specifically to composting and solid waste management in general. The sites for on site observations included the operational compost plants of the Kathmandu City, Teku transfer station and the dumping sites along the Bagmati River. Observations were also made in the farm areas.

3.3 Data Analysis and Interpretation

The data analysis was done using a variety of tools and methods. The primary and secondary data collected during the desk studies and field works were processed and edited. The quantitative data was tabulated and relevant statistical tools and computer software were employed for analyzing and interpreting the results. For the qualitative data personal judgement, expert comments and results of key informants interview and public survey was used as a basis for its analysis and interpretation. Because of lack of uniform data in some cases (particularly regarding the quantity of compost use in the different market segments), several assumptions and generalizations had to be made during the process of data analysis.

Chapter IV

RESULTS

4.1 Municipal Solid Waste Management Scenario in Kathmandu Metropolitan City

4.1.1 Waste Characteristics

Waste Composition:

The composition of municipal solid waste in Kathmandu Metropolitan City is illustrated in figure 4.1. One significant aspect of the waste composition from management point of view is the large volume of organic materials in the solid waste stream. The official figures of KMC for the year 2001 (most recent figure available) indicate that almost 69% (by weight) of the waste generated in Kathmandu Metropolitan City is organic. Paper and plastic are other two important constituent of the municipal solid waste stream.

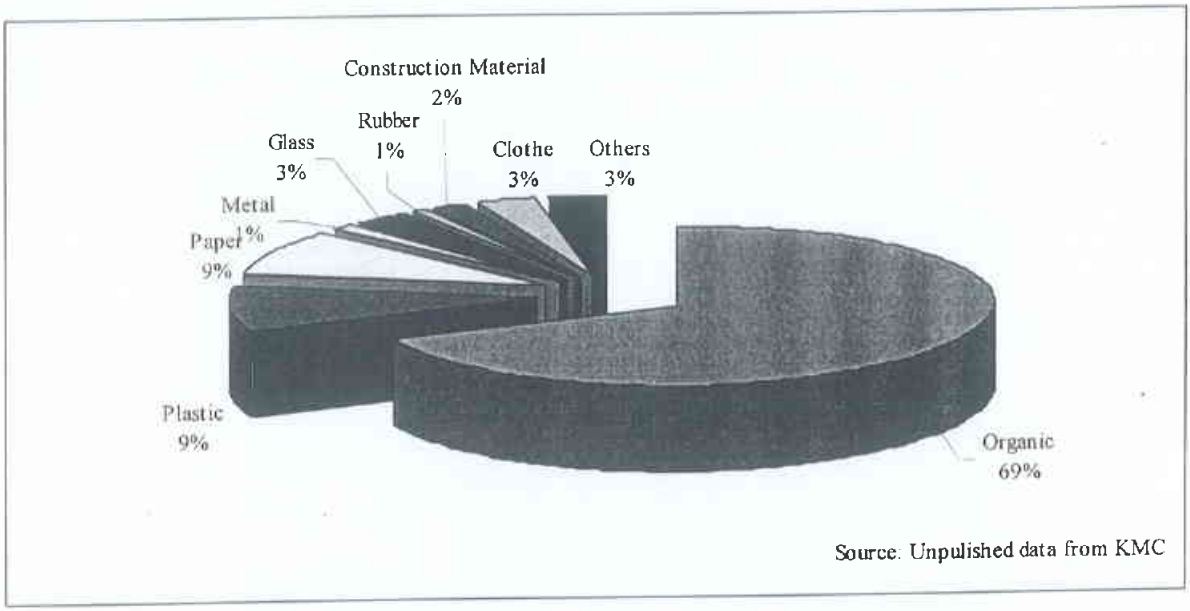

Figure 4.1: Solid waste composition in Kathmandu Metropolitan City (2001)

Waste Generation:

According to the calculations presented in the table 4.1 the total waste generation in the year 2003 was 960 m^3/day. When expressed in tons, it amounts to a total waste generation of 216 tons/day for the year 2003. The calculations have been carried out by taking the population in Kathmandu City as 738173 for the year 2003. Taking per capita waste generation and waste density values as 1lit/day, 0.225 kg/l respectively and an estimated population of 787886, the predicted waste generation for the year 2004 is 1024 cubic meters or 230 tons/day. The estimates differ slightly from the official figures of KMC. The reason for the deviation is the differing population estimates by the study and by KMC.

Recent studies indicate that the organic fraction in the solid waste stream accounts for around 70 % of the total waste by weight. Taking this fact into account the daily organic waste generation of Kathmandu Metropolitan City has been estimated to be approximately 151 tons for the year 2003 and is 161 tons for the year 2004. The waste generation expressed in table

4.1 and subsequent calculations are based on a per capita waste generation of 1 liter/day and waste density of 0.225 kg/l as calculated by the Kathmandu Valley Mapping Project in the year 2000. It should be noted here, that earlier studies indicate a per capita waste generation of around 0.4 - 0.5 kg/day for the City (UNEP 2001), which is at the higher side.

Table 4.1: Waste Generation Estimates for Kathmandu Metropolitan City

Year	2003	2004
Estimated Population*	738173	787886
Average Domestic Waste Generation**	1 lit/d/p	1 lit/d/p
Lose density :density at source**	0.225 ton/m^3	0.225 ton/m^3
Estimated Total Domestic Waste Generation	738.17 m^3	787.89 m^3
Street Waste Generation ***	73.82 m^3	78.79 m^3
Commericial Waste Generation***	73.82 m^3	78.79 m^3
Waste from Instituitions Neighbouring Cities and VDCs ***	73.82 m^3	78.79 m^3
Estimated Total Daily Waste Generation (in m3)	**960**	**1024**
Estimated Total Daily Waste Generation (in tons)	**216**	**230**

Notes: * Taking annual population growth rate of 4.824% from 1991-2001 based on CBS figures
** Source: Kathmandu Valley Mapping Project, 2000
*** Assumed 10% of Domestic Waste Generation

4.1.2 Municipal Waste Management System

Waste Storage:

The household survey carried out in hundred households of Kathmandu Metropolitan City and the interviews with the Solid Waste Management Organizations indicate that two types of waste storage practices exists in the City i.e. commingled waste storage and segregated waste storage. The storage of waste in a commingled form is the more prevalent form among the two practices (table 4.2). 84 % of the households surveyed were found to store the waste in a commingled form while rest of the households segregated the waste and stored the organic fraction of the waste separately from other waste.

Table 4.2: Household storage of waste in Kathmandu Metropolitan City

Sampling Area	Commingled (in %)	Segregated (in %)
Chabahil*	80	20
Minbhawan*	85	15
Dillibazar*	95	5
Nayabazar*	85	15
Teku*	75	25
Total	**84**	**16**
Total Sample Size:100		*Sample Size:20

Results of the household survey (table 4.3) reveal that majority of the households in the Kathmandu Metropolitan City are willing to segregate the organic fraction of the waste from the others and store them separately.

Table 4.3: Willingness of households to segregate the organic fraction of waste

Sampling Area	Willing (in%)	Unwilling (in%)
Chabahil*	85	15
Minbhawan*	80	20
Dillibazar*	95	5
Nayabazar*	95	5
Teku*	90	10
Total	89	11
Total Sample Size:100		*Sample Size:20

Waste Collection:

There are several organizations involved in the collection of waste generated in the City. The most prominent organization is the Kathmandu Municipal Corporation. In the last decade there has been a substantial increase in the number of solid waste management organizations, other than KMC. These organizations primarily include private limiteds and NGOs. In a smaller scale community based organizations and youth clubs are also involved in the collection of waste. Table 4.4 lists all the prominent non governmental solid waste management organizations (NGSWMOs) in the Kathmandu City. The organizations visited during the study are listed in table 4.5.

Table 4.4 Prominent NGSWMOs in Kathmandu Metropolitan City

S. No.	Organizations	Class
1	Kathmandu Mahanagar Solid Waste Management Services	A
2	SILT Envrionmental Services Pvt. Ltd.	A
3	A to Z Cleaning Services	A
4	K.P. Cleaning Services	A
5	Karmachari Kalyan Kosh	A
6	Bauddha Youth Group	B
7	Pragatishil Pvt. Ltd.	B
8	Jana Jagriti Safa Suggar Campaign	B
9	Nepal Bahu Uddesya Group Pvt. Ltd.	B
10	Samyukta Sewa Pvt. Ltd.	B
11	Our Cleaning Campaign and Services Pvt. Ltd.	B
12	Jana Jagaran Abhiyan	B
13	Women Environment Abhiyan	B
14	Sarsafai Abhiyan Pvt. Ltd.	B
15	Jana Jagaruk Safa Sugahr Abhiyan	B
16	B and B Cleaning Services	B
17	Nepal Fulbari Pollution Control Centre	C
18	Nepal Pollution Control and Environmentas Management Center	C
	Source: Unpublished data from KMC	

Notes: Class A: Organizations having formal agreement with KMC and involved in street sweeping, waste collection and transportation

Class B: Organizations without formal agreement with KMC involved in waste collection and transportation

Class C: Organizations without formal agreement with KMC involved in waste collection (final disposal in KMC containers)

In the last few years a general trend of privatization can be recognized in the waste management sector. According to the official figures of KMC (table 4.6) out of the total 975 cubic meter of average daily waste generated in the year 2059 (2002/03), 895 cubic meters

were collected by KMC and the NGSWMOs. Almost 73% of the waste was collected by KMC while the rest of 26% was collected by the NGSWMOs. On comparing this figure with that of 2056 (1999/2000), within the short period of four years, a substantial increase in the amount of waste collected by the non governmental sector can be observed. In the year 2056 the non governmental sector accounted for only 7 % of the total waste collected and increased to 17, 20 and 26 % for the year 2057 (2000/01), 2058 (2001/02) and 2059 (2002/03) respectively. According to the latest figures of KMC (*for the first eight month of year 2060 (2003/04)), the NGSWMOs collect 24% of the total waste generated while KMC collects 63% of the total waste generated, taking the overall collection efficiency to 87%. 13% i.e. around 29.5 tons of the waste generated in the City still remain uncollected.

Table 4.5: Surveyed NGSWMOs in and around Kathmandu Metropolitan City

Code	Organizations
1	Silt Environmental Services Nepal Pvt. Ltd.
2	Kathmandu Mahanagar Solidwaste Management Service
3	A-Z Cleaning Services
4	Our Cleaning Campaign and Services Pvt. Ltd.
5	Samyukta Services Pvt. Ltd.
6	Nepal Pollution Control and Environmental Management Centre
7	Jana Jagaruk Safa Sugar Abhiyan
8	Sagarmatha Environment Development Center
9	Environment Preservation Center
10	Gaurinagar Sudhar Samiti

Table 4.6: Waste generation and collection in Kathmandu Metropolitan City

Year	2056 (1999/2000)	2057 (2000/01)	2058 (2001/02)	2059 (2002/03)	2060* (2003/04)
Waste Generation (in m^3)	911	944	949	975	1008
Total waste Collected by KMC and Private (in m^3)	784	674	651	895	877
Waste Collected by KMC (in m^3)	729	557	522	653	635
Waste Collected by Private Sector (in m^3)	55	113	133	244	242

Source: Unpublished data from KMC

Note: *The figures of 2060 (2003/04) are for the first eight months of the year

Mainly three modes of waste collection exist in Kathmandu Metropolitan City i.e. roadside collection, door to door collection and container collection. In door to door collection people temporarily store the waste in the households and is later handed over to the collectors (Appendix B: Plate 1 and 2). In case of roadside collection people throw away their waste typically in a plastic bag in a pre designated area or anywhere near the roadside (Appendix B: Plate 3) which is later collected by the respective organizations. In case of container collection people dispose off their waste in containers at designated areas which is then collected by KMC. According to the KMC figures for the year 2059 (2002/03), out of the total 895 cubic meter (201.5 tons) of average waste collected per day, roadside collection accounted for around 50.4% while door to door collection and container collection accounted for around 28.8 and 20.8% respectively (figure 4.2).

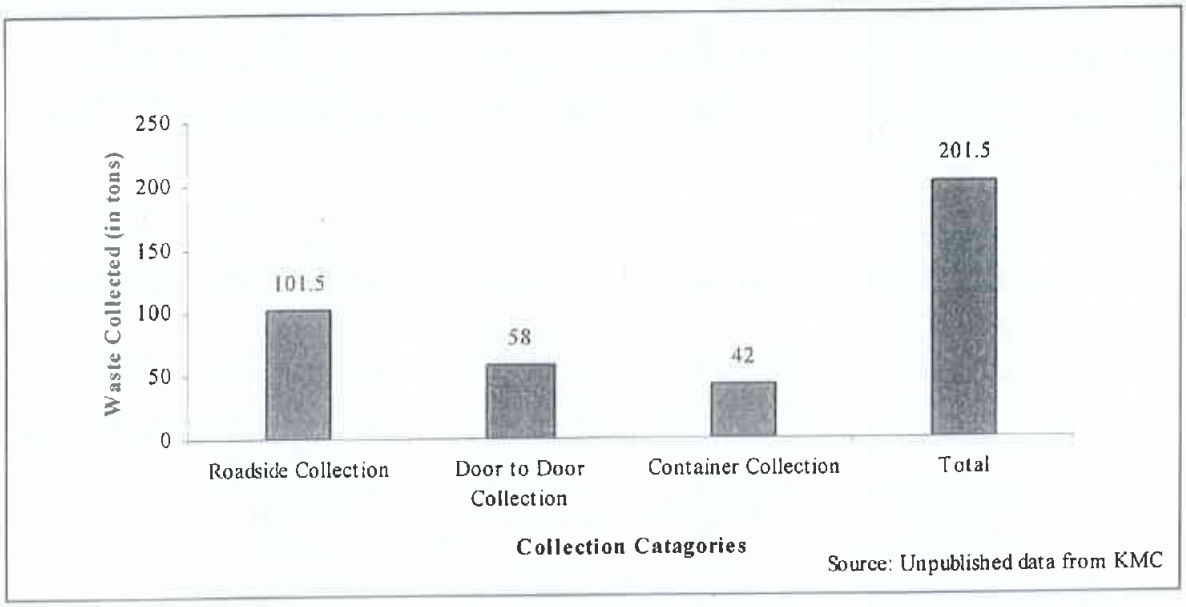

Figure 4.2: Waste collection in Kathmandu Metropolitan City for the year 2002/03

Table 4.7: Waste collection method of NGSWMOs

Code	Waste Collection		
	System		Frequency
1	Door to door + Road Side	Commingled	Once a day
2	"	Commingled	Once a day
3	"	Commingled	Twice a day
4	"	Commingled	Once in two days
5	"	Commingled	Once a day
6	"	Commingled	Once a day
7	"	Commingled	Thrice a week
8	"	Commingled	Once a day
9	"	Commingled	Once a day
10	"	Commingled	Once a day

Note: Refer table 4.5 for the name of the organizations associated with the codes

Table 4.8: Waste management services in households of Kathmandu Metropolitan City

Sampling Area	Door to Door Collection (in %)	Container Collection (in%)	Street Collection (in %)	No Service (in %)
Chabahil*	90	10	0	0
Minbhawan*	55	0	15	30
Dillibazar*	100	0	0	0
Nayabazar*	85	0	0	20
Teku *	90	5	5	0
Total	**84**	**3**	**4**	**10**
Total Sample Size: 100				*Sample Size:20

The NGSWMOs collect the waste in two ways i.e. door to door and roadside (table 4.7). Door to door collection is the primary service the organizations provide, however, because many households, shops, institutions near the roadside throw their waste along the roads, the sweepers also collect waste from the roadside. The waste collection service provided by KMC

does not include door to door collection. The waste is either collected from the containers placed in different locations or directly from the roadside. The container collection and roadside collection of waste has a negative impact on the environment. The waste dumped along the roadside and the container is often blown away by wind or washed away by water. Additionally the piles of waste dumped along the roads (Appendix B: Plate 3) and containers is an eye shore degrading the aesthetics of the City. They also emit objectionable odors and contribute in degrading the environmental quality of the surrounding.

