PRACTICAL APPROACH TO INCREASE THE LEVEL OF PEOPLES' AWARENESS AND COLLECTION OF MUNICIPAL SOLID WASTE

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A thesis submitted in partial fulfillment of the requirements for the degree of
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Declaration

This is to certify that the thesis work entitled as "Practical Approach to Increase the Level of Peoples' Awareness and Collection of Municipal Solid Waste" has been carried out by Jhumana Akter in the Department of Civil Engineering, Khulna University of Engineering & Technology, Khulna, Bangladesh. The above research work or any part of this work has not been submitted anywhere for the award of any degree or diploma.
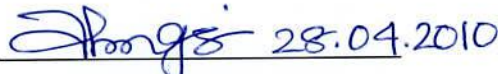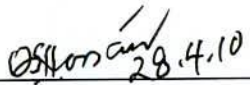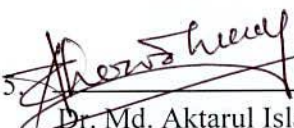
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Jhumana Akter, April 2010

DEDICATION

To

my parents who taught me morality

and

my beloved husband

ABSTRACT

Due to inadequate waste management related infrastructures, lack of peoples' awareness, motivation and participation, severe financial constraints, absence of appropriate and sustainable technology and ineffective legislation and law enforcement Municipal Solid Waste (MSW) remains unmanageable in most of the cities of Least Developed Asian Countries including Bangladesh and possesses threat to city dwellers, stakeholders and creates new issues to planners and city management authority. The primary but most important steps in the waste management hierarchy are to store the wastes in a designated place by any means, ensure primary waste collection from the sources and public awareness about improvement of solid waste management.

This study focuses on the decisive evaluation of the existing system and level of source storage, primary collection and city dwellers awareness and perception of MSW management at Ward No. 24 of Khulna City Corporation (KCC) of Bangladesh. It occupies an area of 161.05 hectares with a total population of 52,624. Waste generation rate in study area varies from 0.28 to 0.47kg/cap/day, which amounted as 15 to 25ton/day. Moreover, due to lack of motivation, awareness and commitment, a considerable portion of waste, 30-35%, are not properly stored, collected or disposed in designated places for ultimate disposal. By extensive data collection, it has been observed that only 53-54% of total generation of waste is collected and disposed per day by KCC. Rest of the waste remains uncollected thus creates unhealthy environment all around such as bad odor, soiled street and aesthetically problem.

Several practical steps have been undertaken in this ward to improve the level of people's awareness and collection systems such as stakeholders' dialogue, mass awareness rally, commitment signature, distribution of awareness leaflet, children art competition, door-to-door campaign, installation of festoon, introduction of newly designed Rickshaw Van. A statistical analysis is also carried out to analyze people's attitude and investigate the actual scenario of the study area. The percentages of door-to-door, self disposal and open dumping practices were 9.5 to 70.1, 17.0 to 70.0 and 9.0 to 29.6, respectively. With this situation almost 50% of people was quite satisfy with the existing MSW practices where the rest percentages expressed their dissatisfaction. Due to all these taken initiatives, collection efficiencies changes to 20.0 to 80.0, 9.41 to 40.0 and 12.0 to 49.33, respectively in terms of door-to-door, self disposal and open dumping practices. With this collection efficiency percentages of people's satisfaction and dissatisfaction changes to 67% and 33%, respectively. However it is difficult to identify the actual situations which are positively related to different influence factors such as public attitudes; habits and customs of living; economic conditions and standards of living etc., which are changes with time and preference In the context of Bangladesh, the findings are beneficial for any responsible authority or concerned stakeholders who are interested for development of an effective sustainable solution of MSW. To get real achievement in any implemented system, all the necessary components should be accomplished with great care in an integrated and sustainable way.

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Abbreviations

BBS	:	Bangladesh Bureau of Statistics
CBO	:	Community Based Organization
DoE	:	Department of Environment
HCs	:	Haul Containers
IN	:	Iqbal Nagar
KCC	:	Khulna City Corporation
KDA	:	Khulna Development Authority
KUET	:	Khulna University of Engineering and Technology
LDACs	:	Least Developed Asian Countries
MDC	:	More Developing Country
MP	:	Muslim Para
MSW	:	Municipal Solid Waste
MSWM	:	Municipal Solid Waste Management
NGO	:	Non-Governmental Organization
RP	:	Roy Para
SDS	:	Secondary Disposal Site
SFP	:	South Farazi Para
SG	:	South Gollamari
TK.	:	Taka
TP	:	Transfer Plant
UDS	:	Ultimate Disposal Site
US$	:	U.S. Dollar
US PHS	:	U.S. Public Health Service
WB	:	West Bagmara
YR	:	Year

Definitions of Symbols

- α, the probability of Type I error (rejecting a null hypothesis when it is in fact true)
- n = sample size
- n_1 = sample 1 size
- n_2 = sample 2 size
- $\bar{x}$ = sample mean
- μ_0 = hypothesized population mean
- μ_1 = population 1 mean
- μ_2 = population 2 mean
- σ = population standard deviation
- σ^2 = population variance
- s = sample standard deviation
- s^2 = sample variance
- s_1 = sample 1 standard deviation
- s_2 = sample 2 standard deviation
- df = degrees of freedom
- $\bar{d}$ = sample mean of differences
- d_0 = hypothesized population mean difference
- H_0 = Null hypothesis
- H_A = Alternative hypothesis
- s_d = standard deviation of differences
- $\hat{P}$ = x/n = sample proportion, unless specified otherwise
- p_0 = hypothesized population proportion
- p_1 = proportion 1
- p_2 = proportion 2
- d_p = hypothesized difference in proportion
- $x_1 = n_1 p_1$
- $x_2 = n_2 p_2$
- χ^2 = Chi-squared statistic

Units of Measurements

gm	:	Gram
kg	:	Kilogram
km^2	:	Square kilometer
Kg/m^3	:	Kilogram per Cubic Metre
kg/day	:	Kilogram per Day
kg/family	:	Kilogram per Family
kg/cap/day	:	Kilogram per Capita per Day
m	:	Meter
m^3	:	Cubic Metre
Tk. /family /month	:	Taka per Family per Month
t/day	:	Ton per Day

CHAPTER ONE

INTRODUCTION

1.1 General

The management of solid waste continues to be a major challenge in urban areas throughout the world, but particularly in rapidly growing cities and towns of the developing world (Seik, 1997). Ineffective and inefficient solid waste management can result in environmental health hazards and can have negative impacts on the environment. Solid waste presents a problem of disposal, but is also seen as a possible resource. However, when the disposed objects are handled correctly, they can have value and are called "waste". The collection, handling and disposal of solid wastes in large cities constitute a problem that is causing worldwide concern. It is a fact that solid waste composition differs from one community to another according to their culture and socio-economic level. However, solving inadequate management of solid waste in general is very challenging because of its heterogeneous nature. On the other hand, solving the problem in urban area of developing countries is more challenging because of two factors: a) low socio-economic level of the majority of population and their lack of awareness of scope of problem as well as b) lack of a suitable technology platform needed to face problem.

In Bangladesh, specifically in the urban areas, appropriate measures for waste disposal are urgently needed due to the rapid population growth, which resulting the huge increase of MSW. Indiscriminate throwing of solid waste by the generators at the waste collection stations and improper collection system have resulted in scattered garbage, offensive odor, polluted water and breeding place for mosquitoes and flies. The sanitary environment in the urban areas has deteriorated causing adverse impacts on the health of the residents. Furthermore, partially collected wastes are disposed unscientifically at the final disposal site in an open low-lying areas or abandoned land, even along the roads, causing serious adverse environmental impacts, which threat to human and nature.

Solid waste management in Bangladesh is still in the primitive stage and needs modernization and automation through innovative and appropriate approach for its proper management. One of the main problems in solid waste management is to find out the generation of solid waste in a city as waste generation varies with each individual (Chan, 1993). The information of waste generation rate, trend of waste compositions and characteristics is important. This helps in estimating the projected generation rates and improves the efficiency of storage, collection, transportation and disposal in order to develop a sustainable solid waste management plan.

1.2 Municipal Solid Waste Management (MSW)

Wastes are useless or unwanted solids or any other materials produced at all levels of human activities. Municipal solid waste dynamics in less developed countries (LDCs) and more developing countries (MDCs) reveal that rapid population growth and urbanization have led to the massive growth of cities in LDCs, which has far outstripped efforts of municipal governments to provide basic services to their citizens (Taylor, 2004). Urban solid waste is the product of a wide range of activities that take place in household, commercial, industrial, institutional and agricultural activities in urban areas (Pacione, 2001). Municipal solid waste comprises primarily household collected waste, but also includes light commercial and industrial waste collected by local authorities.

According to Read (1999), it is best to address municipal solid waste because, as the waste that the public has most contact with, the management of municipal solid waste has achieved a high political profile. Household waste is an element of municipal solid waste, which is one of the most challenging sources of waste to manage effectively because of the diverse nature of its material. According to Noehammer & Byer (1997), residential programme can differ in the point of collection, and in other factors such as programme type, materials collected, number of segregations, provision of collection container, collection frequency, collection day, collection vehicle type, availability of education programme and economic incentives.

1.3 Background of the Study

Due to inadequate waste management, lack of people's awareness, motivation and participation, severe financial constraints, absence of appropriate technology and ineffective legislation and law enforcement, management of MSW remains unmanageable and possesses threat to city dwellers and other stakeholders. Therefore, solid waste - the most striking,

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complex and focusing environmental and social issues - must be managed in an appropriate way, which is absent in most of cities in LDACs including Bangladesh. In Bangladesh, the urban population has been increasing at a very steep rate, about 6% and is concentrated mostly in six major cities, where nearly 13% of total population and 55 to 60% of total urban population are living. Management of these steeply increasing vast quantities of solid wastes is a very complex process indeed. Due to severe financial constraints, absence of appropriate technology, lack of people's awareness, motivation and participation, ineffective legislation and law enforcement to protect the environment and to handle the waste, the whole system is becoming a threat to city dwellers, planners and other stakeholders. To ensure a clean, hygiene and environmental-friendly city, the city authority is looking for a safe and sustainable solution for the appropriate management of solid wastes.

To have a clean, hygiene and environmental-friendly cities in the LDACs, an appropriate MSW management technique based on prevailing socio-economic settings, technological capabilities and present needs of a particular urban area to be considered through participation in a constructive dialogue amongst the concerned stakeholders. This study also critically identified the present status and constraints of MSW management of the study areas and proposed an approach to solve this problem putting priorities on some specific areas. It advocates the need for the reality check of the employed approach for required refinement. To this endeavor, in order to develop a safe and sustainable management of MSW in Bangladesh through the practical application and reality check, Khulna, the third largest city of Bangladesh is considered as the main case study area. Some initiatives had been taken to increase the level of MSW collection and public awareness.

The outcome of this research will clearly represent the present situation of MSW generation, collection and basic problems in MSW management system in the study area. The findings will be beneficial for any responsible authority or concerned stakeholders who are interested for development of an effective sustainable solution of MSW.

1.4 Objectives of the Study

The overall objective of this study is to facilitate environmental and social consciousness and improvement with a focus on decisive evaluation of existing system and level of source storage, primary collection and city dwellers awareness and perception of MSW management

in selected target area. The outcome of this research will represent the present situation of MSW management system of the study area, related problem, and possible solution and finally utilize outcome of performed initiatives clearly.

The objectives of this study can be listed by the followings:

(i)   ' To collect information on existing MSW system in the study area.

(ii)   To conduct field survey in order to investigate the status of MSW system.

(iii) To assess these scenarios regarding the objectives of waste management.

(iv) To investigate the attitudes of the householders and determine their actual participation in the process.

(v)   To summarize the study based on the implemented initiatives in the study area.

1.5 Scope of the Study

At present no effective MSW management is practiced in ward no. 24 and even in any major cities of Bangladesh. Management of municipal solid waste is beset by a number of problems. Generated MSW are partially collected and just dispose into open low-lying areas, known as Ultimate Disposal Site (UDS) by city authority. The reliable information is collected based on the data of primary and secondary sources. The change of MSW generation, composition, collection, transfer and disposal are determined by comparing the data obtained in the target area.

Public attitudes about and willingness to participate in MSW management are the main driving forces in such endeavors. Equally so is the need for increased levels of collection and transfer in order to achieve an increased level of disposal in an environmentally friendly manner. Informal waste collection by different private organization (NGO, CBO etc.) has already put a positive impact on the overall MSW management system in the residential areas of ward no. 24. Some initiatives were taken in this research to control solid waste management to have a sustainable waste management plan.

1.6 Research Framework

Figure 1.1 diagrams the research design and method of research used in the study. It is a logical explanation of steps that can be followed to replicate the same kind of research in the future at elsewhere. It explains in a nutshell a possible method of evaluating householders' attitudes towards and willingness to participate in a domestic waste management programme. The major steps are to (i) define the aim of the study; (ii) define ways to achieve the objectives; (iii) describe the data required to achieve the aim of the study and method of data collection; (iv) provide background information about urban solid waste management; (v) methods of data analysis to results that describe and explain the findings; and (vi) draw conclusions and assess the successfulness of the research.

Aim: Investigate household solid waste management programme for ward no. 24 residents of Khulna city by assessing public participation and willingness

Objectives: Facilitate environmental and social consciousness and improvement through environmental initiatives and technology dissemination with a focus on decisive evaluation of existing system and level of source storage, primary collection and city dwellers awareness and perception of MSW management in ward no. 24.

(Chapter 1)

Literature review: Details about source and types of MSW, various methods of estimation of MSW generation, physical composition and various characteristics of MSW are described in this chapter. Brief reviews of relevant literatures are also discussed here.

(Chapter 2)

Overview of study area: Overview of the study area together with theoretical overview of municipal solid waste management programmes; attitudes towards domestic solid waste management; barriers to and motives for household solid waste management system in target area.

(Chapter 3)

Data description and collection method
- Householders' general waste data – socio-demographic, socio-economic and spatial data; household solid waste management awareness and views about it, potential participation and willingness to participate in domestic solid waste management
- Household questionnaire survey

(Chapter 4)

Data analysis: Descriptive analysis of all collected data, describe householders' attitude towards and participation in household solid waste management; explain the relationship between householders' characteristics (age, gender educational status, employment status, income, housing tenure, housing type as well as their residential location and willingness to participate). Development of hypothesis and analyze with a view of realizing the actual facts questionnaire survey results:

(Chapters 4 & 5)

Summary and conclusions: Assess the achievement of objectives; draw conclusions of the findings and provide summary for further research to improve household solid waste management system

(Chapter 6)

Figure 1.1: Research design for the practical approach.

1.6.1 Organization of the report

The report consists of six chapters. Chapter 1 provides background information about municipal solid waste system and has set out the problem formulation, objectives, scope and limitation of the study area and the research framework. Chapter 2 describes the literature review which includes theoretical overview of municipal solid waste management programmes; attitudes towards domestic solid waste management; barriers to and motives for household solid waste management system in target area. Chapter 3 deals with the overview of the study area and the existing solid waste management system. This is achieved through a theoretical description concerning the nature of municipal solid waste generation, storage collection, transport and disposal systems adopted. Informal management system is reviewed as well as household participation and behavior in household solid waste management system. Chapter 4 describes the methods of data collection. Respondents' awareness of domestic solid waste management system is evaluated based on households' knowledge of household solid waste and their views about waste collection systems. Chapter 5 analyzes all tables and graphs and provides description of willingness to participate in the local household solid waste management programme. Chapter 6 presents an evaluation of objectives, as well as the summary and conclusions.

CHAPTER TWO

LITERATURE REVIEW

2.1 General

Since the beginning, humankind has been generating waste, be it the bones and other parts of animals that they slaughtered for their food or the wood that they cut to make their carts. With the progress of civilization, the waste generation became of a more complex nature. At the end of the 19th century the industrial revolution saw the rise of the world of consumers. Not only the airs get polluted but the earth itself became more contaminated with the generation of non-biodegradable solid waste. The rapid increase of population and urbanization is largely responsible for the increase of solid waste (http://edugreen.teri.res.in/explore/solwaste/what.htm).

The purpose of this chapter is to provide background of different sources & types of MSW, generation rates estimation & it's affecting factors, common methods of collecting MSW, research planning etc.

2.2 Solid Waste – a Consequence of Life

Solid waste comprises all the wastes arising from human and animal activities that are normally solid which are discarded as useless or unwanted. The term solid waste means all-inclusive, encompassing the heterogeneous mass of throwaways from the urban community as well as the more homogeneous accumulation of agricultural, industrial and mineral wastes (Tchobanoglous et al., 1993). Solid waste can be classified into different types according to sources:

  a) Municipal Solid Waste (MSW)

  b) Industrial waste

  c) Agricultural waste

  d) Municipal sludges and

  e) Others waste

MSW comprises mainly residential, commercial, institutional, street sweeping, etc. Industrial waste includes waste from any factory or industrial process (excluding mines and quarries). Agricultural waste includes waste and residues resulting from diverse agricultural activities- such as the planting & harvesting of paddy, jute, trees & vine crops; the production of milk; the production of animals for slaughter, etc. Municipal sludge comprises human sludges and other types of sludges from wastewater treatment plant, water treatment plant, or air pollution control facility. Others waste includes rest of all solid, semi-solid materials resulting from industrial, commercial, mining and agricultural operations, and from community activities such as inert waste, civic amenity waste, construction and demolition waste, automobile bodies, etc. (Tchobanoglous et al., 1993).

Humans and animals have used the resources of the earth to support life and dispose the waste from the days of primitive society. Disposal of human and other wastes did not pose a significant problem in early times, for the population was small and the amount of land available for the assimilation of wastes was large.

The relationship between public health and the improper storage, collection and disposal of solid wastes is quite clear. Public health authorities have shown that the rats, flies and other disease vectors breed in open dumps, as well as in poorly constructed or poorly maintained housing, in food storage facilities and in many other places where food and garbage are available. The U.S. Public Health Service (US PHS) has published the results by tracing the relationship of 22 human diseases to improper solid waste management.

Ecological phenomena such as water and air pollution have also been attributed to improper management of solid wastes. For instance, liquid from open dumps and poorly engineered landfills has contaminated surface waters and groundwaters. In mining areas the liquid leached from waste dumps may contain toxic elements such as copper, arsenic and uranium, or it may contaminate water supplies with unwanted salts of calcium and magnesium. Although nature has the capacity to dilute, disperse, degrade, absorb or reduce the impact of unwanted residues in atmosphere, in waterways and on land; ecological imbalances have occurred where the natural assimilative capacity has been exceeded.

2.3 Sources of MSW

Municipal solid waste (MSW) are the heterogeneous composition of wastes, organic and inorganic, rapidly and slowly biodegradable, fresh and putrescible, hazardous and non-hazardous, generated in various sources in urban areas due to human activities (Ahmed and Rahman 2000, Ahsan 2005). Table 2.1 shows the types of MSW associated with various sources.

Table 2.1 Types of MSW associated with various sources within a community

Sources	Typical waste generators	Types of solid wastes
Residential	Single and multifamily dwellings	Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, special wastes & household hazardous wastes.
Industrial	Light and heavy manufacturing, fabrication, construction sites, power and chemical plants.	Housekeeping wastes, packaging, food wastes, construction and demolition materials, hazardous wastes, ashes, special wastes.
Commercial	Stores, hotels, restaurants, markets, office buildings, etc.	Paper, cardboard, plastics, wood, food wastes, glass, metals, special and hazardous wastes,
Institutional	Schools, hospitals, prisons, government centers.	Same as commercial.
Construction and demolition	New construction, road repair, renovation, buildings demolition	Wood, steel, concrete, dirt, etc.
Municipal services	Street cleaning, landscaping, parks, beaches, other recreational areas, water and wastewater treatment plants.	Street sweepings; landscape and tree trimmings; general wastes from parks, beaches, and other recreational areas; sludge.
Process (manufacturing, etc.)	Heavy and light manufacturing, refineries, chemical plants, power plants, mineral extraction and processing.	Industrial process wastes, scrap materials, off-specification products, slay, tailings.
Agriculture	Crops, orchards, vineyards, dairies, feedlots, farms.	Spoiled food wastes, agricultural wastes, hazardous wastes (e.g., pesticides).

