DEVELOPING A SUSTAINABLE WASTE MANAGEMENT MODEL FOR THE PRIMARY WASTE COLLECTION SYSTEM

MD HASAN UZ ZAMAN

M.Sc. ENGINEERING THESIS

DEPARTMENT OF CIVIL ENGINEERING
MILITARY INSTITUTE OF SCIENCE AND TECHNOLOGY
DHAKA, BANGLADESH

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MD HASAN UZ ZAMAN (SN. 1016110001)

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Civil Engineering

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DECLARATION

I hereby declare that the study reported in this thesis entitled as above is my own original work and has not been submitted before anywhere for any degree or other purposes. Further I certify that the intellectual content of this thesis is the product of my own work and that all the assistance received in preparing this thesis and sources have been acknowledged and/or cited in the reference Section.

_____

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ABSTRACT

Developing a Sustainable Waste Management Model for the Primary Waste Collection System

A detail research was carried out to develop a sustainable solid waste management model for BGTC&C. The total solid waste generation and rate of generation was found to be 1253 kg/day and 0.214 kg/capita/day respectively. It was found that more than 75% of solid waste was organic in nature and mainly food waste. Paper, book etc were second (10.91%). About 19% of generated waste was recyclable, 76% was compostable and rest about 5% was inert. Rainy season had more solid waste generation than other seasons. Existing solid waste management practice of BGTC&C poses potential risks to health and environment. About 45% inhabitants residing close to dumping site and waste workers experienced different types of diseases. Composition and characteristics of solid waste of BGTC&C suggest composting. A pilot project was executed on composting and found to be economical and viable. About 1.8 lac taka was profit against expense of 6 lac taka. Compost fertilizers were applied in vegetable field, flower garden, nursery and leased land. Crops production was about 1.5 times more and most importantly use of artificial fertilizer was reduced to a great extent (70%). Apart from earning it could generate employment opportunity for few persons. Arrangement of adequate dustbins and their maintenance, establishing secondary transfer station and employing segregator, training of workers and awareness program for residents, closing all unhygienic dumping sites, improvements of transportation moods, relying on 3R policy etc has resulted a model of primary waste collection system for BGTC&C. The model broadly addresses different goals of Sustainable Development Goals. This model planned within financial capability of the institution may be an example for other such big Government and non Government organizations and housing societies which will be supportive to local authorities endeavor in solid waste management. This model has turned waste into resource, reduced pollution and improved environment and generated a source of income too. So this study has great significance considering its outcome and general applicability.

সারসংক্ষেপ

Developing a Sustainable Waste Management Model for the Primary Waste Collection System

বর্ডার গার্ড ট্রেনিং সেন্টার এন্ড কলেজ (বিজিটিসিএন্ডসি) এর জন্য প্রাথমিক বর্জ্য সংগ্রহ ব্যবস্থাকে উন্নত করে একটি টেকসই কঠিন বর্জ্য (Solid Waste) ব্যবস্থাপনা মডেল তৈরী করার জন্য বিশদ গবেষণা পরিচালনা করা হয়েছিল। এখানে কঠিন বর্জ্য উৎপন্ন হয় দৈনিক ১২৫৩ কেজি এবং উৎপন্নের হার দৈনিক প্রায় ০.২১৪ কেজি/প্রতিজনে। গবেষণায় দেখা গেছে উৎপাদিত কঠিন বর্জ্যের প্রায় ৭৫% জৈব প্রকৃতির (Organic) এবং প্রধানত খাদ্য বর্জ্য। খাদ্য বর্জ্যের পরই রয়েছে কাগজ ও কাগজজাত বর্জ্য যা প্রায় ১০.৯১%। উৎপন্ন বর্জ্যের প্রায় ১৯% পুনর্ব্যবহারযোগ্য, ৭৬% কম্পোষ্টযোগ্য এবং বাকী ৫% নিষ্ক্রিয় (Inert)। এখানে বর্ষা মৌসুমে কঠিন বর্জ্য সকল ঋতুর মধ্যে বেশী পরিমানে উৎপাদিত হয়েছে। বিজিটিসিএন্ডসি এর বিদ্যমান কঠিনবর্জ্য ব্যবস্থাপনা স্বাস্থ্য ও পরিবেশের জন্য ক্ষতিকর প্রভাব ফেলছে। বর্জ্য ডাম্পিং সাইটের কাছাকাছি বসবাসকারী বাসিন্দা ও বর্জ্য অপসারণে সরাসরি নিয়োজিত ব্যক্তিবর্গের ৪৫% বিভিন্ন ধরনের রোগে আক্রান্ত হয়েছে বলে জানা যায়। এখানকার বর্জ্য কম্পোষ্টিং এর জন্য উপযোগী বিধায় একটি কম্পোষ্টিং পাইলট প্রজেক্ট হাতে নেয়া হয় যা অত্যন্ত কার্যকরী ও লাভজনক বলে প্রমানিত হয়। এখানে বৎসরে আনুমানিক ৬ লক্ষ টাকা খরচ করে প্রায় ১.৮ লক্ষ টাকা লাভ অর্জন সম্ভব। উৎপাদিত কম্পোষ্ট সার সবজি ক্ষেত, ফুলের বাগান, নার্সারী ও ধানক্ষেতে প্রয়োগ করে প্রায় ১.৫ গুন অধিক ফলন পাওয়া যায়। একই সঙ্গে পরিবেশের জন্য ক্ষতিকর রাসায়নিক সারের ব্যবহার অনেকাংশে (৭০%) কমে যায় এবং কয়েকজন বর্জ্য শ্রমিকের কর্মসংস্থান হয়। পর্যাপ্ত ডাষ্টবিনের ব্যবস্থা এবং তাদের সঠিক রক্ষনাবেক্ষণ, মধ্যবর্তী ষ্টেশন স্থাপন (Secondary Transfer Station), বর্জ্য বিভাজনকারী নিয়োগ, বর্জ্য শ্রমিক ও বাসিন্দাদের প্রশিক্ষণ ও সচেতনতা কার্যক্রম গ্রহণ এবং অস্বাস্থ্যকর ডাম্পিং সাইট বন্ধ করা, বর্জ্য পরিবহন ব্যবস্থার উন্নয়ন, ৩R পলিসি কার্যকর করা ইত্যাদির মাধ্যমে প্রাথমিক বর্জ্য সংগ্রহ ব্যবস্থাপনাকে (Primary Waste Collection System) উন্নত করে বিজিটিসিএন্ডসি'র জন্য একটি টেকসই কঠিন বর্জ্য ব্যবস্থাপনার মডেল (Sustainable Solid Waste Management System) তৈরী করা হয়েছে। মডেলটি বর্জ্যকে সম্পদে রূপান্তরিত করেছে, পরিবেশ দূষণ দূর করে পরিবেশের উন্নতি করেছে এবং উপার্জনের সক্ষমতা তৈরী করেছে। মডেলটির কার্যাদি টেকসই উন্নয়নের অধিকাংশ উদ্দেশ্য সমূহকে (Sustainable Development Goals) বৃহত্তর পরিসরে (in Broader Aspect) নিশ্চিত করেছে। প্রাতিষ্ঠানিক আর্থিক ক্ষমতার মধ্যে পরিকল্পিত মডেলটি অন্যান্য বড় সরকারী/বেসরকারী প্রতিষ্ঠান ও হাউজিং সোসাইটির জন্য অনুসরণীয় হতে পারে। এতে স্থানীয় বর্জ্য ব্যবস্থাপনা কর্তৃপক্ষের দায়িত্ব অনেকাংশে হ্রাস পেতে পারে। সার্বিক বিবেচনায় এই গবেষণার ফলাফল অত্যন্ত তাৎপর্যপূর্ণ।

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

BDT	:	Bangladeshi Taka
BGB	:	Border Guard Bangladesh
BBS	:	Bangladesh Bureau of Statistics
BGTC&C	:	Border Guard Training Centre and College
Bn	:	Battalion
BUET	:	Bangladesh University of Engineering and Technology
CCC	:	Chittagong City Corporation
DCC	:	Dhaka City Corporation
DU	:	Dhaka University
FGD	:	Focus Group Discussion
GDP	:	Gross Domestic Products
JCO	:	Junior Commissioned Officers
JICA	:	Japan International Cooperation Agency
JU	:	Jahangir Nagor University
JKKNIU	:	Jation Kobi Kazi Nazrul Islam University
KII	:	Key Informant Interview
KUET	:	Khulna University of Science and Technology
M	:	Million
Mgt	:	Management
MIST	:	Military Institute of Science and Technology
MT	:	Mechanical Transport
NC (E)	:	Non Combatant (Enrolled)
NCO	:	Non Combatant Officer
OR	:	Other Ranks
PI	:	Personal Interview

RU	:	Rajshahi University
SWM	:	Solid Waste Management
SOP	:	Standing Operating Procedure
SDG	:	Sustainable Development Goals
SM Barrack	:	Single Man Barrack
USD	:	United States Dollar
USEPA	:	US Environmental Protection Agency
UZ	:	Upazilla

CHAPTER 1

INTRODUCTION

1.1 Introduction

Generation of waste is inevitable. Solid wastes are all the wastes arising from human and animal activities that are normally solid and are discarded as useless or unwanted by the person or organization that produces the waste. Human activities like domestic, commercial, industrial, healthcare, agriculture etc generate solid waste. Solid waste disposal poses a greater problem because it leads to land pollution if it is openly dumped, guides to water pollution if it is dumped in low lands and pollutes air if it is burnt. Thus disposal and management of this solid waste is a global challenge. It is becoming one of the most challenging tasks for developing countries in order to ensure good human health, as well as a healthy environment (Habib et al., 2021). As such, solid waste needs to be managed in a way that reduces risks to the environment and to human health.

The United Nations (1997) defined solid waste management as "supervised handling of waste material from generation at the source through the recovery processes to disposal." Solid waste management encompasses variety of activities associated with control of generation, storage, collection, transport or transfer, processing and disposal of solid waste materials. These are done in a way that best addresses the range of public health, conservation, economic, aesthetic, engineering, and other environmental considerations. It can include source reduction, recycling too and examples of solid waste facilities include landfills, composting sites, transfer stations, incinerators, and processing facilities. Sustainable solid waste management is one of the prerequisites for sustainable environmental management because the unsafe disposal of solid waste pollutes the environment and causes human health hazards (Ashikuzzaman and Howlader, 2019).

Population density, community size, consumption habits of the population, monthly wages per capita, number of persons per dwelling, percentage of urban population, age, sex, ethnicity of the population, size of housing, geographical characteristics, land use, productive activities and communitarians are some common factors that have the influence on waste generation (Matsuto and Ham, 1990; McBean and Forting, 1993). Human activities create waste and the intense human activities concentration place, such as in urban centers, appropriate and safe solid waste management is a necessity. Waste collection in the urban areas consists of two parts, namely primary collection from door to door and secondary collection which is the transportation of waste from designated place to final disposal points.
Typically one to two thirds of the solid waste generated is not collected by many municipalities (World Resources Institute, 1996). It is also common that 30 to 60 percent of all the urban solid waste in developing countries is uncollected and less than 50 % of the

population is served. Again in developing countries, more than 50 per cent of the collected waste is often disposed of through uncontrolled land filling .The absence of waste segregation is another problem that contributes to piling up waste in cities. For proper solid waste management a reliable estimation of the quantity of solid waste generated in a city is very vital. Physical and chemical characteristics of solid waste are important to implement the waste disposal and management plan for the selection of resource and energy recovery potentials. Many of these waste materials can be reused (Kumar and Bhowmick, 1998) and thus may eventually become valuable resources if they are removed from the waste stream (World Bank, 1999). In fact, waste of most developed countries is regarded as resources. A globally recognized waste management approach is the 3R (reduce, reuse and recycle) strategy. By following this approach, a large amount of recyclable waste, such as discarded container, glasses and plastic bottles, can be recycled annually for a significant market value. Furthermore, a higher presence of organic items (70%) in waste composition provides the opportunity to transform waste into composting fertilizers. The use of organic fertilizers can improve food security by increasing crop production by 25–30% and reducing the necessity of chemical fertilizers by 35–40% along with job creation and reduction of emission of greenhouse gases (Dhaka Tribune, 2015).

Researchers commented that waste composition changes over the years with the economic development of the country, change of season, increased habitation, density of population, changing food habit, social and cultural habits, education, effect of globalization etc. In developing countries, it is common for municipalities to spend 20-50 percent of their available budget on solid waste management. In most developing countries, open dumping with open burning is the norm (World Bank, 2011). Inadequate management of solid waste in most cities of developing countries leads to problems that impair human and animal health and ultimately result in economic, environmental and biological losses (Wilson et al. 2006; Kapepula et al. 2007; Sharholy et al. 2008).

Bangladesh is one of the fastest urbanizing economies in South Asia (The World Bank, 2020). This rapid urbanization is associated with increasing quantity of waste and complexity of its management, particularly in large cities with unwanted consequences on urban livability, environment and public health. Approximately 25,000 tons of solid wastes are generated daily in urban areas of Bangladesh, with 170 kilograms (kg) per capita per year (Ahmed, 2019). The volume of waste was 6,500 and 13,300 tons in 1991 and 2005 respectively (Dhaka Tribune, 2020) doubling in 15 years. Due to fast urbanization, changes in living standards of urban dwellers and the country's economic transitions toward a middle-income economy, the waste amount will continue to increase. As such, the per capita daily urban solid waste generation is projected to increase to 0.60 kg by 2025 from 0.49 kg in 1995 (Ahmed, 2019).

An average of 55% of solid waste remains uncollected in urban areas of Bangladesh, with a variation of collection efficiency from 37% to 77% (Ahmed, 2019). Uncollected waste, particularly plastic and polyethylene items end up in drainage system and water bodies, clogging water flow in drains, polluting surface and groundwater, soil and air. As such municipal solid waste has become a serious environmental hazard and social problem in Bangladesh. Currently a massive volume of solid waste is generated every day in the municipal areas. Unfortunately solid waste management is not significantly improved yet. The challenge to resolve solid waste in such urban and rural areas has become a major concern and created a big threat to society and people simultaneously. Current waste management practices are characterized by the inefficient practice of waste collection, costly removal and disposal mechanisms, shortage of lands for final disposal, absence of policy regarding recycling practices and lack of proper awareness about environmental problems (Abedin & Jahiruddin, 2015).

Segregation is almost absent in solid waste management process in Bangladesh and 3R or 5R are hardly followed here. However, waste recycling takes place in the informal sector by poor scavengers, while the formal sector continues to neglect the critical need for waste recycling, especially for a land scarce and populous country like Bangladesh (Islam, 2021). The informal sectors in Bangladesh recycled 4% to 15% solid wastes produced in different urban areas, which saved about BDT 10,705.5M ($15.29M USD) annually (Enayetullah et al., 2005). Approximately, 60% of post use plastic waste was recycled in Bangladesh, which resulted in a saving of $600M US on the import of virgin materials (Islam & Emon, 2016). Moreover, over dependence on chemical fertilizer can be reduced if organic fertilizer is produced and used, and will save BDT 350M per year (Nasrin, 2016). Besides, it can produce energy if the wastes are treated before dumping and land filling. Additionally, waste can provide fuel and electricity if it is being composted, anaerobic digested, and thermos-chemically processed.

Generally it is the local municipalities which remain responsible for waste management in its area. In the 21st century, educational institutions with large number of students, faculties and employees with family have to take care of their solid waste management through promotion and implementation of sustainable practices (Vega et al, 2010). Institutional solid waste management is a kind of managerial process which is practiced worldwide. These institutions include educational institutes, group of companies, office and other type of institutions. In Bangladesh among these, educational institutes like universities, colleges, research centers etc are important places to implement solid waste management system as majority of the population is involved with it and the generation of the waste here is quite high. Normally solid waste management task of educational institution is undertaken by its authorities. These services include waste collection (either from households or dustbins/ collection points) to final disposal. However, the low financial base and human resource capacity of these authorities mean that in most cases they are only able to provide a limited service. As a result these educational institutions are creating additional burden for local authorities.

On the issue of waste management, plenty of studies have been conducted in Bangladesh and few studies have also been conducted on Chittagong City Corporation and Chittagong University. But Border Guard Training Centre and College (BGTC&C), a large educational institution despite located in Chittagong, has never been studied yet. BGTC&C occupies a huge area. This huge population generates a large amount of waste every day .Besides residential wastes few canteens, big bachelor messes, bakery and food stalls under the institutions generate waste which creates tremendous pressures for disposal. This institution has been endowed with the core responsibility of collecting and disposing these wastes efficiently under BGB SOP 2015 (details are given in Anx A). This institution has also been made responsible to keep the overall environment clean and free from pollution hazards. The solid wastes generation in BGTC&C is increasing proportionately with the growth of its infrastructure, training facilities, population etc, which is posing a serious threat to the solid waste management and disposal system. The beautiful landscape of the institution is now going to be a potential threat of environmental pollution if the generated solid wastes are not disposed in a safe method. No research result is found on BGTC&C campus for identifying solid waste generation, characteristics and disposal. The objective of this study will be to increase efficiency and effectiveness of waste collection and management system of this institution. Accordingly, it will aim to scrutinize the present state of waste generation, characteristics and management practice in BGTC&C area. The study will also look at the impact of present solid waste disposal on environment along with suggesting ways to sustainable solid waste management including primary collection system for ensuring healthy environment.