The results of household survey indicate that most of the household at present enjoy solid waste collection facilities of one type or another (table 4.8). Out of the total households surveyed only 10% of the households did not receive any kind of collection services. The lack of waste collection service in the households was not because of the absence of service in the area, but because of the households' conscious choice not to opt for the service.

Waste Transportation and Final Disposal:

The waste from the source reaches the final disposal site (currently along the banks of Bagmati near Balkhu) in various ways (table 4.9). In case of the NGSWMOs, waste collected from the household and roadside is transported primarily by the means of tricycle and in some areas through handcarts and tractors. Once these vehicles are full they are directly loaded to mini trucks or dumped in a specific place later to be loaded into the minitruck. Once the minitruck is fully loaded the waste is taken to the Teku Transfer Station (Appendix B: Plate 4) or directly to the final disposal site at Balkhu and disposed off along the banks of Bagmati River (Appendix B: Plate 5). The organizations that have formal agreement with KMC are allowed to dispose the collected waste in the Teku Transfer Station (but still many organization directly take the waste to Balkhu), whereas organizations without agreement take their waste directly to Balkhu. Few organizations (mainly community based organizations and organizations operating in immediate VDCs) dispose off the collected waste in the KMC containers (Appendix B: Plate 6). As the waste generated from some of the immediate VDCs are disposed off in KMC containers, it contributes to the overall solid waste stream that has to be managed in the City

In case of the waste collected by KMC each ward is responsible for the management of the waste generated in the respective wards. Each of the thirty five wards is allotted 25-30 sweepers, a tractor, 5-7 handcarts and other tools like shovels, brooms etc. The waste from the roadside are swept and piled up into heaps in a specific place which are then loaded into the tractors or tippers and taken to either Teku Transfer Station or Balkhu depending on the hauling distance. Areas near the Teku Transfer Station take the collected waste to the Transfer Station, where the waste is reloaded into compactors and taken to Balkhu, while waste from areas near Balkhu is taken directly to Balkhu and disposed off. Waste piled up in pre designated spots and containers is loaded to tractors/ tippers and skippers respectively and taken to either the Transfer Station or Balkhu. Once the waste reaches Balkhu, it is dumped into pits excavated along the banks of the Bagmati River and covered with a layer of soil.

The above practices are the predominant form of transportation and disposal of municipal waste in the City. A portion of the waste is never collected and transported to the final disposal site and in most cases is haphazardly and permanently disposed off in rivers and open spaces. According to the official figures of KMC for the year 2002/03, out of the total waste generated, 8% (17.6 tons) of the waste remained uncollected. Similarly early figures for the year 2003/04 indicate that around 13% (29.5 tons) of the total waste generated remain uncollected.

Table 4.9: Waste transportation and final disposal by NGSWMOs

Code	Waste Transportation		Final Disposal
	Primary Transport	Secondary Transport	
1	Tricycle	Minitruck	Balkhu
2	Tricycle	Mini Truck	Teku T. Station
3	Handcarts+Tricycle	Mini Truck	Balkhu
4	Tircycle	Mini Truck	Teku T.Station
5	Handcarts+Tricycle	Tractor+Mini Truck	Balkhu
6	Tricycle	Mini Truck	Teku T. Station
7	Tricycle	Mini Truck	Balkhu
8	Tricycle	Mini Truck	Teku T. Station
9	Tricycle	Absent	KMC Containers
10	Handcarts+Tricycle	Absent	KMC Containers

Note: Refer table 4.5 for the name of the organizations associated with the codes

The observations made during the study reveal that households, institutions and commercial establishments located near rivers and open space, have a tendency to throw away the waste the rivers and/or open space. For instance out of the hundred households surveyed ten did not receive any collection service. The absence of collection service was not because of the lack of service in the particular area, but because of the unwillingness to pay for the service by the households. Majority of these households were situated close to the river banks and they disposed off their waste in the nearby rivers (in Nayabazar it was the Bishnumati River (Appendix: Plate 7) and in Minbhawan it was the Bagmati River). During the survey, households disposing off waste in open spaces (besides river banks) were not encountered, but the on site observations made during the study reveal that if open space exists near households (or institutions and commercial establishments for that matter), people have the tendency of throwing away the waste in the open space, particularly when the settlement is sparse and there is no one complaining.

Overview of Municipal Solid Waste Management System in Kathmandu Metropolitan City:

The figure 4.3 gives an overview of the municipal solid waste management system in the City. The grey boxes in the figure indicate environmentally harmful practices currently existing in the solid waste management system while the white boxes represent environmentally friendly practices.

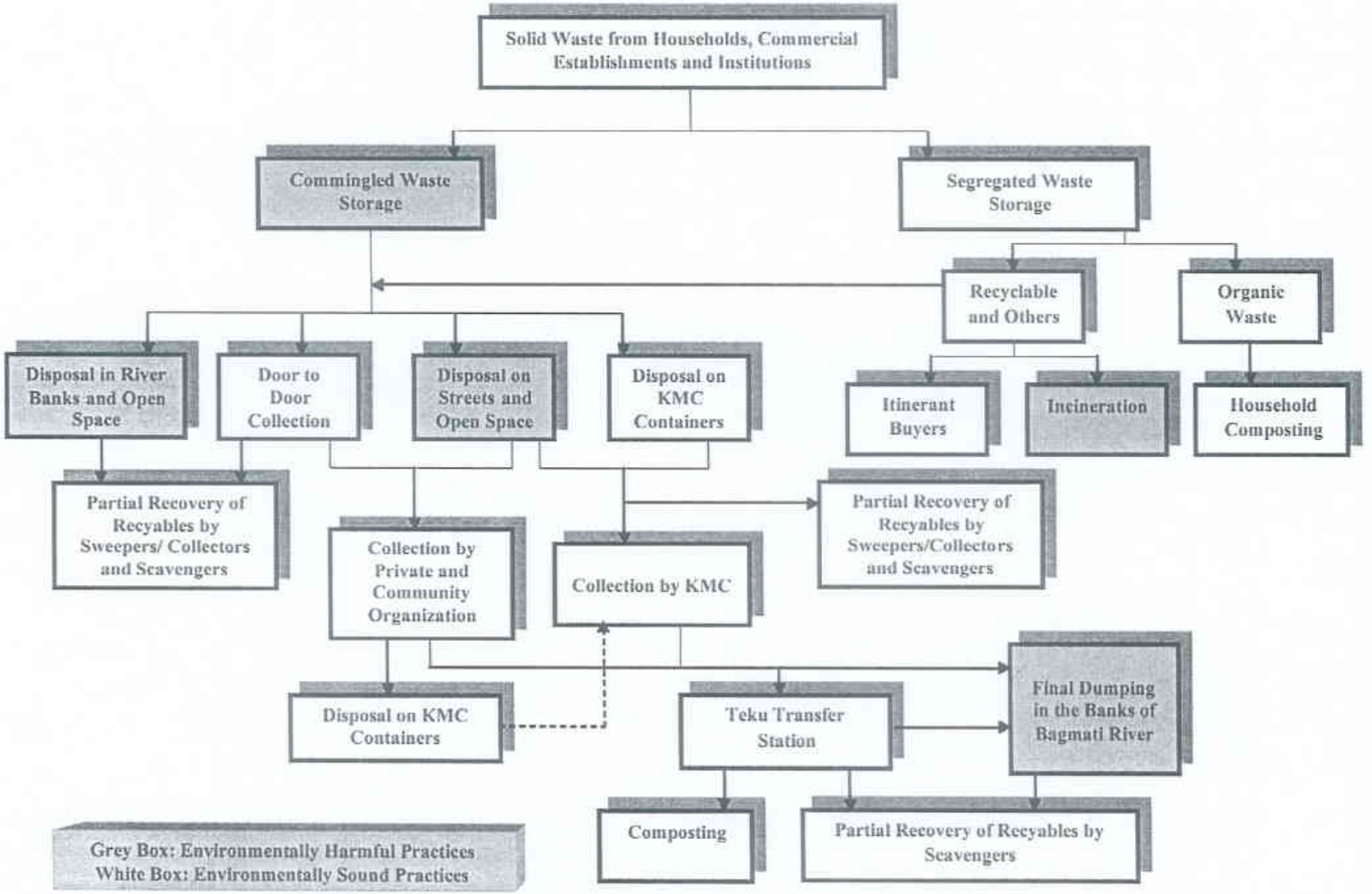

Figure 4.3: Schematic diagram of municipal solid waste management system in Kathmandu Metropolitan City

4.1.3 Institutional Aspects of Municipal Solid Waste Management

Kathmandu Municipal Corporation:

Kathmandu Municipal Corporation is the authorized government organization responsible for the overall management of solid waste in the City and hence looks after and runs the day to day affairs concerning solid waste management in the City. The Solid Waste Management Section under the Environment Department of KMC has seven different units for the management of solid waste (figure 4.4). Another section, the mechanical section, is responsible for the overall maintenance of the equipments used for solid waste management. All the thirty five wards of the Kathmandu Metropolitan City are responsible for the management of the waste generated in their respective wards. In co-ordination with KMC, the ward offices collect, transport and dispose off waste generated in the wards. The ward offices are provided with equipments and manpower necessary for the task by KMC. In some wards the complete responsibility of waste management lies on NGSWMOs. These organizations have formal agreements with KMC and carry out their works according to the terms of reference of the agreement. Other organizations without any formal agreements also work in coordination with KMC.

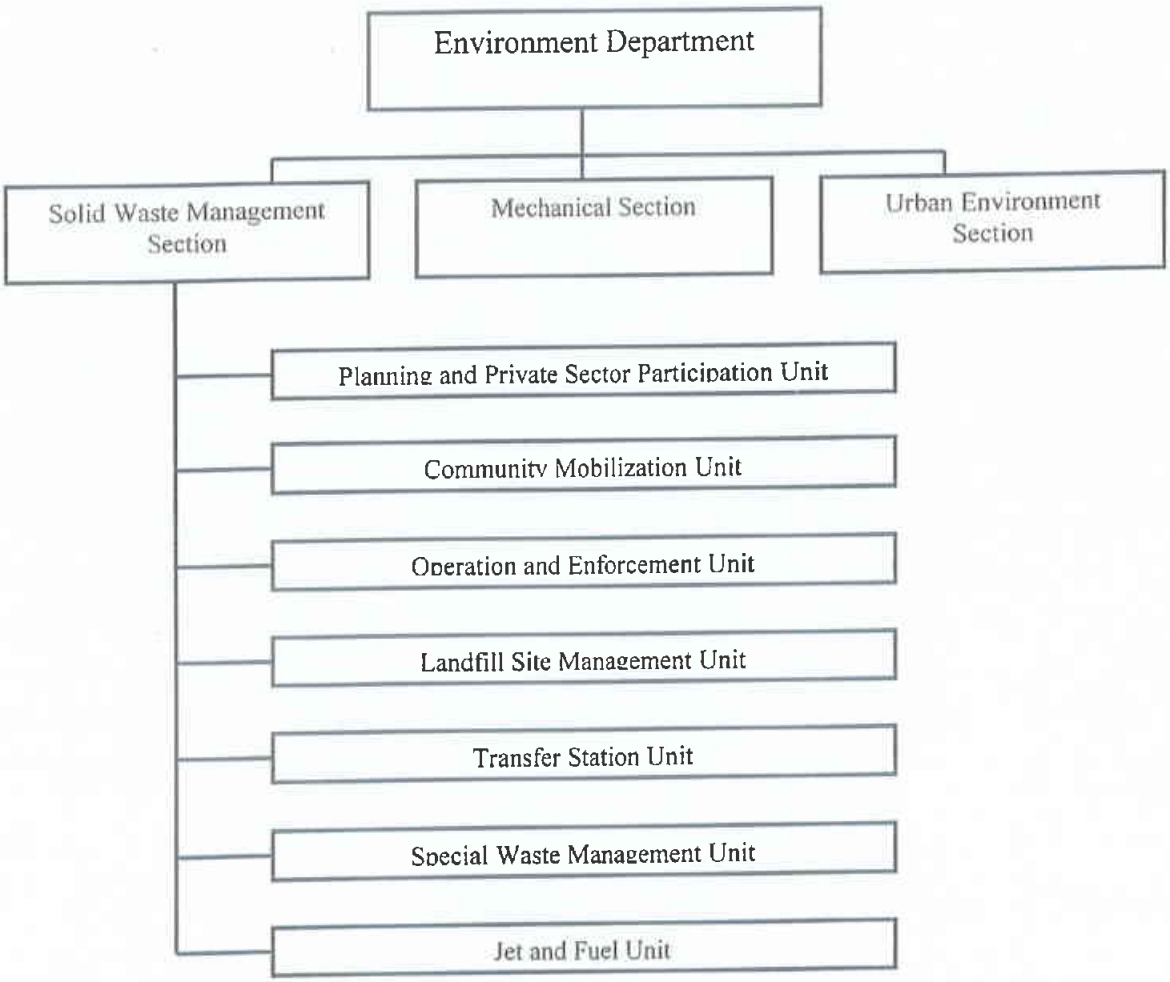

Figure 4.4: Organizational structure of the Environmental Department of KMC

Non Governmental Solid Waste Management Organizations:

There are numerous non governmental solid waste management organizations (table 4.4 and table 4.5) in Kathmandu Metropolitan City. These organizations include private limiteds, non governmental organizations (NGOs), community based organizations (CBOs) and local youth clubs. Details on several of the organizations that were covered in the field survey are given in table 4.10. In the last decade these organizations have grown in their significance in the overall waste management of Kathmandu Metropolitan City. Except for small CBOs and youth clubs, the organizations provide waste collection services to around 1100-4000 households, shops and institutions. Most prominent among the solid waste management organizations are the Pvt. Ltd and NGOs. On a much smaller scale CBOs (*tol sudhar samiti*) and local youth clubs are also involved in waste management activities. Most of the organizations have been involved in municipal solid waste management only from the last five years while some have a longer history. The number of staffs in the organizations and equipments used by the organizations surveyed are given in table 4.11.

Table 4.10: Details on NGSWMOs

Code	Address	Area Served (Ward No./VDC)	Households,Shops & Institutions Served	Legal Status	Formal Agreement with KMC	Years Involved In SWM
1	Tahachal	13,14,15 (C)	3500	Pvt. Ltd.	Present	5
2	Kamalpokhari	1 (C)	1400	Pvt. Ltd.	Present	2
3	Newroad	24 (C)	1100	Pvt. Ltd.	Present	2
4	Koteshwar	35 (C)	1100	Pvt. Ltd.	Absent	9
5	Kalopool	7 (P)	1500	Pvt. Ltd.	Absent	1
6	Swayambhu	3,4,15,16,(P)	4000	NGO	Absent	12
7	Minbhawan	9,10,34 (P)	2500	NGO	Absent	8
8	Dillibazar	7,9,33 (P)	1200	NGO	Absent	2
9	Basundhara	Dhapasi VDC (C)	1200	NGO	Absent	5
10	Chabahil	7 (P)	228	CBO	Absent	11

Notes: (C): Complete responsibility for the SWM of the area
(P): Partial responsibility for the SWM of the area
Refer table 4.5 for the name of the organizations associated with the codes

Table 4.11: Equipments and number of staffs in NGSWMOs

Code	Sweepers/Collectors	Drivers	Administrator	Total Number of Staffs	Number of Equipments
1	51	3	9	63	Tricycle-35 Mini Truck-3
2	39	2*	10	49	Hand Cart-4 Tricycle-11 Mini Truck-2
3	31	1*	4	35	Hand Cart-4 Tricycle-5 Mini Truck-1
4	14	1*	3	17	Tricycle-7 Mini Truck-1
5	14	2*	4	18	Tricycle-9 Tractor-1 Mini Truck-1
6	55	3*	27	82	Tricycle-28 Mini Truck-2
7	52	2*	13	65	Tricycle-20 Mini Truck-1
8	7	1*	6	13	Tricycle-5 Mini Truck-1
9	13	0**	7	20	Tricycle-8
10	2	0**	1	3	Hand Cart - 2 Tricycle-1

Notes: * Vehicles are leased for waste transportation, drivers not the staff of the organizations
** No secondary transport exists, waste collected are transferred to KMC containers
Refer table 4.5 for the name of the organizations associated with the codes

4.1.4 Financial Aspects of Municipal Solid Waste Management

Kathmandu Municipal Corporation:

In the year 2059 (2002/2003), the corporation spent 132,216,391 NRs for the management of solid waste generated in the Kathmandu Metropolitan City (table 4.12). The largest portion of the money was spent on street sweeping. According to the official figures for the same year, KMC collected 653 m^3 of waste (146.925 tons) per day i.e. 53628 tons of waste for the whole year. The cost for one ton of waste managed by KMC can be thus calculated as 2465 NRs. However, this figure does not reflect the true cost of solid waste managed by KMC. There are several other factors that need to be considered.

