ANALYSIS AND DESIGN OF SOLID WASTE MANAGEMENT SYSTEM FOR A RESIDENTIAL ZONE OF DHAKA CITY

by
Md. Abdus Salam

Master of Science in Civil Engineering

DEPARTMENT OF CIVIL ENGINEERING
BUET, DHAKA.

Analysis and Design of Solid Waste Management System for a Residential Zone of Dhaka City

by
Md. Abdus Salam

A thesis submitted to the Department of Civil Engineering of Bangladesh University of Engineering & Technology, Dhaka in partial fulfillment for the requirement of degree

Of

MASTER OF SCIENCE IN CIVIL ENGINEERING

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY
April 2001

The thesis that tilled Analysis and Design of Solid Waste Management System for a Residential Zone of Dhaka City Submitted by Md. Abdus Salam, Roll No: 9212117P, Session 90-91-92, has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Master of Science in Civil Engineering on April 22, 2001.

BOARD OF EXAMINERS

Dr.A.B.M. Badruzzaman : **Chairman**
Professor (Supervisor)
Department of Civil Engineering
Bangladesh University of
Engineering & Technology

Dr. M. Habibur Rahman Member
Professor
Department of Civil Engineering
Bangladesh University of
Engineering & Technology

Dr.M. Mujibur Rahman Member
Professor
Department of Civil Engineering
Bangladesh University of
Engineering & Technology

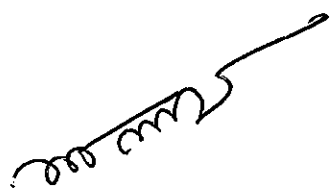
Dr. M. Feroze Ahmed Member
Head (Ex-Officio)
Department of Civil Engineering
Bangladesh University of
Engineering & Technology

Dr. Mohammed Ashraf Uddin Member(External)
Chief Health Officer
Dhaka City Corporation

DECLARATION

I hereby declare that this thesis nor any part of it has been submitted elsewhere for the award of any degree or diploma.

Dr.A.B.M. Badruzzaman
Professor
Department of Civil Engineering
Bangladesh University of
Engineering & Technology



Md. Abdus Salam

ACKNOWLEDGEMENT

The author wishes to express his deepest gratitude to Dr. A.B.M. Badruzzaman Professor of Civil Engineering Department BUET for his continuous guidance and affectionate encouragement at every stage of his study. The author is also grateful to Dr. Md. Mujibur Rahman, Profesor, Civil Engineering Department BUET for his advice and cooperation. The author sincerely expresses his grateful thanks and heartfelt gratitude to Engineer Tariqu Bin Yousuf, of Dhaka City Corporation for his encouragement help, and continuous support.

The author also expresses his heartfelt gratitude to his wife Dr. Reshma Mazumder Shampa, Assistant Professor, Medical College for Women, Uttara for her continuous encouragement and support at every stage of his study.

ABSTRACT

Dhaka, the capital of Bangladesh, with an inhabitant close to 10 million, undergoes regular environmental problems, which are linked to inefficient solid waste management system. The objective of the study was to establish the waste generation rate of Banani, Gulshan Baridhara and Uttara Model Town area to plan an efficient solid waste management system. The other major objectives were analysis and design of solid waste management system with an emphasis on collection and disposal and to determine appropriate methods and means to improve collection and minimization of cost of collection, transport and disposal of solid waste.

Domestic waste generation rate was estimated from Sector-4 of Uttara Model Town through house to house collection by rickshaw van. Population of each household was also determined from questionnaire survey. Commercial waste from five Chinese restaurant of Uttara model town. Hospital wastes from one private medical college hospital and three clinics were also collected. Street sweepings, a significant waste volume were also determined from different locations of Uttara model town.

Domestic waste generation rate was found to be 0.60 kg/cap/day, commercial wastes 0.55 kg/cap/day, clinical wastes 1.75 kg/cap/day and street sweeping wastes 0.16 kg/ meter/day. Due to resource constraint in collecting samples from door to door, and due to constraints in analyzing the samples in the laboratory the sample size was kept purposefully small and may not be statistically representative of the study area. Thus, the results obtained on generation rate should be used with caution remembering that these data will be more applicable for the areas and the communities having same characteristics as the study area. Physical composition analysis of domestic waste shows that major portion is food waste (72.5%) and polythene is the second largest fraction(13.70%). Waste stream analysis shows 58.70% domestic, 7.90%

commercial, 0.32% clinical and 33.08% street waste. Monitoring well were installed at Matuail and Mugdha landfill. Leachate samples were collected and analyzed at Environmental Engineering Laboratory. Analysis of ground water near landfill site (about 300m average) found to be free from contamination. It may be concluded that the presence of natural clay under the fill acts as a sealer and protects the aquifer.

From cost analysis it was found that transportation cost is about 49%, primary collection is about 31%, disposal is about 20%. DCC's 75% cleaners are engaged in street sweeping actives who are under utilized and consuming major portion of yearly allocation. Street sweeping waste collection cost is 8 times higher than the primary collection cost. It was also found that house to house domestic waste collection and street sweeping by private contractor were less costly, than the present practices of DCC. Demountable container carrying trucks were underutilized in zones 1,2,3,4 and 5. This indicates that transportation by 5 ton capacity open truck may be cheaper than 3 ton capacity demountable container trucks. Installation of modified transfer station at Gulshan area may be economical compared to the present operation of transporting each truckload of waste to the Matuail landfill area. It was also found that formal practice of resource recovery and recycling could earn approximately Tk. 71.91/ton of solid waste.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER- 1
INTRODUCTION

1.1 GENERAL

One of the major growing concerns an urban area faces today is solid waste management, because growing volumes of refuse, their collection and disposal plague cities everywhere. Municipal government worldwide are struggling to find the best method to manage their residents waste.

Dhaka's population is growing at a phenomenal rate overwhelming all the efforts to improve the living conditions and posing an enormous challenge to those responsible for management of Capital City development and providing services to citizens. During the last three decades the city of Dhaka has grown from a provincial capital with a population of around one million to the capital of an independent country with a population approaching ten million. The population density is very high with around 200 persons per acre. In parts of old Dhaka, this goes up to about 325 ppa. Recently, a number of newspaper have reported that the old part of Dhaka city near Sutrapur is the most densely populated area of the world (Pratham Alo, 6th July, 2000). According to Bangladesh 2020 (WB and BCAS, 1998) the population of Dhaka city in the year 2020 is estimated to be 25 million. DMDP predicts the population of Dhaka to be around 15 million in the year 2015 (Choudhury, 1998).

A solid waste management system is an interrelated system of appropriate technologies and mechanisms involved in the generation collection, storage, processing, transfer/transport and disposal of solid waste designed to reduce waste at the lowest possible cost. This should also minimize risk to the health of the people and the environment.

Dhaka City Corporation (DCC) is responsible for collection and disposal of solid waste generated in the DCC area. The population of Dhaka city has increased rapidly, with growth rate of 3.72% per year. Solid waste generated from city dwellers from different routine activities. So with the increasing population solid waste generation is also increasing accordingly.

The total amount of solid domestic waste generated every day is about 3,000 tons. Only about 50% of this is collected and some of it is dumped as landfill (Choudhury, 1998). About 50% of generated waste remain uncollected, which makes environmental scenarios of Dhaka City gloomy and dismal for the future. In DCC area 60% houses are low income, 37% are middle income, and 3% are high-income houses. There are about 129,700 households in the slums of the DCC areas as stated in the study.

As a developing country the utility service of Dhaka City did not grow as fast as the population. Presently, the DCC collects waste from roadside bins, street sweeping and demountable containers. Most of these are domestic solid waste. Industrial, clinical and hazardous wastes are not collected in a planned manner. Approximately 30% of the population are using bins and the others are using low laying areas, open drains, streets and open spaces for waste dumping

On the other hand, transportation of solid waste through open truck at day time pollute environments and create nuisance due to irregular cleaning of open bin, removal of demountable containers. As most of the waste are deposited outside and near the bins or containers and that all the bins and containers are placed on the roadside impact of rotten, uncollected wastes lying outside, contaminate the environment public health as well as ecology. Solid waste management may be defined as that discipline associated with the control of generation, storage, collection, transfer and transport, processing and disposal of solid waste in a manner that is in accordance with the best principle of public health, economics, engineering,

conservatives aesthetics and other environmental consideration and which also is responsive to public attitude. These six components are known as the functional elements of a SWM system.

For analysis and design of a solid waste management system for a residential area of Dhaka city six functional element of that constitute solid waste management system must be evaluated.

1.2 OBJECTIVES OF THE STUDY

The primary objectives of the study are

- To estimate, in quantitative and qualitative terms, the present generation rates of domestic, commercial and clinical waste of a residential zone of Dhaka city which includes the areas of Banani, Gulshan, Baridhara and Uttara Model Town.
- To assess the solid waste generation for a specific design period.
- To analyze the present collection system and to design a more appropriate solid waste collection and disposal system for the study area.
- To assess alternatives for minimization of cost of collection, transport and disposal of solid waste.

1.3 METHODOLOGY

The methodology to be applied in this study is literature review of previous studies, review of theory of solid waste management system, assessment of present needs through questionnaire and field survey, sample collection, quantitative and qualitative analysis of solid waste (residential, commercial, clinical), determination of requirements for the present and proposed system, cost comparison of present and proposed system, analysis of alternative options, projection of recommended system for the next five year .

The Banani, Gulshan, Baridhara & Uttara Model Town is selected as the study area. In absence of previous solid waste management related data of these areas survey work will be conducted which will include questionnaire survey in selected residential units, commercial unit, and clinics of Uttara Model Town. As few private organizations started the house to house domestic waste collection services in these areas. So it is expected that data from these collection services will facilitate data collection. Sample and data collector will follow the rickshaw van during house to house waste collection and will record the number of persons living in a residential houses, time spent for collection, qualitative and quantitative data of waste. To design a disposal site data collected from DCC's present landfill at Matuail, old landfill sites at Mugdha and Jatrabari.

The data thus obtained then will be analyzed for the design of solid waste management system for Uttara Model Town, Banani, Gulshan, Baridhara. The chemical analysis of samples will be done at Environmental Engineering laboratory at BUET.

To assess alternatives for minimization of cost of collection, transport and disposal of solid waste privatization cost of different component of solid waste management will be calculate.

Data will be collected from Dhaka City Corporation's Conservancy Department, Transport Division, Engineering Department, Zone offices

1.4 SCOPE OF THE STUDY

Banani, Gulshan, Baridhara, Uttara residential area constitute the high income group of people of Dhaka city. At present, solid waste management system has not been designed by the Dhaka City Corporation for these areas. No survey work has been done to determine waste generation rates, volume of domestic wastes produce from these areas, transport and manpower requirement, future demands. Some private companies are collecting domestic waste by rickshaw van from houses to the DCC's container or stationery bins. Information on these functional elements will enable one to design an appropriate solid waste management systems.

This study can establish some important basic data for designing of a solid waste management system. Waste generation rate, total volume of waste, labor, transport and equipment requirement, disposal, resource recovery and recycling possibilities, cost estimate for private company, door to door collection, transportation and disposal data will be determined. This data may be used for preparation of Terms of Reference to "Lease out" some service to the private company. The study may provide information on the possible option in establishment of transfer station, introduction of house to collection and resource recovery by private initiative. This study can provide information on the future design of system.

1.5 ORGANIZATION OF THE THESIS

The thesis consists of six chapters,

Chapter 1 includes general introduction, objective, methodology and scope of the study.

Chapter 2 includes literature review covering functional elements of solid waste management system. Brief reviews of relevant literature are also discussed in this chapter.

Chapter 3 consists of brief description of present solid waste management practice of Dhaka City Corporation area. This chapter also point out that major problems and limitation of the present solid waste management system.

Chapter-4 presents the data and sample collection procedure, physical and chemical composition analysis of solid waste. This chapter primarily presents the results of waste generation rate of domestic, commercial, clinical wastes, and street sweepings. Chemical composition of leachate has been identified and presented in this chapter.

Chapter 5 presents and evaluates present solid waste management system with needs assessments and cost analysis. This chapter mainly describes the proposed system. Cost estimate, cost minimization and comparison of presents and proposed system.

Chapter- 6 presents conclusions of the study and also provide a number of recommendations for future study.

CHAPTER – 2

THEORY OF SOLID WASTE MANAGEMENT

2.1 FUNCTIONAL ELEMENTS OF A SOLID WASTE MANAGEMENT SYSTEM

The activities involved with the management of solid waste from the point of generation to final disposal have been grouped into six functional elements namely (1) waste generation, (2) On-site handling, Storage and Processing, (3) Collection, (4) Transfer and Transport, (5) Processing and Recovery, and (6) Disposal.

2.1.1 Waste generation

Waste generation encompasses those activities in which materials are identified as no longer being of value and either thrown away or gathered together for disposal. The primary sources of solid waste include (1) Residential, (2) Commercial, (3) Municipal, (4) Industrial, (5) Open areas, (6) Treatments plants, and (7) Agricultural, etc.

Types of solid waste

The principal components of solid waste originating from a metropolitan area includes

Food waste: Food wastes are the animal, fruit or vegetable, residues resulting form the handling preparation, cooking and eating of foods.

Rubbish: Rubbish consists of combustible and noncombustible solid wastes. Typically combustible rubbish consists of materials such as paper cardboard, plastics, textiles, rubber, leather, wood, furniture and garden trimmings. Noncombustible rubbish consisted of items, such as glass, aluminum, in cans, crockery ferrous and other nonferrous metal and dirt.

Ashes and Residues: Material remaining from the burning of wood, coal coke and other combustible wastes Ashes and residues are normally composed of fine powdery materials. Demolition and construction wastes includes dirt's, stones, concrete, brick, plaster, timber, shingles and plumbing, heating and electrical parts.

Special wastes: Waste such as street sweepings, roadside litter, litter from municipal litter container, catch-basin, debris, dead animal and abandoned vehicles are classified as special wastes.

Treatment Plant Waste: The solid and semisolid waste from waste water and industrial waste treatment facilities are included in this classification.

Agricultural wastes: Wastes and residues resulting from divers agricultural activities such as the planting and harvesting of row, field and tree and vine, crops, the production of milk, the production of animals for slaughter and the operation of feedlots are collectively called agricultural waste.

Hazardous waste: Chemical biological, flammable, explosive or radioactive waste that pose a substantial danger, immediately or overtime, to human, plant or animal life are classified as hazardous waste.

Composition of municipal solid waste

Information on the composition of solid waste is important in evaluating alternative equipment needs, system and management programs and plans.

Physical composition : Information and data on the physical composition of solid waste are important in the selection and operation of equipment and facilities in assessing the feasibility of resource and energy recovery and the analysis and design

of disposal facilities. The percentage of municipal solid waste components vary with location, the season; economic conditions and many other factor.

Chemical composition: Information on the chemical composition of solid wastes is important in evaluating alternative processing and recovery options.

Factors that affect generation rate-

(i) Geographic location, (ii) Season of the year (iii) Frequency of collection (iv) Use of Home Grinders (v) Characteristics of population (vi) Extent of salvage and Recycling (vii) Legislation, and (viii) Public attitudes.

2.1.2 Onsite handling, storage and processing

Those activities associated with the handling storage and processing of solid waste at or near the point of generations.

Onsite handling

Onsite handling refers to the activities associated with the handling of solid waste until they are placed in the containers used for their storage before collection. Depending on the type of collection service handling may also be required to move the loaded container the collection point and to return the empty container to the point where they are stored between collections.

Domestic wastes accumulated at several location in and around low and medium rise residential dwelling are placed in large storage container to await removal by waste collection agency where curb collection is used the resident is also responsible for placing the loaded longer storage container (s) at the curbs and for returning the empty containers (s) to their storage location next to or in the dwelling in high-rise apartments wastes are picked up by building maintenance personnel or porters form each floor and taken to basement service area, (2) taken to basement service area by

the tenants or (3) bagged and placed by the tenants in specially designed chutes with openings located at each floor.

In most office, commercial and industrial buildings solid waste that accumulate in the office or work locations usually are collected in relatively large containers mounted on rollers. Once filled these containers are removed by means of the service elevator, if there is one and emptied into (1) large storage container or (2) Compactor used in conjunction with the storage containers (3) stationary compactor that can compress the material into bales or into specially designed containers or (4) other processing equipment such as incinerators.

Onsite storage

Factors that must be considered in the onsite storage of solid waste include (1) the type of container to be used (2) the container location (3) public health and aesthetics and (4) the collection methods to be used.

The types and capacities of the containers used depend on the characteristics of the solid waste to be collected, the collection frequency and the space available for the placement of containers. The types and capacities of container now commonly used for on site storage of solid waste are small capacity plastic or metal or galvanized metal, Barrel plastic or metal or aluminum or fibber Disposable paper bags, plastic bags typical size-120L Medium capacity side or top loading 0.25- $9M^3$. large capacity - open top, roll off debris box), Used with stationery compactor. Equipped with self-contained compactions mechanism; trailer mounted open top 27 m^3.

Container locations

In newer residential areas, containers for solid waste usually are placed by the side or rear of the house. In older residential areas containers are located in alleys. In high-rise multifamily apartment large containers are often placed in specially designed and designated enclosure. In high rise apartments storage containers are located in a basement or ground floor service area.

Onsite processing of solid wastes

Grinding, sorting, compaction shredding, composting, and hydropulpery are all onsite processing methods used to (1) reduce the volume (2) alter the physical form, or (3) recover usable materials form solid wastes.

2.1.3 Collection

The Term collection includes not only the gathering or picking up of solid waste from the various sources, but also the hauling of these waste to the location where the content of the collection vehicles are emptied.

Collection systems equipment and labor requirements

Types of collection system

Solid waste collection system may be classified from several points of view, such as the mode of operation, the equipment, used and the types of waste collected. According to the mode of operation into two categories (1) hauled container system (2) stationery container system.

Hauled container system (HCS)

These are collection system in which the container used for the storage of wastes are hauled to the disposal site, emptied, and returned to either, their original location or some other location Hauled container system are ideally suited for removal of waste from sources where the rate of generation is high because relatively large container are used. Another advantage of hauled container system is their flexibility, containers of many different sizes and shapes are available for collection of all types of wastes.

Analysis of collection system: Definition of Terms

Pickup (P_{hcs}) = time spent driving to the next container has been deposited + time spend picking up the loaded container + the time required to deposit the container after its content has been emptied.

Haul (h) = time required to reach the disposal site, starting after a container whose contend are to be emptied has been load on the truck + the time after leaving the disposal site until the truck arrives at the location where the empty container is to be redeposit.

Off Route: Time spent checking in and out in the morning and at the end of the day + time spend driving to the first pickup point + time spend driving from the last pick up point to the dispatch station + time spend due to unavoidable congestion + time spend on equipment repairs and maintenance + time spent for lunch, talking .

At Site (s): time spent at the disposal site = the time spent waiting to unload + time spent unloading.

Pickup (P_{hcs}) = time spent driving to the next container has been deposited + time spend picking up the loaded container + the time required to deposit the container after its content has been emptied.

Haul (h) = time required to reach the disposal site, starting after a container whose contend are to be emptied has been load on the truck + the time after leaving the disposal site until the truck arrives at the location where the empty container is to be redeposit.

Off Route: Time spent checking in and out in the morning and at the end of the day + time spend driving to the first pickup point + time spend driving from the last pick up point to the dispatch station + time spend due to unavoidable congestion + time spend on equipment repairs and maintenance + time spent for lunch, talking .

At Site (s): time spent at the disposal site = the time spent waiting to unload + time spent unloading = 30 min.

The time required per trip, which also corresponds to the time required per container is given by the following equation:

$T_{hcs} = (P_{hcs} + s + h) / (1-W)$

Stationary container system (SCS)

These are collection system in which the containers used for the storage of waste remain at the point of generation, except for occasional short trips to the collection vehicle.

Stationary container system may be used for the collection of all types of wastes. The systems vary according to the type and quantity of waste to be handled, as well as the number of generation points .There are two main types (1) system in which self loading compactors are used and (2) system in which manually loaded vehicles are used.

Residential collection service

Low-Rise Detached Dwellings- the most common Types of residential services used are (1) curb (2) alley (3) Set out-set back (4) set- out and (5) backyard carry. Where curb service is used, the homeowner is responsible for placing the containers to be emptied at the curbs on collection day and for returning the empty containers to their storage location until the next collection. Where alleys are part of the basic layout of a city or a given residential area alley storage of containers used for solid wastes in common. In set out set back service, containers are set out from the homeowner property and set back after being emptied by additional crews that work in conjunction with the collection crews responsible for loading the collection vehicle.

Set out service is essentially the same as set out- setback service except that the home owner is responsible for returning the containers to their storage location.

In backyard carry service, the collection crew is responsible for entering the homeowner's property and removing the waste from the storage location.

Methods of loading the collection vehicle may be classified as either manual or mechanical. Methods commonly used for residential wastes includes (1) the direct

lifting and carrying of containers, (2) the rolling of loaded containers on their rim, (3) the use of small lifts for rolling the containers to the collection vehicle, and (4) the use of large containers ("tote") or drop cloths into which waster from small containers are emptied before beings carried and or rolled to the collection vehicle.