1.2 **Significance of the Study**

Solid waste management is a great concern for developing country like Bangladesh. Municipalities and suburban areas are mostly affected by load of managing this waste. Researchers also have shown that currently most urban and suburban areas of Bangladesh are facing serious environmental degradation such as land, water and air pollution. Moreover, many local governments devote a substantial portion of their annual budgets for collecting, transporting and disposing of solid wastes. Presently many private housing societies, industry complex, group of companies are growing. Again there are big government and non government institutions which occupy vast land and houses considerable population. These communities (like BGTC&C) occupy an important position in the overall solid waste management system of local authorities. Bigger communities like universities; housing societies etc can be supportive to local government by handling their own solid waste. So, this study has great significance considering its outcome, general applicability and contribution to ecosystem.

1.3 Problem Statement

Solid waste management practice of educational institutions of Bangladesh is not encouraging. BGTC&C, one of the medium sized government educational institutions is struggling in managing the solid waste to a large extent. The institution itself is responsible for managing the solid waste that is produced every day in the campus from different sources. A significant amount of waste are not collected that lies uncollected in the campus creates big threat for healthier environment. Here wastes are typically collected in a non-segregated manner and carried to the open dumping site by manually driven vans. The dumping site is also dangerously situated within 100 ft of residential area. Such open dumping and scattered disposing of solid waste potentially polluting the key components of the living environment, soil, air and water and likely to be responsible for diseases like headache, vomiting, nervous disorder etc. If proper planning and its implementation is not done, it will cause severe degradation of campus environment as well as it will create sufferings of the residents. Extensive research work is needed in this field to find ways to handle the problems arising from present improper solid waste management system. No previous studies have been found on BGTC&C. To ensure a livable and healthier environment in BGTC&C, it is imperative to carry out a detail study. Accordingly this study necessarily need to find out the quantity and quality of solid waste generation; its physical composition, disposal system, impact on environment and overall management system in BGTC&C campus with a view to recommend sustainable solid waste model including improvement of primary collection system.

1.4 Background and Rationale of the Study

In general, cantonment occupies considerably larger area and established with future expansion capacity, as such solid waste are either open dumped inside cantonment or outside away the habitation. Most cases, there were ample lands between accommodations and offices, which were used for dumping of solid waste or even sometimes it is dumped just behind the buildings. But present days, lands are reducing and people are concern about solid waste management and unwilling to live with open dumping, with bad smell and odour. The study area BGTC&C, one of the educational institutes of BGB is found to be very shabby and does not have a regular practice of solid waste management. Waste collections are not even regular. Again much of the wastes are just thrown into the jungle or nearby places. So author decided to work on this. This research will identify the present status of solid waste generation and its composition in BGTC&C. It will examine the present solid waste management system to find out loopholes in the existing practices and obstacles on the way of effective waste management system in the study area. Basing on the findings of the study, the researcher will try to make some recommendations to uplift the condition of solid waste management system of BGTC&C. In order to deal with the prevailing situation, an intensive study is required to analyze the solid waste management scenario of BGTC&C.

1.5 Objectives and Possible Outcome

1.5.1 The specific objectives of this study are:

a. To develop a decentralized sustainable solid waste management system for BGTC&C.

b. To improve primary waste collection system as well as maximizing waste recycling and resource recovery.

c. To improve surroundings/environment around the study area.

1.5.2 Possible Outcomes:

a. The study will help in waste segregation / characterization.

b. It will help to plan for resource recovery and to generate a source of income.

c. It will create awareness among populations about proper waste management system.

d. It will reduce the burden of local government and contribute to the achievement of SDG.

1.6 Limitations

There are few limitations of this research work. Research work will be limited to solid waste management only. Again secondary data of BGTC&C is not available in good form for study purposes. Moreover, information regarding its solid waste management and allocation of resources within institution was not readily available and not clearly defined. The responsible personnel of the institution seem to neglect or bypass the study. The stakeholders were not so much interested about the research work.

1.7 Organization of the Study

. The study have been organized into five different chapters. They are:

The First Chapter is the introductory chapter that has a general introduction to explain the importance of the issue and its relevance, statement of the problem, the objectives of the research, scope and limitations etc.

The Second Chapter deals with literature review. A wide range of solid waste aspects have been covered here.

The Third Chapter covers research methodology in details. All aspects of primary data, secondary data, survey etc are discussed here.

The Fourth Chapter describes results on generation of solid waste in BGTC&C and their characteristics. Characterization of waste will be done with the intention to see feasibility for possible resource recycling and recovery potentials of the solid waste.

The Fifth Chapter illustrates results on present solid waste management system of the BGTC&C. Its system is examined to find out major problems, limitations, efficiency of its waste collection system, disposal of waste, management of disposal site and its effect on surrounding environment etc.

In the Sixth Chapter, Basically it deals with discussion on findings and observations. A sustainable solid waste management model for BGTC&C will be planned considering efficiency of present solid waste management system. Basing on data collected and survey results, a project will be undertaken to see its feasibility. It is expected that planned model will improve primary waste collection system, maximize waste recycling and resource recovery, manage waste disposal site in a better way and ultimately improving surrounding environment. At the same time contribution of this process towards achievement of SDG goals will be checked.

Finally, in the Seventh Chapter, summary of important findings will be mentioned here and recommendations will be made for future application/study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Solid waste emerges from the discarded components, commercial mining and operation, community actions and agricultural materials. Solid waste management is nothing but a technique or process by which the whole activity of treating the harmful solid materials derived from different sources is done (Halim, 2021). In another word we can say that solid waste management involves collection of wastes from primary and secondary sources, transportation of the collected wastes to the secondary storage stations and final disposal of it at the disposal site effectively and in an efficient manner. Solid waste management means to maintain a healthy management system with a view to saving the environment from any improper waste management system.

2.2 General Picture of Solid Waste Management

Bangladesh is considered as a densely populated country where 162.7 million people live in an area of 147570 square kilometers (BBS, 2018) and 1,115.62 people live in per square kilometer (Kormoker et al, 2017). The quick advancement in urbanization, industrialization, and consequently improved lifestyles generate the bulk of solid wastes. The per capita national income of Bangladeshi people reached USD 1,751, with 7.86% GDP growth in the fiscal year 2017-18 that has overcome its status from the least developed to a lower middle income country (BBS, 2017, 2018a, 2018b). Appreciable economic development has usher considerable changes in the lifestyle leading towards urbanization and lavish living standard. Previous studies (Abedin & Jahiruddin, 2015; Rahman, 2017; Shams et al., 2017) showed that fast urbanization and population growth are liable for a large volume of solid waste production in Bangladesh. Sonia et al., (2021) illustrated that rapid population growth, unplanned industrialization, lack of money, insufficient labor, inappropriate technology, and lack of awareness are the main constraints on solid waste management. Rahman et al.,(2020) mentioned that with the economic advancement and population growth, the generation of solid waste is also increased greatly in different areas of Bangladesh .

2.3 Generation of Solid Waste

Among the total generation of solid waste, Ahsan et al. (2014) mentioned households, businesses, and institutions contribute respectively 78%, 20%, and 1% of waste while the other sectors responsible for only 1%. Ashikuzzaman et al., (2019) predicted that solid waste management will be a grave concern for Bangladesh by 2025 as waste generation per capita will be 0.75 kg/capita/day and total amount of waste will reach 21.07 million tons per year. Habib et al., (2021) in their study observed that Bangladesh is the third lowest per capita waste-producing country, and per day MSW generation is approximately 0.41 kg/person.

Bangladesh produces less waste per capita compared to most of the South Asian countries. Jerin et al.,(2022) mentioned that solid waste management falls completely under the local government's jurisdiction, central government ministries have little jurisdiction over waste collection, treatment, and disposal services. But mostly authorities and people are reluctant about proper disposal of solid waste and casually throw or dump waste without much consideration to environment. Sultana et al., (2021) reveal that the majority (78.8%) of the people had a low to moderate level of awareness, while the least number of people (15.2%) had a high level of awareness about proper solid waste management. Rahman et al., (2020) mentioned owing to the lack of motivation, awareness, proper selection of technology and adequate financial support, a considerable portion of wastes, 40% - 60%, are not properly stored or disposed in the designated places for ultimate disposal.

2.4 **Quantity and the Composition of Solid Waste**

Hussein et al., (2018), highlighted that the quantity and the composition of the municipal solid waste are critical for the determination of the appropriate handling and management of these wastes. In this respect, the composition of the waste provides valuable information on the utility of the material. Ahsan et al. (2015) in their study put great emphasis on finding reliable composition of solid waste. They mentioned a complete picture about the composition of municipal solid waste is an essential part for selection of the appropriate type of storage and transport system, determination of the potential resource recovery, choice of a suitable method of disposal, and the determination of the environmental impact exerted by municipal solid waste. Similarly different researchers worked on different city corporations and district towns of Bangladesh and data are available on composition of solid waste of Chittagong, Rajshahi, Barisal, Khulna, Sylhet (Alamgir et al. 2007), Pubna (Hasan et al. 2016), Tangail, Rangamati, Gazipur (Hasan and Chowdhury, 2006) Rangpur, Narayangonj, (waste concern 2009). Composition wise wastes are identical but values are different. Waste Concern Bangladesh (2009) in a study showed that composition of solid waste varies among different municipality areas like Urban centre, Pouroshoba and City Corporation of Bangladesh. Among them, Pouroshobha produces maximum food and vegetables waste, on the other hand Urban centre produces greater percentage of rocks, dirt & misc, wood/grass/leaves and paper products.

2.5 **Variations in Composition and Seasonal Variations**

Yasmin et al (2017) study supports the findings of JICA (2005) and opined that physical composition of waste is changing over the years with the economic development of the country, increased habitation, density of population, changing food habit, social and cultural habits, education, effect of globalization etc. They also opined that composition of waste varies with the seasons and income group. During the rainy season, the waste becomes wet and heavy. Along with weight increase, fractions of waste composition also changes. Plenty of vegetables and seasonal fruits in this season lead to an incremental variation. JICA (2005)

found rate of waste generation is higher in the wet season and lower in the dry season. During the wet season, the rate of waste generation is comparatively higher than the dry season. In the wet season, the waste generation per capita per day is estimated at 0.5 kg, whereas in the dry season, it amounts to 0.34 kg per capita per day. The food waste portion varies on average from 66% in the dry season to 68% in the wet season. In commercial waste, the proportion of food waste is almost the same in both wet and dry seasons. Street waste increases substantially (more than 10%) in the dry season to in the wet season. Yusuf and Rahman (2007) also mentioned in general, during the wet season with summer fruits (jackfruits and mangoes), waste quantity increases by 20% .

Nasrin (2014) argues that most seasonally variable material in the municipal solid waste stream is food waste. Residential waste is relatively homogeneous. Although there are some differences in waste generation depending on demographic and other local factors, most households dispose of essentially similar types of wastes. Variation occurs in waste composition depending upon income levels and category of sources. A study conducted jointly by DCC and JICA (2005) reported that highest income group produces almost double as much household waste as the lowest income group in Dhaka. Among the commercial sectors, waste production and composition is pretty constant with the type of dwellings. Among the domestic producers, the upper income group produces significant amount of paper (12%), wood and grass (21%) and plastics (2%) waste whereas in the middle income group, food waste is almost 80% of total waste. The lower income group produces significant amount of sand and dust waste (17%).

2.6 **Environmental Effect of Improper Disposal**

Improper solid waste management is one of the most serious local environmental problems in Bangladesh. Atauzzamaman et al.,(2020) said that in developing countries like Bangladesh, the increasing amount of organic waste is one of the most critical environmental problems. Environmental and health problems such as disease transmission, fire risks, odor nuisance, aesthetic nuisance, water pollution, air pollution, soil pollution, economic losses, etc., occur due to poor solid waste management.

Saifullah et al (2016) in their study mentioned that inefficient management and disposal of solid waste is an obvious cause of degradation of the environment in most cities of the developing world. Khan (2017) mentioned that uncollected waste has been recognized as the root of inferior environment such as scattered garbage, offensive odor; drain clogging, water pollution and mosquitoes. Given that solid waste management directly affects public health, land use, and the environment. The environment and human health face a severe impact due to the unscientific disposal of solid waste. Protection is needed to neighborhood from adverse impacts of landfill gas and leachate. Besides, potential health hazards as well as vegetation damage, unpleasant odors, soil and water pollution are major concerns.

2.7 Solid Waste Management

According to USPEA (2018) internet document the concept of integrated solid waste management is source reduction of wastes before they enter the waste stream, recovery of generated wastes for recycling (including composting), and environmentally sound disposal through combustion facilities and landfills that meet current standards is being used by communities as they plan for the future. Rahman and Ahmed (2015) suggested that there is a need to work towards a sustainable waste management system, which requires environmental, institutional, financial, economic and social sustainability. Habib et al.,(2021) mentioned there are a number of waste management options available, like prevention, reduction, recycling, recovery and disposal. Prevention is the most preferred option, as it is always better than the cure. However, it is not possible to prevent waste generation completely. Disposal is the least preferred method. After prevention, reduction is preferable. By recycling or converting into energy, municipal solid waste can be greatly reduced.

Soni et al., (2016) pointed out that waste is no longer a burden; rather, it is a resource for safely producing energy, composing fertilizer, and/or generating recyclable materials. The major challenges, however, are its collection, separation, and transportation. But Chandan (2020; 2021) questions about the feasibility of recycling waste into energy given the presence of more than 70% moisture content in solid waste coming from kitchen and kitchen markets. Alam (2019) pointed out that waste reuse and recycling activities are still carried out informally.

2.8 Solid Waste and Possibility of Composting

Parvin (2018) illustrated of the solid municipal waste about 70-80% is organic and poses a major potential for production of fertilizer and biogas. She predicted that 70-80% organic waste could be turned into resource by manufacturing it as compost for agricultural use. “Waste Concern”(2009) in a study found that about 76% urban solids are compostable. Accordingly in its one project, organic solids are compost and fertilizers are produced. Yasmin et al (2017) suggested to reduce the volume of solid waste prior to disposed to dumping sites by composting of organic wastes, along with, recycling of inorganic wastes.

Harir et al. (2015) suggested that composting is sustainable in developing countries considering the numerous benefits such as production of organic compost, reduction of waste quantity for final disposal, reduced air pollution and ground water leachate and also creates employment and income and others. Adewale (2011) mentioned that attaining sustainability in waste management requires an option that employs environmental friendliness. Such a technique must be effective, efficient and less costly than many options. Disposal methods such as incinerator, landfill, pyrolysis and gasification are efficient but have negative impacts on the environment as well as threat to public health. Composting is the most suitable for developing countries due to the low costing; low technology; low pollution effect and it has more benefits to the environment and the economy when compared to the disposal of organic

waste into open dumps as is widely practiced in developing countries .Proper utilization of waste can solve the urban waste problem in a great way .Thus composting of organic waste can reduce a significant amount of landfill load and the remaining inorganic portions can be recycled for which a sustainable plan and public partnership is required.

2.9 **Institutional Solid Waste Management Practice**

Aragaw et al., (2016) mentioned educational Institutions (colleges and universities) have the moral and ethical obligation to act responsibly towards the environment; they would be expected to be leaders in the movement for environmental protection. Specifically, it would be expected that universities would drive the efforts towards responsible waste management. It would set an example for the students and the community besides cost reduction for waste management. Waste management programs in higher education institutions in industrialized countries began more than 20 years ago and varied from voluntary and local efforts to institutionalized programs (Armijo et al., 2003). Some of the higher education initiatives focused on recycling and waste reduction have been very successful. Recycling programs are one of the most popular environmental initiatives; in the USA, 80% of the colleges and universities have institutionalized waste programs [Allen, 1999].

Waste management is a great concern for developing countries like Bangladesh. City areas are mostly affected by load of managing this waste. Presently many private housing societies, industry complex, group of companies are growing. Again there are big government and non government institutions which occupy vast land and houses with considerable population. Such communities if handle their own waste management system, can reduce the burden of local government, can be very effective and economically viable. Taghizadeh et al, (2012) mentioned that educational institutions such as universities can be considered as small communities that have significant impact on surrounding urban areas.

2.10 **Study Scope**

Therefore, in this study an endeavor will be taken to analyze introduction of such decentralized and community based waste management system in a government educational institution named BGTC&C for future implementation. It is a big educational institution administered by Border Guard Bangladesh. Unfortunately, there is no published information or literature regarding the waste generation, composition and management system in BGTC&C area. So an attempt will be taken to get information through personal interaction with concern personnel, visiting dumping sites, dustbins etc. In the meantime, researcher has analytically reviewed documents related to the topic of the study of other urban areas with special emphasis on educational institutions, universities, cities etc. Therefore, reviewed documents, papers, articles and reports on waste management will be cited extensively in the study. Results of such study can be very useful for other such institutions/ universities/educational outfits to implement their own solid waste management.

CHAPTER-3

RESEARCH METHODOLOGY

3.1 Introduction

This research is explanatory and quantitative in nature. This chapter explains in details the methodology and the key issues in implementation of the research. Two types of data have been collected namely solid waste sample from the area as primary data and other data from the freely available website as secondary data. Major research method includes the following:

3.2 Primary Data Collection

The study uses both primary and secondary data. The study was conducted from October 2020 to November 2021. This study mainly focused on the present status of solid waste management practice in BGTC&C and identifies the lacking of present waste management. To find out the solid waste management practice, the primary data was collected from various classes of people and the respondents were selected randomly.