An important factor is the cost of landfill management. The cost of landfill management in table 4.12, not only reflects the cost of managing 53628 tons of waste collected by KMC but also reflects the cost of landfill management for the waste collected by the non governmental

Table 4.12: Operational cost of KMC for MSWM in the year 2059 (2002/03)

Headings	NRs/Year	% Spending
Street Sweeping	85,165,482	64
Collection	24,326,563	18
Transfer Station	2,915,490	2
Transportation	9,826,474	7
Landfill Management	9,982,382	8
Total	**132,216,391**	**100**

Source: Unpublished data from KMC

sector i.e. 20039 tons of waste for the year 2059 (2002/03). Thus, for each ton of waste managed in the landfill the operating cost is 136 NRs. If the cost of land filling is excluded then the cost per ton of waste managed by KMC is 2279 NRs for the year 2059 (2002/03). The waste collection costs of 24,326,563 NRs for the 53628 tons of waste collected by KMC has to be on the higher side as several organizations (table 4.4) dispose off the waste collected by them in KMC containers which is recorded as waste collected by KMC. In this particular case the costs involved in collecting the waste from the source up to the disposal in KMC containers (which is borne by the organizations) is not reflected in the collection cost of KMC. Another factor to be noted is the cost of operating the transfer station. Only a fraction of waste generated in the City reaches the transfer station. Majority of the waste are directly transported from the source to final disposal site, hence if all the waste had to be handled in transfer station prior to its transportation to final disposal the cost would be much higher. The total cost of waste managed by KMC for 2059 (2002/03) including the landfill cost is 2415 NRs/ton (2279+136) if the other factors discussed above are neglected.

Non Governmental Solid Waste Management Organizations:

The non governmental solid waste management organizations collect service charges from their customers for the solid waste related services. Every organization has its own rate of service charges. In an average the service charges levied by the organizations ranges from 75-100 NRs per month (table 4.13). The service charges vary from a minimum of 20 NRs to a maximum of 20,000 NRs per month. Most of the organizations also collect waste for free from the households which cannot afford to pay the fee. The predominant basis for levying service charge to the households, shops, institutions etc are their relative size and the amount of waste generated by them. Normally the fee ranges from 20 NRs to 500 NRs per month while for some prominent waste generators like some of the big hotels, the service charge can reach up to 20000 NRs per month.

Service charges are the only means of income for all of the organizations. The monthly income of the organizations depends on the service area, service charge levied and the efficiency in collection of service fees. The income of the organization is not fixed and varies from month to month. Table 4.13 summarizes the average monthly income and expenditure of the organizations. It can be seen from the table that the margin of income and expenditure is negligible. There is no substantial operational profit for the organization involved in the municipal solid waste management sector. However, these organizations provide employment to the people involved in the organizations and the very fact that they provide employment is the prime factor motivating the staffs and driving the organizations.

The official figures of KMC (table 4.6) for the first eight month of year 2060 (2003/04) indicate that NGSWMOs collect around 242 m^3 of waste per day i.e. 54.45 tons per day or 19874 tons for the whole year. The waste collected can be attributed to the sixteen

NGSWMOs (class A and B) out of the eighteen prominent organizations (table 4.4) and other smaller community based organization involved in waste management. This is because the latter organizations dispose off the collected waste in KMC containers which is ultimately regarded as waste collected by KMC. Thus for the year 2003/04 on an average the sixteen organization will collect around 1242 tons of waste each for the whole year. The current annual operating cost of the organizations is around 1577143 NRs (based on table 4.13). Thus, it is safe to assume that the cost for each ton of waste managed by the non governmental sector (excluding the cost of landfill management) from collection to final disposal is 1270 NRs. If the cost of waste managed in landfill i.e. 136 NRs/ton (refer calculations for KMC in chapter 4.1.4) is added, the operating cost for complete management of waste by the private sector amounts to 1406 NRs/ton. Comparison of costs between the KMC and NGSWMOs reveal that the latter are more efficient than KMC.

Table 4.13: Service charges and income of NGSWMOs

Code	Average Service Charge (in NRs)	Average Monthly Income (in NRs)	Average Monthly Expenditure (in NRs)
1	75	200000	200000
2	100	260000	240000
3	100	100000	100000
4	100	100000	100000
5	75	80000	80000
6	100	350000	350000
7	80	100000	100000
8	100	80000	80000
9	100	80000	80000
10	75	12000	12000

Note: Refer table 4.5 for the name of the organizations associated with the codes

4.2 Composting in Kathmandu Metropolitan City

4.2.1 Household Composting

Many households in Kathmandu Metropolitan City are involved in composting of organic fraction of the waste generated in the households. Mainly two types of composting exist in the households of Kathmandu Metropolitan City, they are composting in compost bins and composting in traditional compost pits (Appendix B: Plate 8 and 9), although other practices like vermi-composting, composting in flower pots etc. also exists. Out of the hundred households surveyed, 10% of the households made composts in compost pits while 4% of the households made compost in compost bins (table 4.14).

Table 4.14: Household composting in Kathmandu Metropolitan City

Sampling Area	Household Composting		
	Pit Composting	Bin Composting	Absent
Chabahil*	2	2	16
Minbhawan*	3	0	17
Dillibazar*	1	0	19
Nayabazar*	2	0	18
Teku*	2	2	16
Total	**10**	**4**	**86**
Total Sample Size:100			*Sample Size:20

Table 4.15: Compost bins distributed by NGSWMOs

Organizations	Quantity
Kathmandu Municipal Corporation	400
Center for Progressive Infrastructure	300
World Vision	250
Youth Corner Club	60
Gharelu Tatha Sana Udhyog	30
Gaurinagar Sudhar Samiti	38*
Total	**1078**
Source: Unpublished data from KMC	

Note:* Figure from field survey

Several organizations (table 4.15) are actively involved in promoting household composting in compost bins in the City. These organizations are promoting composting in bins by providing training on composting and distributing specially designed compost bins (Appendix B: Plate 8 and 10) at subsidized rates. From the figures available through KMC and the survey, the total amount of compost bins distributed by various organizations in the City amounts to 1078. According to the figures of KMC 100% of the bins distributed by KMC are being used to make composts. According to the survey done in the Gaurinagar area out of the 38 bins distributed 21% are no longer in use while remaining 79% are making compost in it. KMC sells its bins (Appendix B: Plate 10) at a price of 750 NRs per bin of 100 liters capacity at 30% subsidy. It promotes these bins by giving trainings and providing after sell services like consultation via telephone and home visits. The Gaurinagar Sudhar Samiti sells its bins of 100 liter capacity at a price of 350 NRs (50% subsidy). The Youth Corner Club distributes the bins for free.

Table 4.16: People's willingness for household composting

Sampling Area	Willing (in %)	Unwilling (in %)
Chabahil*	45	55
Minbhawan*	30	70
Dillibazar*	20	80
Nayabazar*	15	85
Teku*	20	80
Total	**26**	74
Total Sample Size:100		*Sample Size:20

Table 4.17: Reasons for unwillingness for household composting

Reasons	Percentage
Bad Smell	7
Lack of space for composting	19
No use of compost	29
No time	9
Extra work	10
	Sample Size :100

Results from the field survey indicate that 74% of the household are not interested in making compost at the household level (table 4.16). They put forward several reasons (table 4.17) for the unwillingness. The most common reasons are associated with the end use of compost (i.e. no use of compost), lack of time and extra burden on the already busy life of the City

inhabitants. Lack of space for composting was also a prominent argument put forward by the households. This specific argument can be attributed to the common perception prevailing among the general public, that the practice of composting requires significant space. Almost all the households surveyed were found to be aware of composting and its benefits (table 4.18).

Table 4.18: Public awareness on composting

Sampling Area	Aware (in %)	Unaware (in %)
Chabahil*	100	0
Minbhawan*	100	0
Dillibazar*	100	0
Nayabazar*	100	0
Teku*	95	5
Total	99	1
Total Sample Size:100		*Sample Size:20

4.2.2 Decentralized Composting at Community Scale

Community composting in general has been carried out by the organizations involved in the management of solid waste. The Environmental Services Nepal Pvt. Ltd. and Our Cleaning Campaign and Services Pvt. Ltd was involved in composting of the organic waste in the past but have discontinued with their program at present. Out of the ten organizations studied only one was found to be presently involved in composting of organic waste (table 4.19). The Sagarmatha Environment Development Center is carrying out an experimental composting project (bin composting). Under the project, organic waste from hundred and fifty households is being composted. The scheme has been financially supported by KMC and local community while the technical support has been provided by Clean Energy Nepal (an NGO). The bin used for composting has a volume of 3000 liters and works on the principal similar to that of its smaller counterpart i.e. 100 liters capacity compost bin distributed by KMC. The organization also has an extension plan which if realized will collect waste from 500 households and compost it in a 5000 liters bin. It is also carrying out composting in pits in a small scale. Besides the private organization, KMC is also involved in small scale composting of organic waste in the premises of the Teku Transfer Station. The composting is carried out in windrows mainly for demonstration purpose, when composting is carried out (composting is not regular) it produces compost at a rate of 50 kg/day. The compost thus produced is sold under the name of Kathmandu Compost in a one kilogram pack at a price of 10 NRs/kg.

Table 4.19: Organizations surveyed and composting practices

Code	Composting	Promotional Activities
1	Absent	Absent
2	Absent	Absent
3	Absent	Absent
4	Absent	Absent
5	Absent	Absent
6	Absent	Absent
7	Absent	Absent
8	Experimental	Present
9	Absent	Absent
10	Absent	Present

Note: Refer table 4.5 for the name of the organizations associated with the codes

Table 4.20: Household's opinion on the operation of compost plant in the neighborhood

Sampling Area	Unconditional Yes (in%)	Conditional Yes (in%)	No (in%)
Chabahil*	15	25	60
Minbhawan*	5	45	50
Dillibazar*	15	0	85
Nayabazar*	25	30	45
Teku*	5	10	85
Total	**13**	22	**65**
Reasons for objection (in %)		Total Sample size:100 * Sample Size :20	
Bad Smell	45		
Adverse Health Impact	6		
Environmental Pollution	14		

The table 4.20 summarizes the opinion of the households on operation of community compost plants in the neighborhood. Most of the households strictly opposed the idea of operation of any compost plants in the neighborhood on the grounds that such plants can emit bad smell, could have adverse health impact and would pollute the immediate environment. 22% of the households surveyed would allow compost plants to operate only in the condition that no negative impacts will occur in the neighborhood because of the operation of such plants. Rest of the households argued that composting was a good idea and that they would allow the operation of compost plants in the neighborhood (without any preconditions).

4.2.3 Centralized Composting at Municipal Scale

Currently no central level facility for composting of the organic fraction of the municipal waste exists in Kathmandu Metropolitan City. For the near future the government has agreed upon the operation of a central level composting facility with Luna Nepal and Chemical Fertilizers Pvt. Ltd. (LNCF). Once operational the composting facility is expected to produce 75 tons of granular compost fertilizers per day through the processing of 300 tons of municipal waste.

4.3 Compost Production Potential in Kathmandu Metropolitan City

In order to arrive at an estimate of compost production potential several assumptions has been made below. The organic fraction in the solid waste stream has been taken to consist of 70% of the total waste by weight. Studies on mass balance carried out during the operation of Teku Compost plant in 1989-1991 indicate that in order to produce 1 ton of compost 7 cubic meter of municipal waste is required (SWMRMC and GTZ, 1989 and 1991 a). The same studies found that 1 ton of compost had a volume of 1.3 cubic meters (0.769 ton/m^3). Most of the studies (several studies indicate a sharp decline in organic content) carried out in the last decade indicate that the organic fraction in the municipal solid waste of the City has remained more or less constant at around 70% (UNEP 2001). Assuming that the waste stream of the late 80's and early 90's is comparable with current waste stream in terms of the compostable waste content, the ratio of 7:1 i.e. 7 cubic meter of waste for 1 ton of compost production is used in the calculations below. The average waste generated and collected for year 2060 (2003/04) has been taken from the figures available for the first eight months of year 2060 (2003/04). Calculations for different composting scenarios are given below.

Scenario 1: Composting of Total Waste Generated

The average daily waste generated in 2060 (2003/04) = 1008 m^3 (table 4.6)

Now, taking the ratio of 7:1,

The total compost production potential = 1008/7

= **144 tons/day**

Scenario 2: Composting at the Current Collection Rate

The average daily waste collection in 2060 (2003/04) = 877 m^3 (table 4.6)

Now, taking the ratio of 7:1,

The total compost production potential = 877/7

= **125 tons/day**

Scenario 3: Community Composting by NGSWMOs

242 m^3 (table 4.6) of waste or 24% of total waste generated is collected by the NGSWMOs according to KMC figures (table 4.6). The 242 m^3 of waste collection is the contribution of only sixteen organizations (table 4.4), as other organization dispose the collected waste in KMC containers and consequently are regarded as waste collected by KMC.

Average daily waste collection by NGSWMOs in 2060 (2003/04) = 242 m^3
Average daily waste collection by one NGSWMO = 242/16 = 15. 13 m^3

Now, taking the ratio of 7:1,

Average compost production potential of a NGSWMO = 15.13/7

= **2.16 tons/day**

Scenario 4: Household Composting

Average household size= 4.42 (CBS 2001)
Per capita waste generation = 1 liter/day (table 4.1)
Total daily waste generation per household = 4.42 liter

Now, taking the ratio of 7:1,

Average compost production potential per household= **0.63 kg/ day**

The above calculations are strictly based on the assumption that 7 cubic meter of fresh municipal waste produces 1 ton of compost. If a more traditional approach is taken, assuming that 50% weight reduction occurs in the process of converting the fresh organic waste to stable compost and that the waste stream consists of 70% organic waste, slightly different estimates of compost production potential for the same scenarios are obtained. The compost production potential then are 132 tons/day, 115 tons/day, 1.99 tons/day and 0.74 kg/day for scenario 1, 2, 3 and 4 respectively. The per capita waste generation for the calculation has been taken as 0.48 kg/day based on a study carried out by RESTUC in 1999 (UNEP 2001), population for the year 2004 has been taken as 787886 (Table 4.1), collection rate for scenario 2 and 3 has been taken as 87% and 24% of total waste generated respectively. Details of the calculation are given in appendix c.

4.4 Composting and Market Segments in Kathmandu Valley

4.4.1 Agriculture

Market Characteristics:

Kathmandu Valley which consists of the Bhaktapur, Lalitpur and Kathmandu district has traditionally been an agricultural area (Appendix B: Plate 11). With rapid urbanization taking place in the Valley, although farmlands are being drastically converted into towns and cities, still a substantial area (table 4.29) is devoted for farming. Interviews with fifty farmers in the three districts revealed the following.

Large amount of compost is presently being used in the agricultural areas in the Valley. Most predominant forms of compost used in the farm areas are compost derived from cattle and chicken waste along with the compost made out of plant residues from the farm. Typically compost required for farming is made by the farmers themselves (Appendix B: Plate 12). Compost is applied in various combinations in the farm areas of the valley (table 4.21-4.23). Frequently ash is also mixed with the compost for application in the field.