Where collection vehicles with low loading heights are used wastes are transferred directly from the containers in which they are stored or carried to the collection vehicle by the collection crew. In some cases where open body are used crew members stationed on the truck will lift the loaded container into the truck with the help of the collectors on the ground, empty the container, and return it to the collectors on the ground.

Commercial - Industrial services

The collection service provided to large apartment buildings and commercial activities typically is centered on the use of large moveable and stationary containers and large stationary compactors.

Communal collection

In this system householders discharge their waste into the communal bin at specific locations over a considerable distance and refuse collection vehicle collects the accumulated waste at a frequent interval, usually once in a day. In most of the third world countries this type of collection system is followed.

2.1.4 Transfer and transport

The functional elements of transfer and transport refers to the means, facilities, and appurtenances used to effect the transfer of waste from relatively small collection vehicle to large vehicles and to transport them over extended distance to either processing centers as disposal sites. Factors that tend to make the use of transfer operations attractive include (1) The presence of illegal dumps and large amount

amounts of litter (2) the location of disposal site relatively far form collection routes (typically more than 10 mile) (3) The use of small- capacity collection trucks. (generally under 20 yd^3). the existence of low density residential areas (5) the widespread use of medium-sized container for the collection of waste from commercial sources and (6) use of hydraulic or pneumatic collection system. Transfer and transport operations became a necessity when haul distance to available disposal site or processing centers increases to the point that direct hauling is no longer economically feasible.

Transfer stations

Important factor that must be considered in the design of transfer stations includes-

1. Type of Transfer operation to be used.
2. Capacity requirement
3. Equipment and accessory requirement
4. Sanitation requirement.

Types of transfer station

Depending on the method used to load the transfer vehicle transfer station may be classified into three types-

(1) direct discharge (2) storage discharge (3) combined direct and storage discharge.

2.1.5 Processing and recovery

The main purposes of processing to improve the efficiency of operation, to recover resources and to recover conversion products and energy. Important processing techniques used routinely in municipal solid-waste system includes: compaction, thermal volume reduction (incineration) and manual separation of waste components.

2.1.6 Disposal

Waste disposal on land has always been the lowest cost disposal option. Alternative method such as composting or Incineration usually, but not always, involve the use of high cost capital plant and equipment that needs skilled management and labor and is also costly to operate, the term sanitary landfill means an operation in which the waste to be disposed of are compacted and covered with a layer of soil at the end of each day's operation. The factor that must be considered in evaluating potential solid waste disposal site includes (1) available land area (2) impact of processing and resource recovery (3) haul distance (4) soil condition and topography (5) Climatological conditions (6) surface-water hydrology (7) geologic and hydrologic condition (8) local environmental condition (9) Potential ultimate use for the completed site.

2.2 RELEVANT STUDIES

2.2.1 Waste generation in DCC area

The amount of solid waste being generated in DCC area has been studied by several consultants and agencies in the period of 1986 to 1991. Table 2.1 shows comparison.

The BKH (BKH, 1986) carried out a survey in Old Dhaka between April to July. Average domestic waste generated from 130,050 house was found to be 100.96 tons/day. Survey results showed that pucca houses generated 6.25Kg./week, semi pucca house 5.83 Kg /week kucha house 3.79 Kg/week. The reported waste generation assuming with 0.20% street markets and 10% small industry to be 130 ton / day for old Dhaka. BKH(1986) also conducted a spot check at disposal site and found 450 tons of waste delivered in a day.

In 1990 the data produced by Bhide (WHO,1990) shows that during two days survey 360 trip/day waste was found and assumed on truck density was 500Kg/m^3.

Calculated waste quantity was 1,105 tons/day. With an assumed population of 6 million. The calculated waste collected was 0.19.16Kg/Capita/day. Data supplied by Dhaka City Corporation of one day 02-6-85 estimated delivery was 888 Tones / day.

In 1991 Mott Macdonald International Ltd.(MMI) carried out field survey in day time and night time on 8 May and 12 May. MMI reported that 560 m^3 (on truck volume) was delivered to the waste disposal site during daytime. At an average "On Truck" density of 550 Kg / m^3, total 308 tones were delivered. Nighttime survey result shows 614 m^3 (On Truck Volume) was delivered to the waste disposal site during the night time. At an average " On Truck " density at 661 Kg. / m^3, total 375 tones were delivered. MMI(1991) found total 683 tons / day delivered at disposal site. MMI(1991) estimated the waste generation for 1991 and found 1500 Tons / day. It was reported that waste stream fraction of Dhaka city was 46.8% domestic, 21.8% street sweeping, 19.2% commercial, 12.9% industrial and 0.5% clinical. (Fig-2.1) MMI(1991) presented from UNCRD source a comparison data of waste generation rates of some Asian cities, (Table -2.2) shows that Dhaka is amongst the lest wasteful of Asian cities having a per capita waste generation rate of 0.47 Kg./ capita /day.

Table : 2.1 DCC waste stream data

(Typical 24 hours collection, Disposal)

Date	Origin Data	Assumed Collected	Volume Collected	Density Assumed	Tones Landfill	Tones Generated
1985-96	BKH	50%	936	0.56	520	1040
1985	DCC	50%	1600	0.56	888	1776
1990	LBI	50%	N/A	N/A	1250	250
1990	WHO	50%	1381	0.80	1105	2210
1991	MMI	50%	1134	0.58	683	1366
1991	JICA	50%	N/A	N/A	770	1540

Source : DMDP(1992)

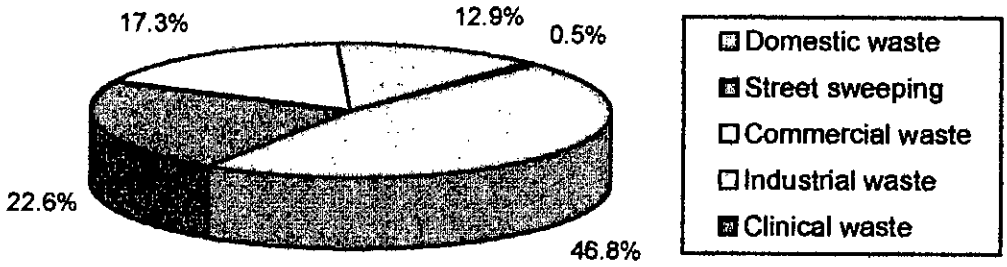
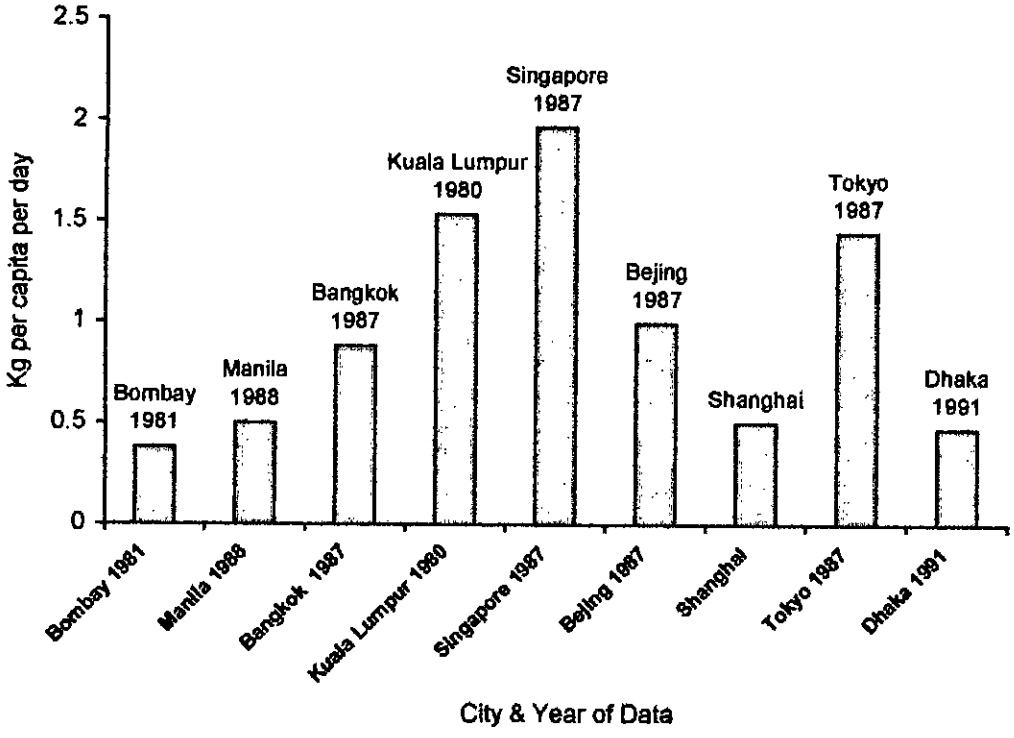


Fig. 2.1 Waste stream fraction of Dhaka city.



Source : DMDP(1992)

Fig. 2.2 Waste generation in selected Asian cities.

Table: 2.2 Waste generation in selected Asian cities.

City	Area Km2	Population 1000	Waste Generation 1000 Tons/year	Kg. Capita/Day
Bombay	466	8243 (1981)	1150	0.38
Manila	636	7561 (1988)	1380	0.50
Bangkok	1569	5609 (1987)	1800	0.88
Kuala Lumpur	43	1306 (1980)	730	1.53
Singapore	618	2613 (1987)	1873	1.96
Beijing	16807	9880 (1987)	3580	0.99
Shanghai	6341	12323	2250	050
Tokyo	600	8554 (1987)	441	144
Dhaka	344	3397 (1991)	580	047

Source : DMDP(1992)

2.2.2 Physical and chemical compositions

Ahmed (1993) reported that domestic waste mainly contains 84.37% food waste in residential area and 79.49% in commercial area. The result found from Ahmed analysis is shown in Table 2.4. From chemical composition analysis Ahmed found 45.5% moisture content from domestic refuse and 57.2% fixed residues.

Table 2.3 : Composition of waste in residential and commercial area.

Constituents	Residential area % by dry wt	Commercial Area % by dry wt
Food waste	84.37	79.49
Paper	5.68	9.22
Plastic	1.94	1.48
Cloths	1.83	1.59
Glass Metal and etc.	6.38	10.22

Source : Ahmed (1993)

BKH(1986) analysis the domestic waste (collected from Old Dhaka) in BCSIR lab and results found are shown in Table 2.6. From BKH results it is found that the pucca house food waste is 83% paper and Card board 10.5%, and for kutcha house food waste is 90.7%. Chemical composition for mixed refuse analysis found by Islam (1992) was a moisture content of 95.37% and 83.37% fixed residue. These are shown in Table-2.3.

Table: 2.4 Domestic waste Analysis by BCSIR

Material	**Pucca**	**Semi Pucca**	**Kutcha**
Vegetable Material	83.0		90.7
Inert Material	4.2		6.0
Paper and Card board	10.5	83.0	2.0
Glass	0.3	6.0	Nil
Metal	0.2	8.1	0.5
Plastic	0.2	Nil	Nil
Textiles	1.1	1.8	0.6
Wood	0.1	0.21	0.1
Straw	0.3	0.6	0.1
Bon	0.1	0.1	0.1
TOTAL	**100**	**100**	**100**

Table : 2.5 Chemical composition of waste generated in Dhaka City Analyzed by EED (1975), Ahmed (1985), Islam(1992)

Constituents	Refuse from Disposal site EED, 1975	Domestic refuse Ahmed 1985	Market Waste Ahmed 1985	Mixed refuse Islam 1992
Moisture Content	47-55	45.3	53.6	95.31
Fixed Residue	52.2-59.7	57.2	55.6	83.37
Organic Carbon	-	22.6	25.7	21.84
Organic Nitrogen, N(%)	0.4-0.6	0.41	0.36	0.39
Phosphorus, P(%)	0.0-0.05	0.05	-	0.94
Potassium	0.0	-	-	-

Table: 2.6 Composition of solid waste of new Dhaka city.

Constituents	High Income Area	Low and medium income Area.
Food Waste	82.15	88.65
Paper	7.33	5.2
Tin can	1.87	-
Plastic Rubber	1.23	.69
Glass and Ceramic	1.83	2.43
Metal and Wood	3.57	2.43
Textile and Leather	1.92	1.25

Source - Ahmed (1993)

2.2.3 Onsite storage

MMI (1992) reported that in DCC area 2450 C.I sheet and 1595 pucca dustbin provided by DCC for storage of municipal waste C.I. Sheet bins are 900 mm dia 900 mm height and masonry / RCC bins are 1mx 1mx2m (Average) size. DMDP report '92 also estimated the percentages of population using the existing bins and enclosures as means of disposal. The report mentioned:

50% of population using waste enclosure or bins, 20% of population using roads to dispose of waste, 20% of population using drains to dispose of waste, 10% of population using open ground to dispose of waste. Enayetullah (1994) conducted a field survey in Dhanmondi and Kathalbagan area it was found that 35.17% of household disposing waste on dustbin, 41.38% of household disposing waste on road or drain, 13.10% of household disposing waste on vacant plots, 6.90% of household disposing waste in own premise.

The main reasons for not using the community bins are identified by the respondents absents of dustbin and lack of easy access to community bins.

Sinha (1995) mentioned that in Madras, Bangalor and Manila fixed concrete communal bins are provided on foot ways or verges at intervals of 50-200 meters and with very encouraging results (Tridevil et. al. 1992). Only 9% of the slums in DCC area has any form of solid waste collection service, the remaining 91% slums disposes their solid waste into low lands, road side, drains or khals (Louis, Berger, et.al.1991).

2.2.4 Collection

Collection includes not only the gathering or picking up of solid waste from the various sources, but also the hauling of the waste to the location where the contents of the collection vehicles are emptied. George Tehobanglous in his book " Solid Waste Engineering Principle and management issues" mentioned that total amount of money spent, for solid collection and disposal in USA approximate 60-80 percent were spent in the collection phase.

Table: 2.7 Cost of solid waste collection and disposal in US 1971.

Item	**1971 estimated**
Collected waste – Millions Tons.	120
Collection ($ / Ton)	18
Disposal ($ / Ton)	4
Total	22

Yousuf(1996) in his study evaluated and assessed the expenditure of existing primary collection street sweeping and alternative of system. He mentioned that existing expenditure of Zone 1 of DCC in primary collection system was Tk. 74 /m^3. He also evaluated the private collection system expenditure of North Kalabagan and South Kalabagan covering 700 and 375 households respectively for house to house collection and found TK. 94/m^3 by rickshaw van. He opined that, if the neighborhood communities are encouraged to form community based organization

(CBO's) to organize the work of collection of domestic solid waste, collection would be better and it would be highly cost effective. Table 2.8 highlights the comparison of cost and efficiencies of the system of collection.

Table : 2.8 Comparison of cost and Efficiency of the collection systems.

System	Capacity	Cost of Collection Taka/m^3
Conventional handcart and communal bin systems	013 cum / handcart	TK. 74
CBO approach of Rickshaw Van system	0.92 cum /Rickshaw Van	TK. 94
Platform Rickshaw carrying cans	0.92 cum/ platform Rickshaw	TK. 136

Source: Yousuf (1996)

Mohit (1995) stated in his paper described the CBO approach as better suited than other alternative from the perspective of cost effectiveness among the three alternatives.

a. Increase the number of CBO's cleaners and other associated staff of Conservancy Division.
b. Involve private, enterprises in the collection of solid waste.
c. Encourage neighborhood organizations in the collection of solid waste.

An increase in the umber of CBO's in congested area where narrow roads exists are unwanted by the residents because it aggravates the traffic condition. Moreover, the additional cleaners and staffs employed by the DCC would increases the cost of collection of solid waste in Dhaka City.

He mentioned that North and South Kalabagan Samaj Kallayn Parishad (CBO) approach reveals that a house to house collection of domestic waste is very effective from the view point of cost and overall improvement of environment

Mott Macdonald in 1991 conducted a survey on waste collection performance of DCC. According to that study, in an open truck system:

- The basket used to load the waste into the body is the wrong shape. It shaped like a shallow saucer. It should be shaped like a wide mouthed bucket. Only 42 litter of waste is loaded on to the basket.
- Body, head and shoulders of the man lifting the basket has closer direct contact with waste that is disease redden and contaminated with urine and other animal and human excreta this is a grave danger to his health, safety and well being.
- Both smaller and larger basket took longer, manually unloading took about 4.5 min/m^3. This compares with 14.6 minutes for a five man team to load 1m^3 of waste into a Normal sized truck in Dhaka and 6.8 per m^3 to unload it.

Yousuf (1996) in his study mentioned that intention of introducing demountable container was to containerize the waste with a view to reduce the number of manual handling as reducing the chances of littering and human contact. But in practice it is seen that waste was spilling outside the container. It creates health risk to workers. He also suggested that the system could be workable through the improvement of community based primary collection system which could assure of containerize the waste.

2.2.5 Transportation

From DMDP (1992) report it is found that in 1991 DCC had a fleet of 159 Truck of 5 ton and 1.5 ton capacities during physical verification it was found 63 number (40%) are off road due to technical fault. At that time no demountable container was

running. UNCH project No. 154 strongly recommended demountable container for the collection of waste in old Dhaka at night in 1991. The costs study by Sturdy (1991) show that the demountable container system would reduce the cost of collection waste in the nighttime collection area.

MMI (1991) survey result shows that small truck (less then 5 ton) capacity delivered more waste at disposal site than the large truck. They recommended a 3.0 Tone payload truck as the best-cost effective option.

Yousuf (1996) reported that DCC introduced demountable container trucks in some areas in 1995. Transport list supplied by DCC's transport department in 1995 showed that about 19 demountable container trucks (10 number 5 ton capacity and 9 number 3 ton pay load capacity) were carrying waste from Zones 4,5,6,8, and 9 only Yousuf (1996) also mentioned that out of 204 truck 30% to 40% were out of order due to technical problem. Each truck was carrying waste on an average of 2 trips per day. He calculated primary collection cost for Zone -1 and estimated open truck transportation cost to be TK. 74/m^3 and Tk.35/ m^3, respectively. Result shows that primary collection through handcart is 2 times that of transportation cost.

MMI (1991) developed a computer based cost model to compare existing and alternative system for waste collection. From the model result it is found that transportation cost by (3 ton pay load) open truck and demountable container are Tk 31/cum and Tk. 25/cum respectively.

MMI (1991) from physical observation reported that the oval shape covered body makes it difficult for men to stand inside the body. Loading is done from outside but manual unloading requires men to enter the body and "Rake out " waste. Unloading time are excessively higher. Since the entire body are not rarely filled effective use of the payload capacity is unachievable. It creates liter in street. Trucks stand still for

75% of the working shift when the waste is loaded. This results in high operational cost.

2.2.6 Disposal

Bhide (WHO 1990) reported that DCC had waste disposal site at Mirpur with an area of 25 acres, average depth of 5 m in 40% full and at Jatrabari with 25 acres area and with an average depth of 5m. Small sites are located at Islambagh, Hazaribag, Mukiti Sarani, Dayaganj, Mughda, Amligula and Balugath.

MMI(1991) study reported that wastes were deposited in a large depression on the north of the main Dhaka - Chittagong road at Jatrabari. The empty area was about 25 ha. with an average depth of 5 meter. A decision was taken by DCC to develop a 50 acre (20 ha) site to South East of Dhaka at Matuail having an average depth of 5m. It was intended that 1.3 acres would be reserved for low cost housing whilst the reminder would be used for waste disposal. MMI estimated the life of disposal sites at Jatrabari to be 5.5 years and Matuail to be 3.2 years.

Enayetullah (1994), reported that in 1994 the Jatrabari site was filled uoto approximately 70%. Recently, DCC had purchased a new sanitary land fill site at Matuail of 20 ha. area of which 5 ha. would be reserved for DCC's own low -cost housing. The estimated life time of the sites was 3 years.

Yousuf (1996) reported that DCC had been disposing waste at Matuail along the Dhaka Demra road and 3 kilometer out side the corporation jurisdiction. DCC had purchased 52 acres of land out of which 13 acres had been developed for parking / platform and rest 39 acres for land filling. He also estimated the life time of site to be was 4.5 years.

Dhaka Metropolitan Area Integrated Urban Development project Report Volume - 3 in 1981 reported operations cost of collection, Transfer and Disposal site and shown

in Table-2.9. Cost fraction found from the table that collection cost 45%, transfer cost 35% and disposal cost 20%.

Table-2.9 Disposal cost.

Collection by Rickshaw Van cost	Tk. 58/Tons.
by hand trolleys	Tk. 55/Tons.
Transfer cost by 5-7 tone Truck	Tk. 27/Tons.
When disposal site distance more than 4 mile up to 10 mile.	
Disposal site Cost – Bulldozer	Tk. 21/ Tons
Loader	Tk 3/ Tons.