The primary data was collected through questionnaire survey from day labor, waste collectors, cleaner, van puller, separators to assess the exact situation of solid waste management (Annex B and C).

For assessing expert opinion, the key informant interview (KII) was conducted with the various stakeholders (Annex D). A total of 14 (Fourteen) KII were carried out for the purpose. The respondents have been asked about the present situation of solid waste management in BGTC&C, the root causes of poor waste management, major problems and limitations in the waste management system, the managerial activity of BGTC&C authority, the ways of improving the situation etc. A summary of KII has been presented in the following table 3.1.

Table 3.1: Details of KII

S/N	Respondents	Organization	No of KII
1	Commandant	HQ, BGTC&C	1
2	Director, Admin Battalion	Admin Battalion	1
3	Director, Advance Training Battalion	Advance Training Battalion	1
4	Director, Recruit Training Battalion	Recruit Training Battalion	1
5	Assistant Director	All Battalion	4
6	Head of Conservancy department	All Battalions	4
7	Waste Officials	Admin Battalion	2
	Total		14

The household respondents have been selected based on area and type of occupancy. A total 30 household was contacted and required information was received through written questions (Annex E).

Table 3.2: Details of Households

S/N	Households Area	No
1	Officers Family Accommodation	2
2	JCOs Family Accommodation	2
3	ORs Family Accommodation	11
4	Officers Mess	2
5	JCOs Mess	1
6	ORs SM Barrack	10
7	$3^{rd}/4^{th}$ cl Employee Family Accommodation	2
	Total	30

3.3 **Secondary Data Collection**

Secondary information was collected for proper documentation, like research articles, journals, books, periodicals etc. Secondary data about population, volume of waste generation, existing activities on solid waste management were collected from BGTC&C admin office. The main method of the study is surveying method. The collected information was analyzed to develop an understanding of the problems and prospects of existing solid waste management system.

3.3.1 **Official Documents Review.** As an important part of the research, official documents review has been conducted. It includes the review of relevant circular, office orders, manuals, regulations which are related to solid waste management and on the basis of which the whole activity of solid waste management is done. The study has helped to know the organogram of the conservancy department, work distribution of conservancy department, numbers of personnel involved in solid waste management, Budget for this works etc. Consequently, the gap between the official instructions of performing the management work of solid waste based on rules and regulations and the common practice in the field have been identified.

3.3.2 **Personal Observation.** As a part of service, the author had the opportunity to observe the solid waste management system of BGTC&C by himself. While working as Commandant in BGTC&C, the opportunity of observing solid waste collection, transportation and disposal helped to know the total solid waste management in BGTC&C area.

3.4 Methodology of Survey

The standard procedures and methods have been applied for sampling, assessing daily solid waste generation, segregation and waste classification and their characteristics.

3.4.1 **Survey Periods and Seasons**. In conducting a study at local conditions, a variety of waste characterization methods can be used, reported in USEPA (2018). Sampling was designed to be two way stratified for this study because of source of generation and seasonal variation can have an impact on waste characteristics. The first level is stratification by waste generation sources such as residential, commercial, institutional and open areas (as street sweeping). The second is seasonal stratification. Bangladesh has three main seasons: summer, monsoon and winter. Sampling was designed to take place during these seasons and for simplicity the year is sub-divided into the three seasons. Data were collected from 10 November 2020 to 15 January 2021(winter season), from 14 May to 23 June 2021(summer season) and from 1 July to 29 August 2021(rainy season). A total of 199 samples were collected on each day. Accordingly 4179 (Four thousand one hundred and seventy nine) samples were collected during the year of 2020 and 2021 from study area.

3.4.2 **Sample weight**. Generally smaller the sample weight the greater the variance of the waste sample composition. As such adequate weight was taken to ensure minimum variance.

3.4.3 **Field Protocol.** The preliminary survey was conducted to find the different waste generation sources such as residential, commercial and institutional areas etc. A total of 145 households (61% of total households) waste generation were investigated by supplying polythene in each household. The daily average generation rate in each household with per capita generation was evaluated. Then total amount of solid waste generation from residential areas was estimated by knowing total population in study area.

The commercial establishments were categorized as wet canteen, dry canteen, Shipoks, Kabab Ghor, Rest house, Bakery etc. Total volume of the waste generation was found out from all commercial establishments and then average waste generation rate/day was calculated.

In institutional category, seven offices, three educational institutions (schools), twelve training sheds, three multipurpose sheds, two health care centre/clinics were available. Then the total amount of waste generated in institutional areas within BGTC&C was estimated.

The waste generation per 100 m of road length for sweeping was determined by selecting five-paved roads (1 km each) in BGTC&C. Finally the total solid waste generation from residential, commercial, institutional areas and for street sweepings was determined.

Table 3.3: Solid Waste Sampling Sources and Frequency

Ser	Accommodation type	No of Building	Room/ Flat	Sample	Frequency
1	**Residential**				
	Single Officers Mess	1	40	1	7days sample on each season
	Single JCOs Mess	1	26	1	
	SM barrack for Soldiers	10	200	1	
	Tin Shed for Single Man Civilians	2	10	1	
	SM barrack for Instructors	1	20	1	
	Officers Family Accommodation	2	16	16	
	ORs Family accommodation	15	156	64	
	$3^{rd}/4^{th}$ Cl employee Family accommodation	5	50	50	
	Teachers Family Accommodations	1	10	10	
				145	
2	**Commercial**				
	Wet Canteens	5	5	5	
	Dry Canteens	2	2	2	
	Shipoks	1	1	1	
	Bakery	1	1	1	
	Kabab Ghor	1	1	1	
	Rest House	1	1	1	
	Contractors Ration Store	1	1	1	
	Slaughter House & Vegetable Store	1	1	1	
	Temporary Market		3	1	
				14	
3	**Institutional**				
	Offices	7	7	7	
	Schools	3	3	3	
	Hospital/clinic	2	2	2	
	Training Sheds	16	16	16	
	Multipurpose Sheds	3	3	3	
	Firing Range	2	2	2	
	Stores	16	16	4	
				35	
4	**Open Space& Street sweeping**		5	5	
	Grand Total			**199**	

3.4.4 **Laboratory Protocol.** During the survey, polythene bags (similar size and with particular coding of the respondent) were supplied to all designated residential, commercial and institutional areas to collect their wastes for seven days. The collected waste samples were transported to the designated shed for weight measurement and sorting by expert

labours. Collected wastes were weighted and recorded. Then, the wastes within the bag were segregated and weighted separately and recorded. During segregation, portions of the waste from each bag/device were placed on a sorting table and sorted manually, then placed into the identified containers. The composition was then categorized into eight major categories (AIT, 1991) as shown in Table 4. An estimation of wetness of the sample was made and each container was weighed before starting the sorting operation. Standard personnel safety procedures were followed during the sorting process such as wearing mask, gloves, apron, safety glasses and boots, etc.

Table 3.4: Waste Composition Category

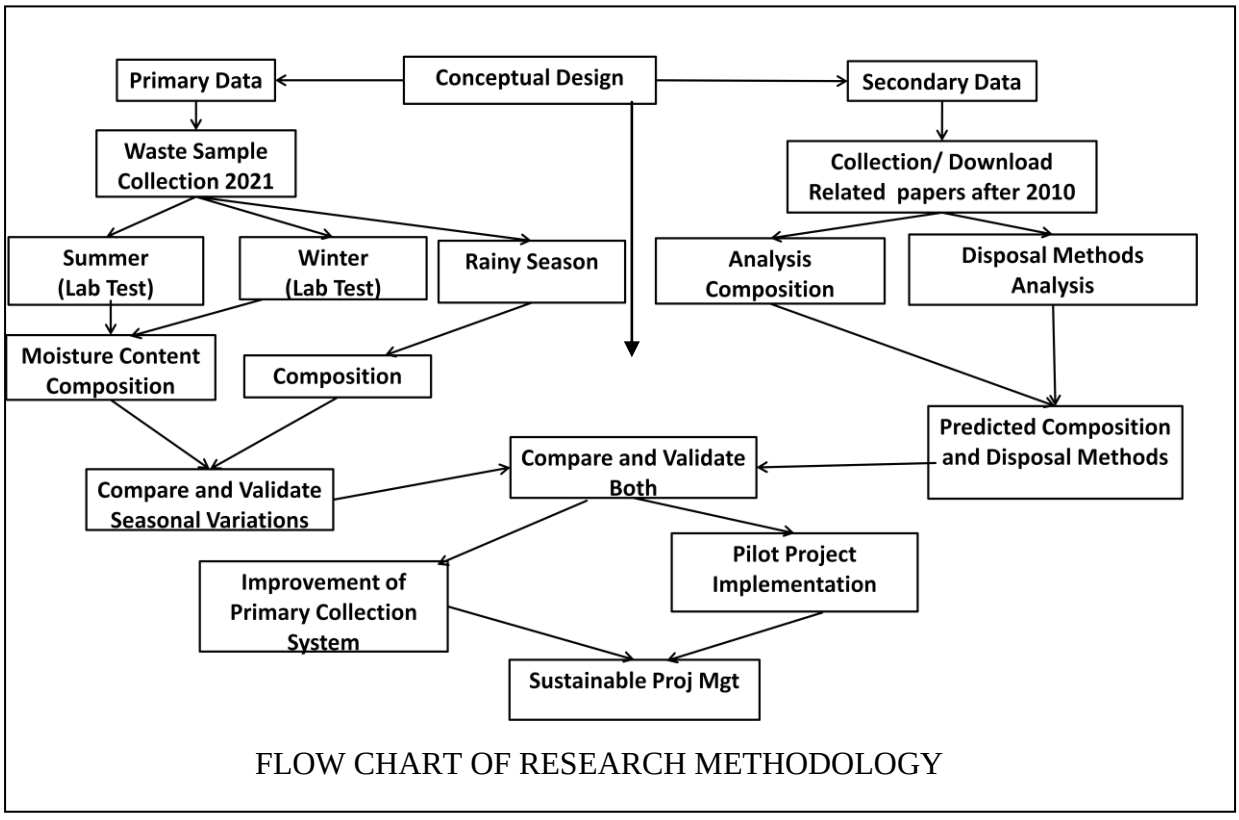
S/L	Waste Category	Waste Components
1	Organic Matter	Waste from foodstuff such as food and vegetable refuse, fruit skin, stem of green, corncob, leaves, grass and manure
2	Paper	Paper, paper bags, cardboard, corrugated board, box board, newsprint, magazines, tissue, office paper and mixed paper (all paper that does not fit into other category).
3	Plastic	Any material and products made of plastics such as wrapping film, plastic bag, polythene, plastic bottle, plastic hose and plastic string.
4	Textile & Wood	Has its origin from yarn, wood and bamboo such as cotton, wool, nylon, cloth, desk, chair, bed board, toy and coconut shell.
5	Leather and Rubber	Any material and products made of rubber or leather such as ball, shoes, purse, rubber band and sponge.
6	Metal	Ferrous and non-ferrous metal such as tin can, wire, fence, knife, bottle cover, aluminum can and other aluminum, foil, ware and bi-metal.
7	Glass	Any material and products made of glass such as bottles, glassware, light bulb and ceramics.
8	Other	Yard waste, tyres, batteries, large appliances, nappies/sanitary products, medical waste, miscellaneous*.

*Dust, ash, shell, bone, straw, rope, brick, stone pottery and fines (pass through 63-mm opening sieve).

3.4.5 **Questionnaire Survey.** A structured questionnaire was designed, pre-tested and modified to collect solid waste related data and daily solid waste traits from selected residential, commercial , institutional areas and open space following the methodology of Hossain et al (2013), Das et al. (2013), Salam et al. (2012), Sujauddin et al. (2008) and Enayetullah et al. (2005).

Questionnaire prepared keeping eye on existing solid waste practices as well as individual knowledge, attitudes, concerns, eagerness to participate on the general issues of solid waste. The sample distribution was selected such that it reflected on different socio-economic conditions (High income, Middle income & Low income). The survey was run across the group of the population and personal interviews were used to collect data.

3.4.6 **Data analysis.** Data was collected from various sources. The data was classified according to the contents. The organized data was then overviewed to get a general sense of emerging trends, patterns and concepts. The data was divided into broad categories like waste generation, waste composition, waste collection and transportation, waste disposal etc.



FLOW CHART OF RESEARCH METHODOLOGY

3.5 **Respondents Details**.

Total respondents were 240 (Male 136, Female 104) in the survey. The following figures and tables are shown for the total respondent‘s basic features. Details are at Table 3.5 of Annex F.

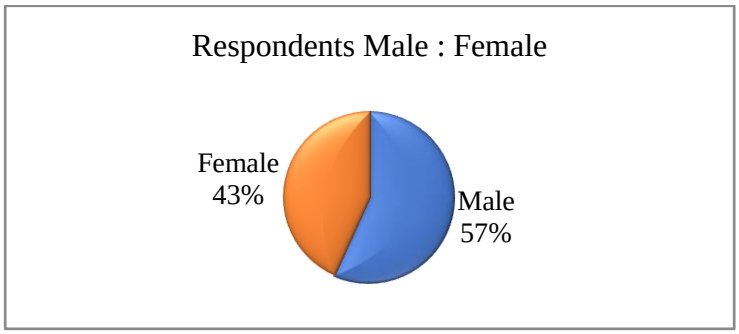


Figure 3.1: Male-Female Ratio of the Respondent**s**

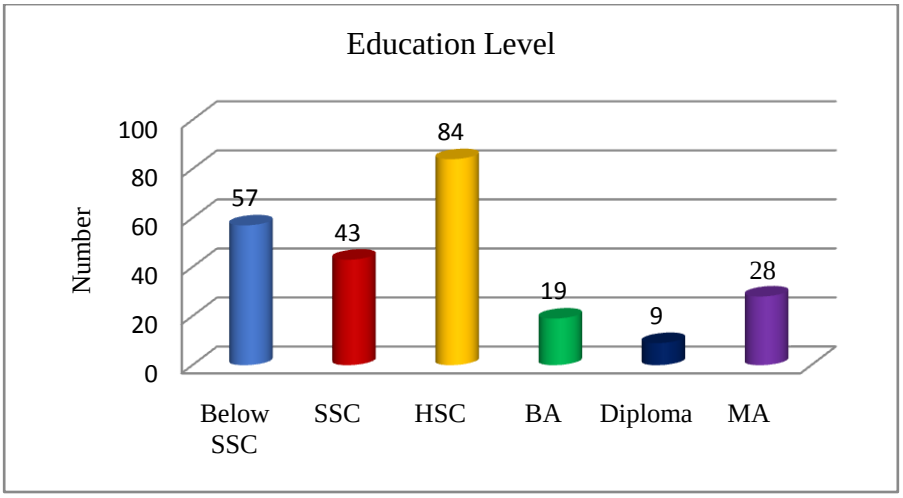


Figure 3.2: Educational Qualification of the Respondents

CHAPTER 4

RESULTS: SOLID WASTE GENERATION IN BGTC&C AND THEIR CHARACTERISTICS

4.1 Introduction

Solid waste generation and composition analysis is a critical first step towards developing successful and effective planning of waste management service and strategies across any campus (Azad, 2021). This chapter aims to evaluate the per capita generation, total daily generation, percent composition and the potential for waste recovery, recycling and reduction in BGTC&C. Characterization of waste will be done with the intention to see feasibility for resource recovery, recycling including composting. To meet this demand, sampling was done in all different waste generation sources such as residential, commercial, institutional and open areas.

4.2 Description of the Study Area-BGTC&C

Figure 4.1: Location of BGTC&C

BGTC&C is the only training centre of Border Guard Bangladesh. It is located about 53 km from Chittagong, 29 km from Bandarban and 99 km from Coxsbazar district. It falls under Satkania UZ of Chittagong district. Satkania UZ Headquarters is about 13 km from here. It covers around 206 acres of land and about 20 acres of Forest land are also being used by this institution. Its latitude is 22°11’68.30” and longitude is 92°10’77.90”.