Source: Daniel with L. Thomas. 1999. Working Paper Series NO. 1. Urban Development Sector Unit. East Asia & Pacific Region

2.4 Generation of MSW

Waste generation encompasses activities in which materials are identified as no longer being of value and are either thrown away or gathered together for disposal. It is an inevitable consequence of production and consumption activities in any economy (www.epa.gov//non-hw/muncpl/index.htm). Generally, it is positively related to the level of income and urbanization, with higher income and more urbanized economies generating higher levels of solid wastes per capita. Waste generation is, at present, an activity that is not very controllable. However, three general trends require to be carefully scrutinized to determine the rate and quantity of MSW generation. The first trend is the quantity. It suggests that the increase of per capita waste generation is parallel to the increase of degree of development. The second trend concerns the concentration of paper in the waste stream, as it is high in developed countries but not so much significant in developing countries. According to the data, the development of a country is closely related to an increase in the concentration of paper in the waste. The third, and perhaps the most important, concern is the biological solid waste management and the quantity of putrescible matter and ash.

The variations and trends in quantity, composition and other characteristics of urban wastes are not confined to the national level. Indeed, they persist even at the community level. The persistence is due to the fact that the characteristics of the waste stream are affected by an array of factors. Ranking high among these factors are degree of industrialization, extent and nature of socio-economic development, and the climate. Like all waste, municipal waste is on the rise and it is growing faster than the population, a natural result of our increasing consumption rate and the shortening of product life-spans

2.5 Types of MSW

There are different types of MSW, which are stated in Table 2.2. Some of MSW are categorized as the followings (Chan, 1993):

Food & vegetable wastes: Consist of food, fruit and vegetable residues resulting from the handling, preparation, cooking and food consuming. The characteristics of these wastes are highly moisture contents and decompose rapidly during hot climate, which will lead to emission of offensive odor.
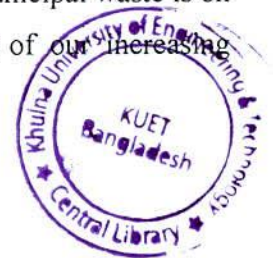
Table 2.2 Typical location of solid waste generation associated with various sources

Sources	Locations where wastes are generated
Residential	Slum, town houses, single family & multifamily detached dwellings, duplexes, low, medium & high-rise apartments, etc.
Commercial	Stores, restaurants, markets, shopping malls, city centers, hotels, motels, warehouses, print shops, service stations, airports, auto repair shops, etc.
Institutional	Schools, hospitals, prisons, medical facilities, governmental centers, etc.
Industrial	Packaging of components, office wastes, lunchroom and restroom wastes (but not industrial process wastes)
Open areas	Street cleaning, landscaping, catch basin cleaning, parks and beaches, other recreational areas, etc.

Source: Tchobanoglous et al., 1993

Table 2.3 Types of MSW associated with various sources within a community

Sources	Major types of wastes
Residential	Food & vegetable wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, tin cans, aluminum, other metals, ashes, street leaves, special wastes (including bulky items, consumer electronics, white goods, yard wastes collected separately, batteries, oil, and tires), household hazardous wastes, etc.
Commercial	Paper, cardboard, plastics, wood, food waste, glass, metals, special wastes (including bulky items, consumer electronics, white goods, yard wastes collected separately, batteries, oil, and tires), hazardous wastes, etc.
Institutional	As above in commercial and hospital waste, etc.
Industrial	Packaging materials, food wastes, etc. (but not industrial process wastes)
Open areas	Dust, rubbish, landscape & tree trimmings, catch basin debris, general wastes from parks, beaches and recreational areas, etc.

Source: Tchobanoglous et al., 1993

Garbage: Solid waste consisting of putrescible animal & vegetable waste materials resulting from the handling, preparation, cooking and consumption of food, which includes waste materials from markets, storage facilities, handling; sale of produce & other food products. MSW are commonly known as trash or garbage.

Rubbish: Consists of combustible and non-combustible solid waste from households, institutions and commercial activities etc., excluding food waste or other putrescible wastes. Generally combustible rubbish includes materials such as paper, cardboard, plastics, textiles, rubber, wood, furniture and garden trimmings. Noncombustible rubbish consists of materials such as glass, crockery, tin cans, aluminum cans, ferrous metals, steel and dirt.

Ashes and residues: These are materials remaining from burning of wood, coal and other combustible wastes in home, stores, institutions and municipal facilities of heating and cooking. This category does not include the residue from power plant. Ashes and residues are normally composed of fine, powdery materials, cinders, clinkers and small amounts of burned materials.

Hospital Waste: (a) Any waste which consists wholly or partly of human or animal tissue, blood or other body fluids, excretions, drugs or other pharmaceutical products, swabs or dressings, syringes, needles or other sharp instruments, etc. which unsafe and may prove hazardous to any person coming into contact with it. (b) Any other waste arising from medical, nursing, dental, veterinary, pharmaceutical or similar practice, investigation, treatment, care, teaching or research, or the collection of blood for transfusion, etc. which may cause infection to any person coming into contact with it.

2.6 Municipal Solid Waste Collection and Storage Systems

City corporations are responsible for waste collection and disposal. The responsibilities include the removal of waste from households, removal of litter from streets, service lanes and other public places, removal of bulky waste from private premises and open areas, and provision of adequate landfill sites. Lessons learnt from collection systems reveal that such systems must be designed to accommodate the particular conditions of the community. The available collection systems are elaborated below.

2.6.1 House-to-house collection

This is sometimes termed a primary collection system. It differs from traditional collection systems in respect of financing, organization and technology. These programmes use local or indigenous resources. In addition, house-to-house collection programmes aim at convincing individual households to pay for private garbage collection services.

2.6.2 Communal collection sites

This alternative method involves communal skips or site collection. In this option householders place their waste at predetermined locations containing a communal storage facility. Communal collection sites operate in a similar way to the "bring" system in which individuals take their wastes to public or on-street collection sites either voluntarily or sometimes owing to some incentive notes that the advantages of a bring system are low labour and capital costs, but the system is also associated with low levels of materials recovery, adverse local environmental impacts, contamination of materials and low community participation.

2.6.3 Block collection

In this system a collection vehicle travels a scheduled route, stopping periodically for residents to bring their refuse. The system eliminates the need for intermediate storage containers, but is less convenient for residents. The key features of block collection are high dependence on maintenance of schedule and high household involvement. This method requires well-planned street routes.

2.6.4 Non-collection system

This system does not involve collection by contractors in the usual sense and does not involve planned and managed removal of waste from residential sites. Instead, residents receive incentives for bringing their refuse to central locations. Such a scheme may be accompanied by some adverse impacts such as improper means of waste disposal. The residents undertook various methods of waste disposal such as dumping waste at street corners, thereby creating health hazards. Under this system households need to be made aware of the methods of available waste management option.

2.6.5 Curbside collection

In curbside collection recyclable materials are set out for commingled collection. This method involves collection directly from the waste producers, i.e. households, shops, offices and smaller factories. Key features of a curbside collection include a high level of service from the point of view of the user and regular and well organized collection service– householders must know when to put out waste. If badly co-ordinated, the result is infrequent collection and resulting health and odour problems.

2.7 Affecting Factors for MSW Generation

The generation rates and characteristics of MSW are varied in different countries and cities because of different influenced factors. The most important factors are listed as the followings:

2.7.1 Source reduction and recycling activities

Individual household waste reduction methods

This factor only reduces the waste collected while the generation rates from each household are remained a same level. The reduction methods are different in both the developed and developing countries. Home grinders are commonly applied in the former. Open burning or dumping into rivers is existed in the latter, which might cause to the air and water pollution.

The extent of recycling and sorting systems

Under this system, some reusable materials are sorted from the waste before sending to processing or treatment plants. Quantities of waste collected are reduced and the reusable materials such as papers and bottles may not exist in the waste stream.

2.7.2 Public attitudes and legislation

Public attitude

Significant reductions in the quantities of solid wastes will occur when public are willing to change their habits, life styles and with awareness in maintaining an aesthetic environment and national resources. The factors that affect MSW are important in planning the solid waste management system and can be considered into the development of national environment policies as well as other policies. Therefore, the impact of these factors in a city should be evaluated separately in each situation.

The habits and customs of living

These factors have greatly affected both the waste generation and composition from many aspects such as festivals, habits or life style. The waste characteristics are varying from city to city and also within the same city itself too. For example, generation rates during festival seasons are usually higher than normal because of the preparation and celebration. Also, different life style would perform its specific waste stream characteristic.

Legislation and regulation

The existence of local, state and federal regulations concerning the use and disposal of specific materials may have affected the generation of certain types of wastes.

2.7.3 Geographic and physical factors

Geographic location

This factor includes geographical characteristics of the land, climate and rainfall season. A significant situation of variation in the amount of garden waste generated, weight of refuse, moisture contents etc. are affected by the changes in seasons or climate. In some countries, the waste amount and characteristics are varied from spring to winter within a year. Furthermore, the raining and typhoon seasons in some tropical countries may have affected both quantity and composition of waste too.

Population density

Wastes are mainly produces through human activities. Therefore, the variation in population density and number has greatly influenced the amount of waste generated within a city and as whole in a country.

Economic conditions and standard of living

The economic status or conditions have affected the amount and types of goods that have been purchased. Usually, wealthier group with higher purchase ability, their goods tend to be higher quantity and more exquisite, thus produce higher amount of wastes and packaging materials.

Gender

Many aspects of solid waste management are "gendered". Looking at gender dimensions of MSWM also enables the planners to note the differences in the behaviour, needs and the roles played by other social groups. Women and men play different roles in the MSWM at all levels. At the household level, for example, they have different responsibilities. At workplaces dealing with waste sorting, collection, transportation and planning there are other key differences. Although the differences are largely culture specific, it is not common to see women among the high level managers of solid waste within municipal or formal private sector institutions (Scheinberg et al 1999).

In every culture there is gender specificity in the generation, disposal, re-use, recycling and management of waste as well as the activities that support the sector. For example, street sweeping and the maintenance of public spaces, separation of waste at source, re-use of waste materials and the collection, transport and disposal from households and businesses fall on one or the other gender. Women and men also differ in their needs and preferences and tend to differ in their willingness to pay for MSWM investments. As a result, gender analysis often leads to policies that recognize women´s contribution to MSWM and aim at promoting community involvement in waste management.

Poverty

Among other issues that are important in analysing social diversity, understanding poverty dimensions is critical. Urban poverty and poor environmental conditions in most parts of the world are inextricably linked. In many cities, the poor do not have access to the formal solid waste collection service, or live in unsafe, marginal and environmentally hazardous areas such as polluted land-sites near solid waste dumps. These conditions lead to poor environmental health which aggravates poverty and leads to impacts such as loss of income due to sickness and disease, inadequate medical treatment and increased spending on health care which depletes household savings.

Improving environmental conditions in cities and towns helps in reducing poverty directly as well as indirectly (Bartone 2000). As a direct impact, improvement in solid waste conditions can lead to better health which in turn, can help to improve productivity and increased incomes. An indirect impact of improved solid waste conditions can lead to decreased health problems and hence, savings from spending on health. The savings and better living environment per se would provide the poor with resources, time and most importantly a 'better quality of life' to enrich their skills (and thereby increase their capabilities) to earn higher incomes and fight poverty. Further, an increase in incomes would also enable the poor to pay for the basic environmental services they need.

Many other aspects of MSWM closely relate to poverty. Poverty is closely associated with low levels of garbage generation and waste collection as well as high levels of waste sorting, re-use and recycling. Poverty also is associated with residential proximity to dump sites as well as exclusion from municipal services.

Industrial, commercial and housing development planning

The rapid development of these planning within a city has main effects on the quantity of municipal wastes. Such urbanization activity may encourage the migrants and thus increase the population and amount of waste generation.

Increase in the use of new products

This trend has effects on the characteristics of waste such as density, moisture content and chemical compositions. The increase of packaging materials, pre-cooked or frozen foods and disposable diapers etc. would have changed the waste stream within a community.

Frequency of collection and service coverage

It is common that higher frequency of collection and thus more wastes are collected.

Fruit seasons

During these seasons, the portion of fruit wastes has usually increased the amount of garbage components and the moisture contents of the refuse.

Waste collection cost from waste producer

Increasing of collection cost would cause to reduce the waste generation rates. However, this may only effective for some bulky wastes, which are collected by special services. In some commercial and industrial areas, the payment by waste generators is due to the number of collection trips, therefore the payees always tend to limit the amount of waste generated.

2.8 Social Concern of Wastes

Human and animals have used the resources of the earth to support life and hence to dispose waste as a natural phenomenon starting from the days of primitive society. The disposal of wastes did not pose a significant problem as the population was small and due to land availability in the early stage of times (www.epa.gov/osw/nonhaz/municipal/index.htm). On the other hands, most of the intake of human and animals and the generated wastes were organic and recycled naturally at every stage. However, problems with the disposal of wastes started when humans first began to congregate in tribes, villages, and communities and the accumulation of wastes became a consequence of life and social concern. As the time goes on, the inherent changes in the society, culture, modernization, urbanization, industrialization, daily usable products and people's habits and living standard make significant changes in the

amount and types of solid waste. As a result individuals and society as a whole started to think the consequences on the society and adverse environmental impacts both the human and nature. The first and minimum requirement that needs to fulfill is the removal of solid wastes from the immediate vicinity of settlements. As soon as waste is out of sight it is no longer perceived as a problem. To ensure this social requirement, a system is required and hence introduced, which is termed as solid waste management. A chain of various complex linkages and an integrated approach is needed to accomplish the target. The first link of this chain is deposition of generated wastes in the source by any means. To bring this link into effect, the society as a whole need to response properly. This task is being solved in more-or-less efficient ways in most societies. However, in most of the Least Developed Countries (LDCs), the first link is yet to be functioned properly. About 50% of waste remains unmanaged and hence scattered in the streets, drains, vacant places in urban areas due to lack of awareness, participation and commitments. As a result the city is facing serious environmental threats and raises social concern among the relevant stakeholders.

Waste management is a social issue, as waste is mainly a social construct. It is perceived that wastes in terms quantity and quality depend to a large part on life-style and social rank. Solid waste management is a complex process because it involves many technologies and disciplines. These include technologies associated with the control of generation, handling, storage, collection, transfer, transportation, processing and disposal of solid wastes (Tchobanoglous and Kreith 2002). All of these processes have to be carried out within existing legal and social guidelines that protect the public health and the environment and are aesthetically and economically acceptable. It is evident that social value and individual commitments and responsibilities towards society can only play key role in the above stated link of the chain of waste management.

2.9 Planning for improved the situation of MSW

Many municipalities struggle with achieving acceptable quality and coverage of MSW services due to budget constraints, lack of cooperation of generators, conflicts between different stakeholders, and the difficulty of managing transport fleets and identifying and managing disposal sites. Better solid waste management is important because uncollected waste is an eyesore, blocks drains and is a public health risk. Planning sustainable solid waste management can be complex, but a logical approach and carefully considering the various

stakeholders and options will increase the chances of developing an efficient, effective and successful system. To improve the MSW situation, the following facts must be considered in the plan of action of this research.

☐ What is happening at present? (Situation analysis)
☐ What should want to happen? (Goals)
☐ How this happen can be made? (Strategic plan)

2.9.1 Situation analysis

Much of information may be secured from primary research after conducting questionnaire survey, though it may be necessary to undertake some secondary sources. The situation analysis also involves detailed consultations with a range of stakeholders. The consultation planning for sustainable municipal solid waste management should also be an opportunity to build co-operation and support and ensure solutions are inclusive and geared towards demand.

2.9.2 Developing action plans

Action plans ideally contain a range of activities: some which are easy and simple to undertake in the short-term, as well as activities which contribute to longer-term goals and which require considerable time and effort. Sustainable MSW cannot be achieved through isolated approaches, for example awareness raising, increasing collection vehicle, improving on-site and storage system etc.

2.9.3 Sustainable solid waste management options

2.9.3.1 Generation and primary storage

Waste generators are important stakeholders in MSW. The success of MSW systems depend on the crucial support and co-operation of householders, businesses and markets etc. Planning can ensure systems meet their needs. Understanding and gaining the support of waste generators, including households, shops and businesses, is vital but frequently overlooked. Key planning questions include:

☐ What are the present behaviors, perceptions and attitudes?

☐ Are waste generators willing to participate in door-to-door collection?

☐ What is used for waste storage in homes at present?

Information gathered at this stage can also be useful for planning other aspects of MSW (e.g. primary collection). Waste needs to be stored in homes before being collected. Households generally prefer the storage period to be as short as possible because - particularly in warmer climates – waste begins to decompose and smell quickly. Household waste storage containers should have lids to protect the waste from the rain, to control odor and keep rodents, birds, cats and dogs away.

2.9.3.2 Attitudes and behavior

The attitudes and behavior of waste generators can have significant impacts on solid waste management. For example they may cooperate and store waste at home, or they may dump mixed waste indiscriminately on the streets. Awareness raising campaigns using messages such as 'Reduce -- Reuse -- Recycle' can be used to change attitudes and modify behavior amongst householders. These can be an important aspect of solid waste management. Successful campaigns could result in reduced wastage in homes; encourage reuse (for example of plastic bags). Each of these reduces the burden on the solid waste management system, and can result in environmental improvements. Engaging waste generators may lead to community-led MSW initiatives. These can be effective vehicles for improving the cleanliness of neighborhoods, gaining widespread support and increasing rates of resource recovery.

2.9.3.3 Primary collection

Primary collection is what helps ensure waste enters the waste management process without ending up on streets or blocking drains. Careful planning is required to ensure solutions address a range of stakeholder needs. Primary collection may be undertaken by waste generators themselves, domestic helpers or paid waste collectors. Key planning questions include:

☐Are householders and other generators using any collection service at present? If so are they happy with this, and if not is there a demand for it? Are people willing to pay for this service?

☐How can the coverage of existing waste collection activities be increased and/or new initiatives be started?

☐How can waste collection from poor as well as richer areas are ensured?

2.9.3.4 Transfer points

With good planning, transfer points can be relatively attractive, clean and efficient facilities. Careful consultation can ensure their location and function is well suited to the local environment and users. One of the most visible aspects of MSW is the transfer point, providing an interface between primary and secondary collection. These are often poorly designed, involving double handling of waste (once to unload tricycles, again to reload trucks) and unsanitary conditions where transfer points are not properly cleaned and used as public toilets. Key planning questions for improving transfer include:

☐How much space is available? How is waste deposited at present (e.g. by hand, tipped from a tricycle)?

☐What is acceptable to householders in terms of location, visual impact, method of disposing of waste?

☐How far are waste generators willing to walk to deposit waste?

☐Do waste pickers access waste from transfer points? If so, should they be discouraged from picking, or can their activities be adapted to improve the management of the transfer point as well as their livelihoods?

2.9.3.5 Secondary collection

Well-planned transportation can make optimal use of vehicles and staff and ensure all waste is collected and reaches its designated disposal or processing point. Secondary collection entails the removal and transportation of waste from transfer points to processing and disposal facilities. This is often one of the most costly elements of MSW systems. Waste characterization study data will play an important part in planning secondary collection as it informs how much waste requires collection, its weight and volume, where it is located

(affecting collection routes) and so on. Key planning questions for secondary collection include:

☐What resources (including staff and hardware) exist at present and how efficiently/inefficiently are they being used?

☐What percentage of total waste generated is being collected?

☐Are the collection routes as efficient as possible?

2.10 TEST of Hypothesis

An inference and a *decision making process* in which SAMPLE information is used to test whether a POPULATION PARAMETER is less than, equal to or greater than a specified value.

It will be possible to measure the reliability of the inference.

2.10.1 Common test of statistics

Many other tests (http://en.wikipedia.org/wiki/Statistical_hypothesis_testing) can be found which are given below:

Name	Assumptions or notes
One-sample z-test	Normal population **or** $n > 30$ and σ known.
Two-sample z-test	Normal population **and** independent observations **and** σ_1 and σ_2 are known
Two-sample pooled t-test, equal variances	Normal populations **or** $n_1 + n_2 > 40$ **and** independent observations **and** $\sigma_1 = \sigma_2$ **and** σ_1 and σ_2 unknown
Two-sample unpooled t-test, unequal variances	Normal populations **or** $n_1 + n_2 > 40$ **and** independent observations **and** $\sigma_1 \neq \sigma_2$ **and** σ_1 and σ_2 unknown
One-proportion z-test	$n\,p_0 > 10$ **and** $n\,(1 - p_0) > 10$ **and** it is a SRS (Simple Random Sample).
Two-proportion z-test, pooled	$n_1\,p_1 > 5$ **and** $n_1(1 - p_1) > 5$ **and** $n_2\,p_2 > 5$ **and** $n_2(1 - p_2) > 5$ **and** independent observations
Two-proportion z-test, unpooled	$n_1\,p_1 > 5$ **and** $n_1(1 - p_1) > 5$ **and** $n_2\,p_2 > 5$ **and** $n_2(1 - p_2) > 5$ **and** independent observations
One-sample chi-square test	One of the following • All expected counts are at least 5 • All expected counts are > 1 and no more that 20% of expected counts are less than 5
Two-sample F test for equality of variances	Arrange so $s_1^2 \geq s_2^2$ and reject H_0 for $F > F(\alpha / 2, n_1 - 1, n_2 - 1)$

2.10.2 Steps to be followed for hypothesis testing

Following steps should be followed to carry this testing:
(http://flinflon.brandonu.ca/DiMuro/171Stats/171HYPOTHESIS%20TESTING.doc.)