2.2.7 Recycling of solid waste in Dhaka

Sinha (1995) mentioned that an informal sector exists in resource recovery and recycling of solid waste in Dhaka City. The poor and socially disadvantaged people working in the street, waste bins, dump site totaling more than 87000 Sinha (1993) people was involved in the recycling activities. This informal sector absorbing almost 10% of total employed work force. Sinha (1993) estimated the approximate population of different sector groups involved in the collection process of recycling activities. These included waste bins tokais - 10,000, dumping site tokais 500, feriwalls -interanet buyers- 10,000, Vhangaridokans-2000, wholesale shop 1000, collection crews 5000. He also estimated that the informal sector was responsible for removing 26% of total generated waste of DCC area.

Ahasan, Haque & Haque (1990), in their paper mentioned that on an average about one fifth (17.31% wt) of total solid waste of Dhaka city were being recycled in 1970. Only waste paper, glass, scrap iron, brass, lead and copper were salvaged and sold.

By 1980s a change the waste recycling activities accordance many new waste material become recyclable by the available technology. These new waste material were polythene paper, hard and soft plastic, zinc, aluminum alloy (casting) and animal bon. By 1985 scrap tin was another new waste material recourse recycling status as technology improved.

From field survey he found that average income of waste pickers per month was Tk. 3,120 from middle-class residential area, Tk. 1,689 /- from industrial area, Tk. 1,290 for Bazaar area, and Tk. 1,148/- from high class residential area. He also presented data on selling price of different recaptured materials at different stages of business in 1990, which are shown in Table 2.9. From the table it is observed that polythene is the most profitable item and aluminum, copper, brass are the valuable materials selling at Tk.35-54/ kg.

Sinha (1993) from field survey presented data about daily quantity of recyclable collected by the different groups in Dhaka . It was shown that the highest amount of recyclable material was collected by the feriwallas itinerant buyers. They were responsible for almost 75% of the total collected source separated items sold by the households of the city. Problem and drawbacks of solid waste management SWM and recycling of Dhaka city were identified by Sinha (1993) were as follows :

Lack of proper place for the processing and manufacturing activities faced by people involved in recycling activities. Lack of government grants and credits in the recycling business. Lack of technical know-how in recycling industries. Prices for recovered materials subject to large fluctuations and unpredictable lack of assurance in the fixed supply, unclean raw materials, seasonal variation of supply. No provisions in the government policy to encourage the recycling practices were other major drawbacks. Lack of participation by NGO's and CBO's to improve the recycling practice, improperly recycled organic waste (80%-90% of solid waste composition) were also identified as major problems.

Sinha (1998) estimated that recycling of organic waste by composting can save DCC from spending Tk. 71 million. It has found that most of the inorganic waste materials of Dhaka City were recycled but the organic portions are left unutilized which create disposal problem. The use of small scale decentralized manual plant would be the most suitable technique for Dhaka city which could save DCC approximately Tk. 38 million/yr.

Table 2.10 : Selling Price of Different Recaptured Materials at Different Stages of Business, 1990.

Selling price	Selling price (taka /kilogram)		
Recaptured materials	Waste Picker to shopkeeper	Shopkeeper to wholesaler or agent	Wholesaler or agent to factory
Paper	2.13	2.44	4.55
Polythene	1.73	3.48	13.25
Soft plastic	12.87	16.78	19.50
Glass	1.66	1.86	2.15
Scrap Iron	4.15	7.11	5.77
Brass	36.83	50.09	53.13
Lead	15.33	19.58	22.50
Zinc	19.50	24.53	26.75
Aluminum	54.20	65.14	67.13
Aluminum alloy	31.50	41.45	43.30
Copper	50.11	63.39	65.00
Bone	1.00	1.42	2.50
Rubber	1.00	1.62	2.13
Source : Bangladesh Urban Studies Volume : 1 Number 1, December 1990			

CHAPTER – 3

PRESENT SOLID WASTE MANAGEMENT PRACTICE OF DHAKA CITY

3.1 LEGISLATION

Dhaka City Corporation is functioning on the basis of "Dhaka Municipal Corporation Ordinance XL 1983". The relevant sections for removal, collection and disposal of refuse collection are as follows.

78 (1) The Corporation shall make adequate arrangement for removal of refuse from all public streets; public latrines urinals, drains, and all buildings and land vested in the corporation and for the collection and proper disposal of such refuse.

78 (2) the occupiers of all building and lands within the corporation shall be responsible for removal of refuse from such buildings and lands subject to the general control and supervision of the corporation.

78 (3) the corporation may cause public-dustbin or other suitable receptacles to be provided at suitable places and where such dustbin or receptacles are provided, the corporation may, by public notice, require that all refuse accumulating in any premises or land shall be deposited by the owner or occupier of such premises of land in such dustbins or receptacles.

78 (4) all refuse removed and collected by the staff of corporation or under their control and supervision and refuse deposited in the dustbin and other receptacles provided by the corporation shall be the property of corporation.

The ordinance has no specific clause or section for industrial hazardous or clinical waste storage handling, collection, transportation and disposal either by DCC or

privately. Necessary by laws have not yet been promulgated on "Standard" of refuse quality and details of punishment of any offence detected by DCC mobile court.

3.2 ORGANIZATION

The management of wastes generated within the city is the responsibility of the local authority. For the purpose of the administration of urban areas the Government sets up such authority under the law promulgated by the state legislature. The Municipal / City Corporations are set up under specific state enactment for major and specific cities and is bestowed with a creation of degree of independence and autonomy in mobilizing resources and providing civic services.

DCC is headed by a Mayor who is an elected representative of the people and under him the chief Executive Officer (CEO), who is deputed by Government for management of five principle areas of responsibility which are engineering, conservancy, revenues, accounts and heath.

Refuse collection and disposal from DCC area is the responsibility of the chief Conservancy Officer (CCO) who manages it with the support of a Deputy Chief (DCCO) and two Assistant Conservancy Officer (ACO). The Assistant Conservancy Officers are also assisted by ten Conservancy Officer working in ten zones with Conservancy Supervisory Inspectors (CSI), Conservancy Inspectors (CI) and Cleaners. The Conservancy department is also supported by the transport department controlling the garbage vehicles and mechanical department for maintenance of vehicles and equipment use in landfill sites (bulldozers, excavators etc). Used in the dumping site. The organogram of the Conservancy Division of DCC and solid waste management related activities & associated department of DCC is given in Figures – 3.1 and 3.2.

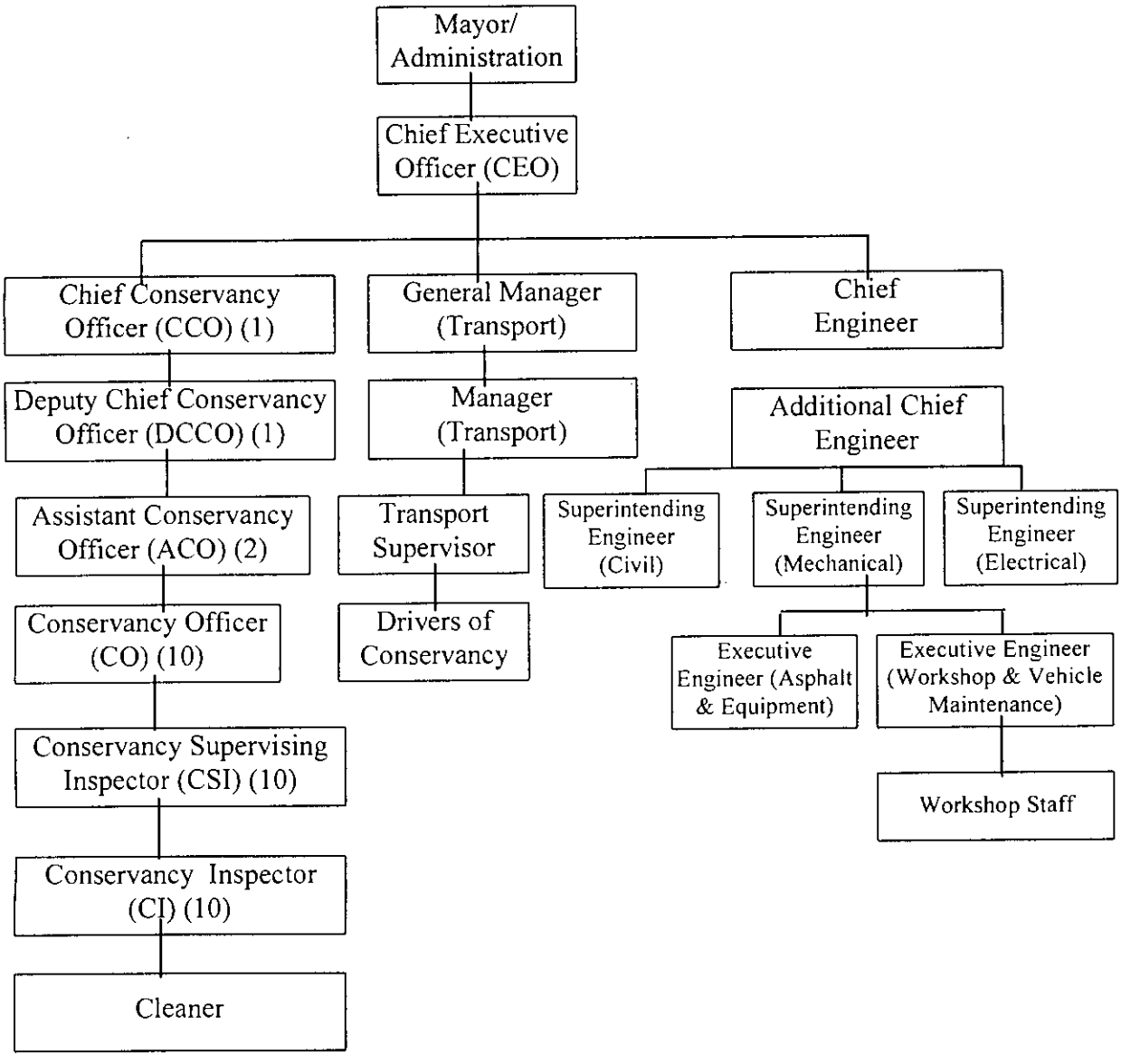


Figure 3.1 Organogram of solid waste management in Dhaka City Corporation (DCC)

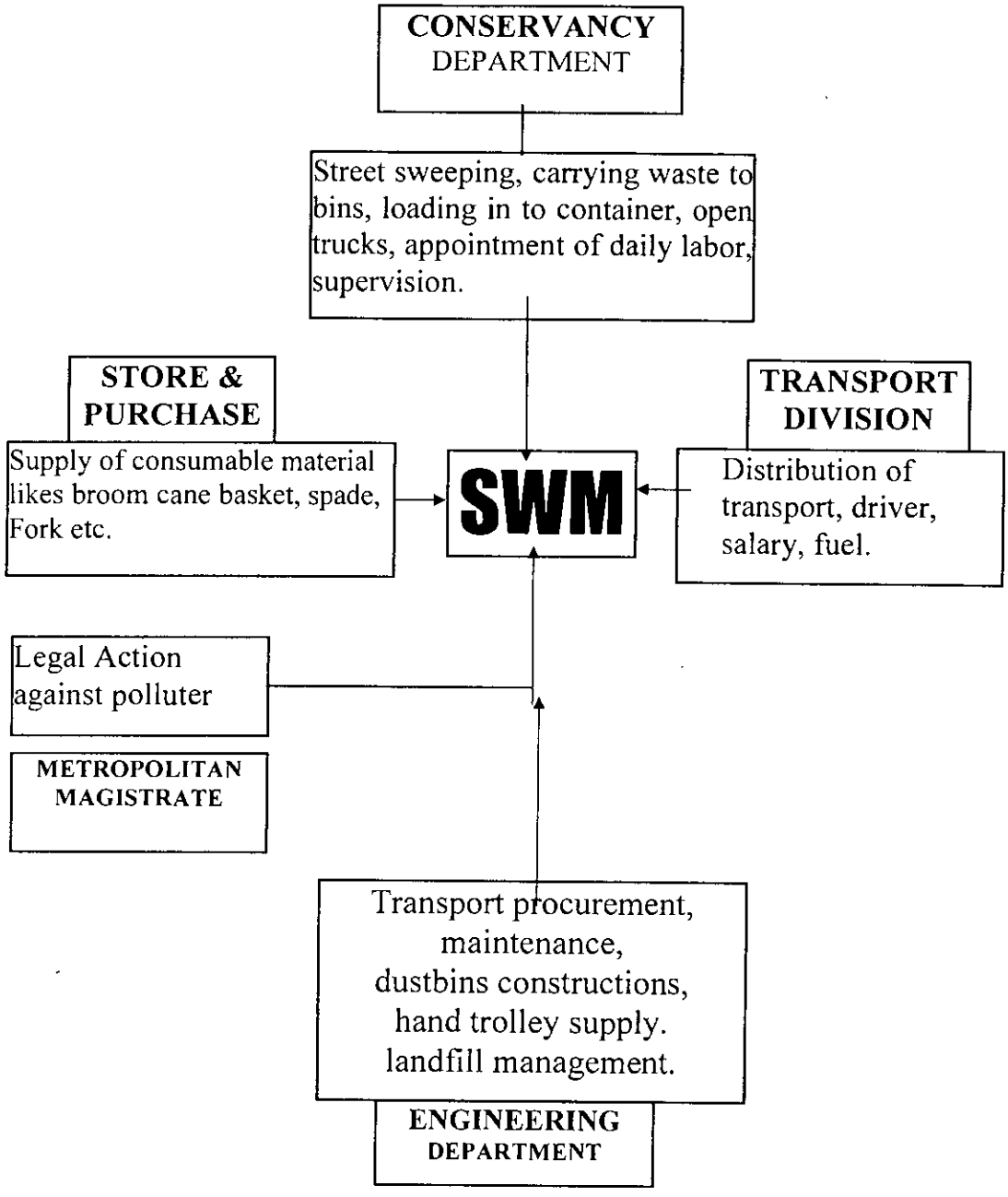


Fig: 3.2 Solid waste management related activities & associated department of DCC.

3.3 COLLECTION

Dhaka City Corporation collects municipal wastes are accumulated in DCC's bins or containers. About 6000 cleaners are employed for street sweeping and collection of waste found in places other than dustbin size. road side, open spaces, ditches etc by hand trolley DCC has 2,080 hand trolleys for primary collection of waste. DCC has 100 demountable truck for collection of accumulated waste from municipal bins at different locations. In some residential areas like Kalabagan, Dhanmondi, Banani, Gulshan, Baridhara, Uttara 'house to house' waste collection service has been organized by some private initiative. Rickshaw vans are used for collection of waste from houses to municipal containers.

Onsite Storage

Dhaka City Corporation provides concrete to and C.I. sheet bins at different places mainly along the roadside. In some areas demountable containers are used for onsite storage of municipal solid waste. Presently, Dhaka City Corporation has 2,450 C.I sheet and 1,595 Concrete dustbins and 410 demountable containers for on site storage of waste. There are no special or separate container, bins for commercial, industrial or clinical waste storage. DCC does not provide any in house storage article, bag, bins for homeowners.

3.4 TRANSPORTATION

Dhaka City Corporation has 96 open truck (3 ton and 5 ton payload) and 100 demountable container carrying vehicles for transportation of waste to the disposal sites. Presently DCC's waste disposal site is at Matuail, which is located 10km from city center and 30 km from farthest boundary at Uttara and Mirpur. DCC has no transfer station this is carrying waste more then 10 miles for disposal.

Transport operation is controlled by transport department headed by a General Manager and Manager Transport. According to the requirement of conservancy department number of trips of vehicle and schedule are fixed by the transport department. There is no database, calculation to determine the number of labor, trucks and trips per vehicle per shift. Open trucks and container are loaded with waste manually. Normally open trucks are assigned for 2 trips per shift and container carrying vehicle are assigned for 3-4 containers per shift depending on distance of the disposal site. Transports are operating in two shifts at daytime and night. With maximum number of containers removed at night. According to DCC's transport schedule it has been estimated that 1,432 tons of waste are being transported to the disposal site per day by present transport fleet. Around 30% of the transport that are always found off-road due to mechanical fault or unknown reasons. Table 3.1 and Table 3.2 show the details of the DCC's demountable container and open trucks, in each zone, respectively.

Table 3.1: List of demountable container truck of DCC

Zone	5 Ton	3 Ton	5 Ton Trip	3 Ton Trip	Total Vehicle	Total No. of Trip per Day	Average distance in Operation	Remarks
1	X	2	X	9	2	9	14 Km.	
2	X	18	X	80	18	80	18 Km.	
3	X	5	X	18	5	18	82 Km.	
4	1	22	2	90	23	92	18 Km.	
5	3	17	10	64	20	47	22 Km.	
6	3	8	11	28	11	39	26 Km.	
7	X	3	X	15	3	15	42 Km.	
8	X	8	X	39	8	39	44 Km.	Lifting 36/36 container eveready
9	X	5	X	32	5	32	35 Km.	Lifting 16/10 container eveready
10	X	1	X	7	1	7	60 Km.	Lifting 35/36 container everyday
	7	89	23	382	96	405		

DEMOUNTABLE

N.B : (a) Container Truck 5 Ton = 7

Container Truck 3 Ton = 89

96

Reserve 4

Total = 100

(a) Number of Container = 405

Reserve =5

Total = 410

Source : Transport Division DCC

Table 3.2: List of open truck of DCC

Zone	5 Ton	3 Ton	2 Ton	1.5 Ton	5 Ton Trip	3 Ton Trip	2 Ton Trip	Total Vehicle	Total No of Trip Per day	Average distance in Operation	Remarks
1	1	5	17	x	2	10	44	23	56	14 Km	
2	1	9	22	1	2	17	59	33	81	18 Km	Collecting
3	1	13	5	1	2	29	23	20	44	22 Km	garbage from
4	2	6	5	x	3	11	9	13	23	18 Km	the different
5	10	8	x	x	17	13	x	18	30	22 Km	dustbins for
6	6	9	1	x	12	16	2	15	30	26 Km	whieh the
7	x	5	3	x	x	10	6	8	16	42 Km	vehicle runs
8	7	x	1	x	14	X	2	8	16	44 Km	very slowly 3
9	3	7	x	x	5	14	x	10	19	35 Km	to 4 Km
10	2	x	x	x	3	X	x	2	3	60 Km	
	33	62	54	2	60	120	1356	150	318		

Source : Transport Division DCC

DCC transports are scheduled as per field requirements. There is no definite route map for transportation of solid waste to the disposal site.

3.5 DISPOSAL

DCC disposes solid waste at Mirpur, Mugda, Jatrabari and Matuail. Jatrabari landfill sites filled up two years ago, Mugda and Mirpur sites are used when Matuail site is inaccessible due to rain or damage of driveways repairing and maintenance unloading platforms.

DCC claimed Matuail landfill to be sanitary landfill, Matuail landfill covers about 92 acres of land. DCC acquired 52 acre of land in 1986. It started as dumping of solid waste in 1993. Low lying agriculture land is enclosed by earth dyke to isolate the dumpsite. No cut and fill or the initial extraction; separation of recapture able material are salvaged by waste pickers (TOKI) from small dustbins, waste dumping site. Layer by layer cover material is used regulars. The dozar, chain dozar, scraper are being used to spread the waste irregularly.

3.6 RECYCLING & RECOURSE RECOVERY

DCC has no processing and resource recovery plant. But processing and resource recovery or recycling in Dhaka city is done by the poor and the socially disadvantage people who are working the street waste bin, dumpsite.

3.7 PROBLEMS AND LIMITATION OF PRESENT SOLID WASTE MANAGEMENT SYSTEM

Conservancy department of Dhaka City Corporation has no scientific and engineering principle based solid waste management planning approach. Conservancy department has no solid waste management specialist Engineering background). Present distribution of labor, transport in different areas has no database demand and conservancy department does not maintain any data base for generation of waste, transport and labor requirement. There is no cleanliness standard. Town planning department did not and does not allocate any space for storage of waste bin, placing of container. Placing of dustbin on the road, near any house creates social problem because of improper use, irregular cleaning and road blockage by collection vehicle, bad smell, rodent, vermin's, flies and unhygienic condition. At present transport fleet of City Corporation is collecting 43% waste by open truck without top cover (DCC). Open truck collection system needs average 3-5 hr for loading and unloading the waste to the trucks. So disposal by open truck yield very low efficiency than haul systems.

3.8 DEVELOPMENT OF SOLID WASTE MANAGEMENT SYSTEM

Privatization

To ensure better collection and cleaning services Dhaka City Corporation in 1990 invited tender for Banani, Gulshan, Baridhara and Uttara area. But schedule of work

was not well defined and satisfactory responses were not found. In 1992 incorporating some terms and condition and specifying the nature of work re-tender notice was invited and about three private companies without any previous experience responded. DCC did not come to the final decision due to high offer rate and few conditions imposed by the interested parties. Privatization issues come in different times but does not materialize.

Compactor Truck

A project proposal of procurement of 75 Nos. compactor truck has been approved by ECNEC and these 75 compactor truck will be add to present transport fleet.