Table 4.21: Compost combinations used by farmers in Madhyapur Thimi

Compost Combinations	Users (in %)
Cattle+Chicken+Plant Residue	55
Chicken+Plant Residue	35
Cattle+Plant Residues	5
Chicken	5
	Sample size: 20

Table 4.22: Compost combinations used by farmers in Harisiddhi

Compost Combinations	Users (in %)
Cattle+Chicken+Plant Residue	40
Chicken+Plant Residue	40
Cattle+Plant Residue	13
Cattle	7
	Sample size: 15

Table 4.23: Compost combinations used by farmers in Kirtipur

Compost Combinations	Users (in %)
Cattle+Plant Residue	7
None users	93
	Sample size: 15

In case of Madhyapur Thimi the raw materials for compost production except for the plant residues and household waste are exclusively bought from the local market (table 4.24). As such, it represents the most developed market for compost among the areas studied. When asked about their willingness to buy municipal compost, all the farmers surveyed showed a positive response. The willingness to pay for the municipal compost by the farmers is particularly important as the area could be the largest user of compost in the valley. The

farmers seem to be willing to pay for the compost, one of the reasons for it being the commercial nature of their farming. Unlike the other two areas studied, where farming is mainly for subsistence and food crops are the main plantation, Madhya Thimi for most part of the year produce vegetable which is sold for profit.

Table 4.24: Source of compost raw materials (excluding plant residues)

Sample Areas	Local Market (in %)	Own Source (in %)	Not Used (in %)
Madhyapur Thimi	100	0	0
Harisidhi	53	47	0
Kirtipur	0	7	93
Total	**56**	**16**	**28**
Total Sample Size:50	Sample Size: Madhyapur Thimi-20; Harishiddhi-15; Kirtipur-15		

In case of Harisiddhi out of the fifteen farmers surveyed 53 % used to buy the raw materials from the local market whereas the remaining 47% had their own sources (table 4.24). The farmers using their own raw materials are mainly farmers having cattle and/or chicken holdings. When asked about their willingness to buy municipal compost majority of farmers responded positively. 40% of the farmers interviewed were not willing to buy municipal compost or any compost for that matter as they had their own cattle and chicken holdings from which their needs were being fulfilled.

In case of Kirtipur, no farmer was found to be buying compost raw materials from the market (table 4.24), the primary reason for it being the lack of surplus raw materials, as most farmers do not have any cattle or chicken holdings in the area. Farmers using compost have their own source of raw materials (i.e. cattle and chicken holdings).

Table 4.25: Market prices of compost raw materials

Study areas	Materials	Price (in NRs per metric ton)			
		Average	Maximum	Minimum	Mode
Madhyapur Thimi	Cattle Waste	586	840	315	631
	Chicken Waste	1200	2000	600	1000
Harisiddhi	Cattle Waste	100	100	100	100
	Chicken Waste	1080	2000	600	600
Kirtipur	Cattle Waste	Market price not available*			
	Chicken Waste	Market price not available*			

Note: * use very minimal, mostly derived from individual households for their own use, in case of Kirtipur, majority of the farmers don't use compost in their farm lands and hence there is no market

Table 4.25 gives the prevailing market price for compost raw materials in the various areas. The price given in table 4.25 does not include the cost of transportation, loading and unloading of the raw materials. In case of Madhyapur Thimi, in an average people pay around 586 NRs for one ton of cattle dung and around 1200 NRs for 1 ton of chicken waste. The fluctuations in price of compost raw materials are dependent on its availability, demand and to a large extent on personal relationships. The transportation cost for the raw materials depends on the distance and load. In case of Madhyapur Thimi people pay 100 to 200 NRs for a tractor load of raw materials. Typically a load of tractor consists of around 0.95 ton of cattle waste and around 0.56 ton of chicken waste. Additionally two man days is required for loading and unloading of the raw materials which amount to a cost of 300 NRs in total (150 NRS per man day). In case of Harrisiddhi no transportation cost and labor cost is required as in most cases the sources of raw materials are close to the farms and the labor for loading and unloading is provided by the farmers themselves.

Table 4.26: Farmer's willingness to use municipal compost

Sampling Area	Willingness (in %)	
	Willing	Not Willing
Madhyapur Thimi	100	0
Harisidhi	60	40
Kirtipur	87	13
Total	**84**	**16**
Total Sample Size:50	Sample Size: Madhyapur Thimi-20; Harishiddhi-15; Kirtipur-15	

Table 4.27: Farmer's willingness to pay for municipal compost

Study Areas	Price including Transportation Cost (in NRs/ton)			
	Average	Maximum	Minimum	Mode
Madhyapur Thimi	439	580	290	464
Harisiddhi	470	1500	100	100
Kirtipur	*			

Note: *Farmers in Kirtipur want the municipal compost at a price similar to their current expenses on Urea at similar level of service

The majority of farmers surveyed were willing to use municipal compost and pay the appropriate price (table 4.26 and table 4.27), given that the compost was of good quality. Most of the farmers in Madhyapur Thimi agreed on a price of 464 NRs/ton with the average being 439 NRs/ton. According to the farmers the price should also include the transportation cost. The farmers were willing to pay separately for the loading and unloading of compost at the prevalent market price i.e. 150 NRs per man day. In case of Harisiddhi, farmers were willing to pay around 470 NRs in average for 1 ton of compost (including the transportation cost). In Kirtipur, farmers could not agree on an exact price for the municipal compost. According to them the compost pricing should be such that, it would allow them to buy enough compost to meet their need, at a cost similar to that they are presently bearing on chemical fertilizers.

Market Demand:

The agricultural sector is the largest consumer of compost in and around Kathmandu City. The figures in table 4.28 are indicative of the present level of compost demand in the agricultural areas around the City. The agricultural areas in Madhyapur Thimi and Harisiddhi have a high demand of compost while the Kirtipur area has almost no demand for compost. If the results of the survey is assumed to be representative of the overall compost use in the Valley, from the table 4.28 taking the average compost application rate for the Kathmandu Valley as 17.274 tons/hectare/year and area under cultivation in the valley as 52865 hectares (National Development Institute, 2002) the current demand of compost by the agricultural segment in the Valley can be estimated to be 913190 tons/year.

Table 4.28: Compost use and land holdings in the farm areas

Obs. No.	Madhyapur Thimi			Obs. No.	Harisiddhi		
	Compost Use (in tons/year)	Land Holding (in m^2)	Compost Use (ton/hectare/year)		Compost Use (in tons/year)	Land Holding (in m^2)	Compost Use (ton/hectare/year)
1	4.737	1527	31.022	1	3	1018	29.470
2	3.452	1018	33.910	2	1.2	3054	3.929
3	4.313	2036	21.184	3	1.05	1527	6.876
4	4.46	2036	21.906	4	0.35	1018	3.438
5	6.337	1527	41.500	5	2	4072	4.912
6	3.875	1018	38.065	6	0.25	2036	1.228
7	0.461	255	18.078	7	0.2	509	3.929
8	3.106	1018	30.511	8	0.06	764	0.785
9	3.537	509	69.489	9	0.4	1018	3.929
10	5.222	764	68.351	10	1	1018	9.823
11	3.337	764	43.678	11	0.15	509	2.947
12	4.145	1018	40.717	12	0.6	1018	5.894
13	3.714	1273	29.175	13	0.4	764	5.236
14	5.367	1527	35.147	14	2	2545	7.859
15	2.95	764	38.613	15	1	1527	6.549
16	3.072	764	40.209		Kirtipur*		
17	3.364	1018	33.045	1	6.45	5090	12.672
18	4.091	1273	32.137	Total sample size: 50			
19	2.092	509	41.100				
20	2.361	509	46.385				

Note: * Out of the fifteen farmers interviewed only one used compost in Kirtipur

Market Potential:

Large areas (table 4.29) within the Kathmandu Valley are under cultivation of one type or another throughout the year. Compost application in the form of soil conditioner and fertilizer in these agricultural areas has a huge potential. At an standard application rate of 30 tons/ha/year and with a combined agricultural area of 52865 hectares (National Development Institute, 2002) the three districts in the valley i.e. Kathmandu, Bhaktapur and Lalitpur have an annual compost application potential of 1585950 tons which clearly exceeds the total amount of compost that can be produced if all the organic waste of Kathmandu City would be composted.

Table 4.29: Potential demand of compost from agricultural sector in Kathmandu Valley

Districts	Cultivated Area (in Ha)*	Theoretical Compost Demand (in Tons/Year)**
Kathmandu	19203	576090
Lalitpur	25586	767580
Bhaktapur	8076	242280
Total	**52865**	**1585950**

Notes: * Figures from National Development Institute, 2002

** Calculation based on an standard application rate of 30 tons/ha/year

4.4.2 Nurseries

Market Characteristics:

Nurseries in the Kathmandu Valley also make extensive use of compost and represent potential market for any municipal compost. Presently different combinations of composts are used in the nurseries and frequently composts are mixed with other fertilizers like ash, bone meal etc. Most of the nurseries buy various compost raw materials from the local market and add them together in required proportion for the use in nursery. The nurseries also make use of plant residues as compost raw material. Nurseries generally buy various fertilizers and compost raw materials (table 4.31) and mix them together to produce compost as per their requirements. In an average the compost thus produced cost the nurseries around 10 NRs/kg. The prevailing market prices of various fertilizers and composting raw materials, based on the survey, are given in table 4.32.

Table 4.30: Materials used for composting in nurseries

Combinations	Users (in %)
Chicken+Bone meal+Cattle+Plant Resisdues	30
Chicken+Bone meal+Plant Residues	40
Ash+ Chicken+Plant Residues	10
Mustard Cake*+Cattle+Bone	10
Chicken+Mustard Cake*+Cattle	10
Non users of compost	0
	Sample size:10

Note: * Residue derived after extraction of oil from mustard grain

Table 4.31: Market price of fertilizers and compost raw materials used in nurseries

Fertilizers and compost raw materials	Average Price (in Nrs/kg)
Mustard Cake*	12
Bone Meal	20
Organic Fertilizer	12
Ash	0.75
Cattle Waste	1
Chicken Waste	1.5

Note: * Residue derived after extraction of oil from mustard grain

Table 4.32: Annual sells of compost by nurseries and sells price

Average Sells Price (per Kg)	Maximum (per Kg)	Minimum (per Kg)	Mode (per Kg)
18	25	10	20
Average Annual Sells (in Kg)	Maximum (in Kg)	Minimum (in Kg)	Mode (in Kg)
636	1200	120	480

Nurseries are also involved in the selling of compost that they make. The sells price (table 4.32) of these composts range from around 15 NRs to 25 NRs/kg and the monthly sells of compost to the customer amount to around 10 to 100 kg. The customers of the compost are households, hotels, offices and restaurants. When asked about the preferences of chemical fertilizers in comparison to compost all the nurseries preferred compost over chemical

fertilizers. The use of compost in nurseries is not a question of preference but that of necessity as most of the flowers and plants require compost. The use of chemical fertilizers in the nurseries is mainly restricted to grass (*dubo*) plantations. Given the appropriate quality nurseries are willing to buy municipal compost at a price of 10-12 NRs/kg. The average amount of compost used by the nurseries has been calculated to be 2.358 tons/year and the average annual application rate is 3.28 kg/m^2 (table 4.33).

Table 4.33: Compost use and land holdings in nurseries

Obs. No	Amount Used Per Annum (in kg)	Plantation Area (in m^2)	Annual Application (in kg/m^2)
1	2400	611	3.93
2	1200	509	2.36
3	120	64	1.88
4	4080	1018	4
5	1080	255	4.24
6	2400	764	3.14
7	1800	764	2.36
8	1500	509	2.95
9	4200	1018	4.13
10	4800	1273	3.77
Average annual application rate (in kg/m^2)			**3.28**
Average compost use per nursery (in kg/annum)			**2358**

Market Demand:

There are currently 200 nurseries (unpublished data from Floriculture Association Nepal) operating in the Kathmandu Valley. From the survey of ten nurseries in the Kathmandu City average compost use per nursery has been estimated to be 2358 kg per year (table 4.33).The figure extrapolated for the 200 nurseries amounts to a compost demand of 407.6 tons per year.

Market Potential:

The potential market for compost in the segment is likely to remain the same i.e. around 407.6 tons per year. A sharp increase in the number and size of nurseries would allow for a greater demand of compost, however, in the foreseeable future the market is likely to remain stable. Even if the number of nurseries increases only a dramatic increase in the output will see a significant increase in the demand for composts.

4.4.3 Households

Market Characteristics:

29% of the household surveyed were found to be using compost of one type or the other (table 4.34), while rest of the household did not use compost. This is interesting as 57% of the households surveyed had plantations in their households (table 4.37). It indicates that only around half of the households with plantations use compost. The different types of compost presently being used in the households of Kathmandu Metropolitan City and prevailing market prices are given in table 4.35. Compost finds its use in the households for mainly two purposes i.e. for decoration plantations and vegetable plantation. Compost is used in

households for plantation of flowers and other decorational plants either in flower pots or gardens (table 4.36). Several households also make use of compost for their vegetable gardens. Households using compost rarely spend money on it, mostly the compost are made from household waste. Other composts used in households are derived from cow dung, chicken manure, or bought from nurseries etc. In most cases no price or only a nominal price is paid for the compost or compost raw materials by the households. Users of municipal compost and compost from nurseries were the only users found paying for compost (including a household paying for cow dung) during the survey.

Table 4.34: Compost use in households of Kathmandu Metropolitan City

Sampling Area	Using (in%)	Not Using (in %)
Chabahil*	35	65
Minbhawan*	45	55
Dillibazar*	25	75
Nayabazar*	20	80
Teku*	20	80
Total	**29**	71
Total Sample Size:100		*Sample Size:20

Table 4.35: Compost types used in households and price paid

Compost type	Users (in %)	Paying Users (in %)	Average Price (in NRs/kg)
Compost from houshold waste	12	0	*
Compost from houshold waste+ Cattle manure	1	0	*
Municipal compost	3	3	10
Compost from houshold waste+ Chicken manure	1	0	*
Compost from chicken manure	1	0	*
Compost from nursery	6	6	20
Compost from cattle manure	5	1	0.5
Total Users	**29**	**10**	*
			Sample Size: 100

Note: * exact price paid or associated costs not available

Table 4.36: Types of plantation in the household of Kathmandu Metropolitan City

Plantation In	Percentage
Flower pot*	32
Garden**	7
Flower pot + Garden	18
None	43
	Sample Size:100

Note: *Plantation in flower pots consists primarily of indoor and outdoor decorational plants
**Plantation in garden include vegetation plantation, lawns and decorational plants

Market Demand:

57% of the households surveyed had plantations of one sort or another (4.37) but only 29% of the households used compost and around 10% of them bought compost from the market (table 4.35). No uniform application rate could be determined based on the findings of the study. Out of the hundred households surveyed only 6 responses were made on the question about

compost application ranging from 15-60 kg per year with 20 kg being the average, but no representative figures on the exact demand can be determined based on it. Nevertheless, it makes it clear, that only a fraction of households with plantation actually make use of compost. Even if they use compost, the compost application is not uniform and systematic and often very irregular.

Table 4.37: Plantation in households of Kathmandu Metropolitan City

Sampling Area	With Plantation (in %)	Without Plantation (in %)
Chabahil*	60	40
Minbhawan*	60	40
Dillibazar*	65	35
Nayabazar*	45	55
Teku*	55	45
Total	57	**43**
Total Sample Size:100		*Sample Size:20

Assuming that the survey data is representative of the households in the City, the total number of households in the City is 152155 (CBS 2001) for the year 2003 (which is actually the figure for 2001) and that 29% (or 44125 households) of the total household in the City use 10 kg of compost in an year, the total demand of compost can be estimated to be around 441.25 tons/year, but only a fraction of it is actually bought. The table 4.38 gives the typical number of flower pots and area of garden in the households of the City.