- To define the population under investigation
- To state the hypothesis
- To mention the significance level (reliability)
- To select a sample, collect data (generally done by the researcher)
- To perform calculations
- To reach and state a conclusion

SPEP 1

A **Statistical Hypothesis** is a theory about a population parameter that may or may not be true.

There are two types of hypothesis:

- **Null Hypothesis** Ho: represents the status quo, the conservative theory from previous experience that is accepted until proven false.

(Trial defendant assumed not guilty unless otherwise proved)

Ho always contains the = sign. It is assumed that Ho is true. It states that there is no difference between a parameter and a hypothesized value

$$Ho = o$$

- **Alternative Hypothesis** H_A: a theory that contradicts the null hypothesis, by specifying a DIFFERENCE between the parameter and the hypothesized value. It contains the **claim**, or what the researcher wants to prove.

$$Ho \neq o \quad or \quad Ho < o \quad or \quad Ho > o$$

STEP 2

A **test statistics** is a formula used to decide whether to **accept** or **reject the null hypothesis**. The formula follows the format

$$\text{Test value} = \frac{\overset{\text{(sample)}}{\text{observed value}} - \overset{\text{(population)}}{\text{expected value}}}{\text{Standard error}}$$

Test for mean

$$z = \frac{\bar{x} - \mu_0}{\sigma/\sqrt{n}}$$

STEP 3

It is needed to state the **significance level** α, or the maximum probability or rejecting the null hypothesis when Ho is true (convicting an innocent person).

Rejecting the null hypothesis when Ho is true is a serious mistake, so its probability α must be small. We will generally use $\alpha = 5\%$, 10% or 1%

α measures the reliability of the inference.

STEP 4

A critical value is selected from a set of tables(http://amchang.net/StatTools/zTest_Tab.php), that will separate the rejection region from the accept region.

The rejection region must have a probability α to contain the test statistics when the Ho is true, and represents the region in which there is a significant difference between the sample value and the hypothesized population value.

One tailed test (right) $(H_A > \quad)$

$$\text{If } z > z\alpha \text{ Reject Ho}$$
$$z < z\alpha \quad \text{Accept Ho}$$

One tailed left $(H_A < \quad)$

$$\text{If } z < -z\alpha \text{ Reject Ho}$$
$$z > -z\alpha \quad \text{Accept Ho}$$

Two tailed test $(H_A \neq \quad)$

$$\text{If } z > z\alpha/2 \text{ or } z < \text{If } z < -z\alpha/2 \quad \text{Reject Ho}$$
$$-z\alpha/2 < z < z\alpha/2 \quad \text{Accept Ho}$$

STEP 5

The test statistics is then compared with the critical value. A decision is made and stated it in terms of accept/reject Ho.

ACCEPT Ho means there is **enough evidence** to reject Ho and prove the claim.

REJECT Ho means that the claim is correct (Ha is accepted).

2.10.3 Question Development

Closed-end Questions:

(a) Dichotomous

If the answer of a question can be given with two possible answers (Yes or No), then question for hypothesis can be developed following Dichotomous style.

(b) Multiple choices

Multiple choices are applicable if a question with three or more answers is available.

(c) Likert scale

Likert scale for question development can be followed for hypothesis testing if a statement with which the respondent shows the amount of agreement/ disagreement. Small airlines generally give better service than large ones i.e.: (1) Strongly disagree (2) Disagree (3) Neither agree nor disagree (4) Agree (5) Strongly agree

(d) Semantic differential

Semantic differential is a scale connecting two bipolar words. The respondent selects the point that represents his or her opinion.

(e) Importance scale

A scale that rates the importance of some attribute is the importance scale.

(f) Rating scale

A scale that rates some attribute from "poor" to "excellent" is rating scale.

(g) Intention-to-buy

A scale that describes the respondent's scale intention to buy is intention-to-buy scale

CHAPTER THREE

OVERVIEW OF THE STUDY AREAS

3.1 General

Bangladesh, the world's seventh highest populated country with population of 147.36 million (July 2006 est.) (Wikipedia, 2007) and one of the fastest urbanizing countries, is a land of physical, climatic, geographic, ecological, social, cultural and linguistic diversity. At present there are 522 urban centers in the country including 309 municipalities and 6 City Corporations (BBS, 1997 and bdnews.com). With over 3.3% annual growth in urban population in Bangladesh during 1991-2001 census years, solid waste generation has also increased proportionately with the growth of urban population. This has been creating a higher per capita waste generation rendering the existing management system ineffective and has put on the risk of massive failure. The land of Bangladesh is of enormous beauty, hundreds of serpentine rivers, crystal clear water lakes surrounded by ever green hills, luxuriant tropical rain forests, beautiful cascades of green tea gardens, world's largest mangrove forest etc.

This chapter describes the general information such as location, city layout, population and socio-economic conditions of the study areas. Overview of MSW management such as source storage and separation; primary collection, on-site storage, secondary collection & transportation; ultimate disposal site and problems of existing management practices of MSW in ward no. 24 are described here.

3.2 General Information

3.2.1 Location

Khulna city, the third biggest industrial city of the country, is located at the south-western part of Bangladesh. It is a divisional headquarters, which serves as a gateway to the seaport of

Mongla, the second largest seaport of the country. Khulna city is situated on a natural levee of the Rupsha and Bhairab rivers and characterized by Ganges tidal floodplains with low relief, criss-crossed by rivers and water channels and surrounded by tidal marshes and swamps. Surrounding districts are Satkhira, Bagerhat, Norail and Jessore. It lies between 22°49' North Latitude and 89°34' East Longitudes and its elevation is 2.13 meters above mean sea level (BBS, 2004). The Khulna City Corporation (KCC) consists in total of 31 wards of which ward no. 24 is one of largest and densely populated ward which is the case study area for this research. It is situated at south-western side of city lengthened up to the Gollamari Bridge. The city map of Khulna is shown in Figure 3.1.
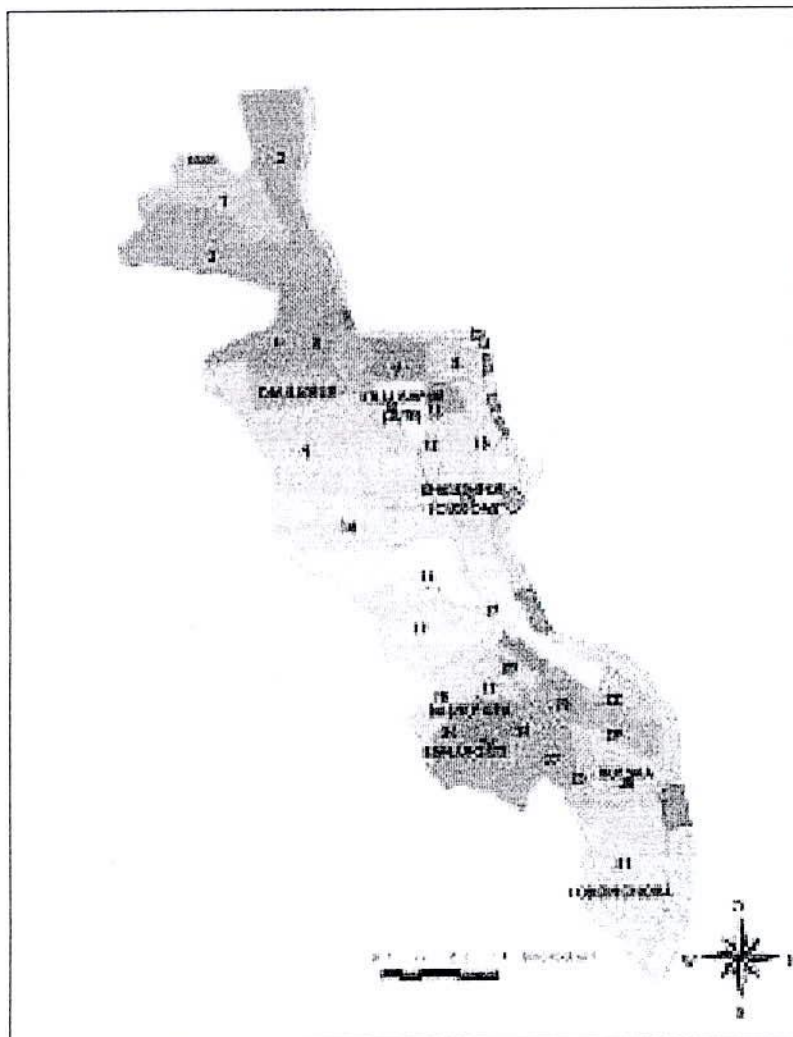
Figure 3.1 City map of Khulna
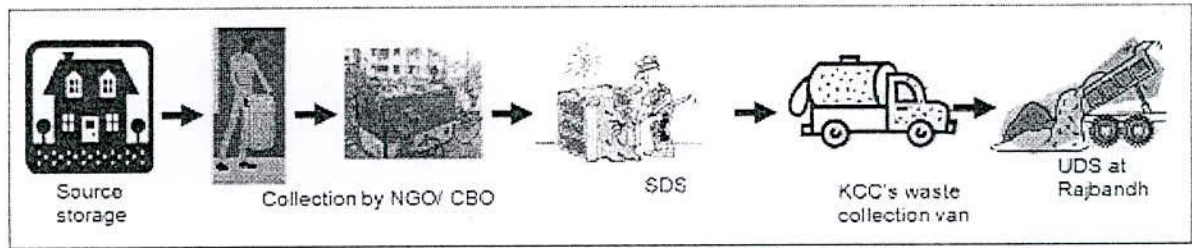
Figure 3.3 Typical waste collection systems in ward no. 24

.3.3.1 Source Storage and Primary Collection

Residential wastes are the main sources of MSW in ward no. 24. The other important parts are commercial wastes from the source of markets, hotels, restaurants wastes, etc; Institutional wastes from the source of schools, colleges, universities, government offices, hospital and clinic wastes, etc. and municipal services wastes such as street sweeping, drain cleaning but excluding the wastes of treatment facilities. It needs the collection and disposal of MSW in daily basis to reduce environmental hazards due to the rapid biodegradable nature. KCC is responsible for overall management of MSW in the KCC area including ward no. 24. But collections of wastes from sources are only dealing by Nabarun Sangsad (NGO) and Paribesh Unnayan Committee 24 no. ward (CBO) in this ward. Limited number of non-motorized Rickshaw Vans and collect wastes from sources by door-to-door collection system against tinny payment from householders as collection services. Householders those cooperating existing management system, store wastes in a plastic or metal container of different size & shape and keep it inside the house or premises, mostly in kitchen and/or corridor. Householders store the wastes at their own responsibility; however, this NGO and CBO even provide the storage bins to some low-income people for motivation. People living in the slum area through their wastes into drain or canals passes through the ward. Moreover, due to lack of motivation, awareness and commitment, a considerable portion of wastes, 25 - 40 %, are not properly stored, collected or disposed in the designated places for ultimate disposal. As a result, the unmanageable increasing quantity of MSW creates alarming environmental problems. Study reveals that source storage and separation of organic, inorganic and hazard wastes are highly neglected by the city dwellers. Generally, single bin is practiced and the collection van also has single compartment, so the waste becomes mixed.
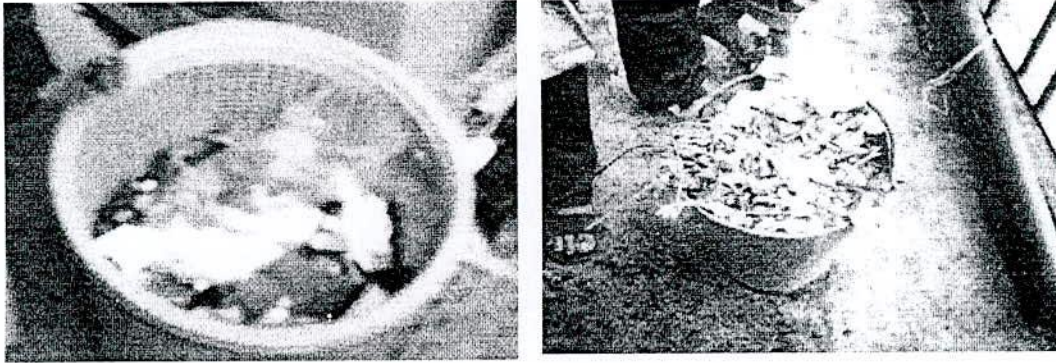
Figure 3.4 Typical picture of source storage

3.3.2 On-site Storage

On-site storage is the Secondary Disposal Sites (SDS), transfer station and handover points, which receives wastes from primary source and transferred to the designated location for processing/ recycling/ treatment and mostly for ultimate disposal. There is no transfer station and handover point in ward no. 24.
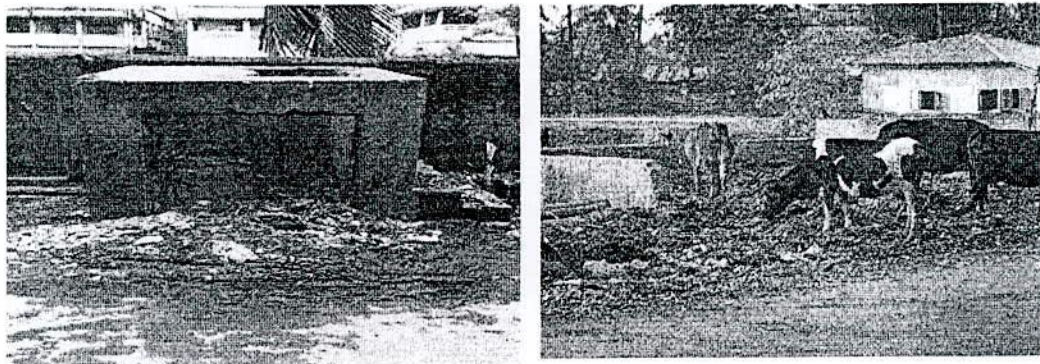
Figure 3.5: Typical secondary disposal sites in ward no. 24

The number of SDS available in this ward is around 43, the location of which is shown in Figure 3.6. KCC authority places some Haul Containers (HCs) and permanent concrete / masonry bins in secondary sites. Only brick masonry bins are also placed at some sites having open spaces near the road side. The SDS situated in the commercial places like Nirala Kacha Bazar is insufficient in its capacity to store the wastes produced in the market daily. Very unhygienic and unpleasant conditions exist in this SDS. Solid wastes are generally

thrown haphazardly in and around the bin. Animal scavenging those sites and odor nuisance is a major problem and peoples passing through this area with conceal neck.
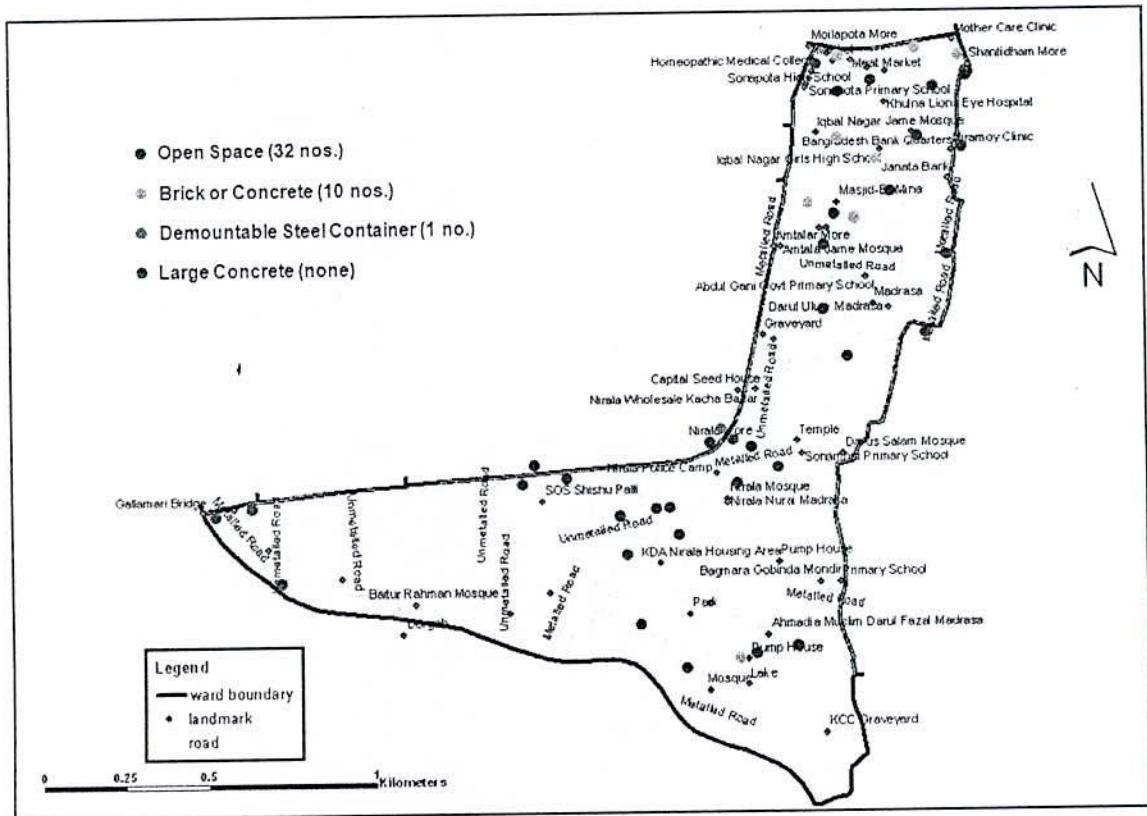
Figure 3.6: Location of SDS in ward no. 24

3.3.3 Ultimate disposal site

The safe and reliable long-term disposal of solid wastes is an important component of integrated waste management. Although source reduction, reuse, recycling, and composting can divert significant portions of MSW, large amount of wastes still needs to be placed in landfills. There are no controlled/engineered/ sanitary landfills in ward no. 24 or in any ward of KCC or any where in Bangladesh, except in the capital Dhaka. The wastes collected from the secondary points are disposed to the ultimate disposal site located at Rajbandh. All types of MSW are disposed here including some portions clinical/hospital wastes. Due to crude open dumping of the wastes, the disposal site poses threat to the nature for adverse environmental impacts.

Figure 3.7   Waste collection from SDS and disposal at UDS

3.4 Problems of Existing Management Practices of MSW

Deficiency and lack of relevant facilities prevail in every stages of solid waste management in ward no. 24. The problems exist in the areas of organizational, human resource and capabilities; technological capabilities, public awareness and motivation; economic and finances and ineffective legislation and enforcement, etc. as discussed briefly in the followings:

3.4.1 Organizational

No technical or logical ratios are maintained among the various types of staffs as per the category and technical capabilities in KCC; so appropriate decision making for proper management of MSW in some cases to be difficult. In other case, coordination between engineering and conservancy department is not coherent, resulting less structural development to proper management. Increasing pressure of MSW day-by-day, sometimes unable to achieve the goal due to lack of statistical previous record of MSW (i.e. generation etc.).

3.4.2 Technological capabilities

It means the technique and technology practices/available for collection, transportation, disposal and treatment facility. Efficiency is the first priority in any system. Most of the transportation vehicle are old enough or collected from different donor authority in second hand condition and most of the time this vehicles stay out from the services for repairing,

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which drop off efficiency. Another is that in SDS due to technical problems such as size, shape, location and design aspects of bin, the spreading waste creates serious pollution. UDS are mainly land in outskirts of the cities where collected part of MSW is dumped in uncontrolled way, e. g. even the amount and kind of waste is not recorded.