Feasibility study

In February 1998 a consultant from the Netherlands. 'Roteb-Solid waste consultancy B.V. Rotterdam in co-operation with Aduco International contractors visited DCC area and submitted a draft report on waste land fillings and hospital waste incineration in Dhaka Bangladesh. On the basis of their report DCC prepared a project proposal and submitted to the respective Ministry for approval. The project cost is Tk. 9308.32 Lac and of which expected grant from the Netherlands Government. is Tk. 4845.82 Lac and Tk. 4462.50 Lac from GOB. Proposed project component includes development of existing landfill, with cover and provide with a degassing system. Extension of existing landfill with an additional area of about 13 hector, resulting in an extra storage volume of about 712,000 m^3 which will extend the life time by 3 years. New landfill will be provided with a subsoil protection and leachate collection and treatment facility and a degassing and flaring systems. Improvement of operational procedure by providing a weighing scale, office workshop, vehicle cleaning area, power and water supply and a gate house with fencing around the site. Establishing 2 (two) incinerators, one at BSMMU and another at Hospital for the Disabled, for incineration of hospital waste from Government and private hospitals clinics.

Waste to Electricity

A Canadian company and an Italian company showed interest about establishing barge mounted electricity generation plant. Waste from landfill site and diesel oil mixture with a ratio of 1:3 was proposed as the source of initial energy. In absence of reliable data on energy content of DCC's solid waste, lengthy decision making process and prospect of pollution of environment prevented the progress of this proposal.

CBO Approach

Success of Kalabagan Samaj Kallyan Sunga approach of "house to house" collection has promoted its introduction at Banani, Gulshan, Baridhara, Uttara, Dhanmondi, Malibag, Khilgaon, Rampura and many other areas of Dhaka City. Community based organization collecting waste from houses by rickshaw van Dhaka City Corporation recently issued some "rickshaw van" to the local commissioner and NGO's to encourage the system.

CHAPTER – 4

DATA COLLECTION AND ANALYSIS.

4.1 DESCRIPTION OF THE SURVEY AREA

Description of Uttara Model Town

A satellite township Uttara Model Town is located 16 km north of Dhaka. Rajdhani Unnayn Kartipakha (RAJUK) developed this model town in the 1970. It became habitable at the beginning of the 80s. In the first phases Sectors –1 through 7 were developed through 6000 plots. In the 90's the second phase development started in Sector 10 through 14 with additional 6000 plots. RUJUK handed over the Sectors 1 through 8 to the DCC in 1989. DCC Word no-1 consists of Uttara Model Town area Uttara model town is surrounded by low lying area. The Turag Tongi industrial area is on the North, Uttarkhan is on the east. Abdullahapur is on the west and the Zia International Airport is on the south. The Dhaka - Mymensingh highway passes through, the Uttara. A commercial belt is growing along this road. The Zone -10 of Dhaka City Corporation includes Sectors-1,3,4,5,6 and 7. Except for road maintenance work DCC collects taxes, garbage from sector, 9,8 and 2 of which sector 8 and 2 belongs to Public Works Department (PWD).

Description of Banani Model Town

Banani model town is surrounded by lakes in three directions. Dhaka - Mymensingh high ways and the DOHS are on the west, Gulshan model town is on the east, Mohakhali is on the south and on the north is the Banani Graveyard and Navy headquarters. A road from the west, Kemal Attaturk Avenue connect Gulshan and Baridhara to the eastern part. A commercial belt has grown up along this road. High income group people are living in Banani. A number of high rise apartments can be found. Banani model town is under Gulshan thana and Zone 9 of the DCC. Previously it was under Gulshan puroshava, and the DCC took it over in 1984.

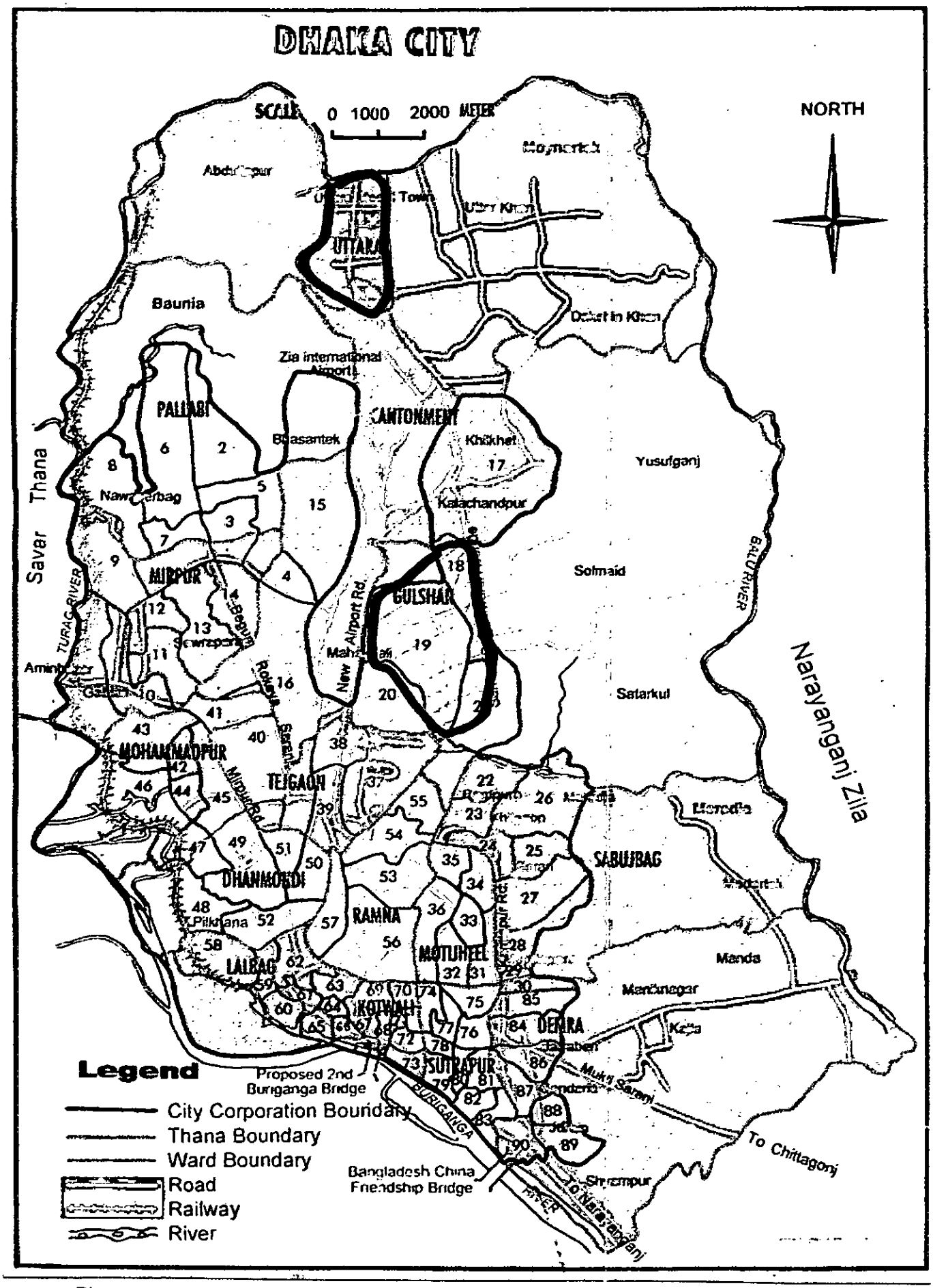


Fig: 4.1 Location map of the Study area

Description of Gulshan Model Town

The Gulshan model town is surrounded by lake in all most all directions. Baridhara on the east, Banani on the west. The low lyings area, Merul is on the south and Kalachandpur on the north. Gulshan area has been developed as diplomatic zone in early part of 70's. High-income people, specially, foreigners, are living here. It is under Gulshan thana and Zone -9 of the DCC. Some commercial plots at Circle no. 2 and along the main road are visible.

Description of Baridhara Model Town

Dhaka's latest diplomatic area Baridhara situated on the east of Gulshan. It is under Gulshan Thana and Zone-9 of the DCC area. It belongs to DCC ward no 18. This area was developed in 80's. Foreign mission and high income population live here.

4.2 HOLDINGS

A survey of residential, commercial industrial and institutional holdings was carried out in Uttara Model Town, Bannani, Gulshan and Baridhara. Existing data were collected from Dhaka City Corporation, Zone-9 (Gulshan) and Zone 10, (Uttara office). Records of the present holding numbers in the DCC's revenue department ware used in this survey. In addition, physical verification was performed. The results obtained from survey are summarized in Table - 4.1, and detailed in Appendix.

Table: 4.1 Present Holding of Uttara, Banani, Gulshan & Baridhara

Description Of Holdings.	Uttara	Banani	Gulshan	Baridhara
Residential	3089	1950	2180	721
Commercial	23	105	121	-
Industrial	28	15	16	6
Institutional	6	1	19	-

Growth rate of Households

House construction in Uttara mainly started in full scale during the mid 80's, RAJUK allotted Sector 1,3,4,5,6 and 7. Data taken from Dhaka City Corporation, Zone-10 (Uttara) revenue departments assessment register and found that due to new construction, households increase at the rate of 7.74% per year.

4.3 POPULATION

A survey work was conducted at Uttara Model Town in Sector -4. During house to house waste collection survey the population of each holding was counted. Results are summarized in Table-4.2. The estimated total population found from 309 household is 2,825.

Table: 4.2 Population survey result.

Rickshaw Van-No.	Shift-1		Shift-2	
	Total number of house.	Population	Total number of house.	Population
Van - 1	58	567	41	352
Van - 2	69	727	50	423
Van - 3	42	439	49	317
Total	169	1733	140	1092

Thus on an average 9.142 persons are residing in each house of Uttara Model Town . From above survey result the estimated population of Uttara, Banani, Gulshan & Baridhara shown in Table 4.3.

Table: 4.3 Estimated and projected population of Uttara, Banani, Gulshan & Baridhara.

Area	Residential Household	Estimated Population	Projected population 2005
Uttara Model Town Sector - 1, 3, 4, 5, 6, 7 & 8.	3089	27,200	39,440
Banani Model Town	1950	17,823	25,843
Gulshan Model Town	2180	19,925	28,891
Baridhara	271	2,477	3,591
Total	7490	67,425	97,765

4.4 WASTE GENERATION RATE

4.4.1 Domestic Waste Generation Rate

In order to develop plan for a solid waste management system the primary data required is the solid waste generation rate. A survey was conducted at the sector – 4 of Uttara Model Town to estimate the solid waste generation rate at the domestic sources in this study area. The primary objective of the survey was:

- To estimate the average quantity of waste generated from each household.
- To estimate how much waste is disposed in the commercial bins each day from a particular area.
- To establish average collection time for house to house collection of domestic waste by rickshaw van method.
- To quantify the number of household that can be covered by one Rickshaw Van in one shift.
- To estimate the density of the waste on "as discarded basis" of domestic waste for a residential area.

To attain the above goals one rickshaw van with one driver and one data collector ware employed to go from house to house and collect waste into the van in selected

areas along the route of collection. Each day the starting time was recorded. While collecting the waste population of that house road number, holding number of that house were recorded. Collection continued until the van was filled with waste. The time at the end of collection route or when van reached the communal /DCC's bin was recorded. Time required to empty the van at the bin side was also recorded. The "as discarded" volume was also measured from each rickshaw van. Spring scale was used to measure the weight of the collected waste. The entire procedure was repeated in the second shift between 2 P.M – 5 P.M. Also, the similar sampling campaign was conducted in block 2 and 3. The summary of the sampling campaign is showing in the Table 4.4.

Table- 4.4 Result of house to house wastes collection survey of Uttara, sector-4

Description	Block-1		Block- 2		Block-3		Ave.
	Shift-1 9-2 PM	Shift-2 2-6 PM	Shift-1 9-2 PM	Shift-2 2-6 PM	Shift-1 9-2 PM	Shift-2 2-6 PM	
Total number of Houses.	58	41	69	50	42	49	
Population served	567	352	727	423	439	317	
Population person Per house.	9.77	8.58	10.53	8.46	10.45	6.46	9.142
Volume of collected waste (m^3)	0.71	0.62	0.76	0.70	0.81	317	
Weight of collected waste (Kg).	399	281	315	208	331	202	
Total Time spent for House to House Collection (min).	180	180	240	165	180	222	
'On Van' as source Density as discarded (Kg/m^3)	449	453	414	297	408	430	408
Waste generated per household (Kg/house/day)	5.5	6.85	4.56	4.16	7.88	4.12	
Time spent for house to house collection (min/house)	3.25	4.39	3.47	3.3	4.24	4.5	3.85
Waste generation per capita per day (Kg/person/day)	0.56	0.79	0.43	0.49	0.75	0.63	0.60

whole days waste in the garbage bags. At end of the daily business hour i.e 10 P.M each bag was weighted for two consecutive days at each restaurant. The result obtained from this survey is summarized in Table 4.5.

Table: 4.5 Survey result of commercial waste at Uttara Model Town.

Name of Chinese Restaurant	Seating Capacity (Person)	Persons attended in a day		Ave. Attendance (% Capacity)	Waste Generated (kg)		Generation rate kg/person/ day	
		Day-1	Day-2		Day-1	Day-2		Avg
Kinnere	106	40	43	37.7%	37	20	0.68	0.56
Silver Palace	60	35	25	50%	14	18	0.53	
New Chiling	60	14	25	65%	7	18	0.64	
Sea Shell	50	10	30	40%	5	14	0.47	
Sung Haven	65	32	22	41%	12	15	0.5	

From the survey, the average waste generated from a commercial source such as, a Chinese restaurant, was found to be 0.56 kg/capita/day. However it is interesting to note that "Kinnere" the most expensive restaurant of the lot generated waste at a higher rate of 0.68 kg./capita/day, than other expensive chinese restaurant.

Waste generation from chinese restaurant of Uttara Model Town was found to be 0.56 Kg./person (customer)/day with average use of 50% total capacity of the restaurant. DMDP report estimated commercial waste volume to be 17.37% of the total generation from combined source. World Bank suggested 0.1 to 0.2 kg/cap/day with 150 kg/m^3 density, MMI (1991). Since the survey was carried out for few restaurant of the Uttara Model Town, so this result can only be applied to hotel and restaurants of study area only. Detailed survey can establish the commercial waste generation rate.

The waste generation rate of Uttara Model Town in Sector-4 estimated from the survey was 0.60 Kg/cap/day and 5.5 kg/household with 9.14 persons/household. This is approximately six times higher than that obtained by BKH(1986) for old part of Dhaka 6.25 kg/WK/household. The study team of BKH left a bag with the residents of a household for collecting domestic waste for a week. Since, the sampling campaign was conducted in April it is likely that the hot and humid climates caused the residents to leave the bags outside to get relief from pungent smell. This enabled the scavenger to go through the bags accounting for a lower generation rate of as mentioned in the BKH study. Bhide (1996) reported a value of 0.1916 kg./day, which is also lower than that obtained in the study DMDP(1991) report stated that for a total population of 3,397,188 in Dhaka City in 1991 total estimated waste generated per day is 1,500 tons. This generation rate of 0.4415 kg/capita/day is also less that obtained in the study. The higher per capita generation rate may be attributed the higher living standard at Uttara Model Town compared to that in old Dhaka, the study area of BKH study. The UNCRD(1998) study reported a waste generation rate of 0.47 kg/capita/day with a density of 400kg/m^3. In this study comparable waste density of 408 kg/m^3 was obtained.

Due to resource constraint in collecting samples from door to door, and due to constraints in analyzing the samples in the laboratory the sample size was kept purposefully small and may not be statistically representative of the study area. Thus, the results obtained on generation rate should be used with caution remembering that these data will be more applicable for the areas and the communities having same characteristics as the study area.

4.4.2 Commercial waste generation

To estimate the waste generation rate of commercial entities few chines restaurant ware selected at Uttara Model Town. Polythene bags and questionnaires were supplied to the chines restaurant and the managers were requested to collect the

4.4.3 **Clinical waste generation rate**

A survey was conducted in four selected hospitals and clinics at Uttara Model Town. The data found from physical measurement and questionnaire survey are shown in Table 4.6.

Table- 4.6: Survey result of clinical waste generation rate

Name of Hospital and Clinics	Women Medical College Sec.-1	Jhanara Clinics Sec.-1	Greenland Hospital Sec.-7	Aichi Shishu Hospital Sec.-7	Average
Bed Capacity					
Designed	300	50	25	40	
Present	43	15	10	10	
Daily Patient Admitted (Ave)	4	3-4	1-2	2-3	9.37
No. of Patient Present on					
23-06-98	22	15	16	12	16.25
24-06-98	16	14	18	17	
Generation rate kg/patient/Day	1.8	1.7	2.2	1.31	1.75

Waste generation rate found from field survey from the study area is 1.75 Kg/cap/day. The rate is higher than the rate mentioned in DMDP(1991) report. According to ICDDRB this rate is considered 1.5 Kg/cap/day (MMI,1991). The obtained result is higher may be because of low occupancy of clinics beds. The results may vary with types of the hospital or clinics. The total solid waste generation also includes those generated by the staffs. Since the result is expressed in terms of number of patients, these may be an inherent bias in the data.

4.4.4 Street sweeping waste

Although often neglected in studies, in Dhaka City a large portion of the solid waste generates daily consists of street sweeping. This study was also geared towards estimating the average waste generation rate of street sweepings. It was also intended to estimate the performance of the cleaners and cost per unit length of the street swept by the cleaners.

To attain the above objectives data were collected on the entire street sweeping operation. It was found that wastes accumulate in a 3-4 ft wide strip along both edges of a street. Due to movement of generated due to vehicular movement waste do not accumulate at the center of the road, those move towards the edges. On an average 2-3 cleaners sweep the street edge and accumulate the swept wastes is at approximately 10 ft intervals. Usually, cleaners dump these into roadside drains. However hand pushcarts are sometimes used to collect these waste for disposal into concrete bin. Usually, the major streets are swept in 2-3 day interval and the smaller by-lanes are swept once in 10-15 days.

The quantity of waste varies with the location, intensity of traffic, existence of trees, plants median, island, shoulder of the carriage way road side drain facility, footpath encroachment by the household, shops, vendors, condition of the road surface, construction work by plot owners etc.

Survey results

One sweeper can sweep 7 feet road along both the edges of 1 to 4 feet wide in one minute, and collect the waste in a hand trolley. One cleaner can sweep in a shift including 2 hr off period, 6 hr working time about, 775 meter or 2,542 feet of road including collection and dumping of street waste to the nearest bin.

Street sweeping waste found from main roads at the rate of 0.36 kg./meter road /day and from internal road 0.16 kg./meter of road /day .This amount is likely to be double for the road with median or divider.

Waste generation rate from this source found from field survey in Uttara is 0.16 Kg/m/day for internal roads and 0.36 kg/m/day for main roads. No previous data were available for comparison. DCC considered 0.1916 kg./person/day and World Bank suggested for estimation of waste volume 0.05 to 0.2 kg/cap/day with density 500 Kg. /m^3. The survey result presented in kg/meter length of the road, because waste were found only along the edges of the roads, no mater what the width of the road was. When generation rate expressed in terms of person/day the generation rate is 0.06 kg/capita/day. The street sweeping generation rate may be established if long term intensive field survey is conduct in several roads of DCC area. At present generation rate of 0.36 kg/meter of road/day for main roads and 0.16 kg/meter of road/day for by-lanes can be used for the residential area like Uttara, Banani, Gulshan and Baridhara model town only .

4.5 COMPOSITION OF DOMESTIC WASTE

To analyze the physical composition of the domestic waste the samples collected by the rickshaw van from the control area were sorted according to the specific type of waste component. Each time representative batch of samples weighing between 120 kg – 150 kg was first selected from the van load of wastes. This pile was quartered, again then one quarter was quartered again, and then one quarter from the last step was used for composition analysis by separating the waste into each component such as food waste, ploythene, paper and cardboard, plastic, glass, metal, and tin cans. Each component was then weighed to determine the respective wet weight fraction. Results of this analysis are shown in Table 4.7 and Figure 4.2.

Table: 4.7 Composition of domestic waste in residential area (Uttara Model Town)

Constituent	Percent by weight
Food Waste	72.50
Garden waste	4.02
Polythene	13.70
Paper and Card board	5.63
Plastics	3.31
Glass, Metal	0.45
Tin can	0.39

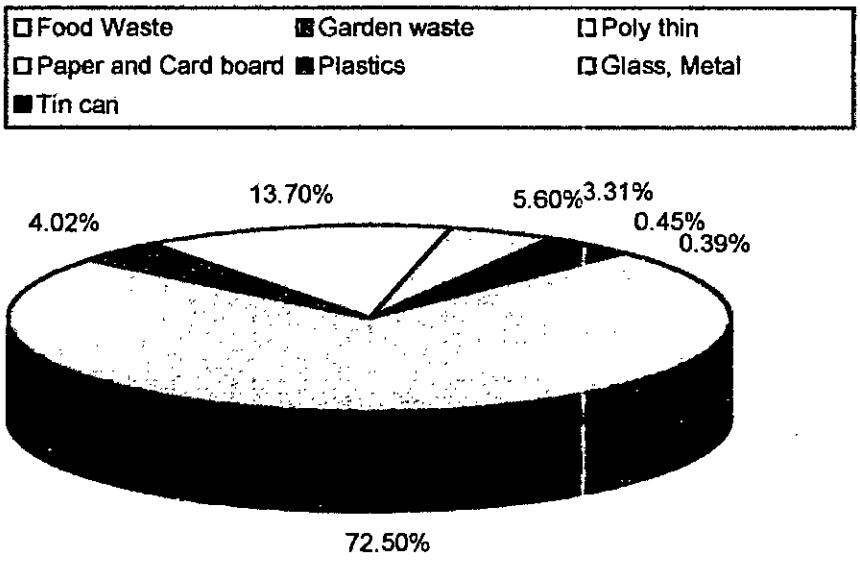


Fig. 4.2 Composition of domestic waste at Uttara Model Town.