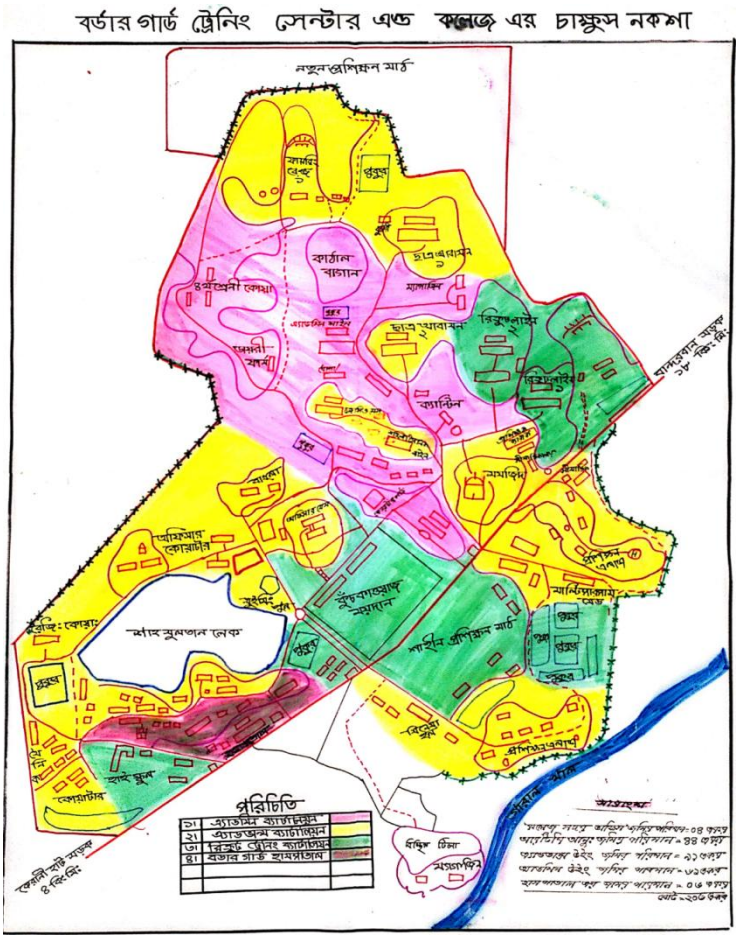


Figure 4.2: Sketch of BGTC&C in 2020

The area is generally undulating having many small hillocks. The institution is divided into two parts by Chittagong–Bandarban road. Southern part holds mainly training ground, training sheds, offices, helipad, conference rooms, computer training shed, multipurpose shed, ponds, park, cinema hall, a fast food shop, deer house etc. Although there is no planned accommodation but due to Corona few sheds are converted into accommodation for isolation and quarantine. Foods are not cooked in this side except fast food shop. People living this side are supplied with cooked food from mess situated on the northern side of the road.

Northern part has most of its establishments. All accommodations are situated in this side. Most are buildings and few are tin shed buildings. Family accommodation areas include Officer's Family accommodation, JCOs and ORs family accommodation in PASRA area and $3^{rd}/4^{th}$ class employee accommodations are in BISPARIBAR areas. There are Single Officers Mess, Single man JCOs Mess, Single Instructors Mess, Single Man(SM) barracks for single man and single woman , Guest house and separate accommodation for Recruits here. There are tin sheds accommodations for civilians working inside. Three dry canteens, one wet canteen, one bakery shop, a cattle firm, wood workshop are also available here. Accommodation Buildings are mostly 4/5 storied buildings and tin sheds are one storied.

Table 4.1: Profile of BGTC&C in 2020

Ser	Residential	Commercial	Institutional	Open Space& Street sweeping
	Single Officers Mess	Wet Canteens	Offices	Total 16 Km of road inside the campus
	Single JCOs Mess	Dry Canteens	Schools	
	SM barrack for Soldiers	SHIPKS	MI Room/clinic	
	Tin Shed for Single Civilians	Bakery	Training Sheds	
	SM barrack for Instructors	Kabab Ghor	Multipurpose Sheds	
	Officers Accommodation	Rest House	Firing Range	
	ORs accommodation	Stores		
	$3^{rd}/4^{th}$ Cl employee accommodation	Slaughter House		
	Teachers Accommodations	Cattle Farm		
		Temp Market		

4.3 Population and Their Type of Living Conditions

There are mostly three types of population considering living conditions. Firstly persons live with family; secondly persons live in single man mess and barracks and thirdly persons temporarily occupying facilities like training sheds, offices and Schools etc. In an average 5840 people were living inside BGTC&C during the period of research (BGTC&C Reports, 9-11/2020. Mostly these are nucleus family with 1 or 2 members. Some of them keep parents and maid or servants. There are around 700 students and teachers in three schools who temporarily use the area. In an average, around daily10 labors work in different places. Officers fall in higher income group; JCOs in middle income group and rest are in low income group. Monthly net earnings range from 10,000 to 1,00,000 tk. Officers have higher educational background and among others 90% of them are from village with Higher Secondary level educational background.

Table 4.2: Population of BGTC&C in 2020

Ser	Accommodation type	No of Building	Number of Storied	Room/ Flat	Population	Remarks
1	Single Officers Mess	1	4	40	30	
2	Single JCOs Mess	1	4	26	40	
3	SM barrack for Soldiers	7	4	140	3920	
4	Tin Shed for Single Civilians	2	1	10	60	
5	SM barrack for Instructors	1	4	20	80	
6	SM barrack for Recruit	2	5	40	700	
7	Officers Accommodation	2	5	16	90	
8	ORs accommodation	15	5	156	690	1x8 storied
9	$3^{rd}/4^{th}$ Cl employee accommodation	5	1	50	195	
10	Teachers Accommodations	1	1	10	35	
					5840	

Around 700 students and teachers are available in 3 schools and 10 labours works inside the campus

4.4 Waste Generation in BGTC&C Campus

Analysis of waste flows within universities and institutions is the first step in designing successful and comprehensive management system (Armijo de Vega et al., 2008) towards environmental protection (Smyth et al., 2010). All ranks of BGTC&C, trainee, recruits and staff are increasing day by day due to gradual expansion of its courses, training and related activities. As the population is increasing the amount of waste production is also increasing. Waste produced not only from the residents but also from the non-residents who study or work in the campus during working hours as well as class periods. They produce waste in the classroom, office and canteen while working including taking foods. Wastes generated in different places in the campus were measured with sampling in the living places. The amount of waste was significant. These wastes should be managed properly; otherwise it will create a big problem in near future in terms of environmental pollution as well as threat to human health.

4.5 Data Analysis

Collected information/data has been analyzed with the help of appropriate statistical tools and techniques. MS Excel and computer software are used to analyze the data collected through questionnaire survey and field study. Details are described in following paragraphs.

4.6 Results

4.6.1 Solid Waste Generation in Single Man Mess

All single man mess was included in the survey. Single man mess is the highest solid waste contributor in the campus, which is responsible for average solid wastes of 826.0 kg/day. The average waste generation rate per person was estimated to be 0.171 kg/day. Details are at Table 4.3 of Annex F.

Recruits produce more waste than other single man mess since they are in preliminary/ basic training and their foods are also enriched than others considering their hardship. They consume more of green vegetables in their diet which produces more waste. Again they also use more papers, cloths, socks, training gears and instruments etc.

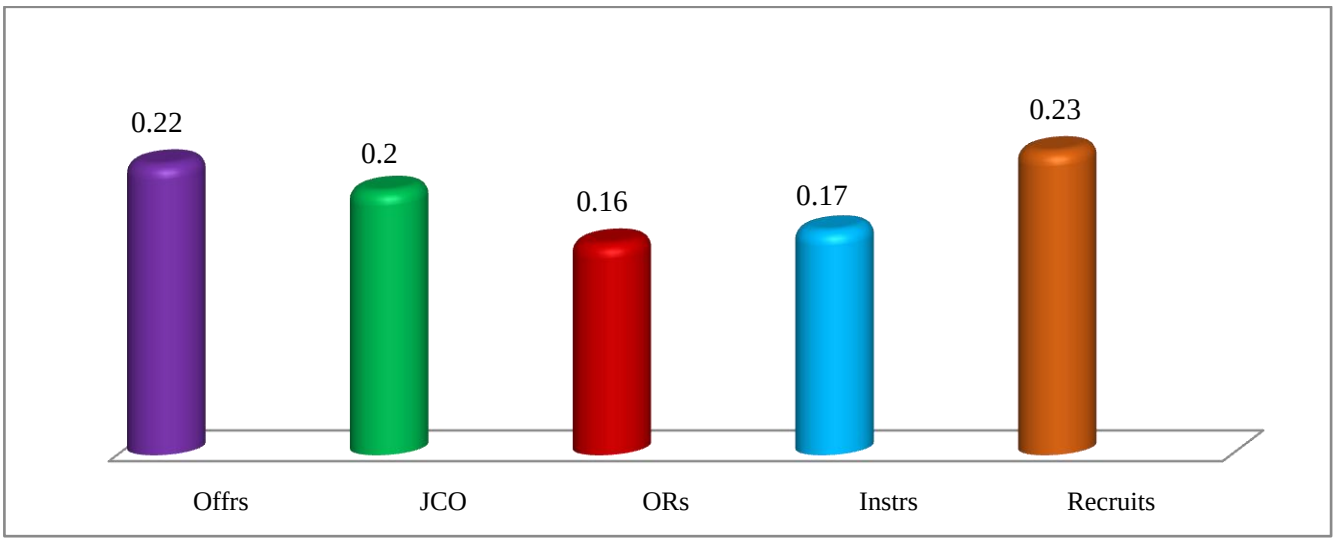


Figure 4.3: Comparison of Waste Generation Rates in Single man Messes (Kg/day/pers)

Single man mess solid wastes incorporate significant amount of paper and cardboard. The highest composition was food waste. Furthermore plastics, organics, and other wastes are identified as potential constituents of the Single man mess solid wastes. Hazardous wastes are not found in the single man mess. Compositional Analysis of Solid Waste of Single Man Mess is given at Table 4.4 of Annex F.

4.6.2 **Solid Waste Generation in Family Quarters (Residential Area)**

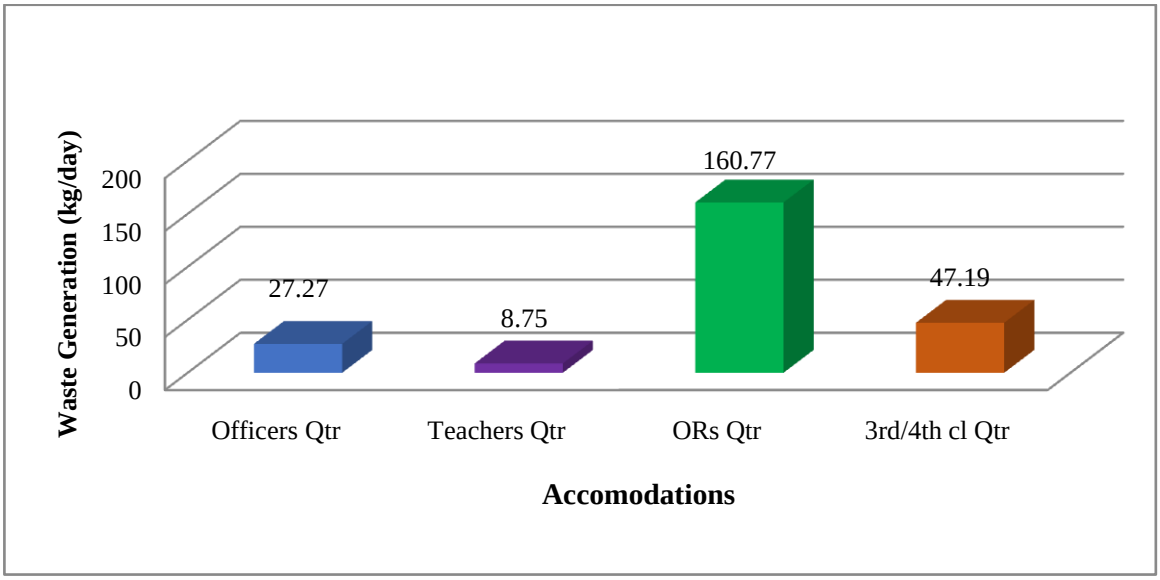


Figure 4.4: Solid Waste Generation in Family Quarters (Residential Area)

Table 4.5 and 4.6 of annex F shows the waste generation in four types of residential areas. There are 212 households (945 populations) in four areas in the campus. Among them 145 houses were sampled. ORs quarters contributed the major portion (71%) to the total waste stream. The average highest generation rate was found to be 0.303 kg/capita/day at Officers Quarters whereas the lowest was 0.233 kg/capita/day in ORs quarters. The mean generation rate in residential areas was obtained as 0.242 kg/capita/day.

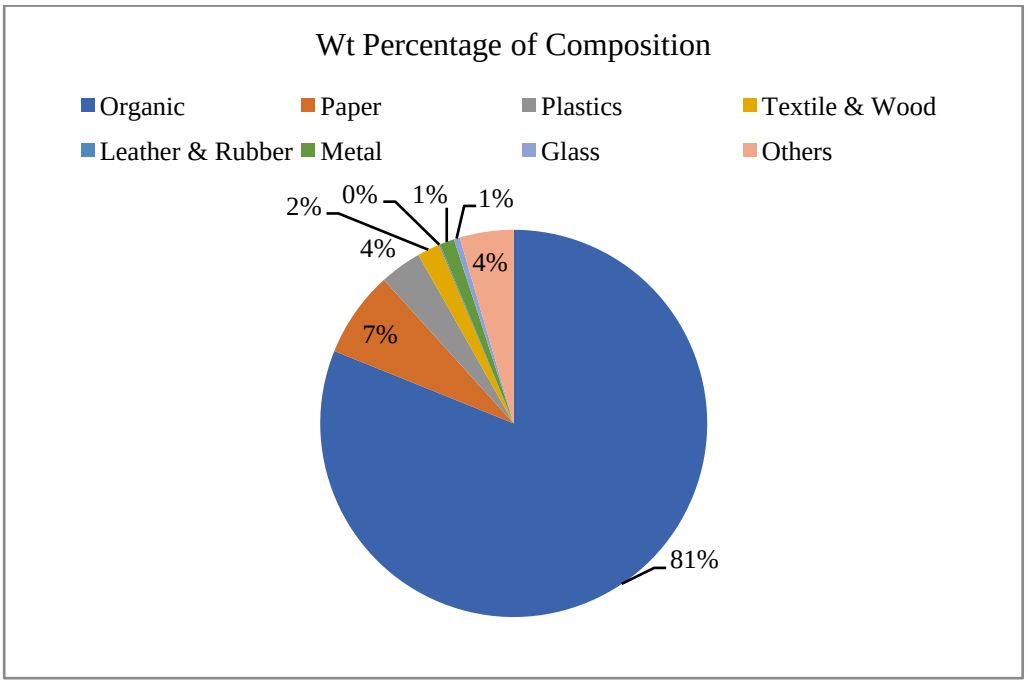


Figure 4.5 : Compositional Analysis of Solid Waste of Residential Areas

Vegetables & food waste is highest (81.1%) in comparison with other solid wastes generated in Family quarters.

4.6.3 **Solid Waste Generation in Commercial Areas.** Commercial areas include canteens, bakery, rest house, kabab ghor, slaughter house, stores, temporary markets etc. It is to be noted that due to covid, no one was allowed to go outside of BGTC&C but temporary markets were arranged by civil contractors inside the campus. Details are at Table 4.7 of annex F.

The total amount of solid waste generation by commercial areas in the campus is 80.63kg/day. It includes packing materials, spoiled goods, vegetable, foods and meat remnants, bottles, plastic bag, disposable cookeries, polythene, polypropylene, printer paper, etc.

Vegetable and food waste appears highest (84%) in comparison to other solid wastes generated. In the commercial areas, there were extra foods, leftover foods, spoiled foods or

vegetables which are responsible for making it higher than other places. The solid wastes originated from the commercial areas did not comprise hazardous wastes. Rather compostable organic wastes holds overpowering majority as shown in table 4.8 of annex F. As most of commercial areas solid wastes are organics, there is ample prospect for composting and reusing of the wastes.

4.6.4 **Solid Waste Generation in Institutional Area & Training Areas (of BGB Trainee and Recruits).**

There are 3 schools, 24x training sheds, 3xMultipurpose sheds, and 2xClinics, 2xFiring range in BGTC&C campus. Schools were closed due to Covid but those were used by trainee of BGTC&C. To maintain safety distances, these were used for training of BGB personnel. Each course was divided into 2-5 sections as per requirement of safety. The total solid waste generation by all institutional areas is 55.05 kg/day (Table 4.9 of Annex F).

Highest (53%) proportion of waste is paper and organics were only 12%. Students use papers for study, presentations, preparation of training aids etc. There were two recruit parades within the period where lot of papers were used for decoration of parade ground, stage, cultural program, in preparing information board, brochure, cards etc. Again lots of papers are collected from firing range since all ammunitions are wrapped with papers and papers are discarded before firing. There were significant amount of plastics due to use of water bottle by students. Solid wastes originated from the institutional areas have been found insensitive to the seasonal variations. In general, the majority of these wastes are potentially reusable and recyclable. The solid wastes collected from the institutional areas did not embrace much metals, glasses, as well as hazardous wastes. Details are at Table 4.10 of annex F.

4.6.5 **Solid Waste Generation in Open Areas/Street Sweeping**

The waste generation per 100m of road length for sweeping was determined by selecting five paved roads (1km each). Roads of BGTC&C have trees on both sides which add maximum to the weight of road waste. Accordingly total road waste was found out. It was found to be 48.00 kg/day. In open space/ road sweeping, significant amount of dried leaves, sand, dirt, construction/demolition debris were found (others-35%). Since there were five construction places, so construction debris was more. Here organic matters were comparatively low. Details are at Table 4.11 of annex F.

4.6.6 **Total Solid Waste Generation by BGTC&C**

Maximum waste originates from residential accommodations followed by commercial areas, institutional areas and open/street areas covers. Total solid waste generation in the campus was 1253 kg per day (Table 4.12 of annex F) and individual solid waste generation rate is found 0.214 kg per day in the campus.