3.4.3 Human resource and capabilities

Manpower in respect of existing MSW management is not sufficient. Due to absence of non-technical persons in conservancy section, proper administrative and technical steps related to MSW are not ensured. So appropriate administrative and technical persons should be posted in the right position. Most of the labors are unskilled and they involved on temporary basis. This uncertainty sometimes lessens the working efficiency.

3.4.4 Public awareness and motivation

Due to lack of awareness, motivation and commitment, people do not cooperate as desired to storage of waste and disposal. Unmanaged wastes are somewhere crude open dumping or some places the reason of drain clogging.

3.4.5 Economic and finances

Budget for MSW management is very little and there is no scope for further financial assistance/aid in this sector. Many municipalities struggle with achieving acceptable quality and coverage of MSW services due to budget constraints, lack of cooperation of generators, conflicts between different stakeholders, and the difficulty of managing transport fleets and identifying and managing disposal sites. Better solid waste management is important because uncollected waste is an eyesore, blocks drains and is a public health risk. However, it is being increasingly recognized that solid waste collection and disposal activities may be one of the best suited for involving private sector through considering well defined timing, duration, service and measurable output. Findings in a number of studies in respect of cities of the developed countries support the hypothesis that the private sector can operate more efficiently than the public sector in providing MSW services.

3.4.6 Ineffective legislation and enforcement

There are no effective rules and regulations for the storage, separation and dumping of MSW in Bangladesh. Peoples can storage and dump wastes in any places at any time. These practices could not achieve a clean and healthy city. Generally wastes are dumped indiscriminately at various places such as on roads; into open drains even authority also agrees to dump wastes at vacant places in locality. There is no example of punishment on behalf of the government or local authority for indiscriminate dumping of wastes.

3.4.7 Others

NGOs and CBOs are only involved in a part of solid waste management, so its involvement does not yet able to change the overall scenario as desired by the city dwellers. Marketing of compost product is a great concern of NGOs, as the market of compost is yet to be established in Bangladesh.

CHAPTER FOUR

MATERIALS AND METHODS

4.1 General

Both primary and secondary data have been used in conducting the study. Primary data have been collected by applying qualitative technique like in-depth interview by questionnaire survey and personal contact approach. Data have been collected purposively from different respondents group like city corporation employees, housewives, concerned ward commissioner and NGO/ CBO personnel. Their opinion has been collected to get an insight into existing waste management system. Their suggestion has also been considered in the study. Secondary data have been collected through pursuing different reports of City Corporation, web materials, BBS, and books. Following steps have been performed to achieve the goals that are previously outlined in the research planning.

4.2 Data Collection

The generation rate and amount of MSW in ward no. 24 are estimated by collecting the relevant data directly from field survey and also from secondary sources. MSW generation and composition data are ascertained from primary sources such as residential, commercial and institutional areas. The background data in the aspects of MSW generation are collected from secondary sources. The interview with the relevant government officials had provided information of the data sources, which also guided the personal observations during the study. The secondary sources of data are:

> Khulna City Corporation (KCC)
> Khulna Development Authority (KDA)
> Department of Environment (DoE), Khulna
> Bangladesh Bureau of Statistics (BBS), Khulna
> NGOs/ CBOs involved in MSW management in the study areas

4.3 Zoning of Ward No. 24

Nabarun Sangsad, a NGO and Paribesh Unnayan Committee 24 No. Ward, a CBO have been working on MSW management in ward no. 24. Since ward no. 24 is one of the biggest wards of KCC, they divided the whole area into five different zones named as zone 1- Nirala 1, zone 2 – Nirala 2, zone 3 – Roy Para, zone 4 – Baghmara and zone 5 – Sher-e-bangla. But in this study the whole area of ward no. 24 is divided into six different zones for the convenience of the questionnaire survey. In this new zoning West Bagmara (WB), Roy Para (RP), Muslim Para (MP), Iqbal Nagar (IN), South Gollamari (SG) and South Farazi Para (SFP) are zoned as zone 1, 2, 3, 4, 5 and 6 respectively.
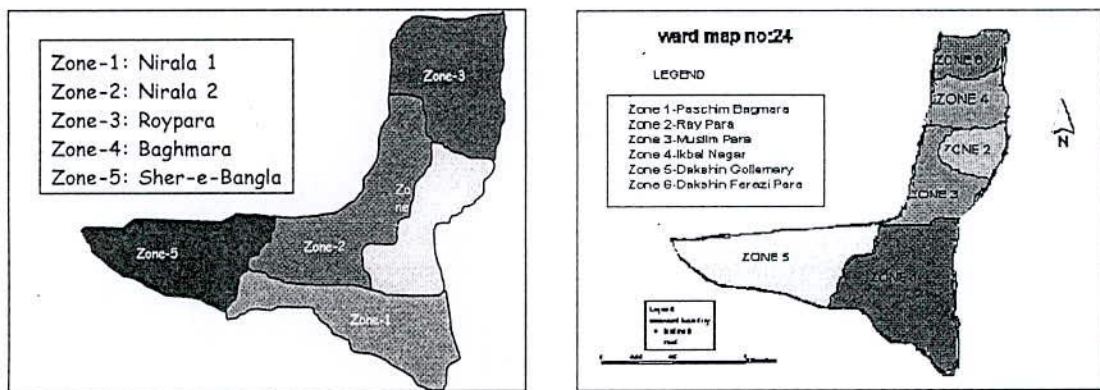
Figure 4.1: Zoning of ward no. 24 (a) Existing zoning (b) New zoning

4.4 Situation analysis

Planning begins with a study of the existing situation and systems. Key questions include:

• What existing information exists on waste streams, quantities and characteristics?

• How does MSW work at present? What are its strengths and inefficiencies?

• What are the existing resources for MSW including personnel, skills, equipment, land etc?

• What are the financial issues?

• Who are the actors?

• What are the key constraining factors (e.g. lack of co-operation of generators, lack of vehicles, no disposal site etc.)?

• What are the socio-cultural issues and expectations (e.g. attitudes and level of cooperation)?

Most of this information was secured undertaking the questionnaire survey. The situation analysis also involves detailed consultations with a range of stakeholders.

4.5 Questionnaire survey

The questionnaire method was used to elicit general information about the respondents, their participation in, and attitudes, their willingness to participate in MSW management system. The exercise is intended to provide useful information for and about the implementation of a sustainable waste management system in ward no.24. The meaning of "attitude" adopted here is the extent to which people are aware of, care about and view household waste management system in their localities. Questionnaire survey is conducted to understand the following status.

- Solid waste management practices
- Source Storage
- Primary Collection system
- Secondary Disposal site
- Secondary Collection system
- Ultimate Disposal

The survey was conducted by taking interviews at least one members of each family. Thus total 1548 families in ward no. 24 were surveyed. Bins were supplied to some households living in the slum area in the surveyed zone. The family members were requested to store waste into the supplied bins. Waste generation data are evaluated by knowing total amount of waste produced in each family and then divided it by no of family members. Almost fifty (50%) of people was quite satisfy with the existing MSW practices in ward no. 24, where the rest percentage expressed their dissatisfaction about the system.

4.5.1 Questionnaire design

Existing MSW management system in ward no. 24 has been studied more explicitly with co-operation of Nabarun Sangsad and Paribesh Unnayan Committee 24 No. Ward. In-depth data have been collected to identify present level of people's awareness & motivation, source storage, primary collection, on-site storage and secondary collection efficiency. The generation and collection rate of MSW and relevant data on the existing solid waste management system in ward no. 24 are collected by conducting a detail questionnaire survey focused on impressions and opinions of residents of ward no. 24. Each questionnaire sheet includes 30 questions (Annexure A) and is divided into three sections:

a) Household Segregation, Storage and Disposal

b) On-site Storage and Disposal and

c) Management aspect.

4.5.2 Information on methodologies for data collection

The study included an overview of statistical methodologies for data collection on municipal waste. On the basis of this overview and in order to improve the level of information, information about storage, collection and disposal of household waste data and municipal waste data were soughed. The following information was collected through the in-depth field survey.

4.5.3 Status of MSW

The preliminary survey was conducted in ward no. 24 on the basis of city corporation office location, commercial, residential and low-income areas. Then three different income level households were selected in each ward depending on different socio - economic status as shown in Table 4.1.

Table 4.1 Household category and the selection criteria

Socio - economic status	Criteria of Selection	Income level (Tk. /family /month)
High class	Independent bungalow type of home, with at least a vehicle and parking space, at least one servant is present.	$\geq 15,000$
Lower to upper middle class	Family owning a flat on rent	4,000 to 14,000
Poor	A group of workers (daily wage) sharing a single room and having a common kitchen; peoples lives in slum areas.	$\leq 3,000$

Limited number of non-motorized Rickshaw Vans of concerned NGO and CBO collect solid waste from sources by door-to-door collection system against tinny payment from householders as collection services. Householders supporting existing management system, store waste in a plastic or metal container of different size & shape and keep it inside house or premises, mostly in kitchen and/or corridor. Householders store waste at their own responsibility; however, this NGO and CBO even provide storage bins to some low-income people for motivation. People living in the slum area throw their waste into drain or canals pass through the ward. Study reveals that source storage and separation of organic, inorganic and hazard wastes are highly neglected by the city dwellers. Generally, single bin is practiced and collection van also has single compartment, so waste becomes mixed. Usually single bin has been used in most of the houses but in some households more than two bins are used. There is no transfer station and handover point in ward no. 24. The number of SDS available in this ward is 24. There are also no controlled/ engineered/ sanitary landfills in any ward of KCC.

4.5.4 Open dump

In the area of Kashem Nagar and Prantica of Gollamary zone some people dump their waste into ponds to fill it and some people dump waste into low land to raise the land level. These types of dumping are categorized as open or illegal dumping.

4.5.5 Composition of MSW

Composition is the term used to describe the individual components that make up a solid waste stream and their relative distribution, usually based on percent by weight. Information on the composition of solid wastes is important in evaluating equipment needs, systems & management programs and plans. For example, if the solid wastes generated at a commercial facility consist of only paper products, the use of special processing equipment such as shredders and balers may be appropriate. Separate collection may also be considered if the city or collection agency is involved in a paper-products recycling program (Tchobanoglous et al., 1993). Some definitions of physical components of MSW are given in Table 4.2.

Table 4.2 Definition of the physical components of MSW

Component	Definition	Example
Combustibles		
a) Garbage	Waste from food stuff	Food & Vegetable refuse, fruit skin, stem of green, corncob, etc.
b) Paper	Any products made of paper	Paper bags, cardboard, tissue, paper, etc.
c) Plastics	Any material and products made of plastics	Wrapping film, plastic bag, plastic bottle, plastic hose, plastic string, etc.
d) Grass, Wood & straw	Any material and products made of wood, bamboo and straw	Furniture such as desk, chair, bed board, toy, coconut shell, etc.
e) Leather & Rubber	Any material and products made of rubber or leather	Ball, shoes, purse, rubber band, etc.
f) Textile	Has its origin from yarn	Cotton, wool, nylon, etc.
Non-Combustibles		
a) Ferrous metal	Any material made of iron which can be attracted by magnets	Tin can, wire, fence, knife, bottle cover, etc.
b) Non-ferrous metal	Any material which can not be attracted by magnets	Aluminum can, foil, ware, etc.
c) Glass	Any material and products made of glass	Bottles, glassware, light bulb, etc.
d) Stone & ceramic	Any non-combustibles other than metals and glass	Shell, bone, brick, stone pottery.

Source: AIT, 1991

Based on the decomposition nature, the components of solid wastes are categorized as organic and inorganic. The composting materials include garbage, grass, straw and papers. In incineration method, it is a process by means of which solid wastes are converted to residue through combustion. For this process, wastes are categorized into combustible and non-combustible components based on the combustion characteristics, moisture contents and heat value. Lists of combustible and non-combustible waste materials are given below:

(1) Combustible materials:

- garbage, food wastes

- papers

- textile

- rubber

- plastics

- wood

- leaves, grass

- leather, etc.

(2) Non-combustible materials:

- metals

- glass

- cement

- stone, gravel, soil, etc.

In ward no. 24, MSW consists of dust, ash, vegetable and animal, bones, putrescible matter, paper and packing of all kinds, rags and other torn fabrics and many other non-combustible trashes. These wastes are often thrown into and / or dumped and piled up roadside or corner dustbins, vacant spaces near markets, road intersections and other such areas. The composition of solid waste in ward no. 24 includes organic food waste, paper and paper products, wood, metal, glass, plastics including hospital waste, construction waste, industrial; waste, dust, firewood and others.

4.6 Analysis of householders' attitudes: Stakeholders' Dialogue

The growing concern of public institutions about environmental matters has led to an interest in the management of municipal solid waste. However, the efficacy of any implementation in MSW system depends mainly on the attitudes shown by citizens towards these problems, as well as towards the measures in a specific plan. The attitudes are likely to be moulded by a variety of factors, including the prevailing culture, individual lifestyle, circumstances and habits, and exposure to external influences. Stakeholders include the various organizations, groups and individuals who have an interest or a stake in the system. The objective of arranging the stakeholders' dialogue is to analyze the opinions and attitudes of citizens in

ward no. 24 who participate in household waste management system and those who do not as analysis is the search for patterns in data and for ideas that help explain why those patterns are there in the first place.

There is a wide range of stakeholders - individuals, organizations and groups both in the formal and informal sector - involved and concerned with MSW management as generators, regulators and legislators. Waste management strategies can only be effective if all the stakeholders work in tandem for a successful venture. As generators of MSW, the public must be aware of the hazards posed by ineffective management of the refuse. Unless the public are involved throughout the management programs, awareness cannot be achieved. Once the public comprehend and acknowledge the main constraints and challenges in the system, no doubt, the actual scenario of waste management will be changed. To this endeavour several Stakeholders' dialogues and formal & informal discussions on solid waste management issues were held at Ward No. 24 with local residents, civic societies, NGOs, CBOs, local ward commissioner and local authority. Stakeholders' Dialogue were arranged to exchange views, experiences, needs and to get opinion of city dwellers, civic societies and people of different groups directly involved in MSW management at KCC. large number of people willingly agreed to participate in programmes, took part in discussions and assured full co-operation. From these dialogues three most important issues are identified:

(i)   Strong need of continuous awareness campaign

(ii)   Need to increase efficiency and coverage of primary collection

(iii)   Need to change situation of on-site storage

In the discussions of these types of dialogues, accumulation of waste at the point of generation, primary collection and transportation, disposal of waste at the secondary site and its maintenance and proper transportation of waste were in the maximum priority. Following recommendations were made based on the opinions expressed in the dialogues.

- A manual or hand book should be published for the proper management of MSW to make Khulna a clean, healthy and environment-friendly city. The manual is to be distributed among the city dwellers. In order to influence people, the instruction of this manual should be demonstrated successively.

- A day can be selected to celebrate it as a "Cleanliness day" for the whole area of KCC. KCC needs to take necessary steps to inspire inhabitants It is also necessary to inspire everyone to participate in this work to clean their own areas.

- A safe and sustainable management for MSW in Khulna city can be selected through adequate discussion and exchange of views considering the socio-economical and local aspects in association with the experts of that field, representatives of the local authority, central/ local representatives of the government, educationalist, civic society and related NGOs/ CBO's and finally the city dwellers.

- Awareness and commitment are the aspects required for proper maintenance of MSW. Exchange of views and awareness should be increased at various levels through discussions, distribution of poster/leaflet and campaign. Such type of activities should be carried out continuously following the specific schedules.

- Mass media including the electronic media and the advertisement related to the awareness for the proper management of MSW should be taken into considerations through special initiatives from KCC.

- A fair may be arranged on MSW management at a convenient time in every year. Different organizations which are engaged with the management of MSW participation in the air to display their activities in order to encourage the people and let them inform various aspects of the MSW.

- Necessary steps should be taken in order to associate the city committee in different areas of KCC regarding the proper management of MSW.

- Financial support should be provided to those organizations who are engaged in various activities of MSW management, such as, increase the number of rickshaws, medical check up of rickshaw drivers and helpers, assurance of regular payment of salary and efficiency and improvement of their works.

- Some NGO give free service of MSW management from the primary source by the grant of donor. Due to this reason the dwellers of this area are very happy for this service. Because of this, the works of CBO and other NGO are interrupted. But the works of those NGOs are closed when the fund is finished.

- It is necessary to coordinate the works of different NGO/CBO's those who are working on MSW in different wards in Khulna city. KCC should take various efforts and give necessary logistics support to reach the goal.

- Acceptable laws on MSW management should be prepared and implemented properly. Proper steps should be taken by informing people to collect the fine if they pollute the environment by disobeying the laws.

- Necessary steps may be taken to motivate the people for the separation of MSW at the point of generation regularly by providing adequate size of dustbins at some selected areas in KCC.

- Proper arrangements should be taken to remove the present bureaucratic restriction regarding the matter of marketing the compost. It is necessary to take the initiative regarding the solution of the problems by discussing with the organizations of compost production on behalf of KCC.

- The performance of different NGO/CBO should be increased in order to give preference of the NGO/CBO's those who are working for a long time on MSW management. It is not important to form new committee on MSW in different areas on behalf of KCC.

- Transfer of waste should be managed more than once by the truck of KCC from the secondary point if necessary. A sustainable management should be formed by the transfer of solid waste.

- Practical action should be taken to remove all dustbins successively by installing transfer station.

- It is necessary to select the location and number of transfer station by proper survey work.

- Proper planning, design and management should be selected by considering the economical, technical, availability of land and current MSW management system.

- It is necessary to make the people conscious by observing the evil effect of the illegal dumping of the waste and the structure constructed in this land. This matter should be disclosed in front of the people.

- KCC should take proper steps to increase the number of container used for the deposition and transportation of waste and it is necessary to construct and maintain the used container in time.

- The solution of the people on MSW by the discussion of meeting in different times should be applied practically.

- KCC should impose special laws for the maintenance of hospital waste.

- Drains should be protected from clogging by proper maintenance of sludge.

- Proper training should be arranged for the organizations those who are working on the MSW management and their works must be coordinated.

- The budget for the MSW in the conservancy section of KCC should be expended the full amount and publish the expenditure of the budget in front of people.

- Necessary steps should be taken by the counselors of every ward to engage the committee of different mosques to increase the consciousness of people on MSW on behalf of KCC.

4.7 Initiatives Taken to Improve the MSW System

After conducting a depth analyze on the issues came out from stakeholders' dialogue, following research actions were planned in order to obtain the research goals and objects.

4.7.1 Motivation and awareness campaign

Stakeholders' dialogue reveals that there is a strong need of awareness campaign among the city dwellers, especially on source storage, waste avoidance & minimisation, separation at source and to promote proper primary Collection. To this endeavour, a campaign leaflet was printed and distributed through mass awareness campaign aiming among the city dwellers keeping provision for the commitment signature of individual to work for a clean, hygiene and environment-friendly Khulna city as shown in Figure 4.2. The leaflet has option where city dwellers will check the following three important points and put their commitment signature:

a) Khulna is a clean, hygiene and environment-friendly city

b) Don't throw waste out, but store them in a designated place by any means

c) Keep your continuous effort to make solid waste management system of Khulna City sustainable

Figure 4.2: Awareness leaflet

Public awareness and attitudes to waste can affect population. No change in MSW management is possible until awareness get developed among the people of all level. Awareness Leaflet was distributed to the people of all level in the study area and was convinced to ensure their participation to build up a sound MSW management system. To increase people's awareness, an Art and Cultural program was arranged at Khulna Art School. Theme of the program was waste management scenario of Khulna City. A good no. of students of Khulna Art School participated in that program. Their thought, idea and suggestion about waste management get reflection through their awesome colourful drawing. At the end of the program they were rewarded for further encouragement to follow the attempts which makes the city clean, hygiene and environmental friendly.