Analysis of physical composition of domestic waste show that the primary component is food waste 72.50%, polythene 13.70%, paper and cardboard 5.63%, and plastic 3.31%. The result obtained is constituent with that presented by Ahmed, (1993) and BKH (1986). During analysis it is evident that considerable amount of Polythen are disposed by people in the residential area which are not collected by rag pickers or scavenger.

4.6 CHEMICAL ANALYSIS

4.6.1 Leachate

Any organic waste disposed of, even in a sanitary way, generates leachate due to both anaerobic and aerobic decomposition. The landfill sites around Dhaka city are natural depressions. The solid wastes are dumped into this depressions without following the standard environmental guidelines. In additions, no protective lining is used in these landfill sites. To determine the extent of probable pollution from the leachate it is essential the leachate samples be collected and characterized through laboratory analysis. To achieve these objectives locations were selected in landfill side at Matuail and Mugdha to sink exploitation wells to collect leachate samples. The site at Matuail was selected on the east side of present concrete paved approach road. At Mugdha, the well location was selected approximately 100 feet east of Progoti Sarani.

At both these locations monitoring wells were setups by drilling up to a depth of 20 feet with a 4-inch hollow steel pipe. A 1.5-inch PVC pipe with 5 feet long strainer at the bottom was lowered into the freshly cut hole. A 2 feet extension was left above the ground level at each location for ease of sampling and for future identification. Sampling bottles were lowered to the bottom of the monitoring well and samples were collected for subsequent analysis in the laboratory. The results of the laboratory analysis are shown in Table 4.8.

Heavy metal concentrations is the leachate, specially chromium, are exceedingly high at the Matuail and Mugda sites. This may have resulted from the disposal of untreated tannery waste originating from Hazaribag area. During the wet seasons the water level around the sites raises and water infiltrates into the landfill due to the absence of any impervious protection. As this water recedes it is likely that considerable amount of pollutants including the heavy metals and organic escape to the surface water sources.

Table: 4.8 Quality of Leachate Samples collected from different landfill site (Matuail and Mugdha).

SI	Parameters	Unit	MAT_29	Mug_27
			29.11.98	27.12.98
1	pH	--	8.5	7.5
2	Color	Pt-Co	14,000	40,000
3	Turbidity	NTU	4,000	1,950
4	Total solids	mg/L	11,350	37,000
5	Total Dissolved Solids	mg/L	4,800	14,000
6	Total Suspended Solids	mg/L	6,550	23,000
7	Electric Conductivity	µS/cm	11,750	
8	Total Alkalinity as $CaCO_3$	mg/L	7,700	5,700
9	Total Hardness as $CaCO_3$	mg/L	1,000	2,450
10	Acidity as $CaCO_3$	mg/L	725	514
11	Chloride	mg/L	800	2,500
12	Sulfate	mg/L	450	515
13	Nitrate-Nitrogen	mg/L	125	160
14	Nitrite-Nitrogen	mg/L	0.675	Nil
15	Ammonia-Nitrogen	mg/L	1,045	976
16	Phosphate	mg/L	86	27.5
17	BOD_5	mg/L	2,600	
18	COD ($KMnO_4$)	mg/L	3,300	2,500
19	Total Coliform (including growth)	#100ml	1,25,00,000	1,42,00,000
20	Feacal Coliform (including growth)	#100ml	10,00,000	15,00,000
21	Iron	mg/L	60.6	208.64
22	Manganese	mg/L	6.38	6.728
23	Chromium	mg/L	51.04	35.51
24	Lead	mg/L	6.255	13.508
25	Copper	mg/L	1.575	6.66
26	Zinc	mg/L	34.70	103.788
27	Cadmium	mg/L	0.15	Nil
28	Nickel	mg/L	0.378	1.313

4.6.2 Groundwater near the landfill sites

To analyze the effect if any, on the groundwater sources around the landfill sites samples were collected from hand pumps located near those areas. However, due to

time and resource constraints only three ground water samples were collected. Two litter water samples were collected in plastic containers and analyzed in the laboratory to determine the concentration of different parameters these are given in Table-4.9

Table: 4.9 Quality of ground water samples collected from within and around the landfill sites (Matuail and Mugdha).

Sl	Parameters	Unit	MAT 80	MAT KAZ	MAT RAN
			29.11.98	10.12.98	10.12.98
1	PH	--	6.5	6.1	7.5
2	Color	Pt-Co	114	96	20
3	Turbidity	NTU	31	18.9	2.2
4	Total solids	mg/L	204	489	431
5	Total Dissolved Solids	mg/L	190	460	400
6	Total Suspended Solids	mg/L	14	29	31
7	Electric Conductivity	µS/cm			
8	Total Alkalinity as $CaCO_3$	mg/L	152	216	246
9	Total Hardness as $CaCO_3$	mg/L	96	260	230
10	Acidity as $CaCO_3$	mg/L		156	26
11	Chloride	mg/L	36	90	130
12	Sulfate				
13	Nitrate-Nitrogen	mg/L	Nil	Nil	1.0
14	Nitrite-Nitrogen	mg/L	Nil	Nil	0.0044
15	Ammonia-Nitrogen	mg/L	0.526	0.491	0.16
16	Phosphate	mg/L	0.185	0.172	0.285
17	BOD_5	mg/L			
18	COD ($KMnO_4$)	mg/L	2.8		
19	Total Coliform (including growth)	#100ml	3,200		20,000
20	Feacal Coliform (including growth)	#100ml	230		Nil
21	Iron	mg/L			
22	Manganese	mg/L			
23	Chromium	mg/L			
24	Lead	mg/L			
25	Copper	mg/L			
26	Zinc	mg/L			
27	Cadmium	mg/L			
28	Nickel	mg/L			

Since, the Atomic Adsorption spectrophotometer at the lab was out of commission for a while, the heavy metal analysis of these samples could not be performed. With these limited data no specific conclusion regarding the level of concentration of the ground water sources could be drawn.

However, it is apparent that the well located about 80 yards south of Matuail landfill site main road is highly contaminated with feacal and total coliform and thus the water is unsuitable for drinking.

4.6.3 Surface water

To determine whether the leachate have transported through the dykes of landfill sites have to the surrounding low laying areas and to the surface water around the landfill sites. Samples were collected from low laying areas around the landfill sites and analyzed in the laboratory to determine the different parameters. The surface water samples collected from two different locations within the dyke around the Matuail landfill sites represent a highly contaminated water body. These samples have high COD value indicating a very low or other aquatic animals. Although, the levels of heavy metals are considerably less than those of the leachate the concentration are still very high for a surface water body. This reduction of heavy metal concentrations in surface water body may be attributed to the fact that the major fraction of the metals probably settled to the bed, following adsorption on to the suspended particles. These settled heavy metals may act as source of contamination to the bottom feeding fish.

Table: 4.10 Quality of surface water samples collected from around the landfill sites (Matuail and Mugdha).

SI	Parameters	Unit	MAT_IND	MAT_INS
			29.11.98	10.12.98
1	pH	--	7.1	7.0
2	Color	Pt-Co	350	425
3	Turbidity	NTU	80	225
4	Total solids	mg/L	2,411	2,550
5	Total Dissolved Solids	mg/L	2,381	1,950
6	Total Suspended Solids	mg/L	30	600
7	Electric Conductivity	µS/cm		
8	Total Alkalinity as $CaCO_3$	mg/L	2,680	3,150
9	Total Hardness as $CaCO_3$	mg/L	1,000	1,500
10	Acidity as $CaCO_3$			
11	Chloride	mg/L	2,600	950
12	Sulfate			
13	Nitrate-Nitrogen	mg/L	22	300
14	Nitrite-Nitrogen	mg/L	0.0	2.25
15	Ammonia-Nitrogen	mg/L	303	330
16	Phosphate	mg/L	33	13
17	BOD_5	mg/L		
18	COD ($KMnO_4$)	mg/L	160	480
19	Total Coliform (including growth)	#100ml	42,00,000	76,00,000
20	Feacal Coliform (including growth)	#100ml	1,00,000	4,00,000
21	Iron	mg/L		1.211
22	Manganese	mg/L		0.108
23	Chromium	mg/L		0.138
24	Lead	mg/L		0.036
25	Copper	mg/L		0.059
26	Zinc	mg/L		0.185
27	Cadmium	mg/L		Nil
28	Nickel	mg/L		Nil

4.7 PRESENT COLLECTION SYSTEM

Transportation : It is found from DCC's transport schedule that open truck carrying 43% and demountable truck carrying 57% waste daily. One Vehicle is assigned for lifting 3-4 container in a day. Zone - 10 (Uttara) round trip distance from disposal site at Matuail is considered 60Km and Zone - 1 (Saidabad) is 14 Km. but for both the Zone Vehicle assigned for lifting 4 container/vehicle. It has calculated form observation that average haul time for Zone 10 is 2.5 hr/trip which is for Zone- 1 (Saidabad) is 0.5 hr/Trip. For Zone- 5, central part of Dhaka city average round trip distance considered 22 km, vehicle deputed for lifting 3 container /vehicle. Under utilization of vehicle and unplanned distribution of trips cause reduction of collection efficiency and increases cost. It is also observed that 15%-25% trip / vehicle/day are not executed / completed by the vehicle driver to save fuel.

Incase of open truck, waste are overloaded to save trip. Most of the vehicle driver drawing overtime bill an average 250 hour/month, which is equal to additional one shift (8hr). From MM1, BKH study report is found that 25%-30% vehicle always found off road due to technical problem.

Open Truck Performances

The performance of open truck engaged in Uttara was studied. It was observed that, 3-5 Labor loaded the waste to the truck. 20-30 min was spent to unload a bin at different location. 3 hr. (Ave) needed to full a 5 tons open truck by 4 labor. 90 minutes needed to full a 5 tons open truck from a one point large storage. 60 min (avg.) required from Uttara to disposal site at Matuail. Up down 2 hr. at night. Manual unloading time at disposal site, 90 min (avg.).

20-40 min (avg.) lost for waiting time at disposal site due to queue at unloading platform.

Results: Survey results can be summarized as 16 min/ m^3 loading time. As the sample size was selected purposively result need to be verified before use.

Demountable Container Truck Performance: Demountable container carrying performance for Uttara Model Town has been observed and results found as- Pickup, 40 min. Haul, 2 hr. Off Route, 90 min, At Site, 30 min (Ave).

Performance analysis of daily collection of solid waste: According to Data Supplied by DCC's Conservancy department of Zone 9 & 10 daily waste collection from Uttara, Banani, Gulshan, Baridhara are shown in table-4.11.

Table 4.11 present collection efficiency of DCC in Banani, Gulshan, Baridhara and Uttara, Model Town.

Collection area	Collected waste volume (m^3/day)			Estimated generation of waste (m^3/day)	Collection efficiency (%)
	Open truck	Container	Total		
Banani, Gulshan, Baridhara	33.6	43.2	76.8	95.46	80%
Uttara Model Town	14	14.4	28.4	54.04	52.52%
Total			105.2	149.46	70%

Waste collection from Uttara, Banani, Gulshan, Baridhara found 102.6 m^3/day which is 68.64% of total estimated generation. DMDP report mentioned that actual daily collection of DCC in 1992 was 59% of estimated Generation. From DCC supplied Data open truck collects 43% and container 57% of total collection. Container are replacing communal bin. In Banani, Gulshan, Baridhara, Uttara total 21 container placed in different place at an avenge 2 nos. container/sq. km or one container in every/140 km of road length. i.e. container interval is about 450ft. it along the road. As DCC provides 4045 dustbin and 410 container as waste receptacles for 344 sq. km of DCC area. Average 11.75 no of dust bin and 1.20 nos. of container in every

square kilometer of DCC are receiving waste. That is for every 960 nos. population use one bin. So insufficient number of bin and long distance interval causes from houses, irregular cleaning, presence of bad smell, flies, vermin's mosquitoes are the main reason is not using by the 50% population bins. From field survey it was found that collection by open truck with five labor load waste from bin to truck needed 15.92 minuets /m^3. The obtained results are similar to MM1 (1991) productivity survey result. MM1 (1991) reported that loading to open truck is 14.6 minuets /m^3. It is also found from field survey that house to house collection of domestic waste by a rickshaw van collects waste from 103 houses in a day. Uttara at sector 4 are average 2 units. In north and south Kalabagan area one rickshaw van collects wastes from 362 (Ave.) in a house because Kalabagan area is a densely populated residential area and each house has 4 units (Ave.). More time spent, (3.85 min/houses,) in Uttara due to low density of house and obtained rate can also be applicable for Banani, Gulshan Baridhara.

4.8 DISPOSAL PRACTICES

Landfill management and monthly operation cost data obtained from DCC's Mechanical Division are shown in the followings:

Table- 4.12: List of Equipment used in DCC Landfill.(Matuail)

Equipment	Number	Monthly use hr.	Consumption Rate	
Chain Dozer (Bull-Dozer)	4	633	18 Litter/ hour	Tk. 5500/day
Scavator	2	364	25 Litter /hour	Tk. 9350/day
Tire Dozer (Wheel)	2	293	30 Litter /hour	Tk. 8250/day
Pay loader	1	218	15 Litter /hour	Tk.4950 / day

A. Equipment and Fuel used

Name of the month	Name of Equipment	Worked hour hr./day	Consumed fuel/ litter
June '98	Bull Dozeer	633	11,394
	Tire Dozeer	293	8790
	Scavator	364	9100
	Pay loader	218	3815
	Power Trailler	3	290
	Duper	31	2050
	Total : 35,439 Litter		

CHAPTER- 5

DESIGN OF SOLID WASTE MANAGEMENT SYSTEM

5.1 NEED ASSESSMENT

5.1.1 Waste stream

As mentioned earlier a detailed survey was conducted to estimate the waste generation rate from different sources at Uttara Model Town. These values were used in calculating the total volume of waste. Data were collected on population, number of residential holdings, commercial units, clinics, offices buildings, etc. Table- 5.1 represents the waste generated from different sources at the different locations of the study area.

Table 5.1 : Waste stream of Uttara, Banani, Gulshan and Baridhara

Category /Types	Estimated Waste Generation (Weight)					Percent
	Uttara kg.	Banani kg.	Gulshan kg.	Baridhara kg.	Total kg.	
Domestic	16,320	10,725	11,990	3,965	43,000	58.70%
Commercial	1,032	800	3,899	50	5,781	7.90%
Clinical	75	60	100	-	235	0.32%
Street Sweeping	9,584	4,093	8,058	2,496	24,211	33.08%
Total generation	27,011	15,678	24,047	6,511	73,247	100%

It is apparent from the above analysis that the major contribution to the waste stream comes from the domestic sources. Also, contrary to the common belief street sweeping contributes significantly to the total waste stream.

5.1.2 Collection equipment and labor requirements for present generation.

5.1.2.1 Vehicle requirements for present generation rate

At present the DCC is operating 6(six) demountable trucks for collection of waste from Uttara, Banani, Gulshan and Baridhara (Table 3.1). Considering collection target of 80% the number of containers required to haul the estimated waste generated from the study area was calculated and are presented in Table 5.2. It is apparent from the table that present number of trucks is inadequate for collecting the estimated generated waste.

Table 5.2: Vehicle requirement for present generation.

Collection area	Estimated waste generation m^3/day	Required container number for HCS	Number of trips /Vehicle/day	Number of Vehicle
Uttara	45	8	3	3
Banani	26.13	5	3	2
Gulshan	40	7	3	2
Baridhara	1085	2	3	1
		22		**8**

Note : Collection target = 80%, Container utilization factor = 0.8, Container size = $6m^3$

5.1.2.2 Requirements for existing house to house collcetion

As mentioned earlier some private initiative and community based "house to house" domestic waste collection services have been started in Uttara, Banani, Gulshan, Baridhara areas. To improve the domestic waste collection services by incorporating these private initiatives a system has been designed for "house to house" collection of domestic waste by the contractor in proposed first phase of the solid waste management system. After observing the improvement of the collection service and establishing the proper controlling and management technique in solid waste collection by private agencies the other component like street sweepings,

transportation, disposal, treatment, recycling may be designed for private agencies. To design the proposed solid waste management system and to expand the existing private system following estimations have been made using the data generated in the waste stream survey to get the present operational cost of private initiative.

Table 5.3: Requirements for existing house to house collection

Area	Estimated Domestic Waste Generation m^3	Rickshaw van size m^3	No. of Trips /day	No. of Rickshaw Van	Driver
Uttara	16.320	0.76	2	14	14
Banani	10.72	0.76	2	9	9
Gulshan	11.99	0.76	2	10	10
Baridhara	3.965	0.76	2	3	3
			Total	36	36

Note : Utilization factor = 0.8

It is observed from the above analysis that 36 number of labors are required to introduce the house to house waste collection using rickshaw van. From Table- 5.4 it is observed that if manpower is distributed in planned way then only 40 cleaners are enough for street sweeping. DCC employed total 137(105 for street sweeping and rest are for others activities) cleaners in Uttara, Banani, Gulshan, Baridhara areas. So no additional cleaner need to be recruited to start house to house collection system.

5.1.2.3 Cleaner requirements for street sweeping

With the result obtained from street sweeping study an analysis was performed to determine the number of cleaner required for street sweeping. From Table-5.4 it is observed that only 40 cleaners are required. Whereas, DCC employed 105 cleaners for street sweeping in Uttara, Banani, Gulshan, Baridhara areas.

Table 5.4: Cleaner requirement for street sweeping

Area	Length of Road (Km)		Sweeping frequency for		Sweeping Rate Km/Cleaner/day	No of Cleaner
	Main	Internal	Main road	Internal road		(Main road + Internal road)
Uttara	6	42	Daily	Every 3rd day	0.775	5+11=16
Banani	3	18.27	Daily	Every 3rd day	0.775	2+5=7
Gulshan	10	26	Daily	Every 3rd day	0.775	8+7=15
Baridhara	1	4.76	Daily	Every 3rd day	0.775	1+1=2
	20	91.03				= 40

5.2 COST ANALYSIS OF PRESENT SYSTEM

5.2.1 Primary collection cost for the study area

Yousuf (1996) calculated primary collection by hand cart system against all types of waste collected by present transport system and total number of cleaner employed in that particular zone. In zones 9 and 10 it has been observed that actually 76% cleaners are engaged for street sweeping activities. In some areas rest of the cleaners are engaged for truck loading. Drain cleaning task is assigned for the same cleaner, they clean the drains occasionally one time in a month for a particular area. As present, the communal bin collection system is in operation. Only those waste dumped around the house are collected by handcart. It was found that in high-income areas wastes are generally dumped properly, so, the cleaners are primarily engaged on streets sweeping only. Thus, they are under utilized than the low-income areas. So, primary collection cost is mainly due to street sweeping activities because present employees are almost assigned for street sweeping activities. Cost analysis for street sweeping works of DCC found separately Tk. 470/ m^3 (Table 5.6) and

private company Tk. 280 /m^3 (5.3.2.2). So proper planning and designing of street sweeping function can save collection cost and improve the collection efficiency

To collect all types of solid wastes using the existing equipment and labor of DCC to the community bin locations following calculations have been made to estimate the possible expenditure. Data were taken from DCCs salary sheets, previous study reports and information supplied from DCC's conservancy department.

Table 5.5 Primary collection cost for the area Uttara, Banani, Gulshan and Baridhara.

A. Capital Cost

Concert bin No.	Initial Capital Tk.	Maintenance Tk.	Estimated life (month)	Total capital Tk.	Monthly Tk.
(1)	(2)	(3)	(4)	(5)=(2)+(3)	(6)=(5)/(4)
104	12,48,000/-	1,24,800/-	120	13,72,800/-	11,440/-

B. Operational Cost of Existing facilities

Cleaner No. (1)	Cleaner Salary & allowances Per month Tk. (2)	Total Salary per month Tk. (3)	Consumable material per month Tk. (4)	Total operate cost per month Tk. (5)=(3)+(4)
32	1904+317.33	71,082.66	3,082.88	74,165.54

Average Unit cost-

Daily collection of Waste M^3/ day Tk. (1)	Monthly collection M^3 (2)=(1)×30	Monthly capital Tk. (3)=A(6)	Operational Tk. (4)=B((5)	Total Cost Tk (6)=(3)+(4)	Cost/M^3 Tk. (7)	Cost/ Ton Tk. (8)
102.6	3078	11,440/-	74,165.54	85605.54	27.81	68.50

5.2.2 Street sweeping cost for the residential area.

Data obtained from DCC records, previous study reports, and present study have been used to determine the cost related to street sweeping. It includes capital cost, cost of hand trolley and its maintenance, operational cost, consumable materials such as broom, spade, fork, soap, basket etc. DCC informed that most of the cleaner assigned for street sweeping. In generally the street sweeping of DCC are designated to sweep, gather, collect and deposit street waste to the nearest bin.