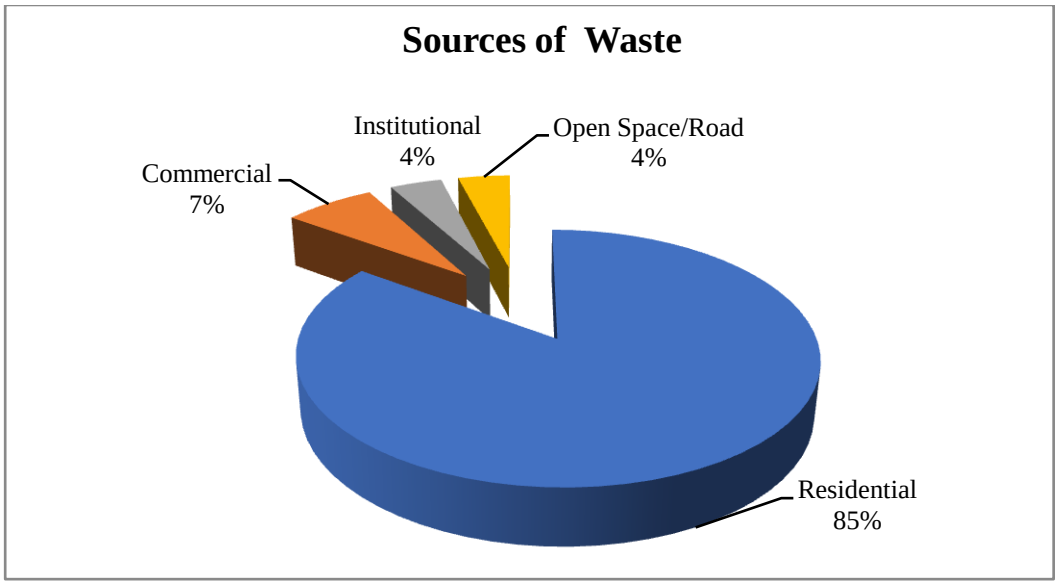


Figure 4.6: Total Solid Waste Generation in BGTC&C

4.7 **Discussion**

4.7.1 **General**. BGTC&C is one of the medium sized academic institution in Bangladesh with many infrastructural facilities. The permanent inhabitants in the campus area are about 5840. The total solid waste generation in BGTC&C Campus is 1253 kg/day. The waste generation rate in the campus is about 0.214 kg/capita/day. Standard rate of waste generation is considered as 0.25 kg/cap/day in the academic atmosphere (Khondoker et al.,2017). The rate is slightly lower than expected. This could be due to Covid. A comparison among CU, RU, JU, JKKNIU and BGTC&C rate is found acceptable.

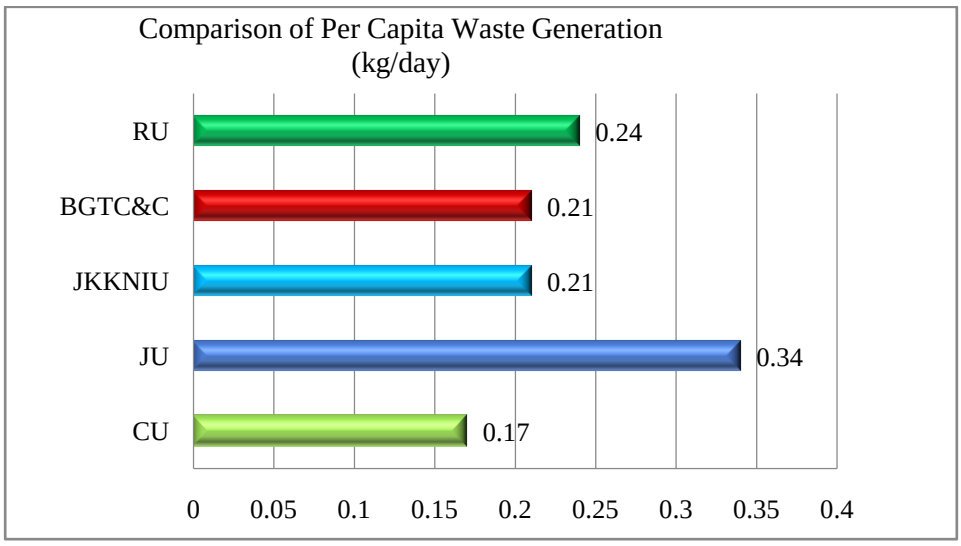


Figure 4.7: Comparison of Per Capita Waste Generation with Other Educational Institutes

4.7.2 **Physical Composition of Total Solid Waste Generated**

Composition of solid waste depends upon a number of factors, such as food habit, cultural tradition, socioeconomic and climatic condition (Islam, 2016). Composition of solid waste varies not only from city to city but even within the same city itself and also seasonally. The solid waste collected in BGTC&C campus consists of wet organics (primarily food waste), dry organics (straw, wood), inert materials (sand, soil, earth), and recyclables (plastics, metal, glass, paper).

As shown in Table 4.13 of annex F, Vegetable and food waste appears the highest (75.17%) in comparison to other solid wastes. This result is in consistent with the findings of Salam et al. (2012); Islam (2021) and Habib et al. (2021) that highest portion of solid wastes are composed of vegetable and food waste. The result also has similarity with Jahangir Nagar University (Saadat et al., 2012) and Chittagong University (Rahman et al., 2013). Paper, book and printed materials (10.91%) are the second highest waste generation in the campus. It is also little higher than JKKNIU and CU. Reasons could be parade and cultural program for which huge papers are used. Moreover during covid period, packing materials were used more. It is also found that the lowest amount (0.53 %) of waste belongs to glass and ceramics (Fig.8).

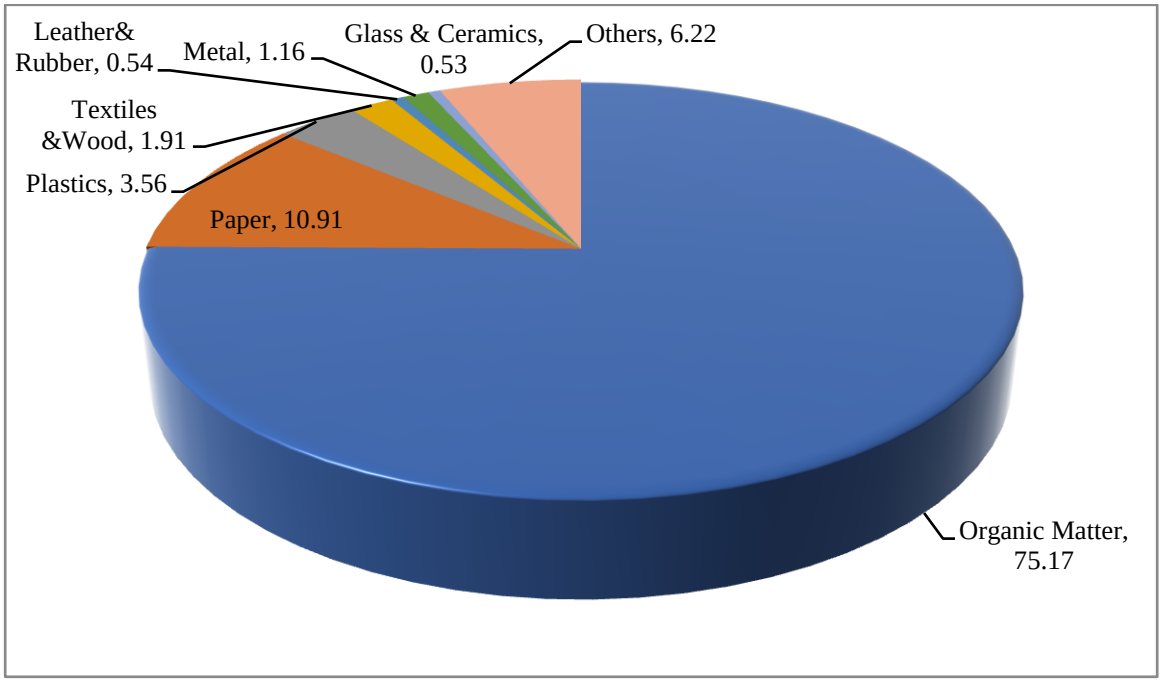
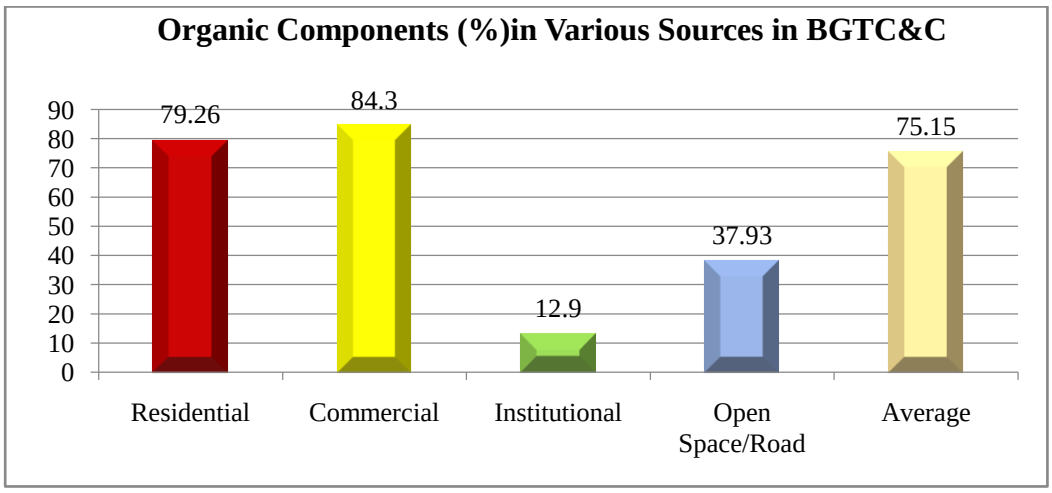


Figure 4.8: Compositional Analysis of Solid Waste of BGTC&C

4.7.3 **Organic Component**

The major component of waste generated in BGTC&C campus is organic material which produced as the residue of food and vegetables. Around 75% of waste is organic materials at BGTC&C campus. Main part of this component comes from kitchen/household activity and a significant fraction comes from bakery, kabab ghor and canteens. The largest amount of organic waste generation was from leftovers of prepared food waste produced in SM barracks and in canteens. One main reason for high food wastes in SM barracks is that many students do not take their full meal due to time shortage, taste of food. Even many cannot take meal for punishment, tiredness, sickness etc.



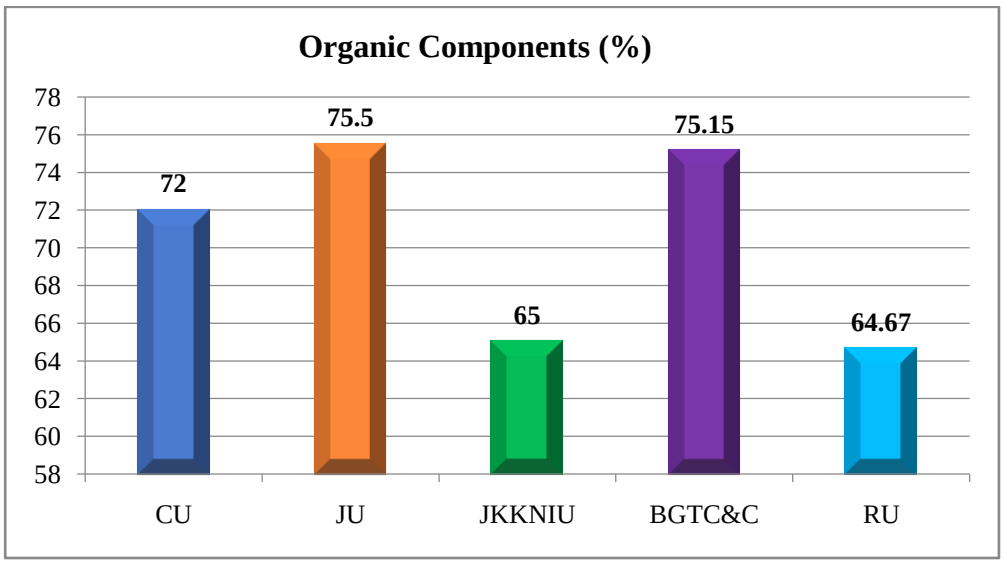


Figure 4.9: Comparison of Organic Component with Other Educational Institutes

4.7.4 **Recyclable, Non Recyclable and Compostable Components**

Total amount of recyclable waste in the BGTC&C campus is 233.26 Kg and non recyclable part is 1020.40 kg. That is about 19% of generated waste is recyclable and 81% is non-recyclable in BGTC&C campus. Main recyclable part is paper product. Being in educational institution, most trainee use more paper. Around 10.91% of total waste is paper product which comes as backdated newspaper, paper, wrapping paper, paper boxes used by different offices and trainee. Amount of paper was more due to Corona where more items used to come by courier and in packet. Even fruits, frozen item etc were supplied by cartoons. Other recyclable components are plastic, leather, rubber, metals, glass, ceramics, electronics materials which are all together about 6.94%. Among this 81% (1020 kg/day) of non recyclable solid, about 76 % (942 kg/day) is compostable and rest about 5% (78kg/day) is inert. Details are at table 4.14 of annex F.

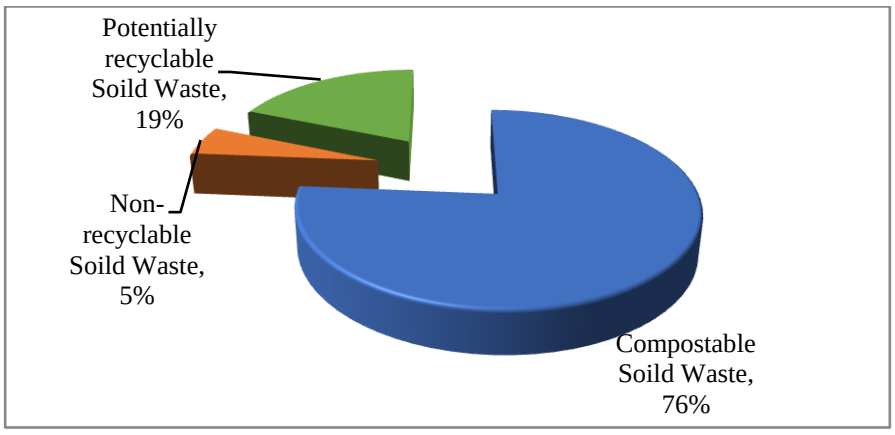


Figure 4.10: Weight Percentages of Solid Wastes based on Recyclability and Compostability

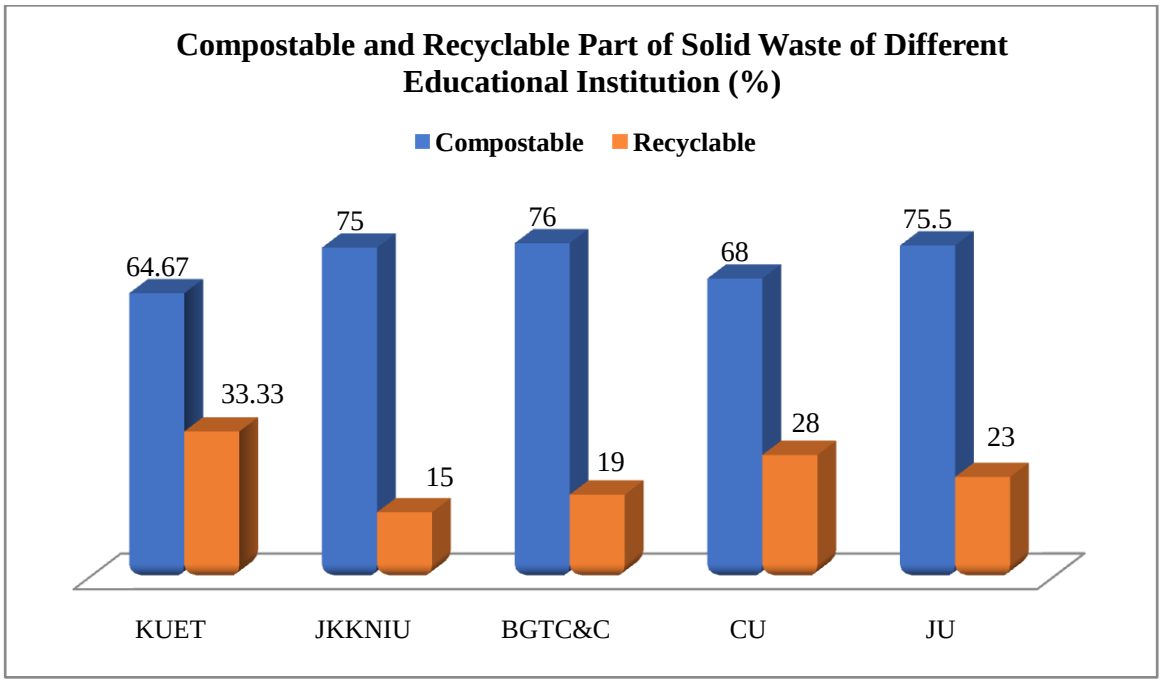


Figure 4.11: Comparison of Recyclable and Compostable Part of Solid Wastes with Other Educational Institutes

Percentage of recyclable waste in the campus is about 19% . This result coincides with the findings of JKKNIU (Khan,2018) and JU (Rahman et al., 2013). Non- recyclable waste generation is higher (81%, 1020.40 kg) in comparison to recyclable waste. This result also coincides with the findings in Chittagong University and Jahangirnagar university solid waste generation where non- recyclable waste is 70-80% (Khan,2018 and Rahman et al., 2013). The high composition of food waste is influenced by the students' lifestyle of buying packed food during covid period. Normally, students buy packed food from canteens, which remain open seven days in a week.