Table 4.38: Flower pots and garden in the household of Kathmandu Metropolitan City

Statistics	No. of Flower Pots in Households	Garden Area in Households (in m^2)
Average	56.4	89
Median	25	64
Mode	20	32
Maximum	300	159
Minimum	5	16

Market Potential:

The average volume of a typical flower pot used in the City is 3.6 liters. Assuming substrate for plantation should be made up of 1/3 compost and 2/3 soil and that compost will be applied to the flower pot twice in a year. The average compost requirement of households with flower pots is 104 kg/year (table 4.39). Taking an application rate of 30 tons/hectare (1 hectare = 10000 m^2), the average compost requirement for the household with garden has been estimated as 267 kg/year (table 4.40).

Table 4.39: Compost requirements for flower pots

Statistics	No. of Flower Pots in Households	Compost Requirements (in Kg)
Average	56.4	104
Median	25	46.14
Mode	20	37
Maximum	300	554
Minimum	5	9

Table 4.40: Compost requirements for garden

Statistics	Garden Area in Households (in m^2)	Compost Requriements (in Kg)
Average	89	267
Median	64	192
Mode	32	96
Maximum	159	477
Minimum	16	48

Out of the households surveyed 50 households had plantation in flower pots and 25 household had plantation in garden (table 4.36). Considering these figures to be representative of the actual situation and taking the total household number as 152155 (CBS 2001), one can arrive at a conservative estimate for the application requirements of compost in the Kathmandu City. Thus 76077.5 household with flower pots would require 104 kg of compost each, taking the total amount required to 7912 tons per year. Similarly the compost requirement for the household (38038.75) with garden area would be 10156 tons/year. The total compost requirement from this segment thus would amount to 18068 tons/year

4.5 Financial Aspects of Composting of Solid Waste in Kathmandu Metropolitan City

4.5.1 Household Composting

Currently household composting occurs mainly in two ways in Kathmandu City i.e. household composting in bins and in traditional compost pits. In case of composting in pits, no direct cost can be attributed to the practice as the land required is generally that of the household and the labor and raw materials is also contributed by the household. The practice of composting in bins is free of operational costs. The labor input comes from the members of the household and hence there is no direct labor costs associated with the practice. Additionally the raw materials for composting are derived from the kitchen waste and thus no raw material cost is associated with the practice. Costs of storage, transportation, marketing etc. are irrelevant in case of household composting as households themselves are the end users. All the steps of the recycling process start in the household and ends in the household thus significantly reducing the cost of composting.

Composting in compost bins have been introduced to households by various organizations. These organizations (table 4.15) distribute the bins of 100 liter capacity to the households in various forms and prices. Some organizations provide the bins for free while others like KMC distribute the bins (along with a reusable bag, instruction manual, effective microorganism solution and tools) at a subsidized price of 750 NRs. Except for the bins that are distributed for free generally the compost bins are sold to the households at a price range of 350 NRs -750 NRs. The price does not reflect the true cost of the bins as they are heavily subsidized. For instance the Gaurinagar Sudhar Samiti, a community based organization, distributes the compost bins at a price of 350 NRs with a 50% subsidy, while KMC distributes the bins at a price of 750 NRs with a 30% subsidy. The actual price of bins currently being distributed ranges from 700 to 1000 NRs per bin of capacity 100 liters. Excluding the cost of transportation and promotion, the cost of bins for any future schemes of household composting on a larger scale is likely to be the same per household. It is safe to assume that the cost of any future household composting schemes will range from around 1000-1500 NRs per household which should include the cost of the bin, transportation and promotion.

4.5.2 Decentralized Composting at Community Scale

Introduction:

Small scale compost production facilities can be designed for production capacities up to 5 tons of compost per day, on a purely manual basis. A purely manual production technology is not effective for compost plants of capacities beyond 5 tons/day, due to increased distances of internal transports, manpower management etc (SWMRMC and GTZ 1991 a) and hence will not be discussed here. For the present study, production capacities between 1.5, 2.5 and 5 tons/day have been analyzed.

Technical Concept:

For a compost plant capacity of up to 5 ton/day the technical basis of compost production is given below (SWRMC and GTZ, 1991 b).

Assumptions:

Active composting period: 4 Weeks
Maturation period: 5 Weeks
Total time for final compost production: 9 weeks (63 days)

Size of Windrow: 20m (length) x 3.5m (breadth) x 2.0m (height), giving a total volume of 70 m^3 after the final setup and a base area of 70 m^2.

It takes 7 cubic meter of fresh waste to produce 1 ton of compost. It leads to the following:

1 windrow procedures 70 cubic meter of compost in 63 days
i.e. 1 windrow produces 70 cubic meter = 10 tons of compost in 63 days
i.e. 1 windrow produces 1 ton of compost in 6.3 days
i.e. 6.3 windrows produce 1 ton of compost in 1 day
Say 6 windrows are required to produce compost at the rate of 1 ton/day.

On the basis of the calculations the number of windrows required for different rate of compost production is given in table 4.41.

Table 4.41: Number of windrows required by rate of compost production

Rate of Compost Production	Size of Windrow	Windrows Required
1.0 ton/day	20.0m x 3.5m x 2.0m	6
2.0 tons/day		12
2.5 tons/day		15
3.0 tons/day		18
4.0 tons/day		24
5.0 tons/day		30
Source: SWRMC and GTZ, 1991 b		

Production Concept:

The incoming waste passes through a reception area where its composition is controlled. If the waste contains mainly organic substances or if inorganic matters can be easily separated, then the waste is unloaded directly on the windrow platforms. If the composition is found to be the

unsuitable for direct fermentation, the waste will be unloaded at the reception area and prepared for composting by sorting, shredding, mixing etc. On the platform, windrows of size 20m x 3.5m x 2.0m (length x breadth x height) will be piled up and moisture controlled and adapted to optimize fermentation. After one week, the windrows will be turned manually. The total number of turnings will be three. Windrow turning is done by moving the waste in the longitudinal direction. After a pre fermentation period of four weeks, the windrows will be transported to the maturation yard. The maturation requires five weeks. After the maturation, the screening of the compost will be carried out manually by using inclinable static screens with a mesh size of 10 mm. After screening the compost is ready for sale. The residues from the screening will be disposed at suitable dumping sites. The total composting of fresh waste will require 60 to 70 days (SWMRMC and GTZ 1991 a).

Financial Analysis:

The financial requirements for community composting based on small scale labor intensive production facilities have been analyzed and evaluated here. The calculations are based on the pre feasibility studies carried out on operation of small scale compost plants for the 1.5 ton, 5 ton and 2.5 ton per day capacity plants under the German Solid Waste Management Project during the late 80's and early 90's (SWRMC and GTZ, 1989 and 1991 a, b). All the tables and figures presented in the chapter (i.e. 4.5.2) are from the studies carried out by SWRMC and GTZ and have been converted using various methods to arrive at the best possible estimate of financial requirements for the year 2003. In order to arrive at an estimate of cost for the year 2003 (using the method of time value of money), the consumer price index for the year 2001 has been taken as 248.1 NRs taking 1990 as the base year i.e. an annual inflation rate of 8.61% from 1990-2001(UNESCAP, 2004). For the year 2002 and 2003, annual inflation rate has been taken as 3% (NPC 2003). Wherever possible the calculations based on time value of money has been omitted and the original prices have been replaced by prevailing market prices.

a. Land Requirement

It is assumed that small scale compost plants (community composting) will be located within the urban area and that land prices will be in the range of 9430 NRs per square meter (i.e. *3 lakh nepalese rupees/aana*). The table 4.42 gives the land requirements and associated costs for three different plant capacities.

Table 4.42: Land requirements and price of land for community composting

Plant capacity	Land Area Required (in m^2)*	Price of Land (NRs/m^2)**	Total Price of Land (in NRs)**
5 ton/day	6,500	9430	61295000
2.5 ton/day	3,600	9430	33948000
1.5 ton/day	2,500	9430	23575000

Note: * Figures from SWRMC and GTZ, 1991 a
** Figures based on current market price, assuming that on an average a *ropani* (509 m^2) of land in Kathmandu City costs 4800000 NRs

b. Construction Cost

The construction cost (table 4.43) includes the cost of constructing the maturation yard, screening yard, windrow yard, reception area, area for special waste, drainage facilities, guard

house and other facilities in the compost plant. The costs of survey and planning and public utility connections are also included in the construction cost.

Table 4.43: Construction costs for different compost plant capacity

Plant Capacity	Construction Cost (in NRs)*
5 ton/day	9915736
2.5 ton/day	3928645
1.5 ton/day	2423096

Note: *Price estimation for the year 2003 based on time value of money, original figures taken from SWMRC and GTZ, 1991a, and converted taking inflation rate of 8.61% for the period of 1990-2001 and 3% for the period of 2001-2003

c. Equipment Cost

The initial set of equipments required and associated costs for the operation of 5 ton/day capacity compost plant is given in table 4.44. Based on the calculations for the 5 ton plant the table 4.45 lists the equipment costs associated with the compost plants producing compost at a rate of 2.5 and 1.5 ton/day.

Table 4.44: Initial equipment requirements and costs for 5 tons/day capacity plant

Type of Equipment	No.	Unit Price	Expenditure (in NRs)
Shovels	20	125*	2500
Picks	20	170*	3400
Brooms	20	20*	400
Handcarts	6	3000*	18000
Screens	6	3635**	21810
Balance (125 kg)	1	14000*	14000
Water Pumps + lines	2	9087**	18174
10% contingencies			7828
Total Initial Expenditure on equipments			86112

Notes: * Figures based on current market price

**Price estimation for the year 2003 based on time value of money, original figures taken from SWMRC and GTZ, 1991 a, and converted taking inflation rate of 8.61% for the period of 1990-2001 and 3% for the period of 2001-2003

Table 4.45: Initial equipment costs for different plant capacities

Plant Capacity	Construction Cost (in NRs)
5 ton/day	86112*
2.5 ton/day	63486**
1.5 ton/day	39936 **

Notes: * Cost estimation for the year 2003 based on time value of money, original figures taken from SWMRC and GTZ, 1991 a, and converted taking inflation rate of 8.61% for the period of 1990-2001 and 3% for the period of 2001-2003

** Cost estimation based on calculations for 5 ton/day capacity plant

d. Operating Costs

The operational costs associated with the plants of different capacities are listed in the tables 4.46 to 4.51. It includes the manpower cost, cost associated with public utility services, total annual expenditure on tools, repair and maintenance cost and overheads (table 4.46-4.50). The total annual operating cost is given in table 4.51.

Manpower Costs:

Table 4.46: Manpower costs for different plant capacities

Plant Capacity	Manpower*		Monthly Salary (in NRs)**		Payments per year*	Total Cost (in NRs)
	Supervisor	Sweeper	Supervisor	Sweeper		
5 ton/day	3	18	4400	3000	15	1008000
2.5 ton/day	2	10	4400	3000	15	582000
1.5 ton/day	2	8	4400	3000	15	492000

Notes: * Figures from SWRMC and GTZ, 1991 a
** Figures based on current salaries for similar positions

Expenditure on Public Utility Services:

Table 4.47: Total annual expenditure on public utility services

Plant Capacity	Total Expenditure (in NRs)*
5 ton/day	24231
2.5 ton/day	12115
1.5 ton/day	5246

Note: *Expenditure estimation for the year 2003 based on time value of money, original figures taken from SWMRC and GTZ, 1989 and 1991a, and converted taking inflation rate of 8.61% for the period of 1990-2001 and 3% for the period of 2001-2003

Total Annual expenditure on Tools:

Replacement costs of tools are estimated on the basis of the following service life assumptions:

Shovels and Picks: 1 year
Brooms: 2 months
Handcarts: 2 years
Screens: 3 months
Balance: 5 years
Water Pumps: 5 years

Annual tool expenditure refers to all items with a service life of up to one year. For all items with a service life of more than one year, replacement expenditure will be covered under equipment.

Table 4.48: Total annual expenditure on tools

Plant Capacity	Total Ecpenditure on Tools (in NRs)*
5 ton/day	96924
2.5 ton/day	48462
1.5 ton/day	26317

Note: *Expenditure estimation for the year 2003 based on time value of money, original figures taken from SWMRC and GTZ, 1989 and 1991a, and converted taking inflation rate of 8.61% for the period of 1990-2001 and 3% for the period of 2001-2003

Repair and Maintenance:

Table 4.49: Total annual expenditure on repair and maintenance

Plant Capacity	Total Ecpenditure on Repair and Maintainance (in NRs)*
5 ton/day	242310
2.5 ton/day	121155
1.5 ton/day	52635

Note: *Expenditure estimation for the year 2003 based on time value of money, original figures taken from SWMRC and GTZ, 1989 and 1991a, and converted taking inflation rate of 8.61% for the period of 1990-2001 and 3% for the period of 2001-2003

Overheads:

Table 4.50: Total annual expenditure on overheads

Plant Capacity	Total Overhead Ecpenditure (in NRs)*
5 ton/day	363464
2.5 ton/day	242310
1.5 ton/day	145386

Note: *Expenditure estimation for the year 2003 based on time value of money, original figures taken from SWMRC and GTZ, 1989 and 1991a, and converted taking inflation rate of 8.61% for the period of 1990-2001 and 3% for the period of 2001-2003

Total Annual Operating Costs:

Table 4.51: Total annual operating costs

Plant Capacity	Total Operating Cost (in NRs)*
5 ton/day	1734929
2.5 ton/day	1006042
1.5 ton/day	721584

Note: * Sum total of all the costs from table 4.46 to 4.50

e. Cost of Production

The cost of production of 1 ton of compost by different compost plants is given in table 4.52. It can be inferred from the table that compost plant of capacity 5 tons/day is the most efficient of the three compost plants in terms of the operating cost. In comparison to the 5 tons/day plant there is an additional cost of nearly 250 NRs and 600 NRs per ton of compost produced by the 2.5 tons/day and 1.5 tons/day plant respectively.

Table 4.52: Unit cost of production of compost

Plant Capacity	Working Days per Year*	Total Production (in ton/year)*	Total Operating Cost (in NRS/year)**	Cost of Production (in NRs/ton)
5 tons/day	220	1100	1734929	1577
2.5 tons/day	220	550	1006042	1829
1.5 tons/day	220	330	721584	2187

Notes: * Figures from SWRMC and GTZ, 1989 and 1991 a
** Figures from table 4.47

f. Total Annual Revenues at Full Production (220 working days)

The total annual revenues based on full production i.e. 220 working days with two sets of compost pricing are given in table 4.53 and 4.54. The table 4.53 gives the annual revenue for the different plant capacities based on compost pricing of 500 NRs/ton (transportation cost included). The pricing of compost at 500 NRs/ton is primarily targeted to the agricultural sector. The particular price is based on the results of the field study (table 4.25 and 4.27) carried out in the agricultural area of the valley. Table 4.54 gives the annual revenue for the different plant capacities based on compost pricing of 10 NRs/kg. This specific price is targeted at the lucrative segment of the market (nurseries, households, institutions and commercial establishments) that are likely to pay a substantially higher price for the compost compared to the agricultural sector. There is a striking difference between the revenues generated by the two different pricing schemes. The revenue generated by the pricing of compost at 10 NRs/kg is twenty times more than that of 500 NRs/ton.