Table 5.6 Street sweeping cost for the residential area.

A. Capital cost

Hand Trolley No. (1)	Purchase Cost Tk. (2)	Maintenance cost Tk. (3)	Life time month (4)	Total capital Tk. (5)=(2)+(3)	Monthly Cost Tk. (6)=(5)/(4)
53	2,65,000/-	2,65.000/-	36	2,91,500/-	8097

B. Operational cost

Cleaner No. (1)	Salary per monthly Tk. (2)	Other allowances per month Tk. (3)	Consumable material cost Tk. (4)	Total opera. cost Tk (5)
105	1,99,920*	33,320	10,308**	2,43,548

C. Unit cost

Estimated waste generation M^3/day (1)	Collection efficiency % (2)	Estimated collection M^3 /month (3)=(1)×(2)×30	Total cost capital & operation Tk. /month (4)=A+B	Cost/M^3 Tk. (5)=(4)/(3)	Cost/Ton Tk. (6)
30.20	59	534.54	2,51,645	470	588.46

Source :* DCC's Payment Sheet(1998). ** Yousuf(1996)

5.2.3 Cost analysis of "house to bin" domestic waste collection by Uttara Kallayn Somity, Sector-4.

To privatize the domestic waste collection service in future, present NGO's initiatives have been analyzed and results are shown in Table-5.6 Yousuf(1996) calculated CBO approach at Kalabagan area house to house domestic waste collection cost as Tk. 94/m^3 (table-2.8). In Uttara model town 'Sector- 4 Kallyan Samity' are operating 3 (three) rickshaw van for house to house collection. The cost of this operation is Tk. 51.28/ m^3 with a net income Tk. 40.24/ m^3(Table-5.6) So, it can be concluded that CBO approach of house to house collection is also a profitable business. In Gulshan Banani, and Baridhara a private agency is taking service charge of Tk. 50.00 - 100/ house hold/ month for the service. DCC has no control or monitoring activities about quality of services and charges. DCC should set out proper guidelines, rules, regulation specification, standards, methodology of collection and handling of waste for the private agency.

Table 5.7 Cost analysis of "house to bin" domestic waste collection by Uttara Kallayan Somity, Sector-4.

A. Capital cost

Rickshawa Van No. (1)	Purchase cost Tk. (2)	Maintenance Tk.(3)	Estimated life time month (4)	Total cost Tk.(5)	Cost/ month Tk.,(6)=(5)/ (4)
3	36,000/-	3,600/-	36	39,600-	1,100/-

B. Operational cost

Van Driver (No.)	Salary of van driver per month (Tk.)	Total Salary (Tk.)
3	1500	4500

C. Unit cost

Average volume of van M^3 (1)	Average No. of Trips/van (2)	Utilization factor (3)	Volume waste collected in a day M^3 (4)=(1)×(2)×(3)	Total waste volume in a month M^3 (5)=(4)×30	Total cost/ month TKO .(6)=A+B	Cost/ M^3 Tk. (7)= (6)/(5)	Cost/ Ton Tk.
0.76	2	0.8	3.64	109.2	5600/-	51.28	85.46

D. Income/ Savings

No.of houses paying service charge no.(1)	Rate of service charge Tk. /month/house Tk (2).	Total collection Tk.(3)=(1)× (2)	Total cost Tk. (4)	Net income or saving Tk. (5)=(3)-(4)	Income/M^3 (6)=(5)/C(5)	Income/ Ton Tk.
500	20	10,000/-	5,600/-	4,400/-	40.24	98.62

5.2.4 Transportation cost analysis.

Transportation of solid waste from Uttara to Landfill(Matuail) has been analyzed. Data taken from previous study reports and DCC records. It is found from DCC's transport schedule that open trucks are carrying 43% and demountable trucks are carrying 57% waste daily. One vehicle is assigned for lifting 3-4 container in a day.

Zone - 10 (Uttara) roundtrip distance from disposal site at Matuail is DCC record 60Km and for Zone - 1 (Saidabad) it is 14 Km. But for both the zones vehicles are assigned for hauling 4 container/vehicle. It has been determined form observation that average haul time for Zone 10 is 2.5 hr/trip and that for Zone- 1 (Saidabad) is 0.5 hr/Trip. For Zone- 5, central part of Dhaka city average roundtrip distance is 22 km as per record, where each vehicle is set for hauling 3 containers. Under utilization of vehicles and unplanned distribution of trips cause reduction of collection efficiency and increases cost. It was also observed that 15%-25% trips per vehicle per day are not being executed or completed by the vehicle drivers to save fuel. Transport department of DCC issue fuel to the transport vehicle at the rate of 3-2.5 litter /km/vehicle.

Yousuf (1996) presented transportation cost of Tk. 35/ m^3, and Tk. 28/ m^3, for open truck and demountable container system. Yousuf (1996) calculated transportation cost of demountable container truck with an assumption of one vehicle carrying 16 containers per day in two shifts. From DCC's transport schedule it has been found that in practice one vehicle was carrying 3-4 containers in a day. With this inherent assumption of large volume of wastes was being transported in a low unit cost of Tk. 28/m^3. When calculation made was done with 4 containers per day, other values and procedures of calculation remaining same, the transportation cost stood at Tk. 73.27 / m^3, or Tk 132/Ton. DCC's transport schedule shows that during 1995 no demountable truck was running in Zone- 1 area. Nineteen number of tipping trucks was operating in Zone- 4,5,6,7 and 8. As DCC never operates more than 5 trips per a day the estimation by Yousuf (1996) are not practical. From this study, the time required to collect waste from stationary bins into a truck is approximately 30 minutes. This reduces the total volume of waste transported in a day. Analysis of the transportation cost shows that for open trucks the cost is about Tk 148.31/m^3 and Tk. 170.95/ m^3, for Gulshan and Uttara respectively. The same for demountable container are Tk. 141.21/m^3 and 158/m^3 respectively (Table-5.9).

Transportation cost varies with the distance from collection area to disposal site. DMDP(1991) reported that transportation cost increases approximately Tk. 15/ton when disposal site is 10 miles form the city. Cost analysis for different areas (Table 5.9) shows that cost increases at the rate of Tk. 15.8 /Ton for Uttara when disposal site is more than 10 miles for open truck and Tk 10/Ton for demountable container.

Table 5.8 Transportation cost analysis.

Capital cost

Type of operation	Pay load (Ton)	Initial capital (Tk.)	Estimated life time year	Total capital per year (Tk.)
Open Truck	3	8,00,000/-	5	1,60,000/-
Demountable container Truck	3	3x93,744+12,64,756 =2,81,232+12,64,756/-	3 (container) 5(Truck)	93,744/-+ 25,29,512/- =3,46,695/-

Operational cost

Type of Operation	Maintenance per year (Tk.)	Labour per /year (Tk.)	Fuel and lubricant (Tk.)	Total operational cost per year (Tk.)
Open Truck	32,000/-	192,000/- +60,000/*-	1,67,024	451024/-
Demountable container	cont. 9374/-+ Truck 50,590/- = 599964	1,32,000/- +41,250/*-	25,0,536/-	4,83,750

Average Transportation cost

Type of operation	yearly cost operation + capital (Tk.)	Volume of waste per trip (M^3)	No. of Trip/ day	yearly waste volume(M^3)	Cost/M^3 (Tk.)	Cost/Ton (Tk.)
Open Truck	6,11,024	4.8	2	3504	170.95	290.63
Demountable container	8,30,443	4.8	3	5256	158	260

Source : Yousuf (1996), * Overtime cost.DCC(1998)

Table 5.9 Transportation cost of different zone of DCC

Collection area /Zone	Round trip distance Km	Open Truck collection System			Demountable container collection system.	
			Pay Load			Pay Load
		Number of trip/vehicle /day	3 ton Cost /M^3 Tk.	5 ton Cost /M^3 Tk.	Number of Trip/vehicle/day	3 ton Cost / M^3 Tk.
Zone-1	14	2	124.50	94.70	4	101
Zone-2,4	18	2	139.80	104	4	116
Zone-3,5,6	22	2	145.33	109	4	121.80
Zone-9	35	2	148.31	122.83	3	141.21
Zone 7,8	44	2	158.14	127.23	3	144.20
Zone- 10	60	2	170.95	136	3	158

From present operation it has been found that stationery containers are on an average 12% more costly than demountable container system. For Zone 9 both these system incur the same cost. It has been shown that open truck system will be economical (10% cheaper) if large capacity truck (5-tons) are used (Table-5.9). So, until DCC adopt such a management plan that would make demountable container cheaper than open truck system it would advisable to adopt some precautionary and appropriate measures that would make the open truck collection system acceptable with a view to less public health hazard, nuisance, littering, environmental pollution free.

5.2.5 Disposal cost analysis

Disposal cost includes purchase of land, site development, construction of sanitary landfill, operation by mechanical equipment and manpower. The data

taken from DCC have been used to determine the cost of present disposal of solid waste to Matuail. Disposal cost was calculated from present operational data of DCC's different equipment engaged at landfill site and it was found to be Tk. 101.47/Ton or Tk. 60.60/m^3 (Table-5.10). In 1981, Dhaka Metropolitan Area Integrated Urban Development project report vol-3 (1981) mentioned disposal site operational cost to be Tk. 24/Ton (Table-2.9).

Table 5.10 Disposal cost analysis

A. Capital cost

Land acquisition (Tk.)	Site development (Tk.)	Sanitary landfill construction (Tk.)
500,00,000/-	200,00,000/-	441,00,000/-
Total cost Tk.	Life time year	Yearly capital cost Tk.
1141,00m000/-	8 years	142,62,000/-

B.Operational cost

Plant and machinery's hire charges (Tk./ Month)	Fuel cost (Tk/Month)	Lubricant (Tk/Month)	Total cost (Tk/ Month)	Yearly cost (Tk/ year)
14,5281/-	4,58,935/-	71,431/-	19,83181/-	237,98,172/-

C. Disposal cost

Total cost Capital + operational (Tk/year)	Daily disposal (Ton/day)	Year's disposal (Ton/year)	Unit cost (Tk./ton)	Cost (Tk/M^3.)
530,40,000/-	1432	52,2680	10147	60.60

Source :DCC

5.3 PROPOSED SYSTEM

5.3.1 Collection

From the findings of the field study and cost analysis it is proposed that house to house waste collection by rickshaw van be engaged in a predefined route. Collection frequency should be once per day. There should be one collector as driver in each van. One van should operated two shift per day. Rickshaw van should deposit waste to the loading platform, for separation of waste incase of composting plant within the collection area. House to House collection service should be lease out to the private agencies. Local social organization CBO's, are already involved in "House to House" waste collection service. Such 'Micro Entrepreneurs' should be encouraged to participate. There should be separate collection vans for 'clinical' and hospital wastes. Clinical waste should be collected in special garbage bags and kitchen or food waste from clinic and hospital should be separated from harmful clinical wastes. Commercial or market wastes should be collected from one location of the market area. The internal shop to shop collection should be done by the respective market authority. There should be specification, schedule, standards rates, safety procedure, penalty provision, collection procedures, methodology for the private agencies, contractors and CBO's for waste collection, transport and treatment and final disposal of waste. There should be committee for monitoring and supervision of "House to Hosue" collection service. There shall be a system of collection of "Service return" from each household for each month in prescribed form and no payment shall be made without any service return. Street sweeping service shall be privatized gradually. Because, it has been found that almost double number of cleaners are presently engaged for street sweeping than the actual requirement. In addition, this service is very poor and unsatisfactory. It is expected that when the service is leased out, quality would improve and cost would be minimized. There shall be penalty provisions for the polluter to make the public realize that producing garbage entails cost. DCC's role shall be planning and monitoring supervising and regulatory. For cost minimization DCC should supply sufficient rickshaw for collection by

converting the illegal rickshaw into vans.

5.3.2 Transfer and transportation

It is suggested that a transfer station to be set up at Gulshan. There should be transport trailer to carry waste from transfer station to disposal site. Waste should be delivered into the trailer from rickshaw van through loading platform. There should be weigh scale to determine the waste load of collection van. There should be space for processing, resource recovery activities and composting plant. Transportation service should be privatized. There should be arrangement for rickshaw van garage or depot within the service area.

5.3.3 Disposal site management

There should be weight bridge at disposal site equipped with a computerized record keeping system. There should be an all weather-unloading platform. There should be space for storing cover materials and practice to use regularly. There should be landfill operation, equipment, maintenance manual and schedule, clean and visible on site directional sign for proper traffic route. Approach area should be sufficient enough for easy movement. There should be ground water monitoring wells. Clay lining, proper drainage system and leachate movement and gas control system should be provided for the proposed landfill site.

5.4 Cost estimate for proposed system.

5.4.1 Cost estimate of "house to house" domestic waste collection by private company.

For Uttara Model town, Banani, Gulshan, Baridhara, estimated waste generation is 43 ton/day, required no of rickshaw van is 87, calculation has been made included with contractor's profit, vat, income tax etc.

Table 5.11 Cost estimate of house to house domestic waste collection by private company.

Item	Cost/dayTk.
A. Capital	953.42/-
B. Maintenance 10% of capital	95.34
C. Operation	5800/-
D. Service charge: Contractors profit, Overhead cost, Vat, income tax 18% of (A+B+C)	1267.00
Total	8115.80

Unit cost of collection = Tk. 188/ton = Tk. 77/ M^3

Yousuf(1996) calculated CBO approach at Kalabagan area house to house domestic waste collection cost Tk. 94/m^3. In Uttara model town 'Sector- 4 Kallyan Samity' operating 3 (three) rickshaw van for house to house collection and cost calculated (Table-5.10) Tk. 51.28/ m^3, and net income Tk. 40.24/ m^3.

Privatization costs calculate for Banani, Gulsahan, Baridhara, Uttara area Tk. 77/ m^3 (Table 5.11). System is design for house to house collection by Rickshaw Van considering contractor's profit, Vat, Income Tax, over heed charge etc. in cost estimate. If DCC operate house to house collection by its own cleaner then estimated cost found to be Tk. 159.27/ton or Tk. 65/m^3. Obtained cost is similar to Yousuf's calculation for Kalabagan area. So it can be concluded that CBO approach of house to house collection is also a profitable business. In Gulshan Banani, and Baridhara are a private agency taking service charge Tk. 50.00 - 100/ house hold/ month for same quality of service. DCC has no control or monitoring activities about quality of services and charges. DCC should set out proper guidelines, rules, regulation specification, standards, methodology of collection and handling of waste for the private agency.

5.4.2 Cost estimate of street sweeping by private company

For Uttara Model Town, Banani Model Town, Gulshan Model Town, Baridhara Model Town estimated waste quantity is 24.231 Ton/day, required number of Rickshaw Van 25, required number of cleaner 69, required number of hand trolley 69. It is assumed that sweeping should be done manually, with a hand trolley by each cleaner, transportation to container location or transfer station by rickshaw van.

Table 5.12 Cost estimate of street sweeping by private company

Item		Cost /Month Tk.
A.	Capital (purchase cost of Rickshaw van, hand Trolley)	17916.63
B.	Maintenance(10% of capital cost)	1,791.66
C.	Operational cost	1,88,000/-
D.	Consumable material	7768.66
E.	Service Charge	3,98,63.23
	Total cost	2,55,340/ month = 8511/day
	Unit cost of street sweeping	= 351/ ton= 0.35/kg = 73/ km= 280/ M^3

It has found from calculation that present street sweeping cost is Tk. 470/ m^3. and this cost can be reduced to Tk. 237/ m^3 or 280/ if designed for private agency. So large amount of money can be saved from rearrangement of street sweeping activities by leased out the service.

5.4.3 Cost comparison of loading platform and manual loading

It has observed that demountable containers are loaded by a labor because waste are deposited outside the container. Due to height of the opening of container waste from

rickshaw van and hand trolley delivered outside the containers. If unloading yard or platform is constructed so that rickshaw van or hand trolley can delivers the waste directly into the container then double-handling of waste can be eliminated and labor for loading to the container will not be needed and would reduce the cost, improve the environment of container surroundings, reduce littering and nuisance.

The waste collects from house to house by the local CBO's, NGO's through rickshaw van unable to unload directly in to the container, first unloaded the van on the road then to load into the container it needs extra labor and time. To save time and extra labor a loading platform considered for proposed system. In Uttara Model Town a loading platform was constructed during study period. To function properly some modification of container shape to be needed. Waste can be unloaded directly from rickshaw van to container. Cost of masonry loading platform calculated and compared to manual loading.

Table 5.13 Cost comparison of loading platform and manual loading

Item		Loading platform (Tk)	Manual loading (Tk.)
A	Capital Cost	6.74/day	Nill
B	Operational cost	Nil	66.66/day
C	Maintenance	1.36/day	Nill
	Total=	8.11/day	66.66 / day
	Unit cost	Tk. 1.7/ M^3	13.88/M^3

In present system maximum waste deposited out side the container and one labour is needed to fill the container and cost involved Tk. 13.55/ m^3. When loading platform uses cost reduce to amount Tk. 1.7/ m^3. 87.75% cost minimization can be achieved by constructing loading platform with some modification of container shape.

5.4.4 Transfer station cost analysis

The proposed system considered that waste of Uttara should be transported to Gulshan transfer station by demountable truck and directly transferred to the transport trailer through loading platform. It has assumed that one transport trailer of 96-yd3 capacity to be required. Cost of transport trailer assumed. Transfer station cost includes construction of loading platform, weighing bridge, structures, operation, maintenance, and land cost omitted.

Table 5.14 Transfer station cost analysis

Item	Capital cost/day (Tk.)	Maintenance cost/dy (Tk.)	Operation cost/dy (Tk.)	Total cost/dy (Tk)	Waste volume (M^3/dy)	Item Cost Cost/ M^3 (Tk.)	System cost Cost/M^3 (Tk.)
A. Transfer station cost.	2020	202	500	2722	146.88	18.53	
B. Transportation cost (i) Uttara to Gulshan	1223.4	192.6	688.66	2104.66	28.8	73.07	
(ii) Gulshan to Disposal site	3913.80	782	1169	5865.57	146.88	39.93	
Total cost	7157.2	1176.6	2357.66	10692	146.88		72.79
cost fractions	66.94%	11%	22.05%				

5.4.5 Cost estimate for new land fill for study area

Present disposal sites is located 60 km (round trip distance) from collection area, Uttara Model Town. Transportation cost increase with the distance. It has found from table-5.8 that 3 ton pay load demountable truck is cheaper than open truck for the collection areas within 22 km(round trip distance) and with the increase of distance 5 ton pay load open truck is cheaper. To minimize the transportation cost an alternative disposal sites near collection area has selected at Khilkate, in-between Uttara and Banani, Gulshan, Baridhara. A calculation is done considering the land purchased cost, site development, construction of sanitary landfill, operation and maintenance is shown in Table-5.15. The result thus obtained is compared with transfer station cost in Table-5.16

Table 5.15 Cost estimate for new landfill for study area

Waste generation M^3/dy	Estimated Life Time / year	Capacity of Land fill M^3	Depth of borrow pit M	Area				
				Pit M^2	Dyke M^2	Approach road	Total acr.	
122	10	445300	7	63614	32283	4000	25	

A. Capital cost.

Purchase of Land Tk.	Dyke construction Tk.	Control, Scale Tk.	Total Cost Tk.	Life time year	Daily cost Tk
2,50,00,000/-	2,79,21,600/-	50,00,000/-	57921600/	10	15,868

B. Maintenance and operation:

Equipment hire charge/day Tk	Fuel/day Tk.	Labour for operation Tk.	Maintenance Tk.	Total cost/day. Tk.
11860*	886*	1333.33	1500/-	15,579

Unit cost of landfill

Daily disposal M^3	Total cost Tk.	Cost/M^3 Tk.
122	31,447	257.76

Source : * DCC

5.4.6 Selection of cost effective transport system

Present transportation and disposal cost of municipal waste of Banani Gulshan Baridhara, Uttara area were compared with three alternatives system. System-1 includs setting up a transfer station at Gulshan when waste coming from Gulshan, Banani, Baridharn area by Rickshaw van and by demountable truck from Uttara. All the waste will be transported to disposal site at Matuial by 2-lagre-volume capacity Trailer with moving floor unloading system. Cost/m^3 found Tk. 133.4. System -2 includes setting up a new landfill site at Khilkhate. Waste form collection area to be be transported to disposal site by demuntable container and cost/m^3 found Tk.373.68.

Present system of transportation includes transportation of waste 45% by open truck and 55% by demuntable container and cost found Tk. 210.68. From comparison of three system of transportation and disposal it has found that system -1, that is, setting up a transfer station is more cost effective and may save Tk. 29,67,597/year then present system.