4.7.5 **Inert materials**

The inert materials found in BGTC&C campus are sand, stone, silt, and bricks. It is about 5%. A large portion of these come from road sweeping. Construction and demolition waste are major part of this inert materials since several constructions are ongoing in the campus.

4.7.6 **Hazardous Materials**

Hazardous materials such as wasted chemicals, expired chemicals, expired drugs, clinic and laboratory wastes) were found significantly low since covid restrictions. Hospital has got their medical waste disposal system as such only MI Room or clinics issued medicine.

4.7.7 **Comparison between Seasons**

The composition and the amount of municipal solid wastes vary due to seasonal variability (Tchobanolous et al., 1996). Table 4.15 of Annex F presents a summary of the annual mean weight fractions, which sorted into the eight waste categories for each of the three seasons. Season 1 to be related to summer, hot weather and fruits season (when jackfruit, mangoes and other summer fruits are available) also the organic fraction is relatively higher than winter season. Thus during the warm season, there is a greater consumption of beverages and bottled water and the generation of pet and glass bottles is high. Grass mowing and tree pruning is more intensive during summer, which lead to a higher production of waste from gardens than monsoon and winter, hence higher production of organic residues. Season 2 is the monsoon season and the fruit season till continues, when heavy rains occurred. All waste components are in wet state hence the bulk density is increased. The last season is winter designated here as season 3. Here seasonally sorted mean weight fractions vary but not significantly except organics. Here plastic is comparatively more because there was the recruit attestation parade where a huge amount of plastic bottles were used during parade practice and also in different ceremonies of the attestation.

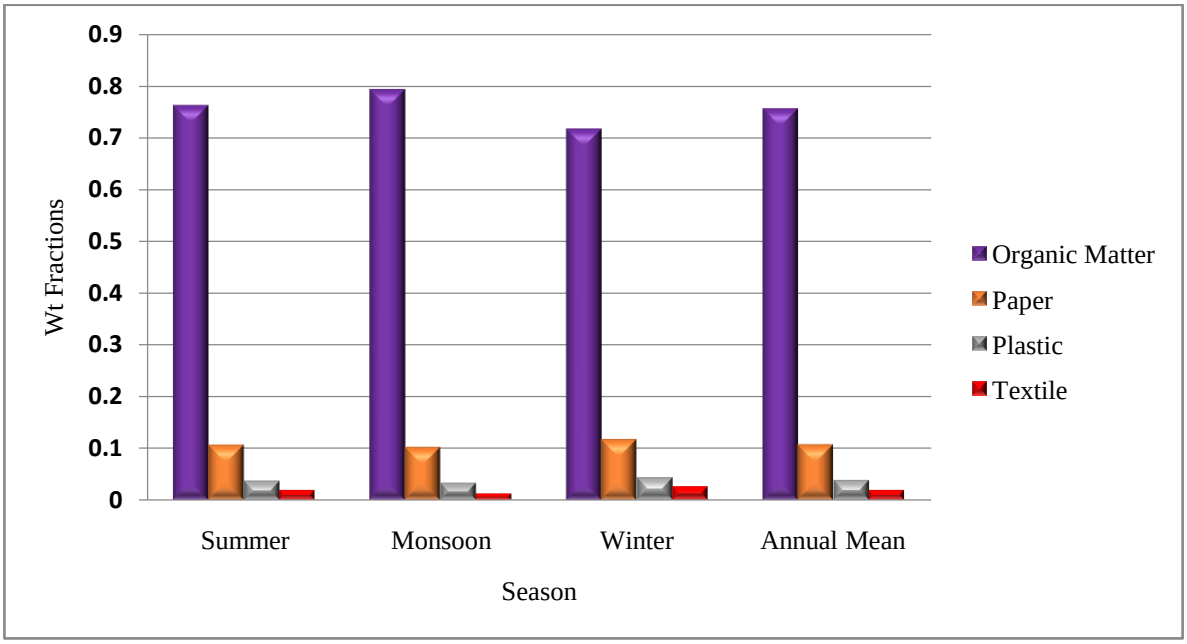


Figure 4.12: Seasonal Variations of Major Solid Waste Components (Wt fraction)

4.7.8 **Use of Solid Waste for Composting**

Several solid waste management methods are being followed throughout Bangladesh, such as sanitary landfill, incineration, recovery and recycling and composting etc. Considering to the economical and environmental benefits of composting, it is the best way for organic waste management (Diaz et al., 1993). Composting is a suitable environment-friendly technique to modify organic waste to organic fertilizers and works as soil conditioners. The main objective of a sustainable agricultural production system can be achieved by using quality compost and thereby improving soil health and increased crop yield. Three types of composting are typical and can produce 0.25 tons of compost from 1.0 tons of organic waste (Enayetullah et al., 2005). These composts are very useful fertilizer. These composts not only increase the productivity but also increase the fertility of the land. The use of the compost fertilizer also reduces the agricultural pollution.

The physical composition of the solid waste of BGTC&C suggests for composting. The moisture content or bulk density solid waste is also found favorable for composting (Table 4.16 of annex F). The C/N ratio is also an important aspect to be looked upon. But on test and trial, compost was prepared and used on the ground which gave very encouraging results. It could fertile the land, crops production was more and most importantly use of artificial fertilizer was reduced to a great extent. Detail discussion and economic aspect is discussed in chapter 6.

Using institutional organic waste to make compost, on the university campus site, or outside, has become a common practice, within the higher education sector (Smyth et al., 2010; Creighton, 1998; Diaz et al., 1993). Universities in Bangladesh like Jahangir Nagor University are practicing such compost (Saadat et al., 2012). SD College in Ambala Cantonment of India has set an example by producing vermicompost from its campus green waste and also of several temples, especially flowers. The college has constructed seven tanks to convert green waste into compost (The Tribune, 2019). Similarly University of Kelaniya, University of Colombo of Srilanka , Somaiya Vidyavihar of Nepal, Thompson Rivers University, UBC Vancuber of Canada (Kaitlin, 2013) , Allegheny College (Meadville, PA) and Guilford College (Greensboro, NC), USA execute the composting program, of their wastes, at their sites (Sullivan, 2010). Some universities, such as Michoacán University of San Nicolas Hidalgo (Mexico), are using the wastes, generated in the gardens, to produce compost, in order to help sustaining their green areas, within the campus (Taghizadeh et al., 2012). Also mixing food waste and yard waste, to make compost, was proposed by Tiew et al. (2010).

CHAPTER 5

RESULTS: PRESENT SOLID WASTE MANAGEMENT SYSTEM OF BGTC&C

5.1 Introduction

The aim of this chapter is to portray the waste management scenario of BGTC&C, based on primary and secondary document analysis. Firstly present solid waste management system of the BGTC&C will be examined to find out efficiency of its waste collection system, disposal of waste, management of disposal site and its effect on surrounding environment. Government run educational institution of a discipline force is expected to be a role model in waste management practice for similar other institutions. Current solid waste management in BGTC&C is basically controlled and managed by Administration Battalion with the help of Recruit Battalion, Advance Battalion and Headquarters.

5.2 Current Waste Management in BGTC&C Campus

5.2.1 Solid Waste Disposal at Different Household Level and Their Behavior

In the houses solid waste is mostly kitchen waste. Bachelor's accommodation also contributes solid waste from kitchen and dining rooms. All persons living in Officer's mess, JCO's mess, Single man accommodations mostly produces kitchen waste apart from living room waste. Occupants of officer's mess and officer's accommodations normally follow proper waste disposal. They do not litter or throw items. Dustbins are used for disposal of waste but of course as a mixed waste. Separation is not done by this populous. Waste collectors also collect waste every day. In general, the occupants of other household are not serious about proper disposal of waste. Kitchen waste and houses waste are polythene packed and put in dustbin. Sometimes these are thrown backyard, in ponds or in open place or even in drain.

Overall sense towards waste disposal is poor. Papers, bottles, containers, metals, clothing, shoes, and other household waste are not separated by housewives since hawkers are not allowed inside BGTC&C and they cannot sell to street hawkers.

Figure 5.1: Tendency of Haphazard Disposing Solid Waste in and around Accommodations

In the office area and school, the draft papers or unwanted papers are thrown in the basket and then every morning NC (E) collects all those paper. Finally this are burnt in the papers burning tomb. But the examination paper scripts are sold to the outside vandor after 6 months.

5.2.2 **Present Solid Waste Storage System (at Building/Area Level)**

Normally wastes are put into polythene at household level and then this polythene is placed in plastic dustbin kept outside buildings. Generally 2/3 building has one dustbin. It means minimum 24 family shares one dustbin of 10 cft which is inadequate. Dustbins are not uniform in size. Few are 4 ft height and few are 3 ft height but dimensions vary. These dustbins are just kept outside without proper fixing arrangement as a result these are pushed to ground by dogs or foxes or cats for food. In few places concrete open dustbins are available. Dustbins are not adequate against requirement. As a result sometimes wastes are placed in open close to dustbins and these are scattered by animals or birds.

5.2.3 **Collection System from Building - Time, Frequency**

Everyday waste collection normally starts from 10 A.M and continue till 1.30 pm. Waste collectors collect polythene with waste from dustbin and place on three wheeler vans. In the process many wastes come out of polythene. The scattered wastes outside dustbins are also collected and put in van. Once van almost filled, it goes for a trip to the disposal sites. Presently all types of waste are dumped in the same place. The solid waste includes kitchen waste, papers, dry leaves, branches of tree, plastics, packets of different commodities etc. The dumpsite contains lot of bottles, broken items of plastic, glass etc. Again since wastes are thrown by plastic packet, it also houses lot of plastic packet.

Figure 5.2 : Different Types of Dustbins

5.2.4 **Details of Collection Personnel**

BGTC&C is headed by a Commandant. Commandant is responsible for overall running of the organization. An Admin Battalion Commander is posted to look after all administrative activities of the institution. He is responsible to perform the functions of waste management for the betterment of the residents and is assisted by an Assistant Director. The activity of solid waste management is done mainly by the conservancy group. Apart from officials, there are total 26 personnel employed for cleaning the entire BGTC&C area. Among them 5-6 are employed for the waste disposal on rotation.

Figure 5.3 : Waste Collectors of BGTC&C

There are female cleaners employed in office areas and in schools. They are enrolled as civilian BGB member in BGTC&C. They are 4th class employee and employed in master roll. Their employment requirement is class VIII pass but on ground all of them are SSC pass. To supervise and employ these personnel, one havilder remain as head of conservancy group. Normally this havilder is changed in every after 3-4 month who is assisted by a Naik. The details as table-5.1 of Annex F.

5.2.5. **Details of Collection Van/Vehicle**

Normally wastes are collected by vans. Vans are operated by two pers. These are manually operated. While working one person drive the van and the other follow him and assist when requires. Some places are a little higher and difficult for the operators or driver to pull, then the 2nd man push and help him in taking all wastes to the dump sites. The sides of vans are 2 feet higher to accommodate more wastes . Intentionally the sides are not raised more than 2 feet because such weighty vans cannot be pulled by two person. Sometimes these vans also litters on the way to dumping point.

Figure 5.4 : Waste Collectors Collecting and Disposing Waste by Vans

No protection/plastic paper is placed on the floor of the van to contain liquid part of the wastes. The types of vehicles and equipment and the number of such equipment that BGTC&C authority uses for conservancy action is given in the following table 23

Table 5.2 : Vehicles and Equipment used for Conservancy Operation

S/L	Types of Vehicle	Equipment Numbers
1	Van/wheel cart	14
2	Trolley	05
3	Bulldozer	01

Source: Admin Wg, BGTC&C

Figure 5.5 : Equipment used for Collection of Waste

5.2.6 **Dumping Sites Details – Authorized and Unauthorized**

Officially there is only one place near Bisporibar area where solid wastes are supposed to be dumped . It is about 5 feet deep with an area of 100 ft x 80 ft and no transfer stations are available in BGTC&C. Basically it was a ditch which required to be filled up and accordingly was made a dumping place. But there are almost 11 (eleven) unauthorized dumping places and 3 (three) papers burning points . All single man barracks has their own concrete dustbins where wastes are dumped everyday and taken to the central disposal sites after 2/3 days. It is also found that open dumping sites close to the residential areas are very unhygienic. There are open ground temporary dump site which neither concrete dustbin nor plastic pot. People just throw their waste behind buildings and these are normally collected after 3-4 weeks. These are mostly papers, bottles, rotten shoes, boot, broken glass, plate etc.

Figure 5.6: Authorized Dumping site near Bishporibar

There is no buffer zone between dumpsite and surrounding establishments. It is only 100 ft away from the 3/4th class employee accommodations. No boundary is available all around dumpsite. It is only 6 ft away from the road. Water accumulates in the dumping site during rain since it is low ground than surroundings. Again occasionally dumping site overflows during heavy rain and water moves to close by accommodation area, ponds and agricultural land.

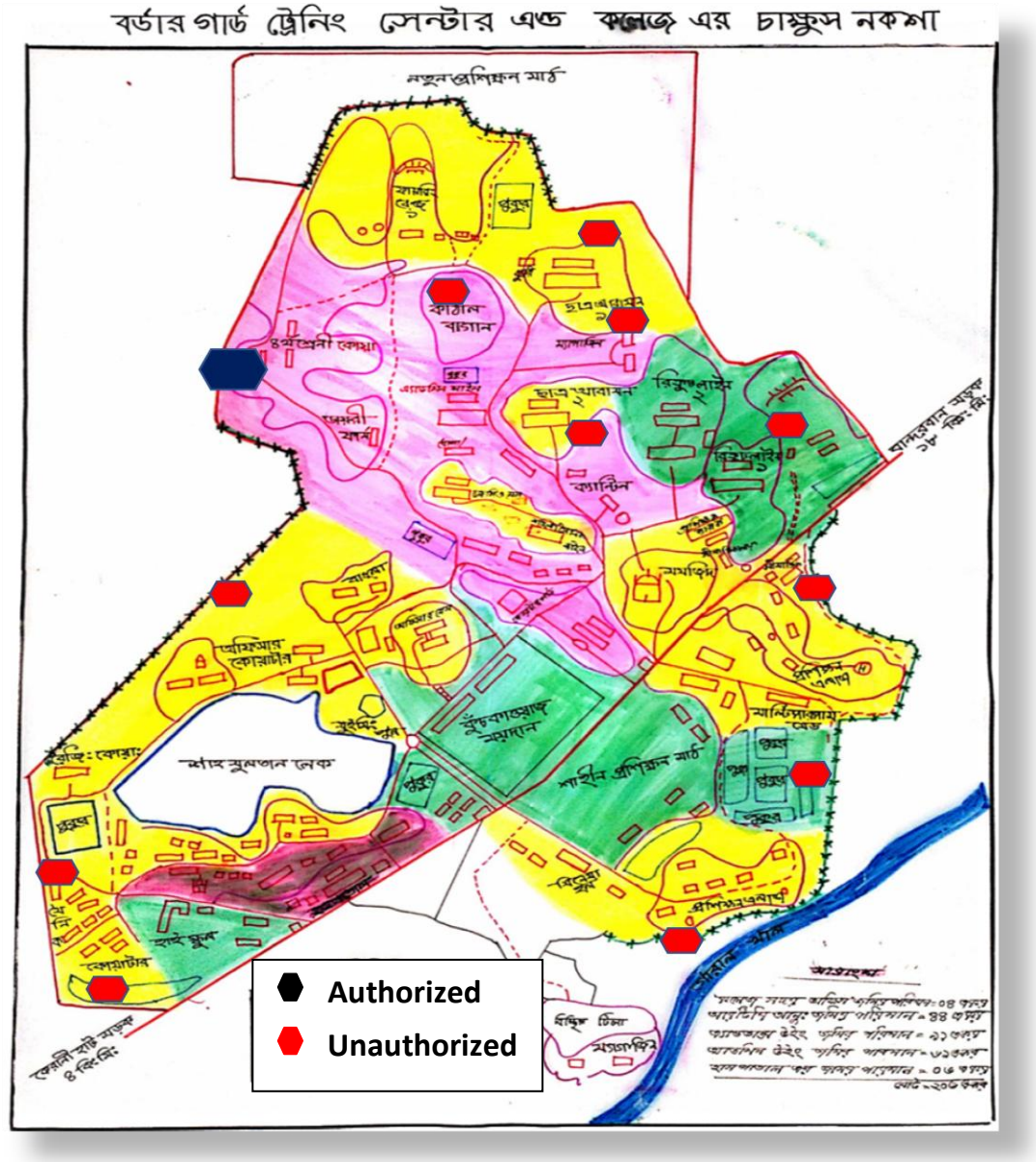


Figure 5.7 : Location of Authorized and Unauthorized Dumping Sites

5.2.7 **Existing Policies/Legislation related to Solid Waste Management:** BGTC&C functions on the basis of The BGB law 2015. This law includes the provision of collection, removal and disposal of solid waste from all public places for ensuring an environmentally sound and sustainable environment and living. In short following are major rules regarding removal, collection and disposal of solid wastes.

a. The centre is held responsible for eliminating all kinds of wastes from public places, toilets, drains, households or lands. It is also bound to collect the refuse and to make efficient disposal of it.

b. The centre shall provide adequate dustbins and receptacles at certain convenient places for refuse accumulation in order to keep environment safe and secure from pollution. The authority by notice shall compel the householders to deposit waste in a certain time in those dustbins and receptacles

c. The staff or workers involved in refuse removal and collection shall be under the strict monitoring and control of the authority.

d. The residential people shall be liable to the elimination of the wastes from their area. The whole activity shall be done under close monitoring and supervision of the centre.