Table 4.53: Annual revenues at full production targeting the agricultural sector

Plant Capacity	Working Days per Year*	Price per Ton (in NRs)**	Total Annual Revenues (in NRs)
5 ton/day	220	500	550000
2.5 ton/day	220	500	275000
1.5 ton/day	220	500	165000

Notes: * Figures from SWRMC and GTZ, 1989 and 1991 a
** 500 NRs/ton (transportation cost included) is the most likely price farmers are willing to pay

Table 4.54: Annual revenues at full production targeting the lucrative market segment

Plant Capacity	Working Days per Year*	Price per Kg (in NRs)**	Total Annual Revenues (in NRs)
5 ton/day	220	10*	11000000
2.5 ton/day	220	10*	5500000
1.5 ton/day	220	10*	3300000

Notes: * Figures from SWRMC and GTZ, 1989 and 1991 a
** 10 NRs/kg of compost is the most likely price the segment is willing to pay

4.5.3 Centralized Composting at Municipal Scale

No central level composting plant exists at present. The financial evaluation of a central level composting plant is beyond the scope of the study and hence is not discussed here. The Solid Waste Management and Resource Mobilization Center under the Ministry of Local Development along with Kathmandu Municipal Corporation have signed an agreement with the Luna Nepal and Chemical Fertilizers Pvt. Ltd. to construct and operate a central level compost plant with an aim of composting the organic fraction of the solid waste generated in the Kathmandu Metropolitan City. According to the initial agreements the contracting party will be responsible for providing LNCF with 300 metric tons of municipal waste per day. The LNCF plans to produce 75 metric tons of granular solid compost fertilizer per day from the 300 metric tons of waste provided to it (with possibility of expansion). The land area requirement for the plant operation at the above mentioned output has been estimated to be 7.5 acres (61 *ropani*) by the LNCF. It is estimated that the total project will cost around 100 million NRs to construct, while the operational cost is estimated to be around 75 million NRs per annum. LNCF plans to sell the compost fertilizer at a rate of 4900 NRs per metric ton.

Chapter V

DISCUSSION

5.1 Existing Barriers to Operation of Composting Schemes

5.1.1 Household Composting

Household composting presently exists in the City in various forms. In course of the study mainly two forms of composting was observed in the household level i.e. bin composting and pit composting (table 4.14). However, other practices like vermi-composting, composting in flower pots etc. is also prevalent in the City. Although composting in household level exists in the City, the scale of composting is very low and hence its relative contribution to the overall solid waste management is negligible. There are several factors that have to be overcome if household composting on a larger scale is to be sought. Majority of the households during the survey were found unwilling to make compost in their households (table 4.16). They had different reasons for opposing the idea of composting (table 4.17) the organic waste coming out of the households. One major argument against the household composting was concerned with the end use of compost. Many households in the City simply do not have any plantations in their households, so compost is of no use to them. Other prominent arguments against composting at the household level was related to lack of time and the extra burden that any household composting would exert in the daily routine of the people. There is an even an attitude of "we do not care" and "it is none of our business" particularly among the tenants regarding household composting. These attitudes and arguments that prevail in the City is hard to overcome and greatly reduces the applicability of any household composting schemes on a wide spread basis. On the financial side the promotion and distribution of compost bins is likely to cost around 1000-1500 NRs per household. This price will have to be either incurred by the household in full or part (subsidized rate) or by the organizations promoting it. Households generally are reluctant to pay money for compost bins, people currently using the bins are mostly self motivated people with a concern for the environment. Pit composting as a household composting option is limited in its application as majority of the households lack the space required.

The capital requirements for the promotion of household composting on a larger scale, lack of environmental motivation, absence of plantations in households and hence reduced utility of compost are likely to be the major barriers for household composting. One can conclude based on the facts presented above that composting in households level is not likely to contribute significantly in the overall management of solid waste in the City. It can be promoted in the households to a certain level by creating awareness and clearing some of the misconceptions, but a significant increase in the present level of composting in households is unlikely. Household level composting should be looked upon as a tool for promoting environmental awareness in general rather than a tool for addressing the solid waste problem of the City. The act of composting in the households can be an activity that increases the awareness amongst citizens of waste as an environmental issue.

5.1.2 Decentralized Composting at Community Scale

Currently no decentralized composting at community scale exists in the Kathmandu Metropolitan City, except for the experimental undertaking of the Sagarmatha Environment

Development Center. Composting of organic waste in the community scale is most likely to be carried out by the NGSWMOs. Based on the volume of waste collected by the organizations, on an average an organization has a compost production potential of 2.16 tons/day. The most probable setup for composting schemes at the community scale would be a plant of 1.5 ton 5 tons/day capacity (depending on the size of the NGSWMOs) based on a labor intensive system of operation. Community composting is likely to be operated near the vicinity of the organization's operational area which in most cases are prime residential areas.

One of the most significant barriers to community composting will be the public objection against the operation of any composting schemes in the residential areas. The labor intensive system in combination with the windrow composting is likely to emit significant odors to the surrounding environment, additionally the probability of transmission of insects, diseases, release of debris cannot be ruled out. Given the number of negative impacts (real and perceived) on the immediate surrounding, public resentment against operation of any composting schemes in the neighborhood is guaranteed. This hypothesis is further strengthened by the results of the household survey, where majority of the household are opposed to the idea of community composting in their neighborhood. Past experiences also support the argument. In 1991 the decision to shut down the Teku compost plant was made by the government on the basis of complaints from people living in the neighborhood of the Teku site. The complaints filed against the site was concerned with the negative environmental effects of the compost plant, especially smells around the site and traffic congestions on the access road (SWRMC and GTZ, 1991 a).

Another important barrier to community composting will be the cost involved in the acquisition of land for composting. A compost plant of 1.5 tons to 5 tons/day capacity will require an area of 2500 to 6500 square meters (table 4.42) and can cost anywhere around 23.6 million NRs to 61.3 million NRs table 4.42) depending on the plant capacity. Further the financial evaluation of the plants of different capacity indicate that the operating cost would exceed the revenue by a factor of around 3 i.e. the operation of the plants are likely to cost 3 times more than the revenue generated from such plants (table 4.52 and 4.53). In order to meet the operating cost, an option for the plant operators would be to increase the service charge. Any substantial increase in the service charge is likely to face opposition from the households as many households do not pay service charges or only reluctantly pay service charges even at the present rates.

Community composting in a smaller scale may be possible and plausible up to a certain limit. The amount of compost produced by such facilities could be targeted to the nurseries, households, institutions and commercial establishments. Compost can be sold to the segment at a rate of 10 -15 NRs/kg. A 1.5 tons/day compost plant, if sold all the compost produced at a price of 10 NRs/kg can make an annual operational profit of 2.6 million NRs (table 4.45) which is quite encouraging. This segment however is limited in terms of the amount of compost that it can absorb. The current demand of compost from the household and nursery has been estimated around 848 tons per year. Assuming that around 150 tons of compost will be absorbed by the institutions and commercial establishments, an annual demand of around 10000 tons is likely. This demand can be met by the output of approximately three compost plants of capacity 1.5 tons/day. Thus, there clearly exists a limit to the numbers of community compost plants that can be operated targeting the lucrative segment.

Relying exclusively on nurseries, households, institutions and commercial establishment cannot be the option for all the community composting plants. Compost produced at a larger scale cannot be absorbed by the lucrative market segment alone and will have to cater to a

larger market segment i.e. the less lucrative agricultural sector. Compost plant of much smaller scale may be feasible, but then, their relative contribution to the overall waste management of the City would be negligible.

Public objection (not in my backyard syndrome), availability of land, availability of start up capital, and lack of marketing possibilities is likely to be the major constraints for any community composting schemes. In face of all the existing barriers widespread community composting schemes aimed at contributing significantly to the solid waste management of the City is unlikely to be viable and sustainable in the long run.

5.1.3 Centralized Composting at Municipal Scale

Central level composting is the most likely option that can contribute significantly to the management of organic fraction of the waste as household and community composting is unlikely to deliver the levels required to have an impact on the municipal solid waste management. It has some inherent advantages over the other two options i.e. household composting and community composting. Central level composting has the ability to process large amount of waste in a single facility. The central level composting facility can be set up in the peripheral areas of the City which will significantly reduce the cost of land. Further the negative environmental effects are unlikely to arouse any direct resentment from the public as such plants would operate far from any residential areas.

One of the most important factors for the operation of such plants and their sustainability will be that of meeting the operational cost with the revenues generated from the compost sells (assuming that the investment on land and infrastructure will be in the form of a social investment, which also will be substantial). If indication from the survey is anything to go by, farmers are willing to pay around 400-500 NRs for a ton of municipal compost. They even expect transportation costs to be included in the price. Selling of compost at the price of 400-500 NRs/ton is highly unlikely to meet the operational cost of any kind of central level composting facilities. If we take the example of Luna Nepal and Chemical Fertilizers Pvt. Ltd. its estimation for operational costs per year is around 75 million NRs and it aims at selling compost at a rate of around 4900 NRs/ton. The cost of compost, whether used as fertilizer or soil conditioner, is still problematic when compared to costs of synthetic fertilizer/soil conditioner, and this is a major factor for decision makers (UNEP 2004).

A hike in the price of compost may reduce operational losses but will render the product uncompetitive in the market. Any compost from the facility is likely to face stiff competition with the already existing alternative compost products, like compost derived from chicken and cattle waste, in terms of both price and quality. There is no doubt on the huge potential (a theoretical potential of 1585950 tons/year and current demand of 913190 tons/year) for the application of compost in the Kathmandu Valley. The estimates for potential compost demand indicate that all the compost (estimated at the current collection efficiency to be 125 tons per day given all the collected waste is composted) that can be produced by the facilities can be easily absorbed in the valley in terms of the theoretical potential as well as current demand. However, currently all the demand is being met by different kinds of traditional composts like composts derived from cattle waste and chicken waste.

Convincing potential customers to use municipal compost may be one of the most difficult aspects of the whole idea. The irony is that even if municipal compost finds its place in the various segments it probably will be on the cost of other composts. These composts currently

available are also contributing to the solid waste management of the Valley as they are derived from chicken waste, cattle waste, plant residues and household waste that are being put into useful end uses. In case of a decreased demand for these raw materials, they are likely to resurface in the municipal solid waste stream. The lack of source separation and separate collection of organic waste in the current solid waste management system is likely to affect the quality of compost produced because of potential cross contamination.

Experiences in other countries and our own (Teku Compost Plant) further strengthen the arguments presented above. Almost all the large cities of the developing countries in the Asia-Pacific region in the past installed imported mechanical composting plants (for instance, built six). Most are now defunct and the remaining ones are not operating at full capacity (e.g., Bangkok, Hanoi, Shanghai, and Tokyo). The reasons why centralized mechanical MSW composting plants are not functioning effectively, are underutilized, or are closed down include: high operating and maintenance costs compared to open landfilling (including foreign exchange costs for replacement parts of imported plants); the cost of compost is higher than commercial fertilizers (both cost to purchase, and labor cost to apply to the fields); incomplete separation of materials such as plastic and glass, making the compost poor for agriculture application; and poor operation and maintenance of the facilities (UNEP 2004).

Availability of land, substantial capital investment requirements, operational deficits, competing compost products (compost from chicken waste, cattle waste, and plant residue), relatively low purchasing capacity of farmers, and lack of source separation and separate collection of organic waste are likely to be the major barriers for any centralized composting at municipal scale in Kathmandu Metropolitan City.

5.2 Alternative Basis for Operation of Composting Schemes

Based on the findings of the study, the paragraphs above discussed the existing barriers on the operation of composting schemes at different levels. The lack of capital for operating and promoting composting schemes, lack of land, lack of environmental motivation, prevailing public attitude, competing compost products, market structure etc has been put forward as prominent barriers for the operation of various composting schemes. These arguments are indeed significant, nevertheless given the appalling state of solid waste management in the City one has to look a few steps forward and explore ways through which the existing constraints can be mitigated. The paragraphs below discuss ways and approaches on the basis of which composting schemes could be justified and existing barriers can be addressed.

5.2.1 Economic Evaluation versus Financial Evaluation

One of the major barriers as identified by the study is the financial requirements of initiating and operating composting schemes. The financial evaluation of the various schemes indicated, that on their own, none of the projects will be financially viable and sustainable. It has to be clear here, that the objective of the financial evaluation presented in the study was not to choose the commercially most attractive production alternative, but to identify the least cost alternative as a basis for a political decision on actions to be taken in addressing the solid waste management of the City. Judging from the findings of compost plant evaluations in the past, it cannot be expected that compost production could be a commercially viable proposition in Nepal. The traditional investment criteria for commercial projects such as internal rate of return return on investment, or net present value is generally not adequate for

evaluating composting schemes since they are likely to produce negative values which are difficult to utilize as a basis for investment decisions (SWRMC and GTZ, 1991 a). If composting is to be viewed as a business or an activity that has to be self financing then it is unlikely to develop on its own. However, as with other waste management options, composting as a form of tertiary recycling process has the environmental merit of reducing waste volume and producing low environmental impact. These merits must be balanced with the financial aspects (Shan 2000).

Composting the organic fraction of the waste can address 70% of our waste management problems and can contribute in improving the environmental quality of the City. Composted manure provides a viable and sustainable opportunity to move large volumes of organic material from the concentrated areas to other areas that need organic soil amendments. Soils amended with organic material require less irrigation as well as fewer fertilizers and pesticides than do depleted soils, in order to achieve optimum crop production. Application of compost enhances soil stability, reducing erosion and preventing the loss of nutrients into streams (TNRCC, 2004). These benefits that compost application provides are of particular significance in Kathmandu Valley, where significant numbers of people still rely on agriculture for their livelihood. Additionally the general public can enjoy a better quality of life derived from improved solid waste management. Human contact with refuse implies a high risk for a variety of diseases including tetanus, typhoid, hepatitis and cholera. Infectious diseases can be spread either by direct contact with the waste, by animals such as insects, birds, goats and cows or by windborne distribution (Hogland and Marques, 2000). Composting also reduces the overall volume of solid waste that needs to be disposed of in sanitary landfill, thus reducing transportation and disposal costs. The SWRMC in one of its study (SWRMC and GTZ, 1991 a), estimated the total cost savings for avoided transports to the sanitary landfill site at about 400 NRs (1991 NRs) per ton of compost produced. Any diversion of organic fraction of the waste to landfill will significantly decrease the level of leachate generation in the landfills and can reduce the probability of groundwater pollution.

An economic analysis can yield better information regarding the net social cost or benefit of any composting projects. It has the potential to give decision makers a clearer picture of the opportunity savings and hidden benefits that would result from composting of organic waste in the City or the negative externalities that current waste management practice exerts to the society. It is by no means simple to assess the economic feasibility of an organic waste resource system as it needs to take into account other positive or negative effects, for example on the environment. There is no agreed methodology for quantifying these effects, so economic comparisons of different recovery processes and treatment and disposal methods are difficult (Lardinois and Klundert, 1993). Although estimating reliable monetary values for all social costs and benefits is often not feasible, the framework of social cost benefit analysis can none the less provide guidance for decision-making and evaluation (Beede and Bloom, 1995).

5.2.2 Policy Interventions

Common property resources and intergenerational externalities provide incentives for households and firms to under consume services in the private market for MSWM. Because the benefits of some kinds of MSW management to households and firms fall short of the benefits to society, the optimal government interventions are those that align the private and societal incentives for MSW disposal as closely as possible (Beede and Bloom 1995). Policy interventions that are particularly relevant in the context of addressing existing barriers to

composting at different levels in Kathmandu can consist of provisions of volumetric and flat tariffs and siting incentives.

Volumetric and Flat Tarrifs:

Government can undertake one or more of the tasks of MSW collection, transport, processing and disposal, charging either a volumetric tariff (a curbside charge per unit volume of waste handled) or a benefit tax (a flat amount per household). A volumetric tariff gives households and firms an incentive to reduce residual waste, either by changing the way they produce and consume, by recycling, or by illicitly dumping or burning waste (Beede and Bloom 1995). The positive aspect of such an approach in the context of composting in Kathmandu City is that it can promote household composting of waste. The volumetric tariff can however backfire, as there is always a possibility for the illicit dumping or burning of waste, particularly by the households situated near rivers or open space as observed during the study.

A flat benefit tax charged to all households as part of their utility of property tax bill may be the most effective way for cities of developing countries to pay for MSWM, reduce the incentive to dump MSW illegally and possibly subsidize MSW management services for poor neighborhoods. Such an arrangement has financed a 100 percent of the cost of MSW management in Santiago, Chile. Santiago, Caracas, Sao Paulo, and Rio de Janeiro all bill households for MSW services on the basis of past MSW management costs. Because of low inflation in Chile, Santiago's MSW management fees have been in line with current MSW management costs. In the other cities, accelerating inflation has led to consistent underestimates of management costs; as a result, management fees have covered only 10 to 70 percent of program costs (Bartone and others 1991 as cited by Beede and Bloom 1995).