Table 5.16 Selection of cost effective transport and disposal system for the study area

System	Collecti on area	Volume Of Waste M^3/day	Transportation cost		Disposal cost		Total cost/day Tk.
			Unit cost/M^3 Tk	Cost /day Tk.	Unit Cost/ M^3 Tk.	Cost/day Tk	
Present Open truck Disposal to Matuail	Uttara	14.00	174.38	2441	60.60	848	3289
	Gulshan Banani Baridhara	33.6	148.31	4983	60.60	2036	7019
Demountable container	Uttara	14.4	158	2275	60.60	872	3147
Disposal to Matuail	Gulshan Baridhara, Banani	43.2	141	6091	60.60	2617.92	8708.92
Total of present system	Uttara,Banani Gulshan,Barid hara	105.2	150/-	15,790	60.60	6375.12	22.163.9 2
Proposed system Systen –1 Transfver station at Gulshan disposal to Matuail	Uttara Banani, Gulshan, Baridhara	105.2	72.80	7,658.56	60.60	6375.12	14.033.68
Systyem –2 Setting New Land fill at near to collection area (Khilkhet)	Uttara, Banani, Gulshan, Baridhara	105.22	116	12,203	257,76	27,116	39,319

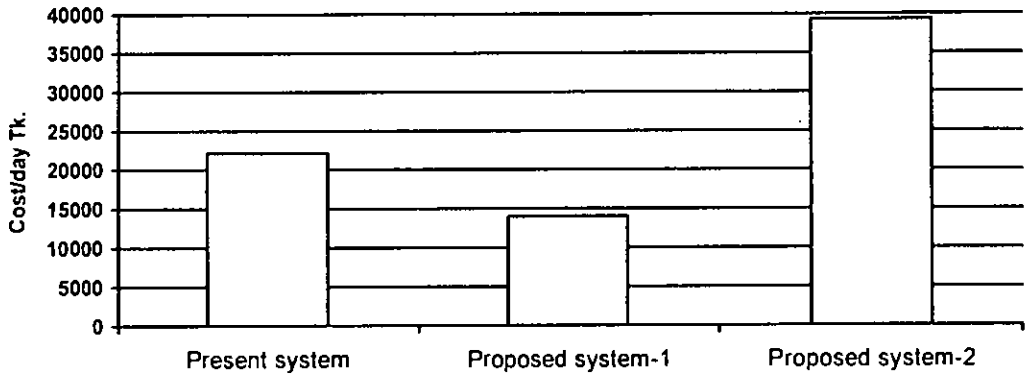


Fig: 5.1 Selection of cost effective transport system

5.5 COST MINIMIZATION

Present street sweeping cost of DCC was found to be Tk. 470/ m^3 whereas, the same for the private contractor is Tk. 280/ m^3, Approximately 40% of cost reduction may be achieved by leasing out the services. Present cost of transportation by open truck and demountable container system was found to be Tk. 150 /m^3. The transportation cost is reduced to tk 72.8/ m^3, a reduction of 51.4%, by setting up a transfer station at Gulshan followed transportation by to disposal site using large capacity trailer with moving floor unloading facility.

Collection cost can be minimized if resource recovery, recycling and compost production from organic waste is formally introduced by DCC with private agency. It has been calculated that house to house collection service cost can be recovered from recycling and compost plant net income of Tk. 0.23/kg can be made. The costs of transportation of waste greatly reduced through resource recovery and composting.
This study has showed that in the Banani, Gulshan, Baridhara and Uttara are out of 137 cleaners 105 are engaged in street sweeping, whereas, the present requirement is only 69. So, 50% of the employees can be used for other activities like "house to

house" collection, or can be relieves of their duties. However, it creates some social problems. But to improve the quality of service and to reduce the cost there may be no other suitable alternative. So, rearrangement of present labor and manpower can also minimize the collection cost.

Resource Recovery and Recycling

Estimated domestic waste generation from Uttara, Banani Gulshan and Baridhara area is 43,000 kg. If the expected collection efficiency is 80%, the total amount of waste collection is 38,700 kg. It has been calculated that from 38.7 ton domestic waste monthly Tk. 92,774 may be earned by converting waste into compost and recyclable materials likes paper, cardboard, plastic, metal, glass, can etc. Converting organic waste to compost Tk. 0.17 may be earned from one kg of domestic waste. When recyclable materials are recovered Tk. 0.29 may be earned from one kg. of waste. As cost of collection is calculated to be Tk. 0.23/kg then net income from one kg of waste may become Tk.0.23. The details of this analysis is shown in Appendix-H

5.6 COMPARISON OF PRESENT & PROPOSED SYSTEM

As mentioned earlier, the present system is communal bin and the proposed system is house to house collection system. At present stationary container system and hauled container system of collection and practices by DCC. Whereas, the proposed system is designed for 100% house to house collection of domestic waste from residential area by private agency or contractors.

In present system extra labor is needed to fill the container before lifting for transportation to disposal site, but in the proposed system waste shall be delivered directly from rickshaw van into the container by unloading platform ram. No formal resource recovery and recycling exists in the present system. In the proposed system resource recovery and recycling to minimize collection cost. In the present system

waste are deposited outside or near the bin. Bins are not regularly and properly cleaned causing the generation of vermin's, mosquitoes, bad odor. Proposed system will eliminate those problems and ensure better environment, public health. It will ensure timely collection, transportation and disposal and less contact of waste to air, thus, reduce pollution of the environment. Proposed system of street sweeping is designed on the basis of this existing data. so that maximum utilization of cleaner will ensure cost minimization. It has been estimated that 50% cleaner of present number will be surplus.

Container utilization capacity will increase due to direct loading of waste from rickshaw van into the container. When collection and transportation will be privatized then the service will be of competitive quality and the cost will also be competitive. When house to house collection service will be leased out from DCC, then no extra charge will be necessary. There will be Weigh Bridge at the disposal site to quantify the in-coming load or weight of waste per trip of vehicle. The transportation expenses per month will be paid according to the collected weight of waste at the disposal ground. In this system missing trip will be unlikely to occur, corruption will be reduced. On the other hand, in the present system it has been found that on an average one trip/ truck/day is being saved by a driver form scheduled trip to save fuel which is subsequently sold. There shall be automated record keeping and monitoring at the disposal site. At present, DCC does not provide any personnel to keep the record of in-coming truck at the landfill site. No monitoring system exists at the site. There is no solid waste filling plan and traffic movement control in the present system and for this reason disposal site sometime get closed or unsuitable for solid waste fillings.

Present and Proposed system cost comparison: Summary of collection, transportation and disposal cost of solid waste are shown in Table 5.18. In calculating the unit cost, one day estimated total cost has been considered in house to house collection, street sweeping for both the system & service charges excluded from Table 5.11 & 5.12.

Table 5.17: Solid waste collection, transportation, disposal cost in different system.

Collection

Description	Tk/ M3	Tk/Ton
Communal bin-hand cart by DCC	27.81	68.50
House to House domestic waste by CBO	51.28	85.46
House to House domestic waste by contractor	77.00	188
Street Sweeping by DCC	470	588.46
Street Sweeping by contractor	280	351

Transportation :

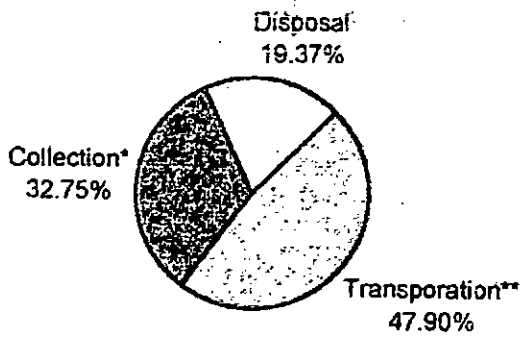
Description	Tk/ M3	Tk/Ton
Open Truck (3 ton) Uttara to Matuail by DCC	174.38	290.63
Open Truck (5 ton) Uttara to Matuail by DCC	136	226.66
Demountable container (3 ton) Uttara to Matuail	158	263
Open Truck 45% + Demountable container 55%	150	250
Transfer station at Gulshan	72.8	121

Disposal:

Description	Tk/ M3	Tk/Ton
Bulldozer, Payloader, Escavator	60.60	101

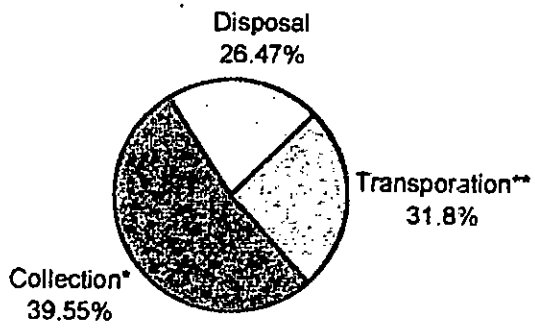
Table: 5.18 Cost comparison of present and proposed system for the study area.

Component	Present System cost/M^3 Tk.	Proposed System Cost/M^3 Tk.
A. Collection:	102.54	95.52
B. Transportation	150.09	72.8
C. Disposal	60.60	60.60
Total	313.12	228.92



* Collection from bin, including street sweeping, gathering of wrongly dumped waste to bin/container location. ** Transportation 45% by open truck 55% by demountable container.

Fig. 5.2: Present expenditure fraction of DCC in different component of solid waste management system.



* Collection includes house to house collection.

** Transportation : Transfer station and Large capacity trailer.

Fig. 5.3: Proposed cost fraction of solid waste management system

CHAPTER- 6
CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

One of the major growing concerns an urban area faces today is solid waste management, because growing volumes of refuse, their collection and disposal plague cities everywhere. Municipal government worldwide are struggling to find the best method to manage their resident waste. The present system of waste management in Dhaka city is environmentally ineffective, inefficient, and hazard to the health of the public and the operators.

Domestic waste generation in residential area was found to be 0.60 kg/cap/day. The average estimated population per house was observed to be 9.142. Source density of domestic waste on as discarded basis was found to be 408 kg/m^3. Physical composition analysis revealed that food waste is 72.5% polythene is 13.7% paper and cardboard are 5.63%, plastics are 3.31%, glass metal is 0.45% and tin can is 0.39%.

In Uttara Model Town clinical waste generation rate has found to be 1.75 kg/cap/day (mixed refuse). Waste generation from Chinese Restaurant of Uttara Model Town was observed to be 0.56 kg/day. Waste generation from street sweeping in Uttara Model Town was found to be 0.16 kg/m/day for internal roads and 0.36 kg/m/day for the avenues or main roads. Street sweeping waste generation rate in terms of population was determined to be 0.098 kg/cap/day. Street sweeping waste composition showed that inorganic sand, silt, earth contribute 95% of the total waste weight. Productivity of street sweeping by one cleaner has been found to be 775 meter/shift/. It was observed that the manual loading rate of waste from communal bin to open truck requires 15.92 min/m^3. Using the DCC's record the collection efficiencies for Uttara Model Town and Banani, Gulshan, Baridhara area were found to be 52.52% and 80%, respectively. Average efficiency for the study area is 70%.

Distribution of transport was found to be 45% by open truck and 55% by demountable container truck. Waste stream fraction was domestic 58.7%, Commercial 7.90%, clinical 0.32%, and street sweeping 33.08%. It is apparent from the analysis that the major contribution to the waste stream comes from the domestic sources. Also, contrary to the common belief street sweeping contributes significantly to the total waste stream. It was observed that DCC's 76% cleaners were engaged in streets sweeping activities and from cost analysis it was found that street sweeping waste collection to communal bin cost Tk. 470/m^3. DCC dose not collect waste from houses and 67% waste has been deposited to the DCC's bin or container without any involvement of DCC's cleaners. In Uttara Model Town CBO's collect domestic wastes from house to house and spend Tk. 51.28/m^3 and the average savings from the service charges is Tk. 40.24/m^3. From cost analysis it was estimated that house to house domestic waste collection by private contractor is Tk. 77/m^3 and cost of street sweeping by private contractor is Tk. 280/m^3. So, collection efficiency can be increased and leasing out the services to the solid waste management contractors, CBO's, NGO's or micro-entrepreneurs can reduce collection cost. It was observed that transports of DCC are engaged without proper planning and need assessment. From cost analysis it was found that transportation by 3 ton capacity open truck cost Tk. 124.5/m^3 for Zone- 1 (Saidabad) and Tk. 171/m^3 for Zone-10 (Uttara). On the other hand cost of transportation by demountable container truck was found to be Tk. 101/m^3 for Zone-1 and Tk. 158/m^3 for Zone-10 (Uttara). It was also observed that transportation cost reduced considerably when 5-ton capacity open truck is used. The same for 5 ton capacity truck wise Tk. 94.70/m^3 for Zone-1 and Tk. 129/m^3 for Zone- 10 (Uttara) respectivly. It was observed that waste transportation by 5 ton capacity open truck was cheaper than the demountable container transportation cost. But for quick handling and disposal, demountable container system must be preferred to reduce the possibility of littering, nuisance, health hazard, and air pollution. It was found from this study that setting transfer station at Gulshan could reduce transportation cost. To transfer wastes of Uttara, Banani, Gulshan, Baridhara using a transfer station costs Tk. 72.8/m^3 instead of Tk.

140.58/m^3 for present system of open truck and demountable truck. It was found from cost analysis that DCC's disposal (landfill management) cost to be Tk. 60/m^3. Cost analysis also showed that recycling and compost production from organic waste may earn Tk. 71.91 per ton of solid waste.

6.2 RECOMMENDATIONS

6.2.1 Recommendations for an efficient solid waste management system

Installation of Modified Transfer Station: To reduce the double handling cost at container loading point and to optimize the transportation cost loading platform and modified transfer station should be setup. From the study result it has been observed that loading through raised platform would save 87.75% of the loading cost (Tk. 12.18/M^3) compared to the present loading system by involving additional cleaner. Setting modified platform at Gulshan, transferring waste using large trailer truck to the landfill site at Matuil would minimize 40% of the present transportation cost.

Privatization of solid waste collection services: To ensure quality of solid waste management service DCC should gradually privatize different service. Domestic waste collection service should be privatized through solid waste management contractors, local NGOs, CBOs, private organizations and specially micro-entrepreneurs. For commercial and industrial waste collection private company may be the best option. Necessary precautionary measures for handling, transportation and primary treatment before disposal should be done.

Establishing Appropriate Technology: For sustainable solid waste management system use of locally available material and appropriate technology should be encouraged. For efficient service, manual and labor intensive street sweeping service should be preferred instead of mechanical broom machine. For "house to house" collection rickshaw van should be preferred instead of self-loading vehicle equipped

with compactor in residential areas. To minimize handling cost of waste before transportation, retaining wall type loading platform may be used.

Waste Management Plan: DCC should prepare a waste management plan for Dhaka City. The solid waste management plan should describe the functional elements such as storage, handling transportation disposal and recycling of domestic, commercial, industrial, hospital and clinical/hazardous waste. The solid waste management plan should describe the possible requirements of labor, equipment and transport for present and future. It should describe the, actions to be taken against polluters, also, it should describe the present and future waste generation.

DCC should prepare solid waste management operation and maintenance schedule, a handbook for its own and also for private company activities. Job description with responsibility and working procedures at different level must be mentioned. This should be explicitly learnt by the supervising staffs and officials. Transportation, disposal, waste handling procedures, polluter offences, must be mentioned in the handbook. Supervision procedure, schedule, reporting, data collection and record keeping procedure must be mentioned in the handbook. Safety provisions for waste handling, transportation and disposal procedure should be mentioned. The service to be leased out to the private company must be prepared which should includes the specification of work, quality standards, units, rates measurement procedure, payment schedule, evaluation and monitoring details.

DCC should establish a solid waste management 'Research and Development' wing to encounter environmental problem. The service of R & D should include monitoring the water quality both surface and groundwater, at and around the landfill sites. It should also conduct research on the development of the completed sites. A viable alternative for processing and disposal of hazardous clinical wastes should also be studied by the R & D.

Cost Minimization: It has been found that there are good prospects of recycling and compost of Dhaka City waste. Compost plant may be established jointly by the DCC and private investors, DCC could save transportation and disposal cost directly from waste volume reduction. Such a plant would generate profit from selling compost. It could also generate employment opportunity, reduced dependency on chemical fertilizer and increase soil fertility. It would increase collection coverage and reduce illegal dumping possibilities. DCC should institutionalize the present unhygienic informal recycling practice, by leasing out the recycling service.

Institutional Strengthening: Dhaka City Corporation (DCC) should reorganize its present conservancy department immediately. Appointment of solid waste management engineers should be made at the top level with specific job descriptions. DCC should deploy, necessary transport and collection vehicles to the solid waste management department including transport operation and maintenance task and facility. Transport drivers should be accountable to this department. At lest 10 (ten) magistrate should be deputed to this department for immediate legal action against the violators. Continuing Professional Development (CPD) should be introduced. Compulsory training program should be conducted for supervising staffs. Provision should be incorporated that no promotion shall be given without completion of compulsory training program course and satisfactory result of CPD.

DCC should establish a solid waste management 'Research and Development' wing to encounter environmental problem. The service of R & D should include monitoring the water quality both surface and groundwater, at and around the landfill sites. It should also conduct research on the development of the completed sites. A viable alternative for processing and disposal of hazardous clinical wastes should also be studied by the R & D.

DCC should set up a modern monitoring and evaluation cell for solid waste

management. There should be a system for recording everyday collection, transportation and disposal information, data must be monitored and evaluated.

Financial Strengthening: There should also be a well-organized financial and budgetary system including a base for revenue generation. User charge for refuse collection should be installed with the delivery of service checked against the citizens willingness and capability to pay for the services rendered and the infrastructure provided for them. There is a need to install and standardize fees for waste collection which can be similar to the regular water bills being charged to resident based on the 'polluter pays' principle to make public realize that creating and producing garbage entails cost. More fund can be generated from industrial commercial unit those are at present producing large amount of waste..

Public Awareness Program: Social acceptability of new system and technique for solid waste collection is hard to achieve especially when they go against local cultural and behavioral traits. New collection style should be introduced in co-operation with community organizations. This can provide important information and understanding by the people and success depends on their active participation and co-operation. Citizen should be well informed of definite time to bring the waste to the collection van or community bin or containers so that no garbage are left to litter or scattered by street scavengers and animals. Penalty provision details should be displayed at collection points, bin sites. Intensive education, information, film and video show, demonstration, comparing program can incorporated in the school curriculum.

Accommodation of Solid Waste Management in Town Planning: Town planning department like RAJUK should provide some space for infrastructure facilities during planning for new township like local waste processing center, modified transfer station, loading platform, bin or container placing area with sufficient maneuvering space for container carrying vehicle during lifting and placing.

6.2.2 Recommendations for further study

Due to resource constraint in collecting samples from door to door, and due to constraints in analyzing the samples in the laboratory the sample size was kept purposefully small and may not be statistically representative of the study area. Thus, the results obtained on generation rate should be used with caution remembering that these data will be more applicable for the areas and the communities having same characteristics as the study area. Thorough data collection from densely populated and mid-income group areas such as Malibagh, Rampura and other part of old Dhaka need to be done to establish the representative generation rate.

The design concept for a sanitary landfill consist of restricting leachate seepage into the aquifer so as to minimize groundwater degradation. To satisfy the design criteria a detailed design of several landfill elements is necessary. The proper functioning of each elements, such as, liner, leachate collection system, storm water routing, Bern, stability of slope, access road, landfill cover, gas venting, converting of existing natural attenuation landfills to sanitary landfill is essential to construct and maintain a landfill in an environmentally sound manner.

As street sweeping waste contribute 33% of total estimated generation and 76% of total cleaner of DCC are being engaged in street sweeping activities so productivity of cleaner and waste generation rate must be established with extensive study.

Waste to electricity production, compost production, prospect of recycling, intensive study in this issue should undertake.

REFERENCES

Ahmed, M.F. (1993), 'Municipal Waste Management in Bangladesh with Emphasis on Recycling' presented in the Regional Workshop on Urban Waste Management in Asian Cities, Dhaka, April 10-12.

Ahsan, Haque and Haque (1992); 'Waste Pickers and Recycling of Solid Waste in Dhaka City' published in Bangladesh Urban Studies, Volume-1, Number-1, December 1992.

Bangladesh Gazette (1983); 'The Dhaka Municipal Corporation, 1983' Government of Bangladesh, Ministry of Law and Land Reforms, Law and Parliamentary Affairs Division, Dhaka.

BBS (1997); 'Statistical Pocket Book of Bangladesh 19097' Statistics Division, Ministry of Planning, Dhaka.

Bhide, A.D. (1990); 'Solid Waste Management at Dhaka, Khulna & Natore' WHO Project Assignment Report: BAN CWS OO1, July-August.

Enayetullah, (1994) ; 'A study of Solid Waste Management for Environmental Improvement of Dhaka City' Master thesis Department of URP, Bangladesh University of Engineering and Technology. Dhaka.

Haque, N. (1993); Community Participation and waste Management' Dhaka City' Paper presented in the Regional Workshop on Urban Waste Management in Asian Cities, Dhaka Bangladesh April 10-12.

Mohit, M.A. (1995); Solid Waste Management in Dhaka City': A case of Neighborhood involvement collection system' Paper presented in a workshop in

World Habitat Day, Dhaka, October 2.