Figure 4.3 Children's thoughts on clean city by solid waste management

4.7.2 Design of waste collection van

To enhance the primary collection efficiency and door-to-door coverage in ward no. 24, covered Rickshaw Vans were designed and fabricated using materials available in local market (GI angle and stainless steel sheet) to overcome the limitations of present Rickshaw Van in Khulna city. Van size is 120 cm x 85 cm x 90 cm with the opening provisions at top and back. The rickshaw van has provision of compartment system in order to separate organic wastes from re-usable wastes. The top cover of van protects waste from precipitation during rainy season. The comments and suggestions came out through stakeholders' dialogue and experiences of users were considered in design. The vans were used for primary collection of waste from source in ward no. 24 with satisfactory performance. In fact, this newly designed rickshaw van collects waste approximately two times than van usually used to collect waste in ward no. 24 as shown in Figure 4.4. The comparison of existing waste collection rickshaw van & newly designed waste collection rickshaw van shown in Table 4.3
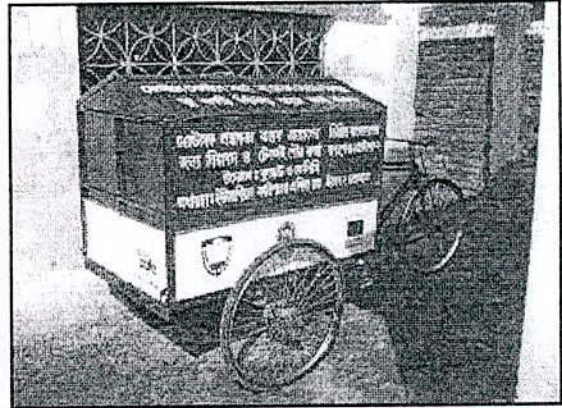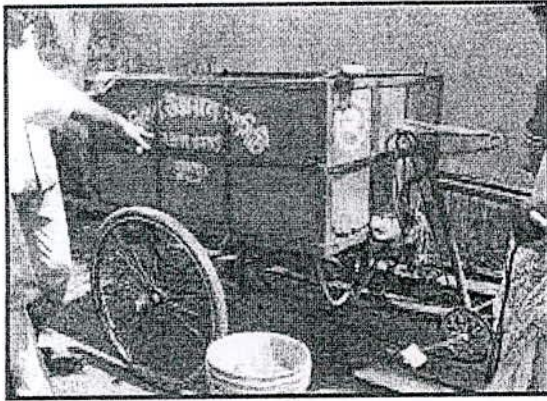
Figure 4.4:(a):Existing waste collection rickshaw Van   (b) Newly designed waste collection rickshaw van

Table 4.3 Comparison of existing and newly designed waste collection van

Components	Existing Waste Collection Van	Newly Designed Waste Collection Van
Materials	IRON Sheet	Steel including inner surface asbestos
Waste carrying capacity	500-550 kg	650-700 kg
Durability	Not so good	fine
Environmental aspects	Unhygienic	Hygienic
Fly & bird nuisance	Yes	No
Odor nuisance	Highly	Less
Lid facilities	No	Yes
Initial cost	Low (15000.00 BDT)	High (22000.00 BDT)
Maintenances cost	High	Low
Corrosive property	High corrosive	Low corrosive
Waste falling	Occur due to top is open	Not occur due to top is closed by a lid

4.7.3 Awareness festoon installation

To attract public attention, a number of festoons have been installed at important public places for increasing public awareness on safe and sustainable management of municipal solid waste in Khulna city as shown in Figure 4.5. Different type of slogans are displaying on these festoon to modify people's thought and mentality on sustainable MSW management.

Figure 4.5   Awareness festoon for display

4.7.4 Design of transfer station

One of the most visible aspects of MSW is the transfer point, providing an interface between primary and secondary collection. These are often poorly designed, involving double handling of waste (once to unload tricycles, again to reload trucks) and unsanitary conditions where transfer points are not properly cleaned and used as public toilets. To change the situation of on-site storage, reduce hauling cost and increase efficiency of solid waste management systems - need of transfer station is highly understood and an affordable one was designed (Annexure B) to increase the overall efficiency of existing MSW management. If some transfer station can be installed at some reliable points of the city, the double handling system of waste can be eliminated. If number of secondary collection points cannot be removed or reduced and remains unmanaged, scattered all over city, the city neighborhoods are bound to remain an eyesore; an environmentally unfriendly place for people to live in.

4.8 Economics of Solid Waste Management

4.8.1 Willingness to Pay

One of the features of the questionnaire was to find out the "willingness to pay" of the residents for the management of waste. Some percentages of them do not care on MSW management system. About 39 % households participate in the fee based collection system and are paying to the concerned NGO/ CBO for collection of their wastes. However, the participation rate is different for different zones. Here too the zone wise situation is different. The majority of the households who were paying fees for the collection of waste were ready to pay only the amount, which they were paying, as they did not find any problem regarding collection of their waste. However, they were questioned on the additional willingness to pay for the better management of the waste and some have expressed the willingness to pay. Some expressed that they could not pay more than the present fee.

4.8.2 Causes of Not Willing to Pay

Willingness to Pay is positively related to the total income. During the survey, it was also found that people living in the slum area and the majority of the rich households have extra land area and they mainly want to throw the waste even if the organic content is high. Social and education status also influences this fact greatly. Awareness development mainly can motivate to make the households participate in the collection system conducted by the concerned institute. Questions were asked regarding the unwillingness of the households to pay. Households have given more than one reason for not willing to pay for the management of the waste. Study shows that a good percentage of the households were not willing to pay as their waste was collected and they do not have any problems from the waste. Some of them do not feel the problem from the waste since they have sufficient space to throw the waste either within their compound or outside. Few households were not ready to pay, as their income was very low. They feel that their priority is hand to mouth survival and not the waste. Majority of households feel that it is the duty of the municipality and the government and so they are not willing to pay. From the survey it was found that poorer section was sceptical on issue of paying service charges. City authorities charge conservancy taxes from city dwellers. So it is not unusual for city dwellers to expect that city authorities will provide a clean city.

CHAPTER FIVE

RESULTS AND DISCUSSION

5.1 General

The estimation of solid waste generation and collection are the basis of design and operation of the functional elements associated with the management of solid waste. In other words, these information are necessary and desirable from the point of view of optimal planning and design to handle MSW. Any future system for collection and disposal of the wastes will have to be related to the quantity of wastes produced.

This chapter describes some general information about ward no. 24, population data and also other necessary information. The chapter analyses the generation and collection efficiency of MSW in ward no.24 together with public attitude and their participation. The MSW generation rates at sources and finally estimation of MSW generation in each zone are provided here. This chapter represents the results of this study including discussion and comparison of the overall situation of MSW management before and after the taken initiatives.

5.2 Collected Information after Conducting Survey

5.2.1 Generalized Land Use Pattern

Land use planning is the term used for a branch of public policy which encompasses various disciplines which seek to order and regulate the use of land in an efficient and ethical way. Land cover is distinct from land use despite the two terms often being used interchangeably. Land use is a description of how people utilize the land and socio-economic activity - urban and agricultural land uses are two of the most commonly recognized high-level classes of use. A new expanded and inclusive use classification system is used to regulate land uses.

Uses are grouped by categories having similar characteristics, but do not list every use or activity that may be within the classification.

The total area of ward no. 24 was divided into six different zones as South Gollamari (SG), West Bagmara (WB), Muslim Para (MP), Roy Para (RP), Iqbal Nagar (IN), and South Farazi Para (SFP), which cover area of 28.16, 36.5, 15.2, 6.13, 6.15 and 7.76% respectively of total area of ward no. 24. Out of these six zones, West Baqgmara and South Gollamary are the two largest zones. In Table 5.1, the amount of area occupied by six different zones and their amounts in percentage has been shown. Figure 5.1 shows the percentage of areas occupied by these six zones respectively.

Table 5.1: Areas of different Zones in ward no. 24

Sl. No.	Name of Zone	Area in Sq. km	% of area of each zone
1	South Gollamary	45.36	28.16
2	West Bagmara	58.86	36.5
3	Muslim Para	24.51	15.2
4	Roy Para	9.88	6.13
5	Iqbal Nagar	9.92	6.15
6	South Farazipara	12.52	7.76
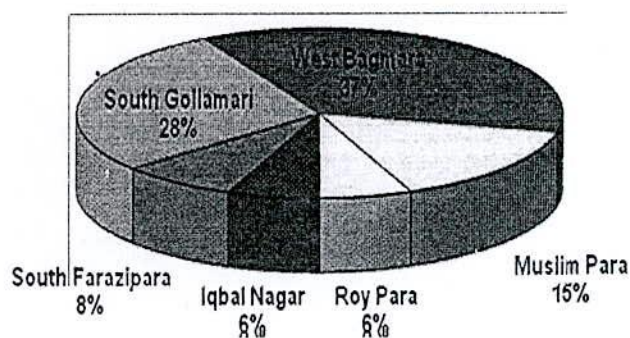
Figure 5.1: Areas of different zone of ward no. 24

5.2.2 Socio-economic condition

Khulna city is strategically focused as far as its development potentialities are concerned. The average household income per month is Taka 5,543 (US$ 90). The export of shrimp and the related activities such as shrimp processing, packaging, transportation, shipping, banking, insurance etc. have further reinforced the development of Khulna city to a great extent (KDA, 2004). Ward no. 24 is an important hub concerning the socio-economic potentialities. People of different category, generally high level to mid level (in term of monthly income) and of different religion are living in this ward. The average family size of this ward is 5 to 6. Because of the establishment of higher number of educational institutes, cultural institutes, markets, restaurants, mosque, governmental & non-governmental office, NGO, CBO and other important features, the ward has turned to most well known ward of Khulna city.

The actual numbers of different institutional, commercial and other landmarks are summarized in Table 5.2. In table 5.3, the amount of area occupied by eight different land use categories and their amounts in percentage has been shown. Figure 5.2 shows the percentage of areas occupied by these six different land use categories respectively.

Table 5.2 General information on the infrastructures at ward no. 24

Item	No.	Item	No.
Educational Institutional	17	Police Box	3
Clinic, Hospital & Pathological laboratory	12	Children Park	1
Prayer center	41	Graveyard	1
Govt. semi Govt. & Non Govt. offices	8	Market	3
Mosque	19	NGO	19
Hospital/Clinic	8	Slum Area	27
Market	3	Road with Lane & By lane	101
Shopping complex	3	Drain	117
Temple	2	Newspaper Office	5

Table 5.3: Areas of different land use pattern of ward no. 24

Sl. No.	Area Name	Area in hectares	Area in %
1.	Road	14.06	8.7
2.	Commercial	5.26	3.26
3.	Clinical	0.16	0.1
4.	Assembly	.38	0.24
5.	Residential	98.83	61.7
6.	Educational	4.12	2.6
7.	Open space	25.33	15.7
8.	Water body	12.91	7.99
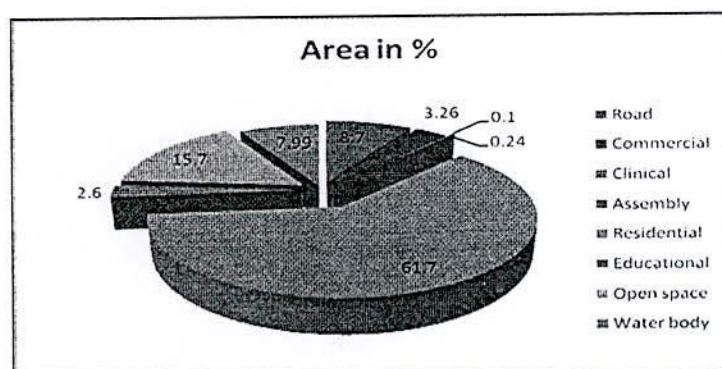
Figure 5.2: Land use pattern of ward no. 24

Table 5.4 Comparison of land use pattern of ward No. 24 and Khulna city

Sl. No.	Land use categories	% of area covered by Ward No. 24	% of area covered by Khulna City
1.	Residential	61.7	52
2.	Road	8.7	24
3.	Commercial	3.26	8
4.	Educational	2.6	--
5.	Open space	15.7	8
6.	Clinical	0.1	--
7.	Assembly	0.24	--
8.	Water body	7.99	8

The average household income per month in rich family is taka 15,000, in middle class family is taka 4,000 to14,000 and in poor family is taka 3,000. The average literacy rate is about 74.84 % in this ward. Among them 78.52% male and 70.61% female are educated.
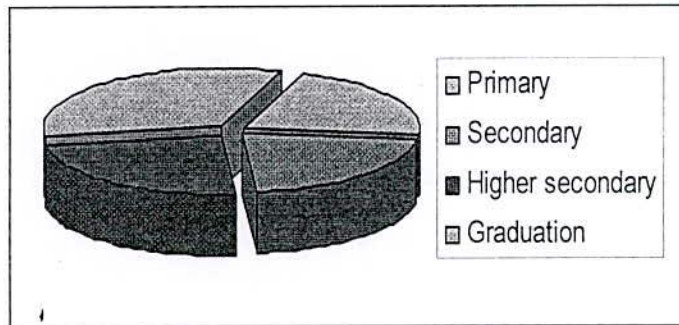
Figure 5.3: Literacy rate of people in ward no. 24

The main socio-economic problems in ward no. 24 of Khulna city are lack of job opportunities; market outlets for products; lack of capital; lack of adequate micro-credit facilities for the poor; lack of financial, technical and physical support facilities for informal sector's activities; lack of job opportunities for the women; local resources not properly exploited; lack of transparency; and lack of comprehensive information base of the city economy.
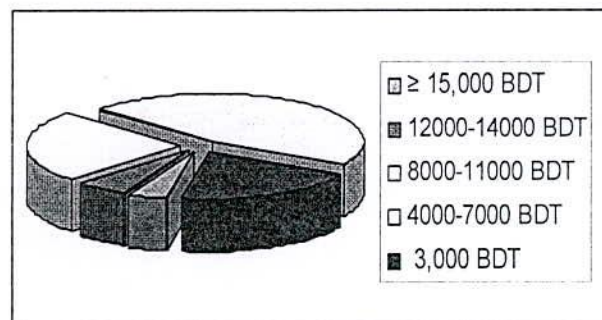
Figure 5.4: Income level of people in ward no. 24

In ward no. 24 most of the people use container to store their daily waste. They keep the waste directly into the bin. They do not use any paper or polythene to packet the waste. Most of the city dwellers do not store waste separately. All types of wastes (such as organic, inorganic, degradable or biodegradable) are stored in the same container. Usually single bin has been used in most of the houses but in rich families more than two bins are used. The generation of waste

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in rich family is more than that of the low and middle class family. These statuses are given in Table 5.5 and Figure 5.5.

Table 5.5 General information of residential area of ward no. 24

Items	Type	Percentage in six zone (%)					
		SFP	SG	IN	MP	RP	WB
Source storage	Container	90	42	95	65	80	75
	Open dumping	10	58	5	35	20	25
Type of	Plastic bin	86	85	12	75	75	82
container	Basket	14	15	2	15	25	18
No. of	1	92	64.6	79	79	65.6	92
containers	≥2	8	35.4	21	21	34.4	8
State of wastes	Mixed waste	98	88	85	83	87.5	95
segregation	Stored separately	2	12	15	17	12.5	5
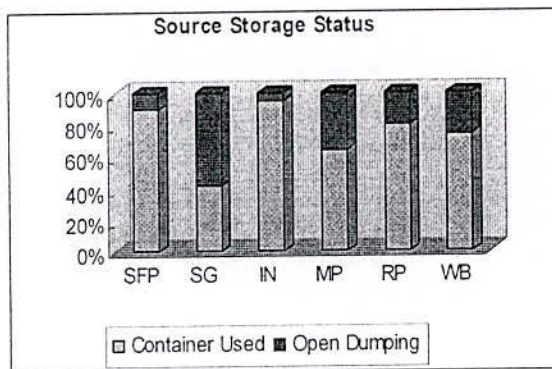
(a) Use of container
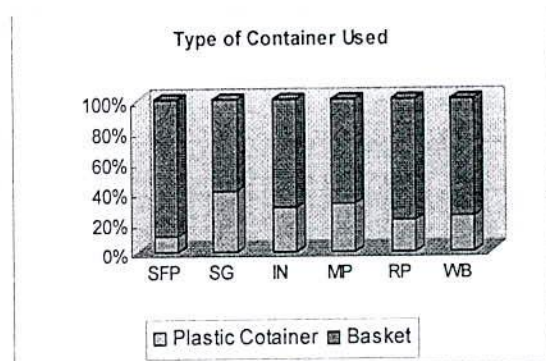
(b) Container type
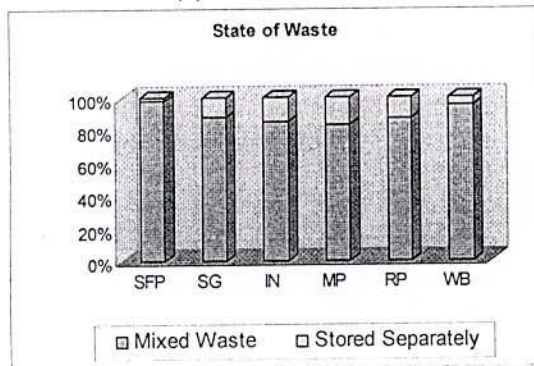
(c) Storage type
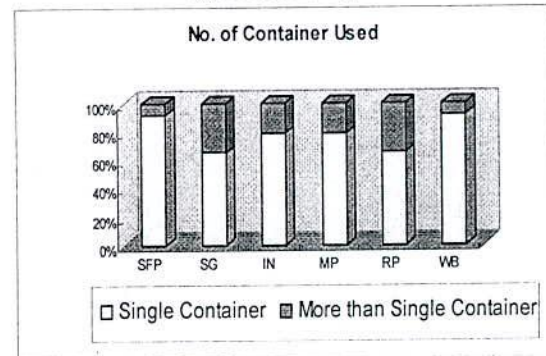
(d) Number of Container

Figure 5.5 Surveyed information on the source storage at the residential areas of ward no. 24

5.3 Generation of MSW at Different Zone of Ward No. 24

Rapid urbanization of the developing countries has increased the urban population significantly resulting in growth of industrial enterprises for the production of different consumer products. As a result, huge amounts of solid wastes are being generated daily from urban areas that have put pressure on environmental management. Table 5.6 states that waste generation rate in study area vary from 0.28 kg/cap/day to 0.47 kg/cap/day. Generation rates also increase with the income level, as it should be due to more consumption. Waste generation rate is higher in Iqbal Nagar zone, where as lower at West Bagmara zone. Average waste generation rate in ward no. 24 is 0.35 kg/capita/day. On this basis waste generated in this ward is about 20 tons per day.

Table 5.6 Generation of solid waste in ward no. 24

Zones	Surveyed families	Population	Waste generation (kg/day)	Waste generation (kg/cap/day)	Total population	Total projected generation (kg/day)
SFP	200	805	298	0.37	2,611	966
SG	328	1651	578	0.35	8,257	2890
IN	178	714	307	0.43	8,129	3495
MP	328	1631	587	0.36	8,930	3215
RP	144	572	269	0.47	7,892	3709
WB	370	1879	526	0.28	15,511	4343
Total	1548	7252	**2565**	**0.35**	52,624	**18,618**

Table 5.7 shows the variation of per capita waste generation rate with respect to income level in the six chosen zones of ward no. 24.Figure 5.6 shows that the solid waste generation rate is increased mostly with respect to the increased of income level. It is due to the higher purchasing capacity of the peoples of high-income group.