The charter of duties related to removal, collection and disposal of solid waste of different appointment holders of BGTC&C is given in Table 5.1 of annex F.

5.2.8 **Knowledge of Workers on Solid Waste Management.** There is no formal training of workers. Normally the senior waste collectors teach the new comer. It is like on job training. Safety, security and hygiene are not informed to them. They severely lack in knowledge and technique of segregation.

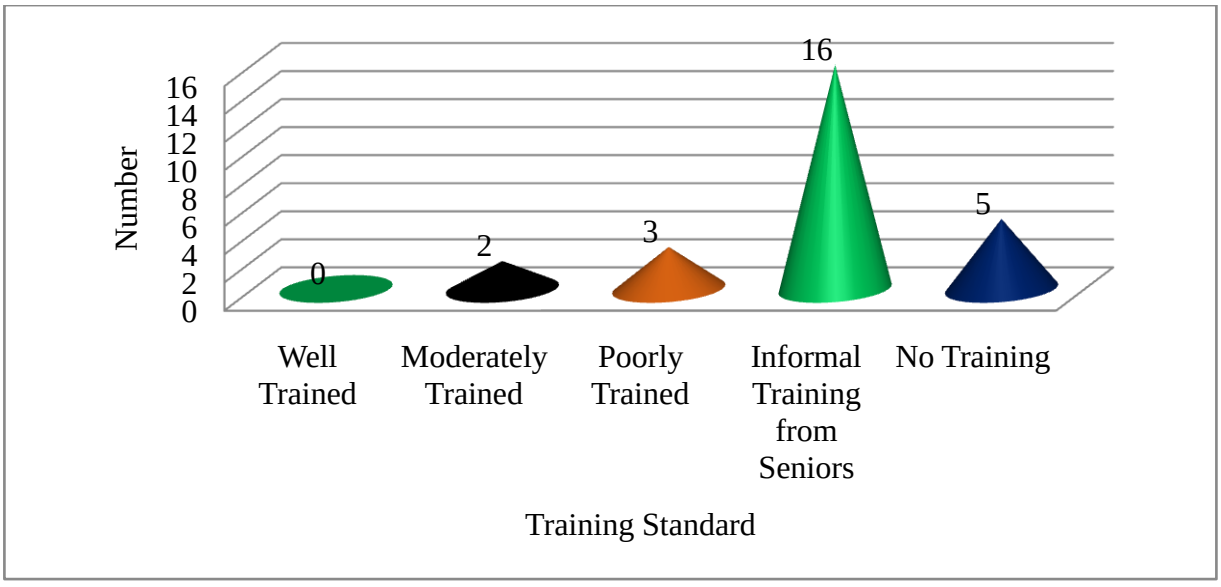


Figure 5.8: Training Standard of Waste Collectors, Separators

5.2.9 **Awareness Level**

In general, people are not educated or trained or informed on proper waste management. They hardly think about negative impact of improper disposal of waste. Awareness level about proper waste management among people is poor.

a. The respondents were asked about policy and legal framework for the BGTC&C to manage solid waste. The data is presented in the following figure:

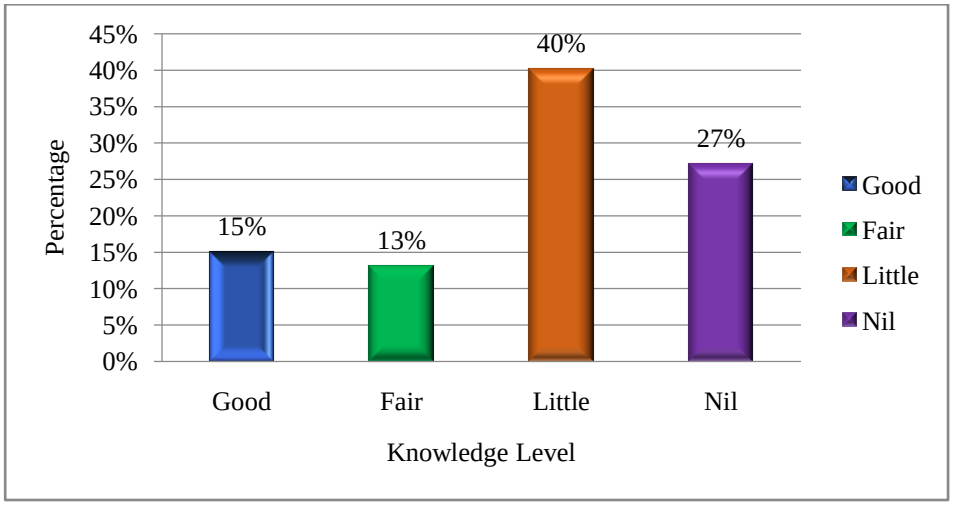


Figure 5.9: Knowledge about Legal and Policy Framework of SWM

The above figure shows that only 15 percent of the respondents have good idea about legal frameworks of solid waste management. Around 13 percent have fair and the large number 40 percent people have very little idea whereas 27 percent has no idea. about solid waste management related legal and policy framework .

b. The respondents from citizen side are not that much aware of the new approach of the government called 3R‘ (Reduce, Reuse & Recycle). In this regard, the following figure shows the real picture of their understanding of the said strategy:

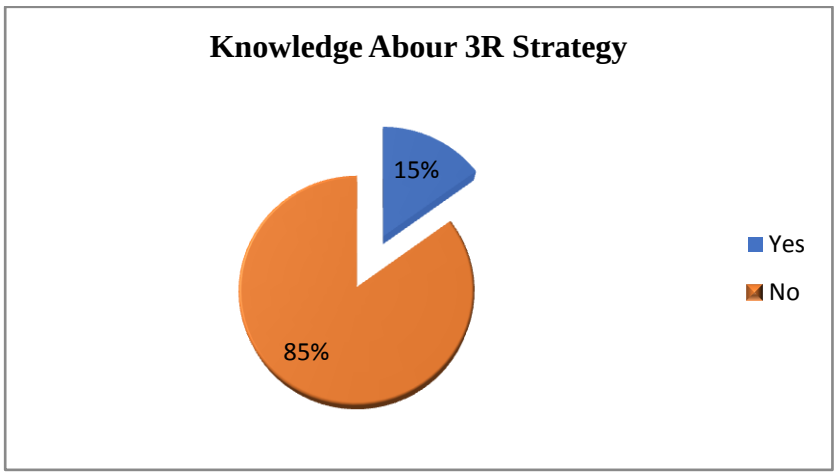


Figure 5.10: Knowledge about 3R Strategy

The above graph shows that 15 percent of the total respondents know about the strategy whereas the rest 85 percent do not have much idea about the national 3R strategy. Awareness and practice can prevent household solid waste management problems. A prior study revealed that the majority of the people (53%) living in a community in Bangladesh are unaware to manage the household solid waste properly (Sarker et al., 2012). However, in Pakistan, 28% of the community people are not aware to manage household solid waste (Yasmin et al., 2017). Approximately 41% of community people in Malaysia had inadequate awareness regarding household solid waste management (Afroz et al., 2012).

5.3 Impact of Present Improper Solid Waste Disposal on Surroundings/Environment of BGTC&C

There are potential risks to health and environment from improper handling such as collection, storage, recycling and disposal of solid waste. Poor management of household solid waste destroys the natural beauty; damage the landscape, creates fire hazards, foul smells, unpleasantness, additional dredging costs of waterways, silting up of reservoirs, and decrease in plant productivity, deterioration of structures and structural foundations, and depreciation of land value (Paghasian, 2017). Unplanned management of accumulation of solid waste of BGTC&C causes significant environment hazards and serious threat to surface water, ground water, soil and air.

a. Open air dumping creates unhygienic and poses enormous threat to the people. It causes aesthetic problem and nuisance due to nauseating pungent odor. Moreover it promotes spreading of diseases too. Haphazard dumping in and around accommodations or buildings causes serious problem for occupants.

Figure 5.11: Present Dumpsite is within 100 feet from Living Places

b. Even only authorized dumpsite is within 100 ft from the accommodations. Here dumpsite is very close to road. People encounter bad smell while moving in this road.

c. During winter season or dry season, fire is set in the dump sites for reduction of waste which again creates an unhygienic condition for odour and smoke. Sometimes smoke remain in surrounding area for quite a long time.

Figure-5.12: Smoke Generated from Fire of Solid Waste

d. In the residential areas, people are hardly aware about safe dumping of the wastes. Moreover, inhabitants dump their waste indiscriminately. As a result, areas are becoming breeding ground of flies, rats, mosquitoes, and other microorganisms. Waste dumped on roadsides and in dumpsters causes odor, irritation, visual annoyance, and fire risks, among other things (Sonia et al., 2021).

e. One of the most adverse impacts of poor waste management is the incidence and prevalence of diseases such as diarhoea and respiratory problems, as well as other illnesses. Survey carried out in Bisporibar area close to dumping site and on waste collectors also shows about 45% inhabitants had different types of diseases or complications in last 6 months. Details are shown in the figure 25 .

f. Polythene is found loitered all around. It obstructs drainage system and clog the openings.

g. Poor waste management has serious consequences for the health of the residents and a report suggests most of the child mortality could be related with this problem.

h. Organic waste which is very much useful for soil is left unutilized. The soil of the other places could be improved.

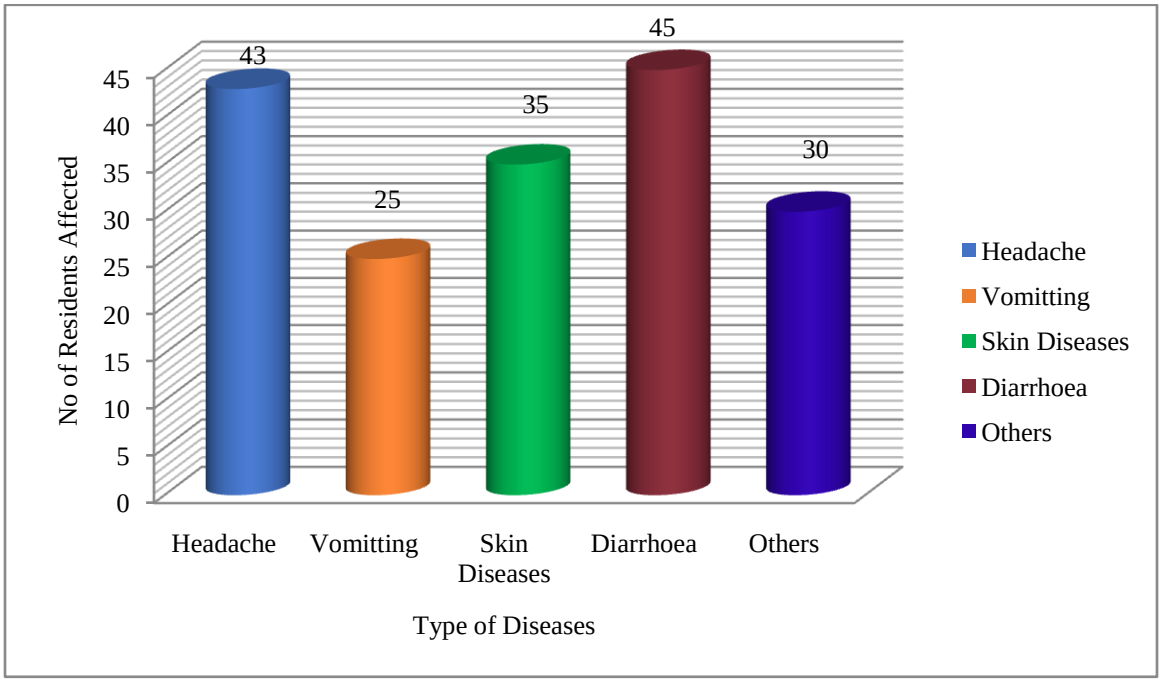


Figure 5.13: Diseases Complained by Bisporibar area and Waste Collectors

5.4 Problems and Challenges of the Present System

(a) Number of Dustbins placed in front of the buildings is not adequate. As such much waste is put in and around of dustbins which are spread away by birds, dogs, cats etc. It also spread bad odor to the surroundings. Again these dustbins are not placed properly and are not maintained too.

(b) Numbers of vanes and workers employed for solid waste management are not adequate. Due to shortage of vans and workers, a portion of waste normally not disposed. Actually workers work till 1:30 pm and leave rest of the waste for the next day. Again vans are manually driven which is tiring and time consuming too.

(c) At present, there is no waste separation or segregation or resource recovery practice in BGTC&C. All wastes are just put to dumping site. No initiative is taken to collect/separate reusable, recyclable wastes.

(d) A large portion of solid waste is casually thrown outside in the backyard or backside of the buildings. Consequently an unhygienic condition prevails behind the buildings.

(e) No transfer stations are available. Transfer stations should be established within the proximity of primary collection route, as this operation is generally done by three wheeler van.

(f) The open truck, vans and dustbins are not regularly washed after the disposal of solid waste. The condition of the truck is not good too which allows littering en-route during transport.

(g) The truck is not covered with hard plastics during its travel from secondary transfer station to dumping site which is a great concern for littering on road and spread of bad smell.

(h) Stakeholders mostly dispose waste in dustbin by polythene and this polythene are collected, transported and thrown to dumping site without segregating polythene from waste. It is an environmental issue.

(j) Placement of the dumping site is wrong since it is very close to accommodations. Moreover being situated in low land, water accumulates in dumping site and overflows during rainy season causing water and soil pollution.

(k) Workers do not use proper gear and their health/ hygienic conditions are not checked. Authority does not supply safety and hygiene equipment to workers which are likely to affect their health.

(l) During dry season, fire is set on the waste as result smokes engulf surrounding areas and bad smell also comes out. It creates breathing problem, restricts vision and irritates eyes.

(m) There is a lack of supervision of work of waste collectors/separators by the conservancy group commander (havilder). Since waste collectors and separators are changed every day as such they do not work with responsibility. Rather somehow spending time is the psyche of workers.

(n) Many residents of BGTC&C are not aware and many are not serious about following proper waste management practices. Moreover there is no awareness program for the residents.

(p) There is no penalty or punishment for littering or violation of proper waste management practice. People are not warned, fined or punished for their wrong doings. Such provision sometimes encourages people t to follow the proper rules.

(q) There is no provision of incentives for workers. The workers employed in waste management take it as fatigue and degrading job. As such they do not complete the task with sincerity and dedication. Waste collectors themselves even throw waste in unauthorized dumping site to avoid load and transport hassle. No provision available for extra food or money for this hard work.

(r) The institute has neither solid waste reduction measures nor recycling, composting or properly disposing mechanisms. Rather, the institute has been doing some sort of improper solid waste management practice. This is simply collection of waste from their sources, transported to a specific location and burns it in an open atmosphere when possible.

CHAPTER 6

DISCUSSION

6.1 Introduction

Solid waste management is defined as the discipline associated with control of generation, storage, collection, transport or transfer, processing and disposal of solid waste materials in a way that best addresses the range of public health, conservation, economic, aesthetic, engineering, and other environmental considerations (Labnac, 2020). The management of solid waste can include source reduction, recycling, storage, collection, transportation, processing, and disposal. Examples of solid waste facilities include landfills, composting sites, transfer stations, incinerators and processing facilities etc. Solid waste management in Bangladesh is regarded as a neglected issue due to various reasons. BGTC&C is not out of this tendency. The foregoing discussion shows that the situation of waste management in BGTC&C is becoming an alarming concern which requires immediate attention. In the days ahead, rate of solid waste generation in BGTC&C will continue to increase as courses, activities, and houses continues to increase as per master plan. In such a situation, a sustainable management of solid waste needs to be planned and executed.

In some developed countries, management of wastes within universities is considered as a part of urban activities and there are comprehensive programs for wastes management within universities (Taghizadeh et al.,2012). Systematic solution to the existing solid waste management problems of BGTC&C is a must considering the sustainability of the environment and safe human living. Accordingly in the following discussion some implementable solutions will be discussed for sustainable development of solid waste management of BGTC&C.

6.2 Sustainable Solid Waste Management System

The primary goal of solid waste management is to reduce and eliminate adverse impacts of waste materials on human health and the environment. This is to be done in the most efficient manner possible, to keep costs low and prevent waste buildup. It also ensures improvement of air and water quality and contributing to the reduction of greenhouse gas emissions.