Siting Incentives:

Policy makers can create incentives that indirectly affect MSW disposal behavior. For example, policy makers in industrial countries frequently face local resistance to the siting of MSW disposal facilities. So called NIMBY (not in my backyard) activism may also arise in developing countries even if government authorities are trying to site and construct environmentally benign facilities. Facilities in developing countries were almost universally so poorly managed that many governments have little credibility when they claim that the new facilities will be well managed. A potential solution might be to require a locality to encourage debate and hold a fair and binding referendum if the government or a firm proposes to build and MSW disposal facility within its borders (Beede and Bloom 1995). This approach is relevant in the context of the City and can be used for the siting of composting plants in the Kathmandu City.

5.2.3 Market Development

The results of the study indicate that farmers (representing the largest market segment) are willing to pay around 500 NRs for a ton of municipal compost (including transportation cost). This price is very low compared to the price farmers are currently paying for other compost raw materials like cattle waste and chicken waste (table 4.25). Excluding transportation costs, farmers are willing to pay around 600 NRs/ton for cattle waste and 1200 NRs/ton for chicken waste. One has to consider the fact that these are just raw materials for compost production and undergo composting resulting in significant weight and volume reductions. The price farmers ultimately pay for one ton of compost derived from the raw materials thus are

significantly higher than that they are willing to pay for municipal compost. Hence, there is an opportunity for an increase in the price of municipal compost to a level where the revenues generated from compost sells can cover the operational costs. Additionally the potential application of compost particularly in the agricultural sector is significantly higher (table 4.28 and 4.29) than the current demand.

Educating the actual and potential customer about the utility of compost could result in significant market gains. The need for education is emphasized by the fact that particularly with municipal solid waste; marketing compost is seriously encumbered by inertia and bias. The encumbrance is largely due to potential users being unaware of the true worth of compost (Diaz et al., 1994). Agriculture in the Kathmandu Valley suffers from a severe soil erosion problem. During the heavy monsoon rains much of the fertile soil is washed away into the rivers. This loss of fertile soil can only partly be compensated by chemical fertilizers while compost with its high content of humus is much better suited to improve the soil after the rains. Considering the erosion problem, compost should be in much higher demand. The fact, that it is not, seems to be partly due to a lack of understanding of the ecological qualities of compost. An even more important problem than erosion in the Kathmandu Valley is the reduction in soil fertility due to insufficient restitution of organic materials for the preservation of the biomass. Another critical point is the increasing acidity of the soil caused by the exclusive application of chemical fertilizer. These problems can be alleviated by the regular use of compost. But since both the negative effects of a diminishing biomass and of increasing acidity on one side and the positive effects of compost application on the other are long term in nature, they are not fully appreciated by farmers and thus not turned into effective demand and a higher market price. Due to the factors mentioned above the sales price obtainable in market does not reflect the true value of compost for the Nepalese economy (SWRMC and GTZ 1991 a). Finished compost can become, but is not automatically, a valuable commodity: its value depends on external demand for soil enhancers, on perceptions of its value, on its quality, and on its accessibility to potential users in the immediate vicinity. It also depends on what alternatives to compost are available to farmers and cultivators in the region, and on the cost of those alternatives from chemical fertilizer to wastewater sludge relative to the cost of the compost. There must be a market or use for the compost at the quality it is produced. This market does not have to produce net income, but it has to be factored into the cost of composting as a positive or negative. The closer the market is, the more likely composting is to be sustainable. Projects for composting must consider marketing and/or absorption of the product as a priority issue, since underfinanced municipalities are unlikely to finance them, even if they result in disposal savings (UNEP 2004).

5.2.4 Enhancing Environmental Awareness

An incentive to promote composting, particularly household composting, in Kathmandu City can be to educate households about the health and environmental implications of existing waste management practices. Backyard composting (household composting) is a longstanding tradition in countries like Australia, Japan, and New Zealand, especially in rural towns. Now it is being promoted by local governments, with inexpensive compost bins being made available, along with "how-to" leaflets and demonstrations (UNEP 2004). Similar methods can also be applied in the City. Variety of approaches like information through radios, television, school programs, community awareness campaign etc can be used to educate people about composting. NGOs, schools and KMC can play a prominent role in promoting environmental awareness. It can help in addressing some common misconceptions about

composting and also in increasing the environmental motivation for composting. Educating the masses can also help in securing their support for community composting or central level composting schemes. Basic training and education of workers in technical, health, and safety aspects is essential. With better understanding of the process, improved processes, and public education, composting should increase at least in cities where sites and skilled manpower are available, and markets can be developed (UNEP 2004).

5.2.5 Optimizing Current Waste Management System

The prevailing waste management system in Kathmandu City can be modified to favor composting of the organic fraction of the waste. A main area of optimization should be the replacement of the commingled storage and collection of waste by source separation of waste and door to door collection services (replacing the existing road side collection). Source separation of waste and separate collection would allow a simpler and more efficient after treatment of waste resulting in greater recovery value. It greatly reduces cross contamination between the different waste types, improving the quality of products derived from the recovered waste and thus the marketability of the products. Source separation and separate collection is seen as a pre-requisite for producing composts of a consistent and reliable quality (UNEP 2004). Modern compost plants have facilities for mechanical sorting of the commingled waste, but it has its limitations. Mechanical sorting always leaves inert material in the composted product, usually very small heavy metal particles from domestic products (paints, batteries etc), small particles of glasses, plastics etc. Due to such problems, compost produced in plants with mechanical sorting facilities has a low quality and is rejected for extensive agricultural applications. Success in composting depends on product acceptability in the existing market. A generalized acceptance of compost relies on its quality. This is a key point and quality control assurance must be implemented in a successful composting operation. High quality compost can only be produced by using high quality raw materials (The phrase "garbage in, garbage out", also applies for composting process). The easiest way of obtaining "a high quality raw material" to be composted, is by using the organic fraction of municipal solid waste sorted at source (Alvarez 2000).The results from the household survey are encouraging in terms of people's willingness for source separation (table 4.3). The results need to be treated cautiously as previous and current experiences (composting by SILT Environmental Services Nepal Pvt. Ltd. and Sagarmatha Environment Development Center) show that in practice the actual source separation achieved is only around 50% (i.e. only 50% of the household separate the waste).

Chapter VI

RECOMMENDATIONS

Based on the findings and observations of the study several recommendations, which can be effective in addressing the issues pertaining to the operation of any composting schemes in the Kathmandu Metropolitan City, have been made below. Recommendations for further study in several areas have also been made.

i. The current waste management system is not optimized for the operation of composting schemes. The commingled storage and collection of waste has to be replaced by separate storage and collection of waste.

ii. Composting at the household level should be promoted as a tool for creating awareness on waste as an environmental issue among the residents of Kathmandu. Economic incentives promoting household level composting and promotional programs can also be employed to encourage household composting.

iii. In order to promote composting at the community level the current organizations involved should be financially assisted by the government. Providing organizations with the land required for operating compost plants can also promote community level composting.

iv. Efforts to justify investments on large scale composting schemes should be based on the net social benefits such undertakings would generate rather than on purely financial grounds.

v. The agricultural sector which is the largest consumer of compost and represents the most significant market for any municipal compost is largely unaware of municipal compost and its benefit. Market development activities aimed at demonstrating the benefits of municipal compost has to be a priority of any future composting schemes.

vi. The existing legislations and policies on waste management are inadequate and can be amended or modified to include provisions that encourage composting of the municipal waste. The provisions can include waste diversion goals from landfill, volumetric or flat tarrifs for waste management services, subsidies for compost products etc.

vii. An area of research can be the comparison of the *status quo* with the environmental and health benefits or costs that can result from the implementation of different composting schemes in the City. Future studies can also focus on assessing the opportunity savings and other hidden costs or benefits associated with composting schemes.

viii. The assessment of soil conditions in the agricultural areas of the Kathmandu Valley and the role compost application can play in its improvement; comparison between the nutrient content of traditional composts currently in use in the valley and municipal composts and a detailed study on the rate of application of compost in various market segments can also be the subject of future research endeavors.

Chapter VII

CONCLUSIONS

The results from the study suggest that composting is not likely to be a viable and sustainable proposition for the management of municipal solid waste management in Kathmandu Metropolitan City given the present state of affairs. There are various factors that need addressing before composting can be a viable option of waste management, particularly if it is to contribute significantly in the management of MSW generated in the City. Numerous barriers exists currently that can undermine the viability and sustainability of composting schemes at different levels.

The results from the market analysis indicate that any amount of compost produced from municipal waste can be easily absorbed by various market segments within the Kathmandu Valley. The question hence is not about whether or not the market is capable of absorbing all the compost produced rather the question is at what price. There clearly exist two market segments in terms of the price they are willing to pay for the municipal compost. One is the lucrative segment comprised primarily of nurseries, households, institutions and commercial establishments. This segment of the market is willing to pay around twenty times more than the other market segment i.e. the agricultural sector. The irony however is that the agricultural sector is the single largest market segment and the most potential and stable one too. Central level composting projects and wide spread community composting schemes will have to cater to the agricultural sector as the demand from the lucrative segment is limited and inadequate to absorb bulk of the compost outputs. The demand from the agricultural sector is associated with a price that is inadequate even to meet the transportation costs of the compost from the plants to the end users. An intensive marketing campaign demonstrating the benefits of the municipal compost backed by a quality product may help in addressing the issue up to a certain extent.

The quality of product required to penetrate the already competitive market (the use of compost made out of catlle waste, chicken waste, plant residues is wide spread) raises another important issue that needs addressing. It is a generally accepted fact that source separated biodegradable waste for composting results in better quality composts. However, commingled waste storage and collection is the norm currently prevalent in the City. In order to produce a more acceptable product the current system of commingled waste storage and collection needs to be replaced by source separation of the organic waste.

Initiation of any composting projects will require capital investment. A substantial area of land will also be required for operation of large scale composting projects. Even if the land required for compost plants is secured and funds made available for the initial capital investment, the compost plants to be operational in a long run will require substantial funds to meet its operational expenditures. Fraction of the operational costs can be covered by the revenues generated from the sells of the compost, but still a huge sum will be required to meet the operational costs of compost plants, particularly that of large scale community compost plants and centralized compost plants.

The difficulties presented above are mainly relevant to wide spread community composting and central level composting and does not apply to the household composting or smaller community level composting schemes. However, the issue with household composting and small scale community composting is that these options are insignificant in terms of the

waste management scene. Theoretically if all the households would make compost by themselves, there would not be any organic waste to be managed, but what is desirable is not always what is possible. The results of the study indicate clearly that various barriers to composting in households exists limiting the potential number of households, that are willing to make compost, to only a few thousand. In case of small scale composting at the community level the most significant constraint will be the siting of compost plant because of the widespread public objection to the operation of compost plants in the neighborhood. Additionally the lack of space for composting (as community level composting is likely to be carried out in the vicinity of prime urban areas) and the high cost of land required for compost plants will also be a major constraint to the operation of community composting projects.

The arguments presented above paint a broadly negative picture on the possibilities of any large scale composting schemes in the City. However, it is important here to mention that the results from the study are not aimed at arguing against any composting schemes but rather preempting the possible pitfalls and exploring ways to address them. One has to consider the fact that the findings of the study are only part of a broader picture. As discussed in the previous chapters various mechanisms can be devised to address the existing barriers (also refer to chapter 5.2). Again, this does not mean that we can undermine the findings of the study. The constraints are real and serious but so is the need of managing the solid waste in the City.

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APPENDIX A: SCHEDULES

Schedule I

Schedule for Household Survey

Date of visit(s): **Venue:**

1. Is there any kind of solid waste related services in your locality

   i. Door to door collection ii. Container collection iii. Street collection

   iv. No v. _____ (Mode of final disposal if no service)

2. How do you store your waste

   i. Commingled ii. Segregated iii. _____ (purpose of segregation)

3. Do you know about composting/compost (or that compost can be derived from org. waste)

   i. Yes ii. No

4. Are you willing to segregate the organic fraction of your waste from others? (if not reasons)

   i. Yes ii. No iii. _____

5. Would you allow any compost plant to operate in the vicinity of your house? (reasons)

   i. Yes ii. No iii. _____

6. Are you willing to make compost in your household? (If not reasons)

   i. Yes ii. No iii. _____

7. Do you use compost in your household?

   i. Yes ii. No

8. What kind of compost do you use and where do you get it from? _____

9. What amount do you pay for the compost and what quantity do you use? _____

10. Do you have any plantations, gardens, in your house? If yes quantify (roughly).

    i. Yes ii. No iii. _____

Schedule II

Schedule for Farmers and Nurseries

Date of Visit(s): **Venue:**

1. What kind of organic fertilizer do you use at present?

   i. Cattle manure ii. Chicken manure ii. From meat production iii. Household compost

   iv. Others v. _____

2. From where do you get your compost ? _____

3. What amount of compost do you require? _____ ($kg/m^2/year$)

4. What amount do you pay for the compost? _____ _____

5. Are you willing to use municipal compost if yes what amount are you willing to pay? _____

6. If you have used/are using municipal compost how does it compare with other organic fertilizers?

   i. Price: More expensive Less expensive Same

   ii. Effectiveness: More effective Less effective Same

   iii. Preference: Highly preferred Preferred Not preferred Same

7. Have you had any specific problems with municipal composts?

   i. Quality: _____

   ii. Availability: Readily available Not readily available Not available at all

8. Do you prefer chemical fertilizer over organic fertilizer?

   i. Yes ii. No iii. I require both iv. Reasons: _____

9. What amount of chemical fertilizer do you use and what price do you pay?

   i._____ ($kg/m^2/year$) ii._____ (NRs./kg)

Schedule III

Schedule for Non Governmental Solid Waste Management Organizations

Date of Visit(s):

Name of the Organization:

Address:

Individuals Contacted:

Telephone:

GENERAL:

1. Year of Establishment:
2. Years involved in SWM:
3. Legal Status:
4. Volume of Waste Collected Per Day:
5. Sources of Waste :

   i. Household ii. Commercial iii. Institutional iv. Street
6. Collection System:

   i. Door to door ii. Container Collection iii. Roadside Collection

   i. Once a day ii. Twice a day iii. Weekly iv. _____

   i. Commingled ii. Segregated (organic and others)
7. Transport System:

   i. Primary transport: i. Tractors ii. Hand Carts iii. Tricycles iv. _____

   ii. Secondary transport: _____
8. Disposal System:

   i. KMC containers ii. Teku Transfer Station iii. Public place iv. _____

   i. Commingled ii. Segregated

   i. Waste from street sweeping
9. Service Area:
10. Service charge: i. Amount: _____ ii. Basis: _____
11. Household/Institutions/Shops served:
12. Households/Institutions/Shops that pay service charge:

13. Annual/Monthly Income from SWM activities:
14. Annual/Monthly Expenses for SWM activities:
15. No. of staffs related to SWM:
16. Equipment numbers:
17. Difficulties in SWM:

COMPOSTING:

18. Compost related activities: Present (go to no. 20) Absent
19. If absent any specific reasons:
20. Any past efforts on composting or future plans:
21. What type of activity: i.Community Composting ii.Experiments iii. Awareness
22. Waste composted per day:
23. How is inorganic waste separated:

    i. Manual separation before composting ii. Separation at the source iii. _____
24. Customers of Compost products:
25. Price of Compost:
26. Income from Compost related activities:
27. Expenses on Compost related activities:
28. Area of land used for composting:
29. Location of compost plant: i. Vacant public land ii. River bank iii._____
30. Complains from locals:
31. Any extra charge in SWM services because of composting:
32. Major Difficulties: (Lack of market, compost quality, compost market, complains, expenses etc)

APPENDIX B: PLATES

Plate 1: A waste collector collecting household wastes in a hand cart in Nayabazaar