Table 5.7 Total generation rate with Income level

Monthly Income (BDT)	Solid Waste Generation (kg/family)
>15000	3.5
12000 to 14000	2.75
8000 to 11000	2.0
4000 to 7000	1.5
<3000	1.0
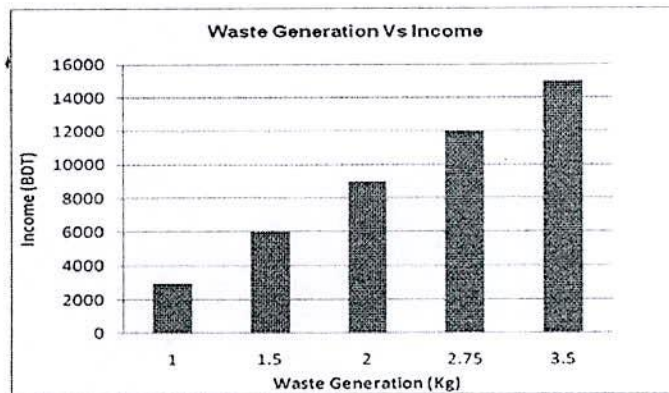
Figure 5.6 Income versus waste generation rate

5.4 Collection of MSW at Different Zone of Ward No. 24

It has been seen that actual generated solid waste from various source of study area is not properly collected. A major portion of waste remain unmanaged – throwing them in the adjacent space, roadsides and drain etc. resulting from inadequate infrastructure facilities provided by city authority, lack of people's awareness and commitment. Moreover, due to lack of motivation, awareness and commitment, a considerable portion of waste, 30 - 35%, are not properly stored, collected or disposed in designated places for ultimate disposal. As a result, unmanageable increasing quantity of MSW creates alarming environmental problems. Amount of collected solid waste is less than that of the generated waste, the situation of collection efficiency and collection coverage is shown in Figure 5.7 and Table 5.8

Table 5.8 Door to door coverage in ward no. 24

Zone	Based on direct survey			Based on secondary data		
	Generated waste (kg/day)	Collection by door-to-door system (kg/day)	Coverage by door-to-door system (%)	Projected Generated Waste (kg/day)	Collection by door-to door system (kg/day)	Coverage by door-to-door system (%)
S.Farazi Para	298	230	77.2	966	518	53.62
S. Gollamari	578	300	52.0	2890	1334	46.17
Ikbal Nagar	307	255	83.0	3495	2538	72.62
Muslim Para	587	215	36.63	3215	1144	35.58
Ray Para	269	229	85.1	3709	3238	87.3
W. Bagmara	526	158	30.0	4343	1103	25.40
Total/ Avg.	2565	1387	**54.0**	18618	9875	**53.04**

Collection time and frequency should be such that maximum amount of waste is collected from source. Different area may be covered by different collection time and frequency. Present waste collection system of study area is inadequate and inefficient. Door-to-door waste collection rate varies from 0.084 to 0.40 kg/cap/day. Average waste collection rate in ward no. 24 is 0.20 kg/capita/day.
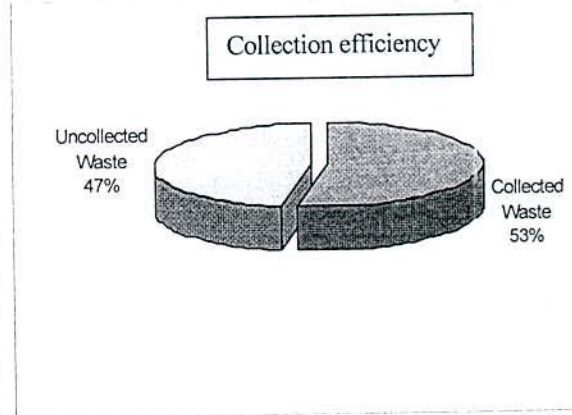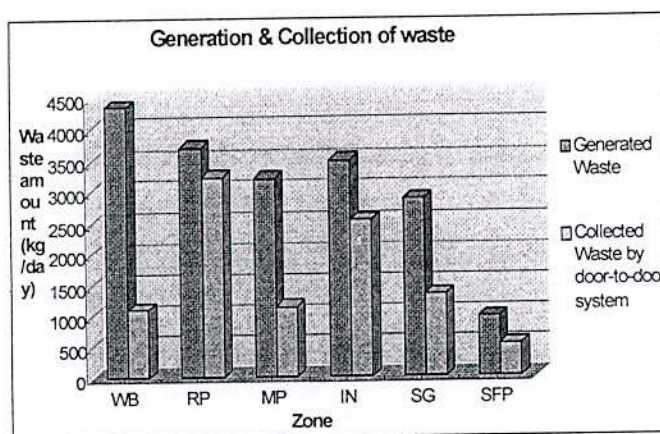
Figure 5.7 Generation versus collection amount and efficiency in six zones of ward no. 24

By extensive data collection, it has been observed that only 53-54% of total generation of waste is collected and disposed per day by KCC. Rest of waste remain on roadside bins creating unhealthy environment all around such as bad odor, soiled street and aesthetically problem. To solve these problems KCC needs to find a proper solid waste management system in the Khulna city. More over NGOs/ CBOs may play a certain role by involving community in waste management.
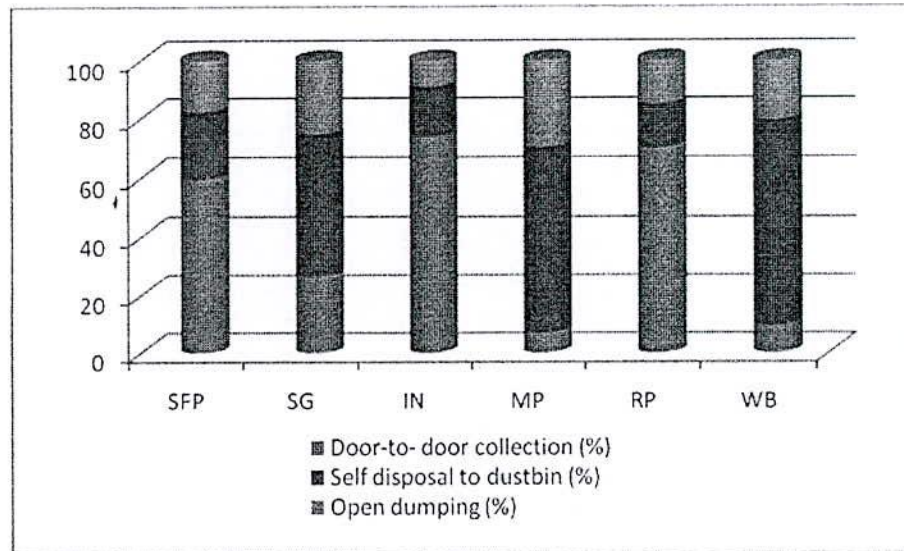
Figure 5.8 Source collection efficiency

Figure 5.8 depicts that highest amount of wastes are collected from Iqbal Nagar zone by door to door collection system but in South Farazi Para zone self disposal to dustbin system is more practiced. In Muslim Para and West Bagmara zones open dumping system is highly practiced, that's why a significant amount of wastes in these zones is remains uncollected.

Table 5.9 Status of primary collection at ward no. 24

Zone	Door-to- door collection (%)	Self disposal to dustbin (%)	Open dumping (%)
S.Farazi Para	59.7	22.8	17.5
South Gollamari	26.7	48	25.3
Iqbal Nagar	74	17	9
Musalman Para	7.03	63.37	29.6
Roy Para	70.1	14.9	15
West Bagmara	9.5	70	20.5

5.5 Hypothesis Development

With a view of fulfilling the research objectives, some relevant hypotheses have been formulated for this study:

1. H_A: Increasing income level increases the waste generation rate.

2. H_A: Increasing efficiency and coverage of primary collection has positive impact on MSW management system.

3. H_A: Changing situation of on-site storage enhances MSW management system.

4. H_A: Ensuring good no. of stakeholders' involvement, make the MSW management system effective.

5. H_A: Changing system of existing MSW increases the level of peoples' satisfaction.

6. H_A: Continuous awareness campaign has positive impact on MSW management system.

5.5.1 Data collection and sample frame

During the first questionnaire survey, total 1548 families were surveyed by taking personal interview, of which 100 is chosen randomly as representative samples. The collected views of the respondents about the MSW management system are categorized in five predefined wetted class. Likert Scale method is suitable for the statement with which the respondent shows the amount of agreement or disagreement. According to this method of sample framing, small airlines generally give better service than large one. The classes with their wetted values are: Strongly disagree (= 1), Disagree (= 2), Neither agree nor disagree (= 3), Agree (= 4) and Strongly agree (= 5).

5.5.2 Statistical analysis

For testing the hypotheses, z- tests have been performed to establish the results. For this purpose weighted averages and standard deviation were also calculated. Pie charts have been drawn for all the hypotheses to show the comparison of the views of the people.

5.5.3 Hypothesis testing

Summary of the responses of the people of ward no. 24 about MSW practices is given in Table 5.10.

Table 5.10: Summary of the responses of the people about MSW practices

Hypotheses	H1	H2	H3	H4	H5	H6
1 = Strongly disagree	17	7	15	8	4	18
2 = Disagree	22	15	22	13	7	23
3 = Neither agree nor disagree	42	52	44	51	58	40
4 = Agree	12	17	12	19	18	11
5 = Strongly agree	7	9	7	9	13	8
Weighted total	271	306	274	308	329	268
Average	2.71	3.06	2.74	3.08	3.29	2.68
Standard Deviation	1.09	0.98	1.08	1.00	0.92	1.14
Z-test Value	**1.91**	**5.70**	**2.22**	**5.79**	**8.55**	**1.58**

1. H_0: Increasing income level do not increase the waste generation rate

    H_A: Increasing income level increases the waste generation rate

    H_0: $\mu = 2.5$; H_A: $\mu > 2.5$; $N = 100$

    $Z_{Cal} = 1.91$, but $Z_{0.05} = 1.645$ (from Z distribution table)

Since $Z_{Cal} > Z_{tab}$ the null hypothesis is not accepted. At 5 % level of significance it can be said increasing income level increases the waste generation rate.
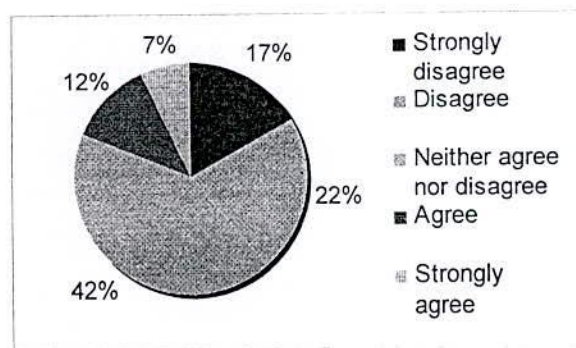
Figure 5.9 Income level effects on waste generation rate

2. H_0: Increasing efficiency and coverage of primary collection has no positive impact on MSW management system

H_A: Increasing efficiency and coverage of primary collection has positive impact on MSW management system

H_0: $\mu = 2.5$; H_A: $\mu > 2.5$; $N = 100$

$Z_{Cal} = 5.70$, but $Z_{0.05} = 1.645$

Since $Z_{Cal} > Z_{tab}$ the null hypothesis is not accepted. At 5 % level of significance it can be said that Increasing efficiency and coverage of primary collection has positive impact on MSW management system
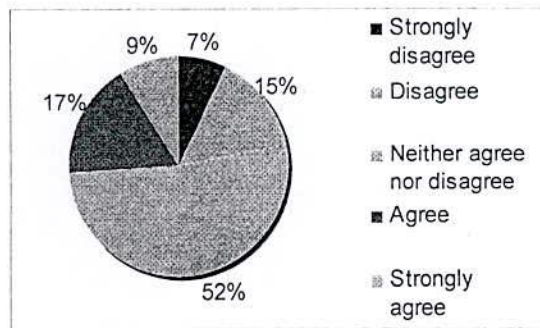
Figure 5.10 People's view on primary collection efficiency

3. H_0: Changing situation of on-site storage has no positive impact on MSW management system

H_A: Changing situation of on-site storage has positive impact on MSW management system

H_0: $\mu = 2.5$; H_A: $\mu > 2.5$; $N = 100$

$Z_{Cal} = 2.22$, but $Z_{0.05} = 1.645$

Since $Z_{Cal} > Z_{tab}$ the null hypothesis is not accepted. At 5 % level of significance it can be said that changing situation of on-site storage has positive impact on MSW management system.
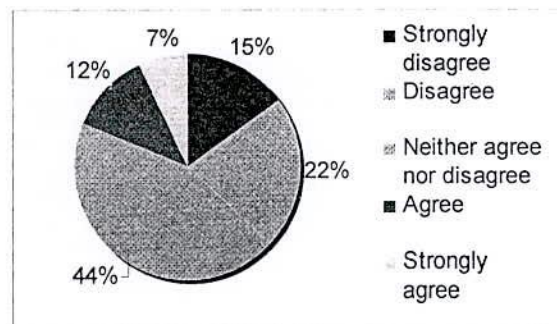
Figure 5.11 People's view on on-site storage situation change

4. H_0: Good no. of stakeholders' involvement has no positive impact on MSW management system

H_A: Good no. of stakeholders' involvement has positive impact on MSW management system.

H_0: $\mu = 2.5$; H_A: $\mu > 2.5$; $N = 100$

$Z_{Cal} = (x - \mu)/ (\sigma/ \sqrt{n}) = 5.79$, but $Z_{0.05} = 1.645$ (from Z distribution table)

Since $Z_{Cal} > Z_{tab}$ the null hypothesis is rejected. At 5 % level of significance it can be said that good no. of stakeholders' involvement has positive impact on MSW management system
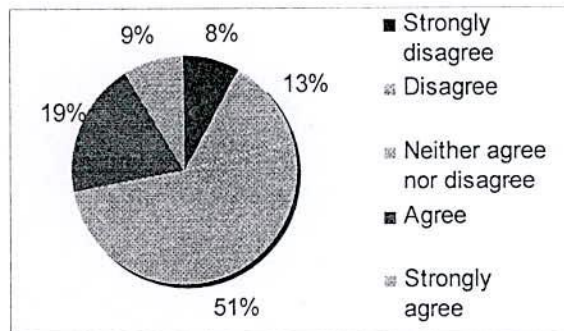
Figure 5.12 People's view on participation in MSW management system

5. H_0: People are not satisfied with the existing MSW management system

H_A: People are satisfied with the existing MSW management system.

H_0: $\mu = 2.5$; H_A: $\mu > 2.5$; $N = 100$

$Z_{Cal} = 1.58$, but $Z_{0.05} = 1.645$

Since $Z_{Cal} < Z_{tab}$ the null hypothesis is accepted. At 5 % level of significance it can be said that changing existing MSW system has positive impact on overall waste management scenario. In this particular case people are somewhat dissatisfied with the existing MSW management system and they expect a sustainable waste management system for living in a clean and healthy environment.
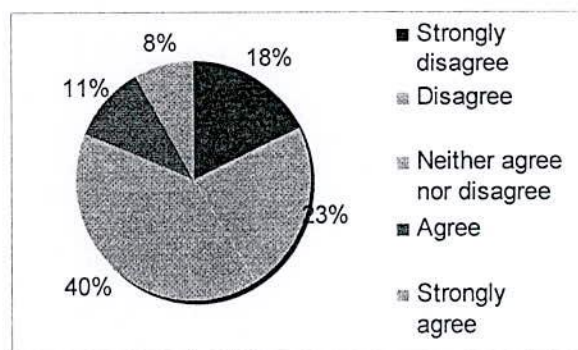
Figure 5.13 People's view on existing MSW management system

6. H_0: Continuous awareness campaign has no positive impact on MSW management system

H_A: Continuous awareness campaign has positive impact on MSW management system

H_0: $\mu = 2.5$; H_A: $\mu > 2.5$; $N = 100$

$Z_{Cal} = 8.55$, but $Z_{0.05} = 1.645$

Since $Z_{Cal} > Z_{tab}$ the null hypothesis is rejected. At 5 % level of significance it can be said continuous awareness campaign has positive impact on MSW management system.
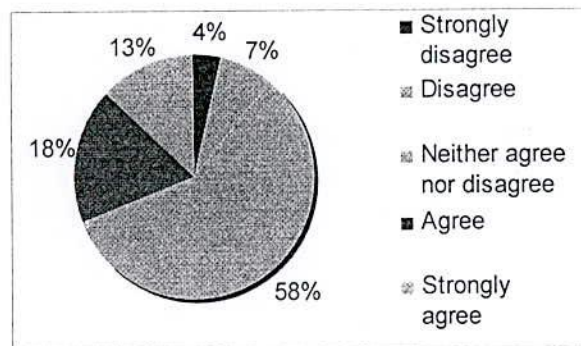
Figure 5.14 People's view on motivation and awareness

The sampling survey data shows that for all the parameters the maximum percentages of people give their opinion in favor of important category. Among all the above important issue, people are concerned mostly about MSW management system. They expect a clean, hygiene and environment-friendly city for living but have very little idea about the effects of waste on environment if it is not properly handled. People willingly agreed that waste generation rate is proportionally related to income level. With increased income level generation of waste is increase. It is due to the higher purchasing and consuming capacity of the peoples of high-income group. There is no doubt that waste is created due to all consuming level of human activities.

In ward no. 24, the entire waste management activities are conducted by NGO and CBO against tinny payment. They collect waste by rickshaw van which is insufficient considering their number also incapable considering the capacity. Most of the householders claim these issues for less waste collection. Other people are not habituate to handover waste due to the payment system charged by the NGO/ CBO for periodic collection of waste. Also there are some percentages mostly living in the slum area that don't have any idea about waste management system. A good percentage of people don't want dustbin near their home. They also suggest removing road-side waste collection point or secondary disposal site.

Householders were also asked to identify their personal level of concern for the existing management system. Changing waste management system will be the right or straightforward exercise to change the overall MSW scenario. Levels of concern about waste management are medium in the case study areas acknowledging that waste problems existed in this area and a level of agreement was also evident, however, when it came to identifying the most pressing waste management problems, and how these problems might best be addressed at household level. No waste management system can success until people get awarded by him. Multiple causes were identified as creating problems for the management of waste indicates awareness amongst the respondents of the complexity of dealing with waste. Overall, the results indicate a concern about waste and an appreciation of what could be contributing to these problems. A specific number of respondents did cite a bad attitude towards the environment as being a factor in the waste problem in the study area, but other respondents mentioned the role of their consumption patterns in terms of generating waste. Greater the involvement in MSW management system, the achievement will be certain. For this peoples' motivation and awareness are the most influencing factor. . It was envisaged that the levels of satisfaction with waste services would be influenced generally by the amount of information respondents received about waste issues. The superior outcome of this research is to carry continuous awareness campaign, only which could bring success at our door.

At 5% level of significance Z-tests values say that among all these; more than fifty percent of people are not satisfied with the existing waste management system. They expect a sustainable MSW management system which could give a healthy and sound environment. The people require more knowledge and practice to improve the waste management system. Some illiterate and people have shown their negligence about MSW management system and they have some wrong knowledge, prejudices, lack of knowledge about the system. Just as the cells of a body need to work together to thrive, so too do the elements of a MSW system. Solid waste management in ward no. 24 is a challenge due to the growing volumes of waste. A detailed understanding of the context, and developing a plan in consultation with a range of stakeholders, can help ensure success and sustainability.

5. 6 Comparison with Previous Situation

After implementation of all the approaches to increase the effectiveness in primary collection and disposal of MSW in ward no. 24, again a survey was conducted to investigate whether the taken initiatives has put any positive impact on the solid waste management system or not. This time the survey was conducted in 450 families to obtain people perception about MSW system in ward no. 24 to compare the impact of the taken initiatives. The summarized comparisons are given in the Table 5.11and Figure 5.15.

Table 5.11: Comparison of collection system at different year

Zone	Door-to- door collection (%)		Self disposal to dustbin (%)		Open dumping (%)	
	Yr. 2008	Yr. 2009	Yr. 2008	Yr. 2009	Yr. 2008	Yr.2009
SFP	59.7	74.00	22.8	14.00	17.5	12.00
SG	26.7	20.00	48	34.29	25.3	45.71
IN	74	80.00	17	9.41	9	10.59
MP	7.03	25.45	63.37	40.00	29.6	34.55
RP	70.1	75.00	14.9	10.00	15	15.00
WB	9.5	32.00	70	18.67	20.5	49.33

Survey result reveals that opinion of different groups of people about the existing solid waste management system in ward no. 24 is quite satisfactory, although the system should be improved by increasing the efficiency in collection, use covered vehicles for transportation of waste, and increase of house to house waste collection system and conducting regular awareness development programme. Table 5.11 shows that the percentage of self disposal system decreases in all the six zones while the percentage of door-to-door collection system increases positively in all the zones except South Gollamari. Because in this zone practices of open dumping system increases. The reasons behind the fact are people living in this zone mostly in slum area. Their literacy rate is also not quite satisfactory. That's why the taken initiatives have put less positive effects.

The comparison results of waste collection status from Table 5.12 and Figure 5.15 varied from year to year. There is no constant trend in the increase rate or in the decrease rate of waste collection or generation. Some year the status of MSW system in a specific zone of the study area is quite satisfactory, in another year it is satisfactory in another zone. These due to

the fact that the all the implemented system does not work together at the same time. According to the situation some taken initiatives work positively, at the same time some initiatives does not work or match as the solution.