Peavy, H.S. and Row, D.R (1985), 'Environmental Engineering' McGraw-Hill Book, Publishing Company Limited..

Trivedi, P.R. and Raj, G(1992), 'Solid Waste Pollution' New Delhi: Akashdeep Publishing House.

Tchobanoglous, George (1977), 'Solid Waste Engineering Principles and Management Issue' McGraw Hill Publications Company.

MMI (1990) : 'Solid Waste Management Draft Technical Manual' Prepared by Mott. Macdonald Limited International, in association with Cuplin planning limited, Engineering and Planning consultants limited.

DMDP (1992); 'Dhaka Metropolitan Development Planning waste management report' Prepared by Mott. Macdonald Internal Limited. Engineering and Planning consultant GOB, RAJUK.

Kok, Martijin(1996) ' Research on Hazaribag area from Urban Planning Prospective'.

Sinha, Maqsood, A.H.M (1995) 'Solid Waste Management and Recylcing in Dhaka': Problem and prospects a paper published in 'EARTH Magazine' issues No. 4, 1995

Sinha, Maqsood, A.H.M (1995) 'Recycling Potentials of Organic Waste in Dhaka' a paper published in 'EARTH Magazine' Issue No. 5, 1995.

Waste Concern (1998), A project proposal named 'Proposal for a pilot 10(ten) Ton capacity Decentralized Organic Waste Recycling Plant Near Kawran bazar Vegetable Market Area. Zone-6, Dhaka' submitted to DCC.

DCC (1998); 'Waste Land filling and Hospital waste incineration in Dhaka, Bangladesh' a project concept paper prepared by Dhaka City Corporation based on report submitted by Roteb- Solid waste constancy B.V. The Netherlands.

Yousuf, T.B (1996); 'Sustainability of Solid Waste Management system of Dhakd City Corporation' M. Eng. Thesis, BUET.

Bagchi, A (1990); 'Design Construction and Monitoring of Sanitary Land fill. Jhone Wiley and Sons.

Choudhury, J.R (1998) 'A Review of Problems of Dhaka Metropolis and Their Suggested Solution' a paper presented in the seminar on Problems of Dhaka Metropolis and Integrated Approach Towards Solution held at IEB on October 16-17.

APPENDIX-A

ABBREVIATIONS

BBS	:	Bangladesh Bureau of Statistics
BCSIR	:	Bangladesh Council of Scientific & Industrial Research
CBO	:	Community Based Organizations.
DCC	:	Dhaka City Corporation
DMDP	:	Dhaka Metropolitan Development Program
DWASA	:	Dhaka Water Supply and Sewerage Authority
LGED	:	Local Government Engineering Department
MSW	:	Municipal Solid Waste
NGO	:	Non-Government Organization'
SAARC	:	South Asian Association for Regional Co-operation.
SWM	:	Solid Waste Management
UNCHS	:	United Nations Center for Human Settlements
UNCED	:	United Nations Conference on Environment & Development
MMI	:	Mott Madconald Limited International.

APPENDIX-B

Information Supplied by Engineering Department
For Uttara ,Sector- 1.

Length of drain	-	1.742 km.
Road (in km.)		3.871 km.

Information supplied by the Revenue Department

⌘	Residential holding	:	140
	Pucca unit	:	140
	Semi-pucca unit	:	x
	Kutcha unit	:	x
⌘	Commercial holdings		5
	Residential hotel	:	x
	Restaurant	:	2
	Market	:	x
	Shoping complex	:	x
	Shops	:	x
	Cinema Hall	:	x
	Clinics	:	2
	Hospitals	:	1
	Maternity Centers	:	x
	Others	:	x
⌘	Industrial holdings	:	x
	Garments	:	x
	Other (if any implementation)	:	x
⌘	Institutional holdings	:	1
	School	:	x
	College	:	1
	Madrasha	:	x
	Mosque	:	x
	Mandir	:	x
	Orphangage	:	x
	Crurch	:	x
	Mission	:	x
	Park	:	x
	Playground	:	x
	Community center	:	x
	Graveyard	:	x
	Shashanghat	:	x

Information supplied by Conservancy Department, Uttara, Sector-1.

No. of cleaners	-	7
No. of storm drain cleaner	-	2
No. of community bins	-	7
No. of of containers	-	x
No. of Rickshaw vans	-	1
engaged (Privately)	-	1

Information Supplied by Engineering Department
Uttara, Sector- 3

Length of drain	-	18.020 km.
Road (in km.)	-	9.010 km.

Information supplied by the Revenue Department, Uttara, sector -3

⌘	Residential holding	:	423
	Pucca unit	:	423
	Semi-pucca unit	:	x
	Kutcha unit	:	x
⌘	Commercial holdings		10
	Residential hotel	:	x
	Restaurant	:	2
	Market	:	x
	Shoping complex	:	10
	Shops	:	x
	Cinema Hall	:	x
	Clinics	:	2
	Hospitals	:	1
	Maternity Centers	:	x
	Others	:	x
⌘	Industrial holdings	:	x
	Garments	:	x
	Other (if any implementation)	:	x
⌘	Institutional holdings	:	6
	School	:	3
	College	:	1
	Madrasha	:	x
	Mosque	:	1
	Mandir	:	x
	Orphangage	:	x
	Crurch	:	x

Mission	:	x
Park	:	x
Playground	:	1
Community center	:	x
Graveyard	:	x
Shashanghat	:	x

Information supplied by Conservancy Department, Uttara, Sector- 3

No. of cleaners	-	10
No. of storm drain cleaner	-	4
No. of community bins	-	10
No. of Handicraft	-	4
No. of of containers	-	1
No. of Rickshaw vans engaged (Privately)	-	2

Information Supplied by Engineering Department
For Uttara (Sector 4)

Length of drain	-	20.842 km.
Road (in km.)	-	10.421 km.

Information supplied by the Revenue Department, Uttara, Sector -4

⌘	Residential holding	:	655
	Pucca unit	:	655
	Semi-pucca unit	:	x
	Kutcha unit	:	x
⌘	Commercial holdings		3
	Residential hotel	:	x
	Restaurant	:	1
	Market	:	x
	Shoping complex	:	x
	Shops	:	x
	Cinema Hall	:	x
	Clinics	:	2
	Hospitals	:	x
	Maternity Centers	:	x
	Others	:	x
⌘	Industrial holdings	:	x
	Garments	:	x
	Other (if any implementation)	:	x

⌘	Institutional holdings	:	9
	School	:	4
	College	:	x
	Madrasha	:	x
	Mosque	:	2
	Mandir	:	x
	Orphangage	:	x
	Crurch	:	x
	Mission	:	x
	Park	:	x
	Playground	:	1
	Community center	:	1
	Graveyard	:	1
	Shashanghat	:	x

Information supplied by Conservancy Department, Uttara, Sector 4

No. of cleaners	-	14
No. of storm drain cleaner	-	6
No. of community bins	-	12
No. of Handicraft	-	5
No. of of containers	-	1
No. of Rickshaw vans engaged (Privately)	-	3

Information Supplied by Engineering Department
Uttara ,Sector-5

Length of drain	-	8.582 km.
Road (in km.)	-	4.291 km.

Information supplied by the Revenue Department, Uttara ,Sector -5

⌘	Residential holding	:	347
	Pucca unit	:	347
	Semi-pucca unit	:	x
	Kutcha unit	:	x
⌘	Commercial holdings		1
	Residential hotel	:	x
	Restaurant	:	x
	Market	:	1
	Shoping complex	:	x
	Shops	:	x
	Cinema Hall	:	x

	Clinics	:	x
	Hospitals	:	x
	Maternity Centers	:	x
	Others	:	x
⌘	Industrial holdings	:	x
	Garments	:	x
	Other (if any implementation)	:	x
⌘	Institutional holdings	:	4
	School	:	2
	College	:	x
	Madrasha	:	x
	Mosque	:	2
	Mandir	:	x
	Orphangage	:	x
	Crurch	:	x
	Mission	:	x
	Park	:	x
	Playground	:	x
	Community center	:	x
	Graveyard	:	x
	Shashanghat	:	x

Information supplied by Conservancy Department, Uttara, Sector 5

No. of cleaners	-	7
No. of storm drain cleaner	-	2
No. of community bins	-	8
No. of Handicraft	-	3
No. of of containers	-	1
No. of Rickshaw vans	-	2
engaged (Privately)	-	

Information Supplied by Engineering Department
For Uttara ,Sector- 6

Length of drain	-	10.426 km.
Road (in km.)	-	5.213 km.

Information supplied by the Revenue Department, Uttara ,Sector -6

⌘	Residential holding	:	239
	Pucca unit	:	239
	Semi-pucca unit	:	x
	Kutcha unit	:	x
⌘	Commercial holdings		1
	Residential hotel	:	x
	Restaurant	:	x
	Market	:	1
	Shoping complex	:	x
	Shops	:	x
	Cinema Hall	:	x
	Clinics	:	x
	Hospitals	:	x
	Maternity Centers	:	x
	Others	:	x
⌘	Industrial holdings	:	1
	Garments	:	1
	Other (if any implementation)	:	x
⌘	Institutional holdings	:	8
	School	:	3
	College	:	1
	Madrasha	:	2
	Mosque	:	1
	Mandir	:	x
	Orphangage	:	x
	Crurch	:	x
	Mission	:	x
	Park	:	x
	Playground	:	I
	Community center	:	x
	Graveyard	:	x
	Shashanghat	:	x

Information supplied by Conservancy Department, Uttara, Sector -6

No. of cleaners	-	11
No. of storm drain cleaner	-	3
No. of community bins	-	7
No. of Handicraft	-	3
No. of of containers	-	I
No. of Rickshaw vans	-	1

engaged (Privately) -

Information to be Supplied by Engineering Department
For Uttara ,Sector-7

Length of drain	-	18.817 km.
Road (in km.)	-	9.408 km.

Information supplied by the Revenue Department, Uttara, Sector -7

⌘	Residential holding	:	476
	Pucca unit	:	476
	Semi-pucca unit	:	x
	Kutcha unit	:	x
⌘	Commercial holdings		3
	Residential hotel	:	x
	Restaurant	:	x
	Market	:	1
	Shoping complex	:	x
	Shops	:	x
	Cinema Hall	:	x
	Clinics	:	2
	Hospitals	:	1
	Maternity Centers	:	x
	Others	:	x
⌘	Industrial holdings	:	1
	Garments	:	1
	Other (if any implementation)	:	x
⌘	Institutional holdings	:	5
	School	:	1
	College	:	x
	Madrasha	:	x
	Mosque	:	2
	Mandir	:	x
	Orphangage	:	x
	Crurch	:	x
	Mission	:	x
	Park	:	1
	Playground	:	1
	Community center	:	x
	Graveyard	:	x
	Shashanghat	:	x

Information to be supplied by Conservancy Department, Uttara, Sector 7

No. of cleaners	-	12
No. of storm drain cleaner	-	4
No. of community bins	-	13
No. of Handicraft	-	4
No. of of containers	-	2
No. of Rickshaw vans engaged (Privately)	-	3

Information to be Supplied by Engineering Department
For Banani

Length of drain	-	11.5 km.
Road (in km.)	-	21.27 km.

Information to be supplied by the Revenue Department, For Banani

⌘	Residential holding	:	1280
	Pucca unit	:	1950
	Semi-pucca unit	:	x
	Kutcha unit	:	x
⌘	Commercial holdings		105
	Residential hotel	:	8
	Restaurant	:	4
	Market	:	1
	Shoping complex	:	1
	Shops	:	x
	Cinema Hall	:	x
	Clinics	:	1
	Hospitals	:	x
	Maternity Centers	:	x
	Others	:	x
⌘	Industrial holdings	:	1
	Garments	:	1
	Other (if any implementation)	:	x
⌘	Institutional holdings	:	
	School	:	3
	College	:	1

Madrasha	:	x
Mosque	:	4
Mandir	:	x
Orphangage	:	x
Crurch	:	x
Mission	:	1
Park	:	6
Playground	:	1
Community center	:	x
Graveyard	:	1
Shashanghat	:	1
Private University	:	2

Information supplied by Conservancy Department, For Banani

No. of cleaners	-	29
No. of storm drain cleaner	-	-
No. of community bins	-	18
No. of Handicraft	-	8
No. of of containers	-	5
No. of Rickshaw vans engaged (Privately)	-	4

Information Supplied by Engineering Department
For Gulshan

Length of drain	-	9.5 km.
Road (in km.)	-	36.0 km.

Information supplied by the Revenue Department, For Gulshan

⌘	Residential holding	:	1839
	Pucca unit	:	2180
	Semi-pucca unit	:	1
	Kutcha unit	:	x
⌘	Commercial holdings		64
	Residential hotel	:	3
	Restaurant	:	18
	Market	:	2
	Shoping complex	:	25
	Shops	:	x

	Cinema Hall	:	1
	Clinics	:	6
	Hospitals	:	2
	Maternity Centers	:	x
	Others	:	x
⌘	Industrial holdings	:	
	Garments	:	19
	Other (if any implementation)	:	1
⌘	Institutional holdings	:	
	School	:	4
	College	:	2
	Madrasha	:	x
	Mosque	:	4
	Mandir	:	x
	Orphangage	:	x
	Crurch	:	x
	Mission	:	x
	Park	:	4
	Playground	:	1
	Community center	:	1
	Graveyard	:	x
	Shashanghat	:	x

Information supplied by Conservancy Department, For Gulshan

No. of cleaners	-	37
No. of storm drain cleaner	-	-
No. of community bins	-	21
No. of Handicraft	-	14
No. of of containers	-	6
No. of Rickshaw vans engaged (Privately)	-	9

Information Supplied by Engineering Department
For Baridhara

Length of drain	-	15.5 km.
Road (in km.)	-	11.29 km.

Information supplied by the Revenue Department, For Baridhara

⌘	Residential holding	:	636
	Pucca unit	:	721
	Semi-pucca unit	:	6
	Kutcha unit	:	x
⌘	Commercial holdings		x
	[illegible]	:	[illegible]
	Market	:	x
	Shoping complex	:	x
	Shops	:	x
	Cinema Hall	:	x
	Clinics	:	x
	Hospitals	:	x
	Maternity Centers	:	x
	Others	:	x
⌘	Industrial holdings	:	x
	Garments	:	x
	Other (if any implementation)	:	x
⌘	Institutional holdings	:	
	School	:	1
	College	:	x
	Madrasha	:	x
	Mosque	:	2
	Mandir	:	x
	Orphangage	:	x
	Crurch	:	x
	Mission	:	x
	Park	:	1
	Playground	:	x
	Community center	:	x
	Graveyard	:	x
	Shashanghat	:	x
	Private University	:	2

Information supplied by Conservancy Department, For Baridhara

No. of cleaners	-	10	
No. of storm drain cleaner	-	-	
No. of community bins	-	81	
No. of Handicraft	-	54	
No. of of containers	-	2	
No. of Rickshaw vans	-	2	engaged (Privately)

NUMBER OF PLOTS IN SECTOR I1, 12,13, 14 OF UTTARA MODEL TOWN

Sector :-11 3 Khata = 943
5 Khata = 313
Total =1256

Sector :- 12 3 Khata = 919
5 Khata = 212
Total =1139

Sector :- 13 3 Khata = 588
5 Khata = 533
Total =1121

Sector :- 14 3 Khata = 941
5 Khata = 98
Total =1039

List of Commercial (Shopping Complex) Unit at Uttara.

Sl. NO.	NAME OF THE COMMERCIAL UNIT	NO OF STORIED	NO. OF SHOP	FLOOR SPACE AREA
1.	Amir Complex	7 G.Floor		
		1st floor	61	17, 186 sft
			62	
2.	A.B. Super Market	7		
		G.floor	17	2,554 sft
		1st Floor	15	
3.	Uttara Vhaban	2 stairs		3,500 sft.
		G. Floor	7	
4.	London Plaza	7		
		G.Floor	28	11,500 sft
		1st Floor	28	11,500 sft
5.	Kusul Center	7		
		Basement	121	14,800 sft
6.	Belly complex	6		
		G.Floor	13	12,000.00 sft
7.	Singapore Plaza	6		6,868sft
8.	Ahmed Plaza	6		4,000 sft
9.	Rajlaxmi Complex	6		
		G. Floor	3	9,000 sft.
		1st Floor	3	
		2nd Floor	6	

LIST OF HOLDING IN SECTOR-8

Sl. NO.	NAME OF THE BUILDING	BUILDING NO	STORIED	UNIT
1	House Buldg. staff Quarter	6	5	2
2.	S.B. Staff Quater	1	3	2
3	S.B. Staff Quarter	2	5	2
4	S.B. Staff Quarter	6	4	2
5	Sonali Bank Quater	2	5	2
6	Sonali Bank Quater	2	5	1
7	Abohawa Staff Quater	4	4	2
8	Abhowa Staff Quater	6	3	2
9	Postal Staff Quater	5	5	2
10	Postal Staff Quater	1	4	2
11	Thana Quarter	2	6	2
12	Forest Staff Quarter	1	5	2
13	Forest Staff Quarter	4	4	2
14	C.I.C. Staff Quarter	3	5	2
15	P.W.D. Staff Quarter	21	5	2
16	Health complex staff Quarter	4	3	2
17	Petrobangla Office	1	4	2
18	T.N.T. staff quarter (under cons.)	1	5	2
19				

'APPENDIX'-C

CALCULATION OF STREET SWEEPING WASTE GENERATION RATE.

According to results obtained from present survey.

Internal road	0.16 kg/meter/day
Main road	0.36 kg/meter/day.

Total road of DCC area	1500 km.
10% main road	150 Km.
Internal road	1350 km

Waste generated from main road	5.4 Ton/ day
Waste generated from internal road	216 Ton/ day
Total estimated generation	270 Ton/day.

Population of DCC area according to 1991 census with 3.72% growth rate	3.397 million
Population of 2000	4.709 million
Per capita generation $= \frac{270}{4709}$	0.05 kg/cap/day.

APPENDIX-D

Determination of Number of Trips / day of haul container system.

A) Waste collection area = Uttara Model Town

Waste disposal site = Matuail

Formula used $Nd = (1-W)H/(P_{hes} + s + a + bx)$

N_d= Number of Trips per day, trips/day.

P_{hcs}= Pick-up time per trip for haul container system, h/trip

= 0.66 h/trip. (from field survey).

S= at site time per trip, h/trip = 0.28 h/trip.

h= haul time per trip, h/trip.

= 2 hr/trip

W= off -rout factor, expressed as a fraction = 0.16

H= Length of work day, h/day = 8 h/day.

$N_d = \frac{(1-0.16)\,8}{0.66+0.25+2} = \frac{6.8}{2.91} = 2.30 = 2$ Trip/day

B) Waste collection from Banani, Gulshan & Baridhara.

P_{hcs} = 0.66 h/trip, S= 0.25 h/trip. h= 1.5 h/trip

W= 0.12 H= 8 hr/day.

$$N_d = \frac{(1-.12)8}{0.66 + 0.25 + 1.5} = \frac{7.04}{2.41} = 2.92 = 3\text{trip/day}$$

'APPENDIX'-E

Re-calculation of Yousuf analysis of life time unit cost of stationery container and demountable transport system.

Open truck (3 ton payload) :

Estimated life time	=	*54 month*
(25 days= 1 month)		
Capital cost	=	*8,07,500.00*
3 ton payload		
Operating cost	=	*4,48,686.00*
Life time cost	=	*12.56.186.00*

Average Haul cost :

Estimated life time	=	*60 month*
(25 days= 1 month)		
Life time cost	=	*12,56,186.00*
Average load	=	*4.8 M^3 or 2.64 Ton*
Average no of load		
Per day	=	*2*
No or loads in life time	=	*12.960 M^3*
Cost/cum-		*Tk. 96. 92/M^3*
Cost/Ton 02		*Tk. 176/Ton.*

Demountable Container (3 Ton pay load)

Capital cost = 1264756+ 4x 93744=	*16,39732.00*
Operation cost	*Tk. 470, 640.00*
Life time cost	*Tk. 21,10312*
Average volume = 4.8 cum	
Average no of load/day =4	
No. of loads in life time volume	*=28800M^3*
	=15840 Ton
Cost / Ton	*=Tk. 133.23/Ton*
Cost/Cum	*=Tk. 73.27/cum.*

'APPENDIX'-F

DAILY SOLID WASTE COLLECTION CAPACITY OF DCC.

Daily collection of Waste by DCC according to list supplied by trnasport division of DCC , 1997

OPEN TRUCK :

5 ton - 60 Trips		x7 m^3	420 tons
5 ton - 120 trips		x 4.8 m^3	576 tons
2 ton 135 trips	x 3.42		456.3 tons
1.5 ton	x 2.42		14.3
			= 1666.87

CONTAINER:

405 Trips x 6x.8	=	43%	
Container	=	57%	
Weight	=	3410.82x60kg/day	204.6 tons

Consider 30% vehicle off route for mechanical or man made reasons.

Daily Collection : 1432 ton/ day

If DCC collection is 60% of total generation.

Estimated generation = 2387 Tons/day.