Plate 2: A waste collector collecting household wastes in a tricycle in Chabahil

Plate 3: Waste dumped for collection along the road side in Gaurinagar

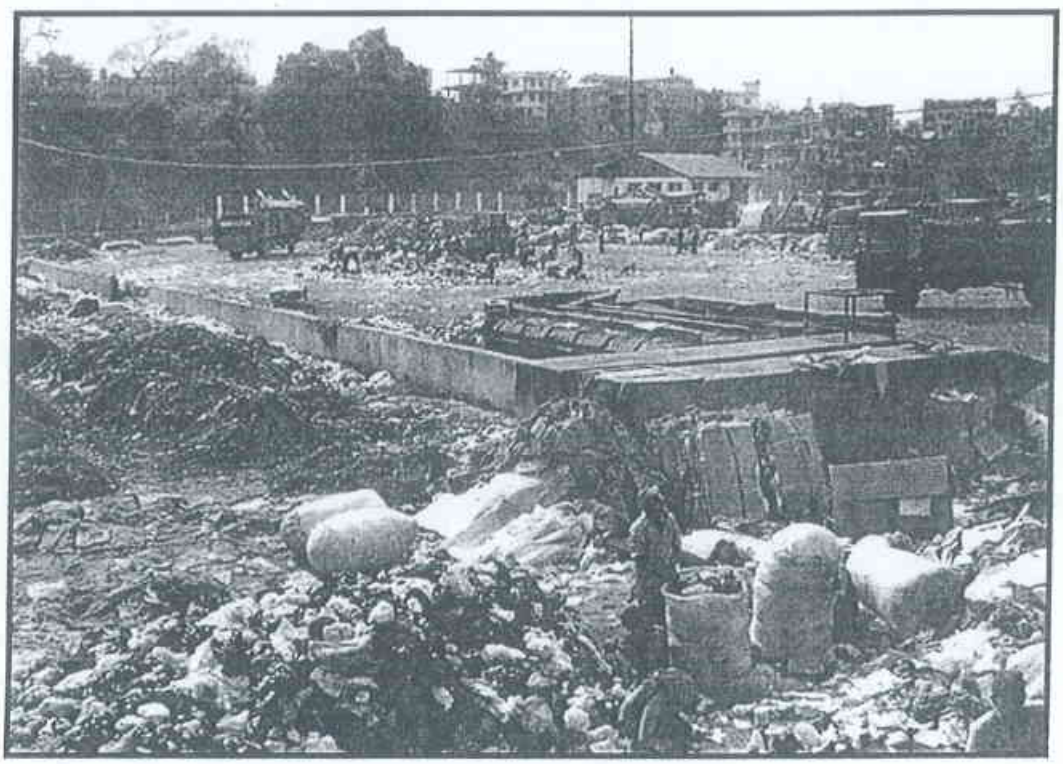

Plate 4: Teku transfer station

Plate 5: Final solid waste disposal site at the banks of Bagmati River in Balkhu

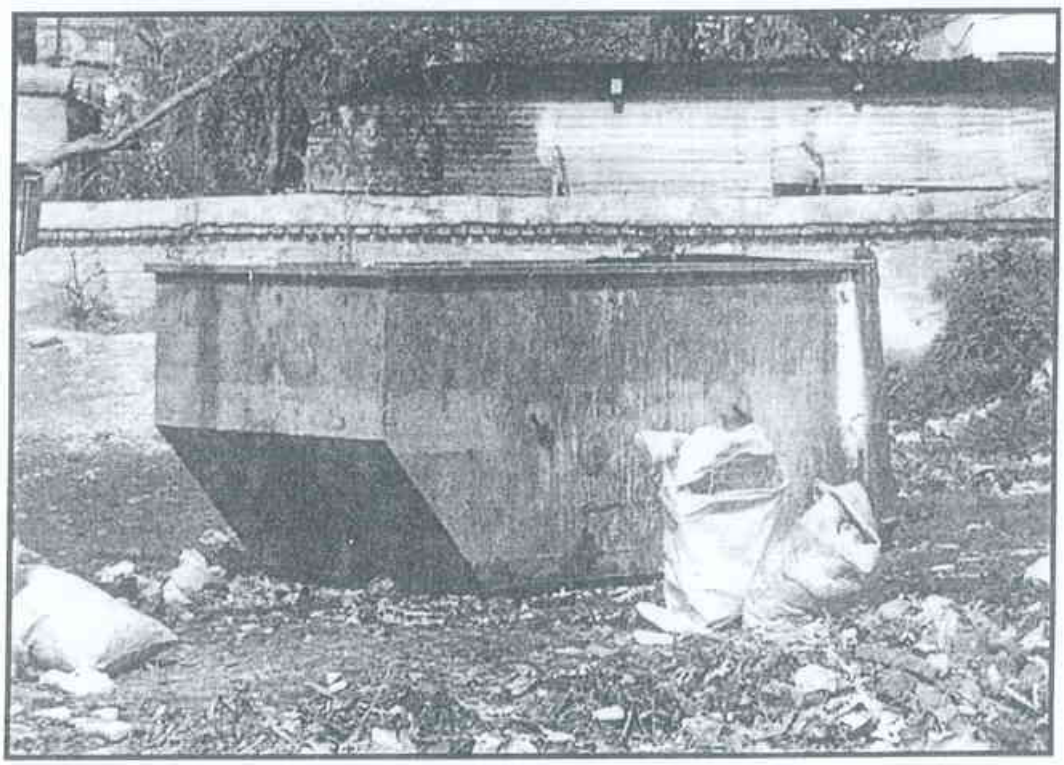

Plate 6: A typical KMC Container

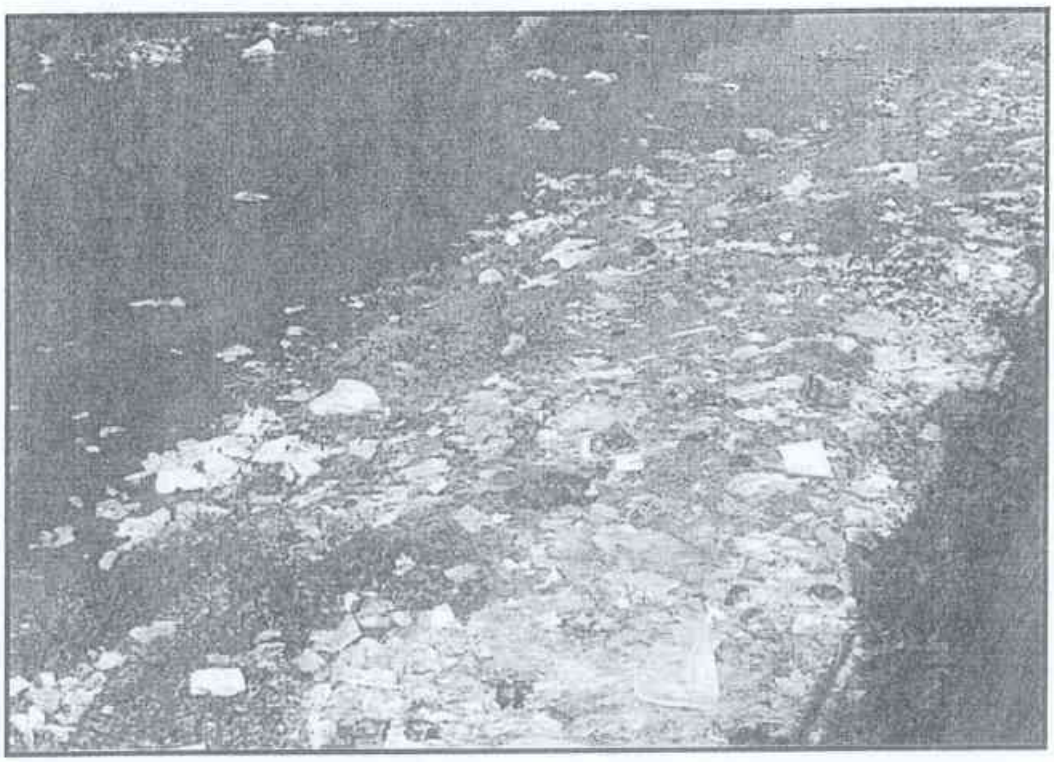

Plate 7: Household wastes dumped in the Bishnumati River at Nayabazaar

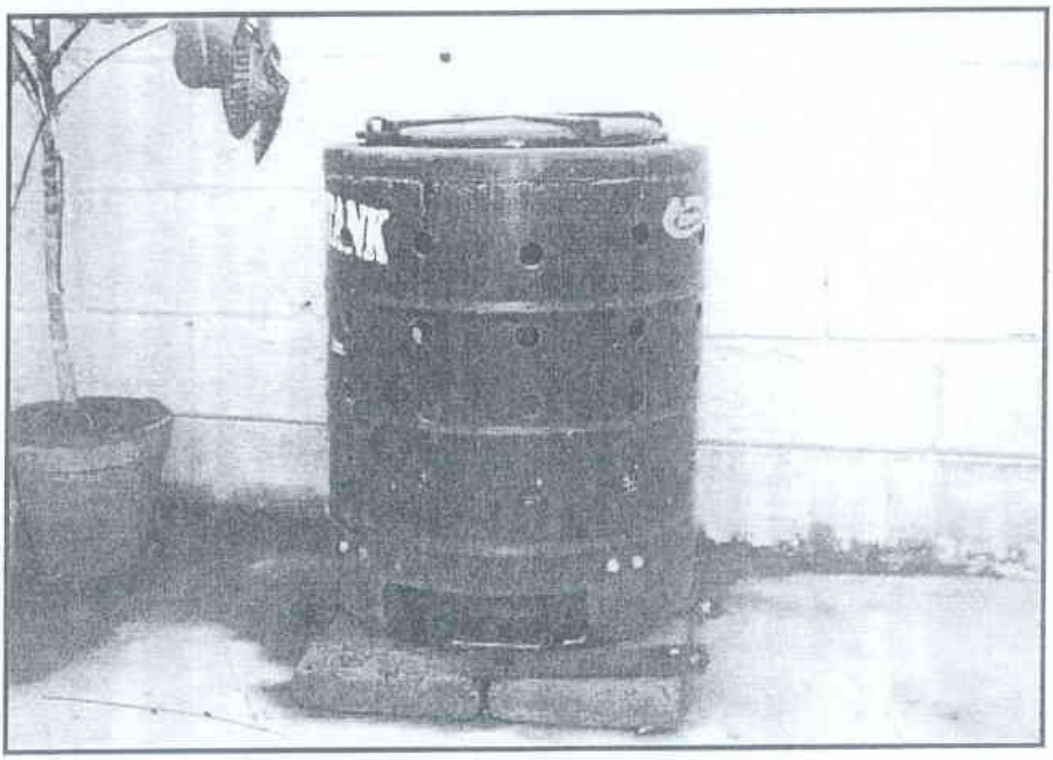

Plate 8: Compost bin used for composting household waste in Gaurinagar

Plate 9: Compost pit at a house in Chabahil

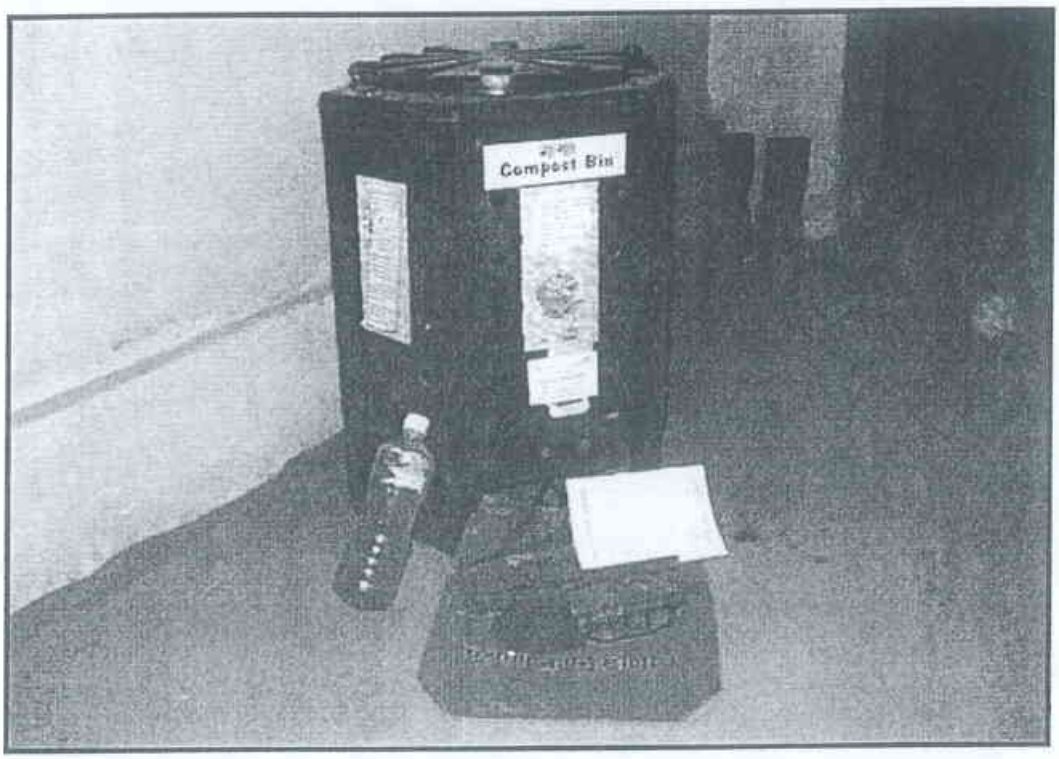

Plate 10: Compost bin (along with accessories) distributed by KMC

Plate 11: Agricultural area in Kirtipur (Kathmandu Valley)

Plate 12: Composting at a farm yard in Harisiddhi (Kathmandu Valley)

APPENDIX C: CALCULATIONS

Calculations on Compost Production Potential

Scenario 1: Composting of Total Waste Generated

Total population of the City for 2004= 787886 (Table 4.1)
Per capita waste generation= 0.48 kg/day (RESTUC, 1999, as cited by UNEP, 2001)
The average daily waste generated for 2004 = 378185.28 kg
70% of 378185.28 kg = 264729.70 kg
50% weight reduction occurs during composting

Total compost production potential = 264729.70/2 kg/day
= 132364.85 kg/day
= **132 tons/day**

Scenario 2: Composting at the Current Collection Rate

Total population of the City for 2004= 787886 (Table 4.1)
Per capita waste generation= 0.48 kg/day (RESTUC, 1999, as cited by UNEP, 2001)
The average daily waste generated for 2004 = 378185.28 kg
The average daily waste collection for 2004 = 329021.19 kg (87% of total waste, table 4.6)
70% of 329021.19 kg = 230314.83 kg
50% weight reduction occurs during composting

Total compost production potential = 230314.83/2 kg/day
= 115157.42 kg/day
= **115 tons/day**

Scenario 3: Community Composting by NGSWMOs

24% of total waste generated is collected by the NGSWMOs according to KMC figures (table 4.6). The waste collection is the contribution of sixteen NGSWMOs organizations (table 4.4), as other organization dispose the collected waste in KMC containers and consequently are regarded as waste collected by KMC.

The average daily waste generated for 2004 = 378185.28 kg
Average daily waste collection by NGSWMOs for 2004 = 90764.47 kg (24% of total waste)
Average daily waste collection by one NGSWMO = 90764.47/16 = 5672.78 kg
70% of 5672.78 kg = 3970.95 kg
50% weight reduction occurs during composting

Average compost production potential of a NGSWMO = 3970.95/2 kg/day
= 1985.48 kg/day
= **1.99 tons/day**

Scenario 4: Household Composting

Average household size = 4.42 (CBS 2001)
Per capita waste generation= 0.48 kg/day (RESTUC, 1999, as cited by UNEP, 2001)
Total daily waste generation per household = 2.12 kg
70% of 2.12 kg = 1.48 kg
50% weight reduction occurs during composting

Average compost production potential per household = 1.48/2 kg/day
= **0.74 kg/day**