Table 5.12: Comments of people about MSW management system

Status	Peoples' Satisfaction (%) Year 2008	Peoples' Satisfaction (%) Year 2009
Very bad	4	3
Bad	7	7
Neither good nor bad	58	41
Good	18	33
Very good	13	16
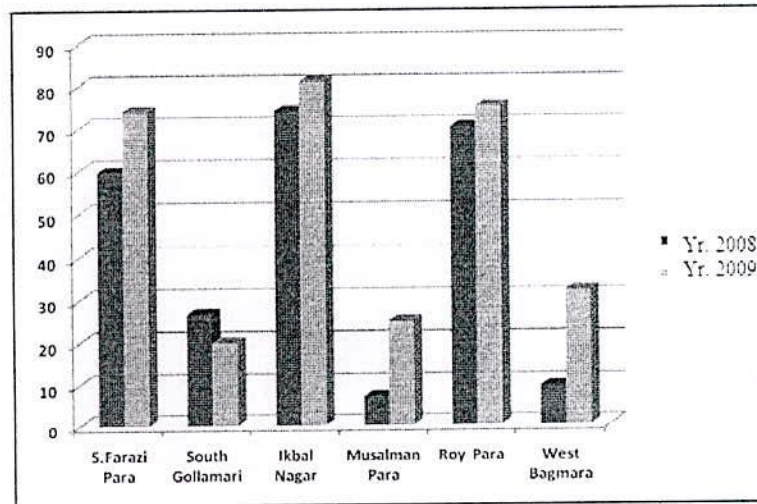
Figure 5.15 Comparison of door-to- door collection rate at different year

Due to continuous awareness build-up program together with other approaches to change the overall MSW management scenario in ward no. 24, it is clear that people's perception and response about waste management practices is encouraging in ward no. 24 comparing year to year response. Now they are pretty much conscious about the fact and at the same time become much cooperative than before which seems like sunlight after a long time of clouded day.
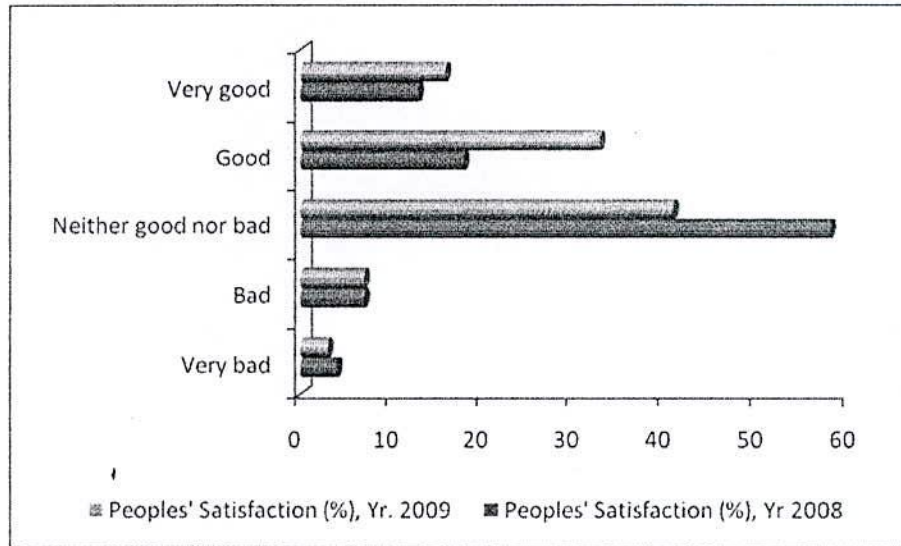
Figure 5.16 People's perception about the MSW management System

5.7 Problems and Constraints

Several practical steps have been undertaken in this ward to improve level of people's awareness and collection systems. Solid waste management system in ward no. 24 displays an array of problems, including insufficient number of Rickshaw vans, financial inability, absence of logistic supports from city authority, evaluation of success and changes and absence of appropriate method. It is observed that taken initiates have already put positive impact on overall MSW management system. The results depict that continuous monitoring, refinement of system, city authority's logistic support and social movement rather than pure technical issue are required. These environmental, and management problems are caused by various factors which constrain the development of effective solid waste management systems. They can be categorized into technical, financial, institutional, economic, and social constraints. Each of these constraints is discussed below in relation to the sustainability of waste management system.

(a) Technical Constraints

There is a lack of human resources at both the national and local levels with technical expertise necessary for solid waste management planning and operation. Many officers in charge of solid waste management, particularly at the local level, have little or no technical background or training in engineering or management. Another technical constraint is the lack of overall plans for solid waste management at the local and national levels. As a result,

a solid waste technology is often selected without due consideration to its appropriateness in the overall solid waste management system. However, the coverage of solid waste collection service is low than that of solid waste generated is dumped at many undesignated sites (e.g., open areas, water channels, streets, etc.). In such a case, the low collection coverage is a bottleneck in the overall solid waste management system in ward no. 24 and it would be most cost-effective to provide resources to upgrade the collection service.

(b) Financial Constraints

In general, solid waste management is given a very low priority. As a result, very limited funds are provided to the solid waste management sector by the governments, and the levels of services required for protection of public health and the environment are not attained.

The problem is acute and, therefore, the financial basis for public services, including solid waste management, is weak. This weak financial basis of local governments can be supplemented by the collection of user service charges. However, users' ability to pay for the services is very limited, and their willingness to pay for the services which are irregular and ineffective is not high either.

(c) Institutional Constraints

Several agencies are usually involved at least partially in solid waste management. However, there are often no clear roles/functions of the various national agencies defined in relation to solid waste management and also no single agency or committee designated to coordinate their projects and activities. The lack of effective legislation for solid waste management is partially responsible for the roles/functions not being clearly defined and the lack of coordination among them. Because of a low priority given to the sector, the institutional capacity of local government agencies involved in solid waste management is generally weak.

(d) Economic Constraints

Economic and industrial development plays key roles in solid waste management. Obviously, an enhanced economy enables more funds to be allocated for solid waste management, providing a more sustainable financial basis. However, ward no. 24 have weak economic

bases and, hence, insufficient funds for sustainable development of solid waste management systems.

(e) Social Constraints

The social status of solid waste management workers is generally low. This owes much to a negative perception of people regarding the work which involves the handling of waste or unwanted material. Such people's perception leads to the disrespect for the work and in turn produces low working ethics of laborers and poor quality of their work.

At dump sites, transfer stations, and street refuse bins, waste picking or scavenging activities are common scenes in ward no. 24. People involved have not received school education and vocational training to obtain knowledge and skills required for other jobs. They are also affected by limited employment opportunity available in the formal sector. The existence of waste pickers/scavengers creates often an obstacle to the operation of solid waste collection and disposal services. However, if organized properly, their activities can be effectively incorporated into a waste recycling system. Such an opportunistic approach is required for sustainable development of solid waste management programmmes in developing countries.

5.8 Lessons Learned

This chapter has summarized some insights on how to increase the level primary collection or the performance rate of household MSW management programmes. Actually the potential determinants of household's behaviour, as provided in the literature, usually include demographic attributes of residents and their awareness of the programme as independent factors that influence the household's decision to participate in the waste management system. Coupled with these factors are other dependent factors of the environmental attitudes of the residents and their economic concerns. It has shown that the success of waste management system is mostly dependent on the design of sustainable waste management system, situational as well as environmental attitudes, and the perception of individual households. Thus, in judging performance in waste management system by households, the focus has most often been on participation: on why people do or do not participate, and on their motivation and attitudes towards MSW management system and other environmental issues

CHAPTER SIX

CONCLUSIONS

6.1 Summary

In order to achieve the objective of this study household survey was conducted to investigate the existing waste management practices of waste storage, generation, primary collection, transfer and disposal and also analyze householders' attitudes and actual participation in waste management system.

MSW management is a technical issue as well as socio-economic. A sustainable system can not be obtained until people realized that they are the waste generator, so it is their responsibility to manage it properly for giving a clean, hygiene and environment-friendly city to their next generation. No change in waste management system is sighted until the people's attitude for changing their habit is changed, which is much more complex and difficult to achieve. The first survey result assured that almost 50% of people was quite satisfy with the existing MSW practices in ward no. 24, where the rest 50% expressed their dissatisfaction about the system. After conducting continuous awareness developing activities and implementing some other initiatives, the second survey result focuses that this percentage has changed to 67% and 33% respectively. The initiatives adopted for collection, transportation and disposal have already put positive impact on overall MSW management system in ward no. 24.

The attitudes of respondents were analyzed as predictors of the respondents. Attitudes were used to indicate the extent to which people are aware of, care about MSW management system in their localities. This study also focuses the degree of participation, the respondents' knowledge, awareness about and attitudes, barriers to and motives of participation in household solid waste management system in ward no. 24. Knowledge about and awareness of household solid waste management activities in the study area are gradually gaining attention. The main reasons for the preferred methods of domestic solid waste collection were methods which demand less effort from households and are convenient, cheap and reliable.

The survey results depict that continuous monitoring, refinement of system, city authority's logistic support and social movement rather than pure technical issue are required. The present scenario of MSW management in ward no. 24 is undergoing changes which could pave way for sustainable urban environment in Khulna city with effective inputs in economic, environmental and social aspects with adequate institutional arrangement. The respondents' willingness to participate in the different was meaningfully explained and it is clear that in order to achieve a high participation rate by households.

6.2 Barriers to MSW Management

One of the most common, but often overlooked, ways to improve waste management system is the removal of barriers to the system. Most of the time people considered time and effort as major inhibitory factors that may lead to drop-outs from participation. Three common barriers emerge in the literature.

- **Distance:** Although the use of central collection may reduce the cost of the programme, it may add personal costs of extra time and effort for the transportation of wastes to a collection centre. Where most of the schemes consist of house-to-house collection, increasing infrastructure, such as curbside provision, leads to an improved waste collection service. It is found that waste collectors in the study area were not prepared to travel a distance of more than 500m to take wastes to a certain point of collection.

- **Collection Vehicle:** Due the shortage of number of collection vehicle, the collection rate of waste is adversely affected. The vehicles used for primary collection are often small and low-cost, such as wheelbarrows, handcarts or tricycles. To increase door to door collection system the number of collection vehicle should be increased. At the same time these type of vehicle is not well designed for waste picking or disposal. Due to the lack of vehicle wastes are collected once time per day, which in some cases create problem for those who do not able to hand over wastes at that specific time.

- **Collection method:** This research reveals that collection rate is higher if wastes are collected on the same day and at frequent intervals, compared to different-day collection schedules. It has also been find that collection day and frequency may be related to convenience, as missing one pick-up day when wastes are collected frequently means that the wait for the next collection is shorter.

6.3 Conclusions

Based on the study, the following conclusions can be made:

1. Waste generation rate in the study area varies from 0.28 to 0.47 kg/cap/day. Average waste generation rate in ward no. 24 is 0.35 kg/capita/day. On this basis waste generated in this ward is about 20 tons per day.

2. Door-to-door waste collection rate varies from 0.084 to 0.40 kg/cap/day. Average waste collection rate in ward no. 24 is 0.20 kg/capita/day.

3. By extensive data collection, it has been observed that only 53-54% of total generation of waste is collected and disposed per day by KCC. Rests of waste remain on roadside bins creating unhealthy environment all around such as bad odor, soiled street and aesthetically problem.

4. The rate of primary collection system changes from year to year. The percentages of door-to-door, self disposal and open dumping practices were 9.5 to 70.1, 17.0 to 70.0 and 9.0 to 29.6, respectively after conducting first survey in the year of 2008, while these were 20.0 to 80.0, 9.41 to 40.0 and 12.0 to 49.33, respectively after conducting second survey in the year of 2009.

5. With increased income level generation of waste increases, which is due to the higher purchasing and consuming capacity of the peoples of high-income group at all stage of human activities.

6. The most claimed issue for less waste collection is waste collection van which is insufficient considering their number also incapable considering the capacity. The newly designed rickshaw van overcomes the objections considering the capacity or service provided by it. Since the number of newly designed rickshaw van is less considering the demand, it increases small percentage of coverage of primary waste collection system in the study area.

7. A good percentage of people don't want dustbin near their home. They also suggest that removing road-side waste collection point or secondary disposal site. With this issue people willingly accepted the idea of constructing the transfer station which provides an interface between primary and secondary collection.

8. The levels of satisfaction with waste services would be influenced generally by the amount of information respondents received about waste issues. The best solution to this issue is people's motivation and awareness development. As a part of this continuous awareness development programme, several activities like awareness leaflet distribution, mass awareness campaign, arranging art and cultural activities, installation of awareness festoon and billboard etc. have been conducted. These activities work positively and add new dimension to the MSW scenario of the study area. The superior outcome of this research is to carry continuous awareness campaign, only which could bring success at door.

9. The comparison results of waste collection status varied from year to year. There is no constant trend in the increase or decrease rate of waste collection or generation. Some year the status of MSW system in a specific zone of the study area is quite satisfactory, in another year it is satisfactory in another zone. These happened due to the fact that all the implemented system does not work together at the same time. According to the situation, some taken initiatives work positively, at the same time some initiatives does not work or match as the solution.

An affordable system should be developed to ensure all kind of logistic support from the concerned authority. The component of the system should be informed to the stakeholders through continuous awareness development programme. The results of the study also depict that continuous monitoring, refinement of the system, city authority's logistic support and the social movement rather than pure technical issue are required for the sustainability of the affordable system.

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No.:   **Date:**

Household Questionnaire Survey Sheet

(To be filled out by the residents of Ward No. 24 of KCC, Khulna)

....

Name: _____

Address: _____

Zone: _____

1. Gender

Male	
Female	

2. Age

18-21	
22-50	
Older than 50	

3. Highest educational qualification obtained

Primary or less	
Secondary	
Higher secondary	
Others	

4. Occupation (e.g. teacher, clerk, student)......................................

5. Gross income per month

Less than BDT 3000	
BDT 4000-BDT 7000	
BDT 8000-BDT 11000	
BDT 12000-BDT 14000	
More than 15000	

6. Name of the suburb in which you live...

7. Since when have you been living here?...

8. Type of housing: ....
....
....

9. How many people are there in your household?.......................................

10. Are you the

Owner?	
Tenant?	
Other (please specify)..
....

11. Are you aware of any household waste management initiatives in your locality?

Yes	
No	

11(a) If Yes, briefly describe them...

....

12. What sources of information do you use to learn more about waste management initiatives in your locality (mark where applicable)?

The media (television, radio, newspapers)	
Municipality	
Public meetings	
Other (please specify)...
....

13. Do you have a Municipal Corporation dustbin within 500 meters of your home?

If yes please specify what kind:	
If no, do you want dustbin near your home:	

14. Do you segregate your waste at home?

If yes, please choose: Dry__ Organic__	
No	
Others	

15. After you put out your waste, do you know where the waste goes?

| If yes, please specify where: | |
| No | |

16. . Do you make a financial contribution to the current waste collection system?

| If yes, please specify how much | |
| No | |

17. Which method of waste collection system is practiced at your home ?

Door-to-door collection system	
Self disposal	
Open dumping	
Other (please specify)...

18. . On an average, how much waste generates & how often collections are done per day?

| Total generated waste (kg): | |
| Total collected waste (kg): | |

19. Do you use any of the following items for source storage?

Plastic container:	
Basket	
Others	

20. How many container/ baskets are used for source storage?

One	
Two	
More than two	

21. Do you see any of these environmental problems in your neighborhood?

Rubbish heap	Dirty streets	Open drains	Flies and Mosquitoes:	Others

22. Do you think that the abovementioned problems cannot be solved until people get aware?

If yes, how?	
If no, why not?	

23. Do you recycle your solid household waste?

Yes	
No	

24. How much do you pay for waste removal per month? (specify "0" if you do not pay)...

25. Are you willing to participate in the waste management system in your locality?

Yes	
No	
Participating already	

26. How often would you prefer your wasteto be collected?

Once per day	
Twice per day	
Other (please specify)...	

27. Would you prefer your waste to be collected on a different day to other waste being collected?

Yes	
No	

27 (a) Please give reason(s) for your answer..

....

....

28. Would you be prepared to pay an extra on the amount for the collection of your waste for better management?

Yes	
No	

28 (a). Please give reason(s) for your answer ....

....

29. Please give comments you may have about an effective waste management system:

....

....

....

....

30. Give your opinion to the following aspects (with tick mark to the correct position):

a) Increasing income level increases the waste generation rate

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree

b) Increasing efficiency and coverage of primary collection has positive impact on MSW management system.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree

c) Changing situation of on-site storage enhances MSW management system.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree

d) Ensuring good no. of stakeholders' involvement, make the MSW management system effective.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree

e) Changing system of existing MSW increases the level of peoples' satisfaction.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree

f) Continuous awareness campaign has positive impact on MSW management system

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree

Thank you for your time and cooperation.
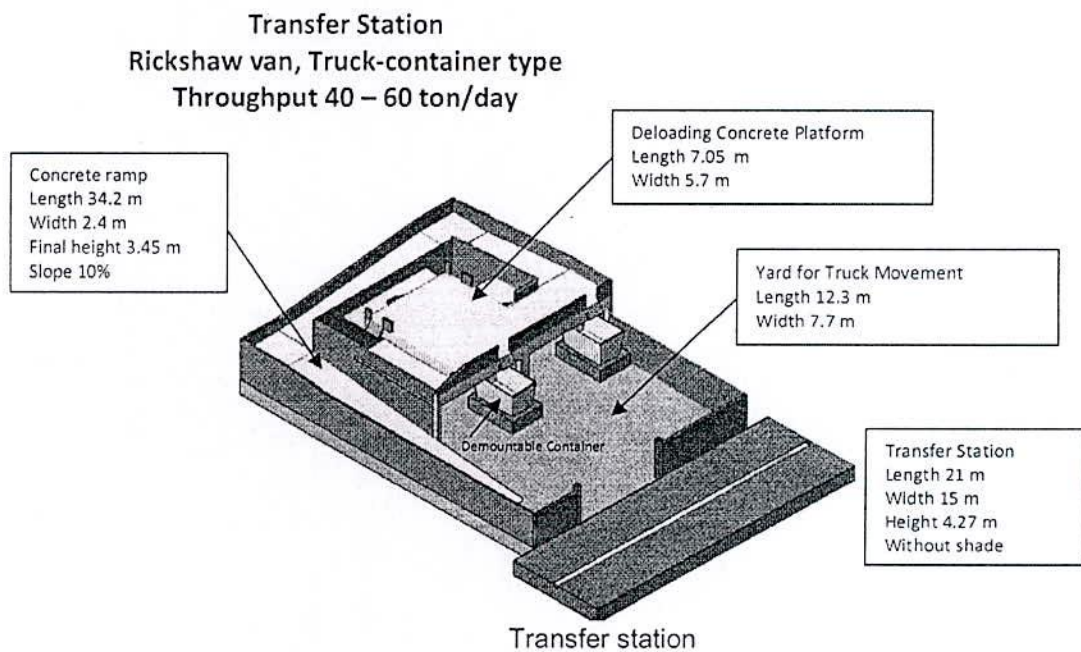
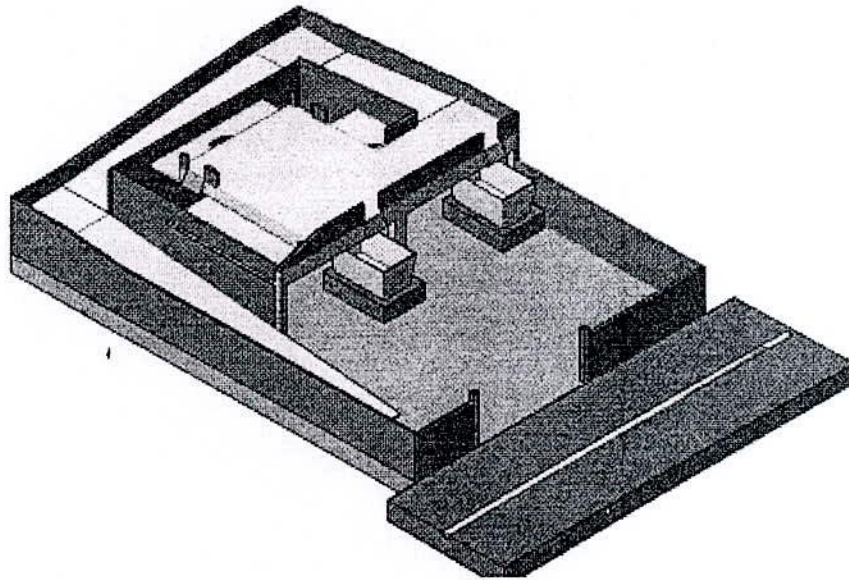Interview taken by:

Identity:

Signature:

Annexure B

Planning and Isometric View of Transfer Station

Table: Model Transfer station types

Type	Deloading vehicles	Onloading vehicles	Equipment on station	Throughput [t/day]	Special requirement [m²]
I	Rickshaw,vans	Container carriers	Loading gang 4 – 5 labour	40-60	315

Transfer Station
Rickshaw van, Truck-container type
Throughput 40 – 60 ton/day

Concrete ramp
Length 34.2 m
Width 2.4 m
Final height 3.45 m
Slope 10%

Deloading Concrete Platform
Length 7.05 m
Width 5.7 m

Yard for Truck Movement
Length 12.3 m
Width 7.7 m

Demountable Container

Transfer Station
Length 21 m
Width 15 m
Height 4.27 m
Without shade

Transfer station

Details of Transfer Station

Isometric View of the Transfer Station

Isometric View

15 m

2.4m width Road
Slope 100:12

60cm down platform
5.9mX1.5m

Opening
1.9mX2.9m

Opening
1.9mX2.9m

2.4m width
Road
Slope 100:12

Platform for vehicle movement
5.7mX7.05m

60cm
down
platform
2mX2.9m

2.4m width
Road
Slope 10:1

60cm
down
platform
2mX5.7m

21m

Yard for truck movement
12.3mX7.7m

ROAD
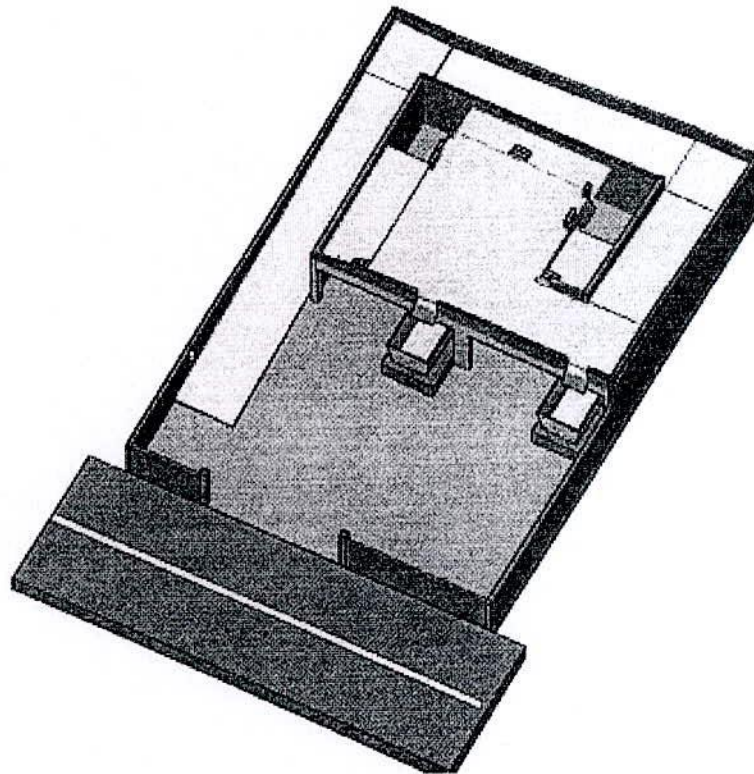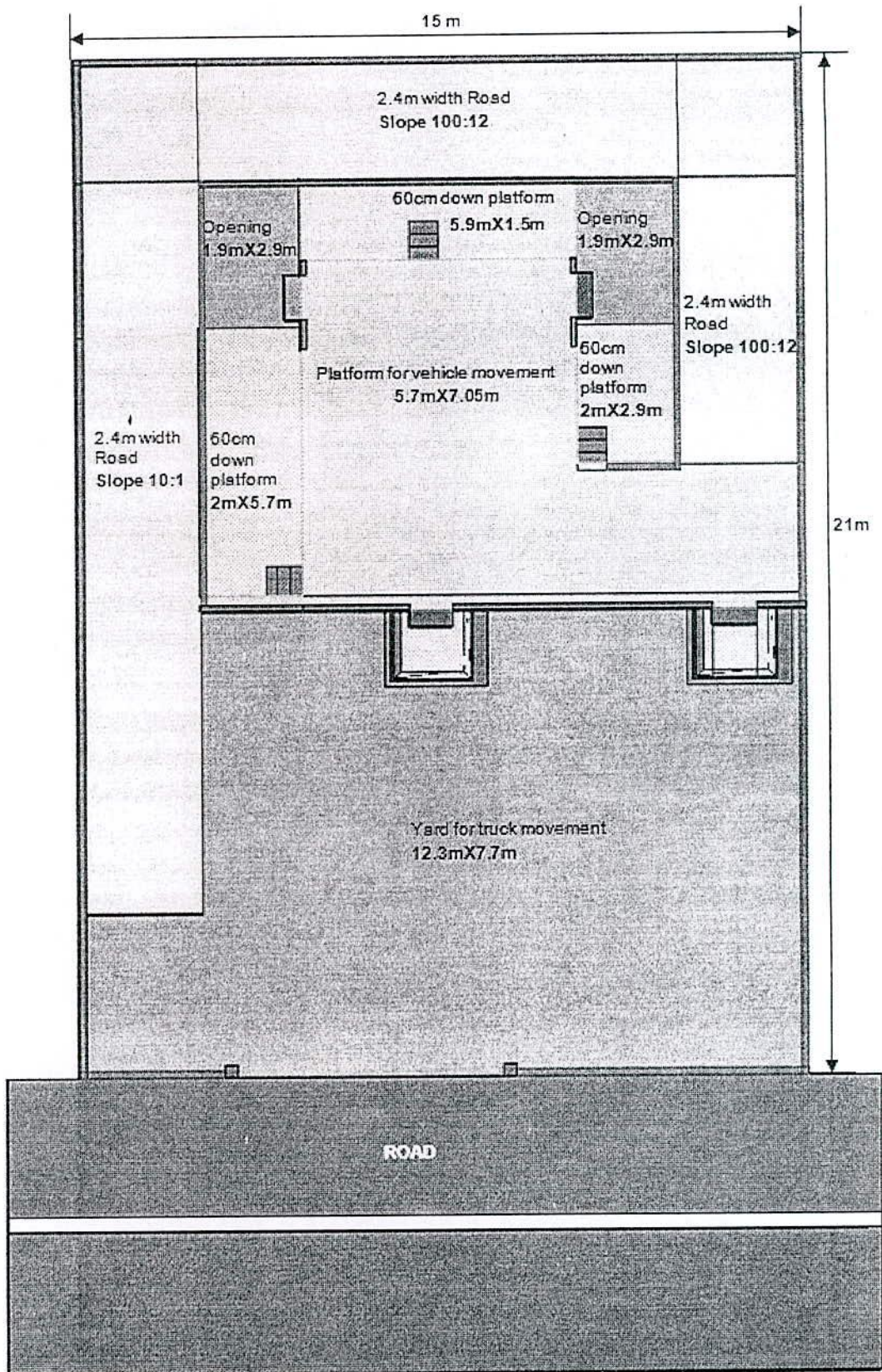
Plan of Transfer Station

Annexure C

Z Distribution Tables of Probability

Commonly used z values

Probability	z value	Condition
0.20	0.85	* this is often used in in power calculations power=0.8, β=0.2
0.10	1.29	
0.05	1.65	* this is often used for testing statistical significane p<0.05
0.025	1.96	* this is often used to define the 95% confidence interval (2.5% each side)
0.01	2.33	
0.005	2.58	
0.0025	2.81	
0.001	3.10	

Table of z and probability

The z value is the sum of the first row and first column, and probability is the cell of that row and column. for example z of 0.23 is 0.40905

	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.50000	0.49601	0.49202	0.48803	0.48405	0.48006	0.47608	0.47210	0.46812	0.46414
0.1	0.46017	0.45620	0.45224	0.44828	0.44433	0.44038	0.43644	0.43251	0.42858	0.42465
0.2	0.42074	0.41683	0.41294	0.40905	0.40517	0.40129	0.39743	0.39358	0.38974	0.38591
0.3	0.38209	0.37828	0.37448	0.37070	0.36693	0.36317	0.35942	0.35569	0.35197	0.34827
0.4	0.34458	0.34090	0.33724	0.33360	0.32997	0.32636	0.32276	0.31918	0.31561	0.31207
0.5	0.30854	0.30503	0.30153	0.29806	0.29460	0.29116	0.28774	0.28434	0.28096	0.27760

0.7	0.24196	0.23885	0.23576	0.23270	0.22965	0.22663	0.22363	0.22065	0.21770	0.21476
0.8	0.21186	0.20897	0.20611	0.20327	0.20045	0.19766	0.19489	0.19215	0.18943	0.18673
0.9	0.18406	0.18141	0.17879	0.17619	0.17361	0.17106	0.16853	0.16602	0.16354	0.16109
1.0	0.15866	0.15625	0.15386	0.15151	0.14917	0.14686	0.14457	0.14231	0.14007	0.13786
1.1	0.13567	0.13350	0.13136	0.12924	0.12714	0.12507	0.12302	0.12100	0.11900	0.11702
1.2	0.11507	0.11314	0.11123	0.10935	0.10749	0.10565	0.10383	0.10204	0.10027	0.09853
1.3	0.09680	0.09510	0.09342	0.09176	0.09012	0.08851	0.08691	0.08534	0.08379	0.08226
1.4	0.08076	0.07927	0.07780	0.07636	0.07493	0.07353	0.07214	0.07078	0.06944	0.06811
1.5	0.06681	0.06552	0.06426	0.06301	0.06178	0.06057	0.05938	0.05821	0.05705	0.05592
1.6	0.05480	0.05370	0.05262	0.05155	0.05050	0.04947	0.04846	0.04746	0.04648	0.04551
1.7	0.04457	0.04363	0.04272	0.04182	0.04093	0.04006	0.03920	0.03836	0.03754	0.03673
1.8	0.03593	0.03515	0.03438	0.03363	0.03288	0.03216	0.03144	0.03074	0.03005	0.02938
1.9	0.02872	0.02807	0.02743	0.02680	0.02619	0.02559	0.02500	0.02442	0.02385	0.02330
2.0	0.02275	0.02222	0.02169	0.02118	0.02068	0.02018	0.01970	0.01923	0.01876	0.01831
2.1	0.01786	0.01743	0.01700	0.01659	0.01618	0.01578	0.01539	0.01500	0.01463	0.01426
2.2	0.01390	0.01355	0.01321	0.01287	0.01255	0.01222	0.01191	0.01160	0.01130	0.01101
2.3	0.01072	0.01044	0.01017	0.00990	0.00964	0.00939	0.00914	0.00889	0.00866	0.00842
2.4	0.00820	0.00798	0.00776	0.00755	0.00734	0.00714	0.00695	0.00676	0.00657	0.00639
2.5	0.00621	0.00604	0.00587	0.00570	0.00554	0.00539	0.00523	0.00508	0.00494	0.00480
2.6	0.00466	0.00453	0.00440	0.00427	0.00415	0.00402	0.00391	0.00379	0.00368	0.00357
2.7	0.00347	0.00336	0.00326	0.00317	0.00307	0.00298	0.00289	0.00280	0.00272	0.00264
2.8	0.00255	0.00248	0.00240	0.00233	0.00226	0.00219	0.00212	0.00205	0.00199	0.00193
2.9	0.00187	0.00181	0.00175	0.00169	0.00164	0.00159	0.00154	0.00149	0.00144	0.00139
3.0	0.00135	0.00131	0.00126	0.00122	0.00118	0.00114	0.00111	0.00107	0.00103	0.00100
3.1	0.00097	0.00094	0.00090	0.00087	0.00084	0.00082	0.00079	0.00076	0.00074	0.00071

| 3.3	0.00048	0.00047	0.00045	0.00043	0.00042	0.00040	0.00039	0.00038	0.00036	0.00035
3.4	0.00034	0.00032	0.00031	0.00030	0.00029	0.00028	0.00027	0.00026	0.00025	0.00024
3.5	0.00023	0.00022	0.00022	0.00021	0.00020	0.00019	0.00019	0.00018	0.00017	0.00017
3.6	0.00016	0.00015	0.00015	0.00014	0.00014	0.00013	0.00013	0.00012	0.00012	0.00011
3.7	0.00011	0.00010	0.00010	0.00010	0.00009	0.00009	0.00009	0.00008	0.00008	0.00008
3.8	0.00007	0.00007	0.00007	0.00006	0.00006	0.00006	0.00006	0.00005	0.00005	0.00005

Annexure D

Photographs

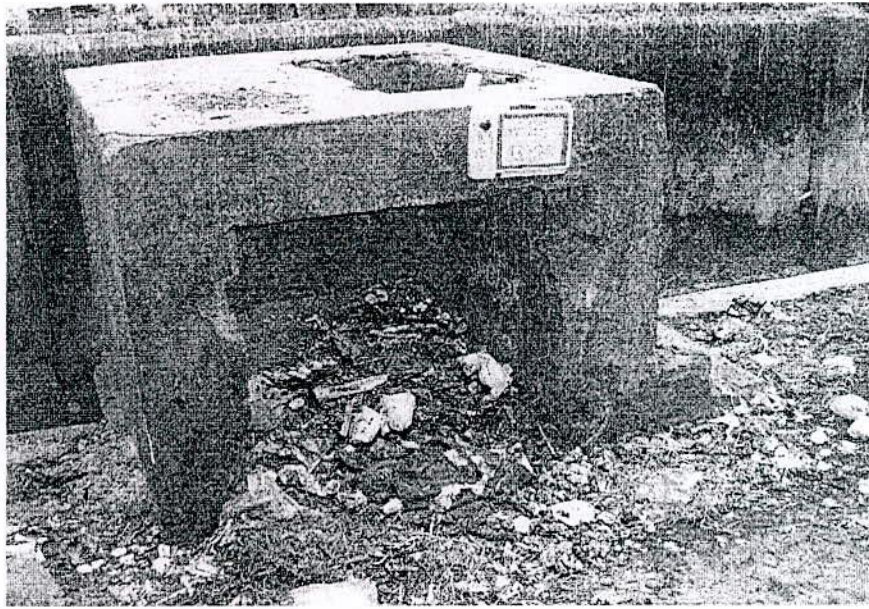Photograph D-1: Stakeholders' dialogue at ward no. 24
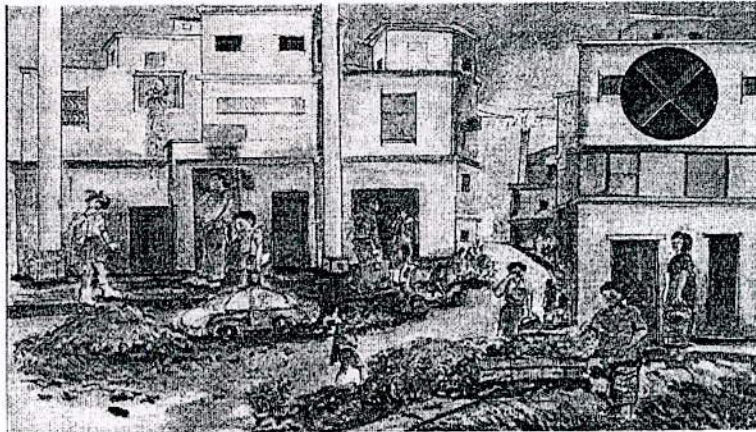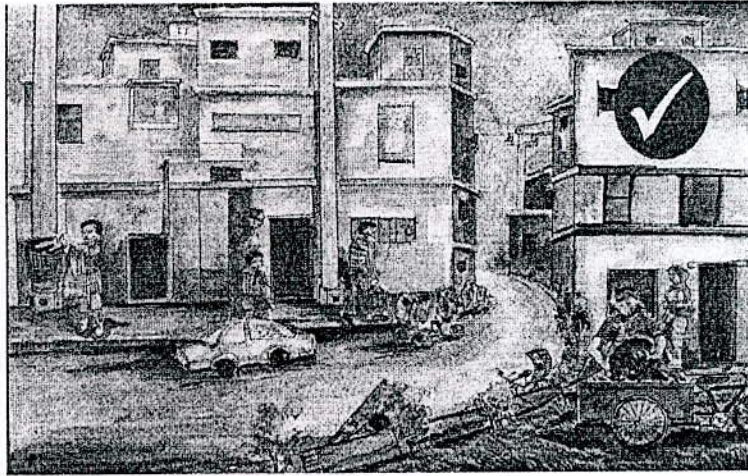
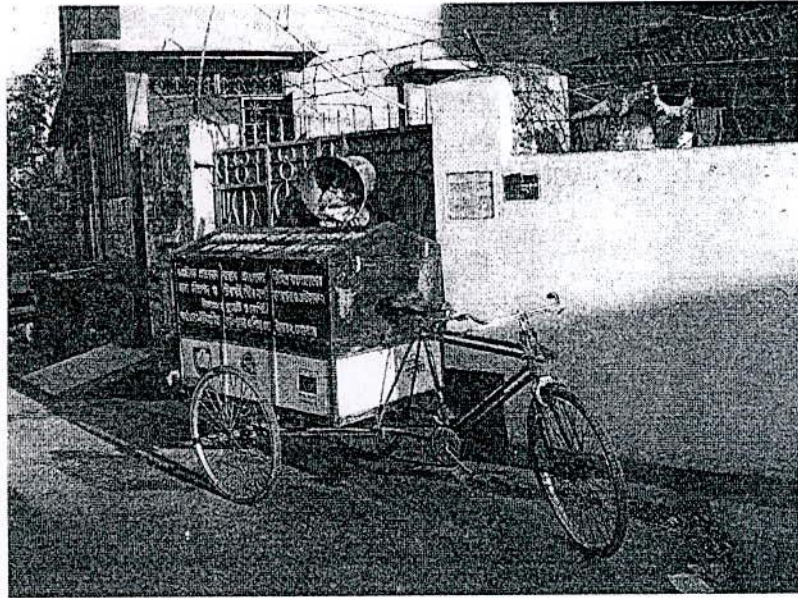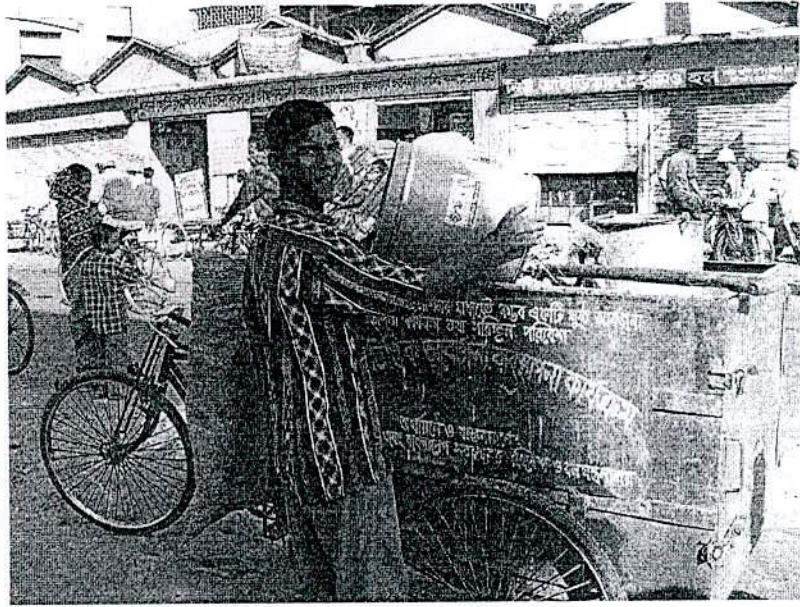Photograph D-2: Some idea for designing awareness billboard
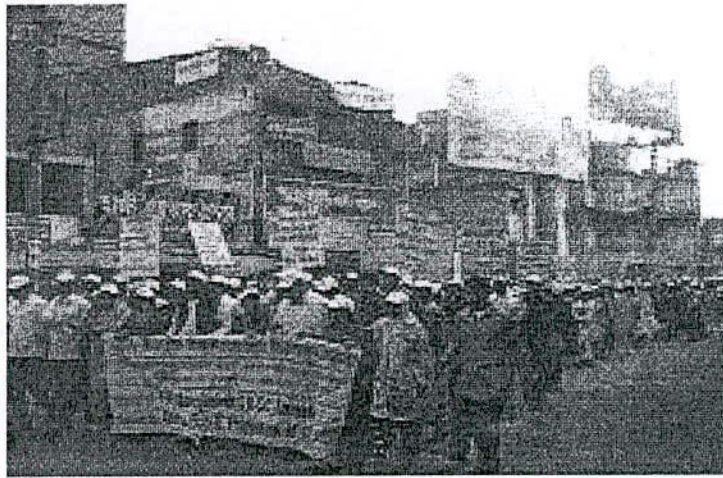
Photograph D-3: Mass awareness campaign at ward no. 24

Photograph D-4: Different view of newly-designed waste collection rickshaw van

Photograph D-5: Waste management scenario at ward no. 24

Photograph D-6: Door to door solid waste collection system at ward no. 24