6.2.1 **Findings from Questionnaire Survey of Households**

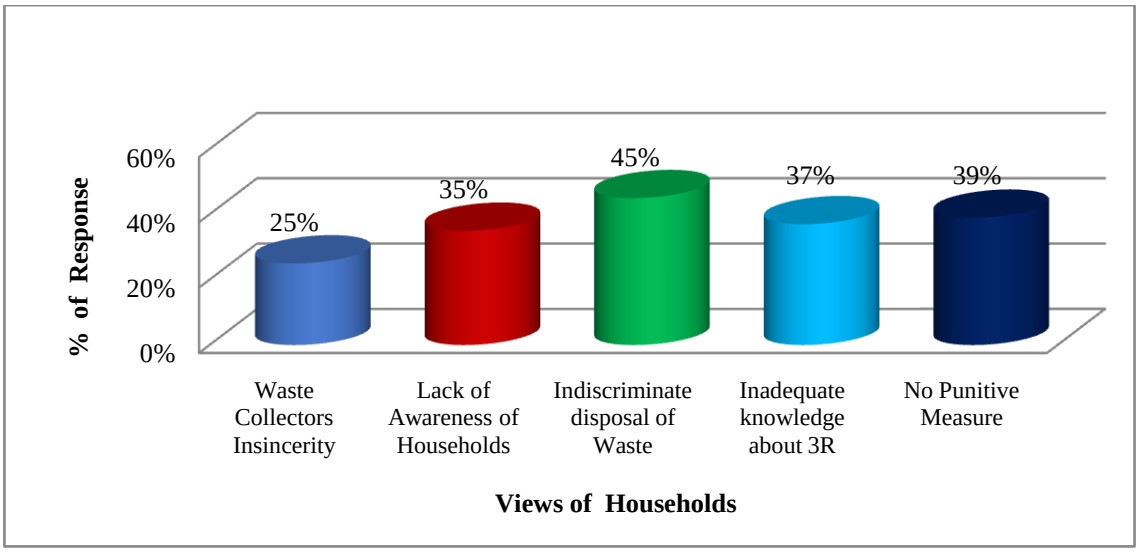


Figure 6.1: Reasons for Poor Solid Waste Management received from Households

Few of them gave their opinion that waste collectors lack training. Some of them are raising their voice regarding financial crisis and awareness is the prime factor for not implementing proper solid waste management.

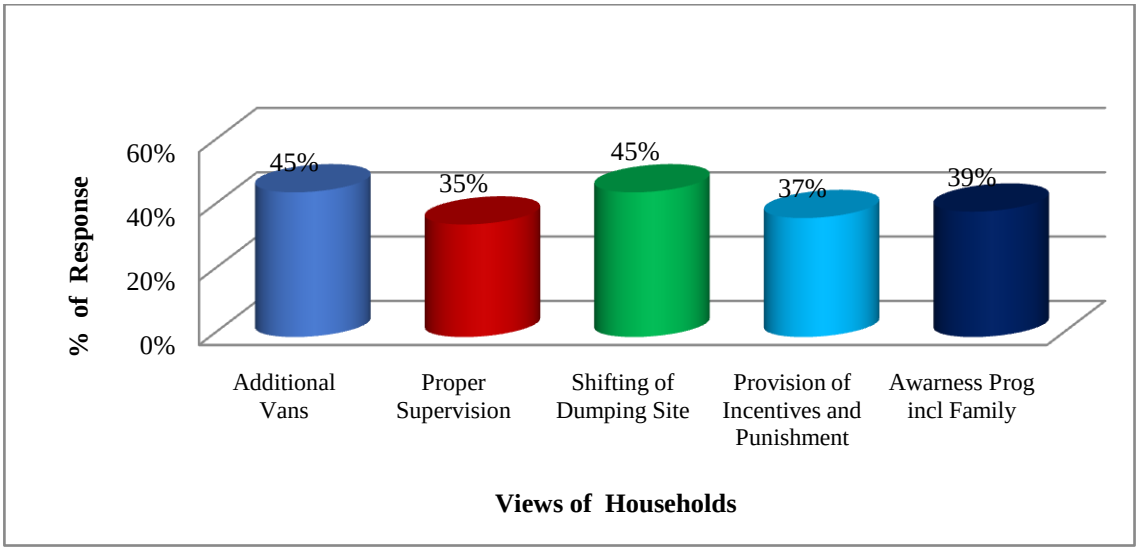


Figure 6.2: Suggestions for Improving Present Condition received from Households

Few of them suggested for additional vans and dustbin too. Few opined for training of waste collectors also.

6.2.2 **Findings from KII**

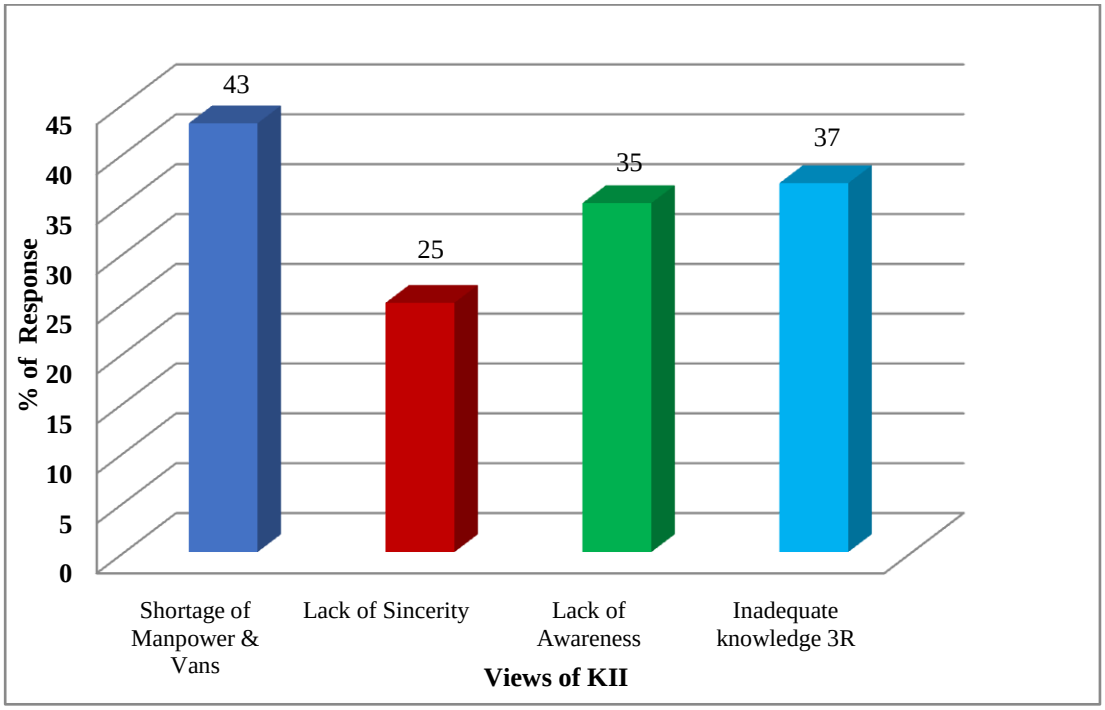


Figure 6.3: Reasons for Poor Solid Waste Management received from KII

They strongly agreed that the current conditions of solid waste management are not only poor but also affect the healthier life of the dwellers.

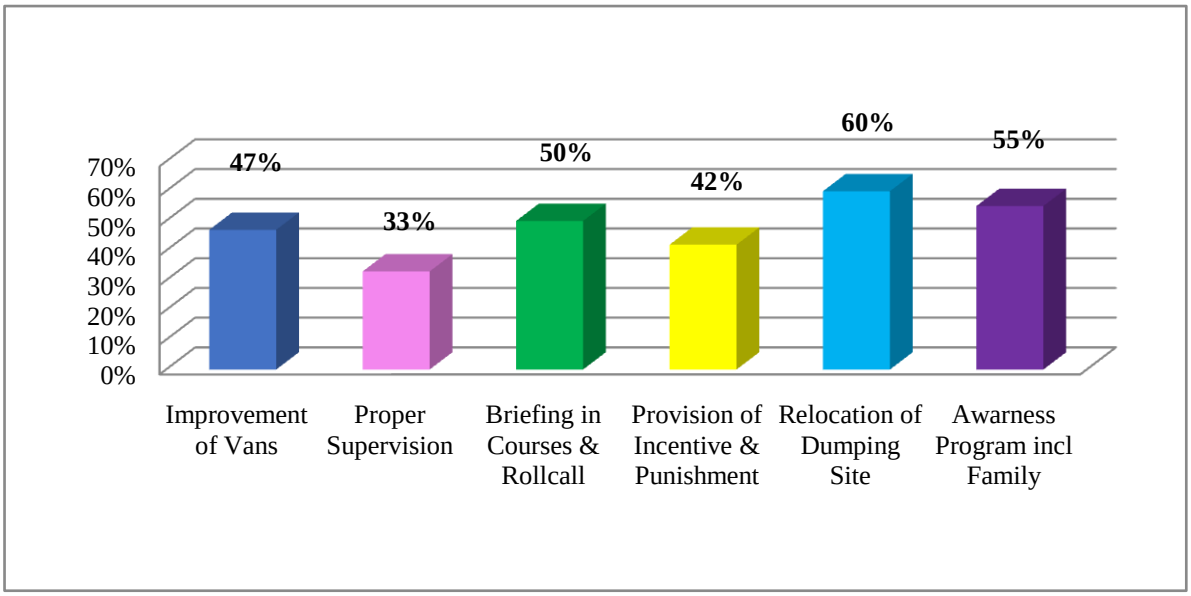


Figure 6.4: Suggestions for Improving Present Condition received from KII

Besides, few suggested for collecting waste twice in a day. Few suggested for bigger vehicle for waste collection and disposal.

6.2.3 **Findings from Waste Collectors, Separators and Van Drivers etc through Survey**

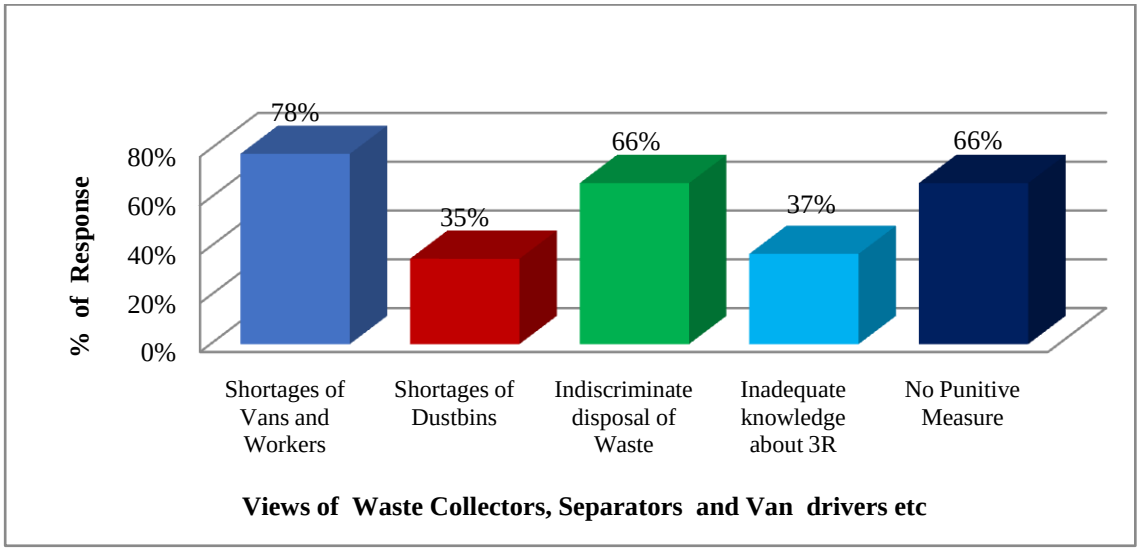


Figure 6.5: Reasons for Poor Solid Waste Management received from Waste Collectors, Separators and Van Drivers etc

Few mentioned about less budget allocation, lack of supervision of senior, look down attitude of others towards waste collectors, separators etc.

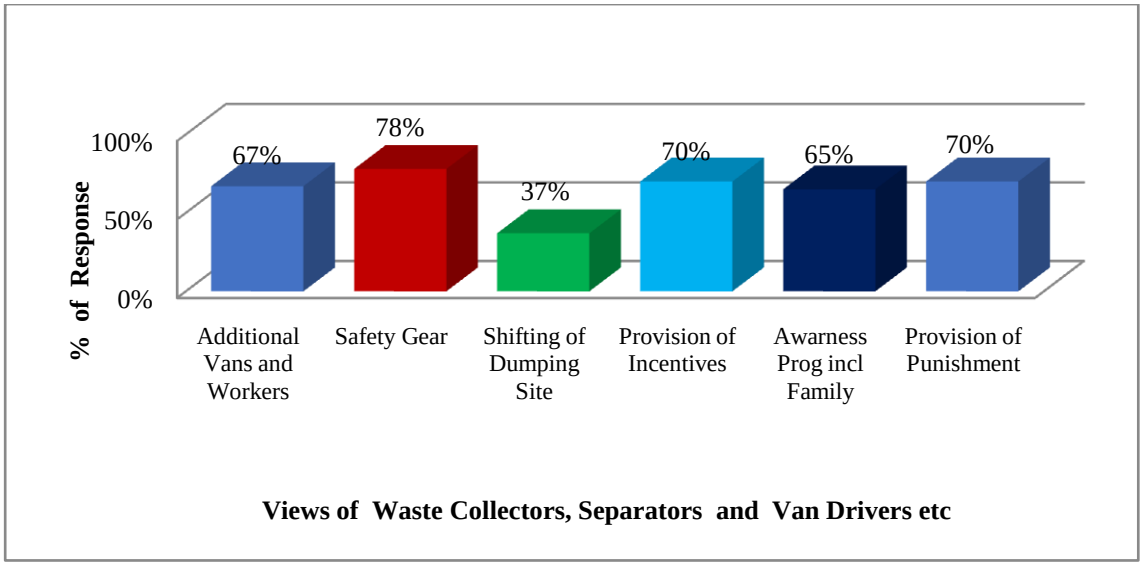


Figure 6.6: Suggestions for Improving Present Condition received from Waste Collectors, Separators and Van Drivers etc

Few suggested for extra food for waste collectors. Increase of salary was also proposed by few.

6.3 Waste Management Model for Primary Waste Collection System

6.3.1 Arrangement of Adequate Dustbins

Considering the total manpower in a building, requirement of dustbins were calculated. Accordingly additional 26 dustbins were procured and placed with support so that dogs or cats cannot overturn it. A routine cleaning and maintenance schedule was enforced.

Figure 6.7: New Dustbin and their Maintenance

6.3.2 Creating a Secondary Transfer Station (STS)

There was an old and abandoned squash room which was renovated and a secondary transfer station was established. All collected solid waste is now brought here and segregation works are done here.

Figure 6.8: Newly established Secondary Transfer Station

6.3.3 **Upgradation of Vans with Electric Motor**. Three Wheeler vans which were difficult to pull or paddle manually have been upgraded with electric motor. It can now be operated by motor engine and thereby gain efficiency in volume of waste transport and time apart from reducing fatigue of workers. Moreover, an old BGB pickup which was kept to be auctioned has been reconditioned and is being used for transport of solid waste. Now all solid can be transported easily with less time.

Figure 6.9: Vans with Electric Motors

6.3.4 **Employment of Three Additional Employees for Segregation**

Segregation of waste is a colossal job. Three workers are employed for segregation purpose. Now as a part of resource recovery, three civil employees' separates bottle, papers, plastics, metal, cloths etc and put them in separate sacks. As a result, reusable, recyclable and compostable wastes are now separated. Now total eight persons are employed for waste management. They work for 15 days at a go.

6.3.5 **Segregation, Selling and Earnings**

Recyclable papers are segregated and each sack is sold by 150 taka outside. Bottles were sold in each fortnight. Polythene were segregated and put in bigger polythene and sold in that uncleaned condition.

Figure 6.10: Sacks of Paper, Bottle, Can, Polythene and Others

6.3.6 **Incentives for Collection of Polythene**

For deposition of each 5 used polythene ,1 new polythene used to be given. For each used bottle 1 lollypop were given in canteen. Broken glass, plastic sandal, broken wood/timbers etc are also collected for selling to vhandari businessman.

6.3.7 **Provision of 3 Ton Truck**

An old 3 ton truck was available in unit which was made functional for transporting waste to dumping site. Truck was given appropriate cover while transporting and properly tighten so that it does not fall in the road. In the middle of the research, a new 3 ton trucks was issued from HQ, BGB.

Figure 6.11: Pickup, 3 Ton and Dump Truck used for Waste Management

6.3.8 **Production of Composting Fertilizer**. Solid waste of educational institutional can be utilized for production of compost fertilizer. Khan (2017) in his research found that composting would be a great option for waste management for JKKNIU campus where major portion (about 65%) of its wastes are biodegradable organic waste. Again Chittagong City Corporation (CCC) has already established a compost plant having 10 ton/day capacity. CCC is selling the compost directly to farmers with a price of compost is Tk 15 per Kg. According to the CCC, their annual income from sale of compost is between Taka 4 -4.5 million per year while the operational cost is around Tk. 3 million per year. Moreover, over dependence on chemical fertilizer can be reduced if organic fertilizer is produced and used, and will save BDT 350M per year (Nasrin, 2016). The chemical and physical composition of waste suggests that such waste can be utilized for compost

fertilizer which is economically viable. The prevailing market price of compost solid in Dhaka at present is Tk. 10-18. This unique venture of Waste Concern demonstrates that a small-scale decentralized community based composting plant can be a commercially viable and self sustained project for income generation and poverty alleviation.

The abandoned grenade of BGTC&C shed was repaired and provision was made for composting facility. The experts from Halishohor Waste Management Plant were hired for initial set up. They used to visit weekly and advice & train workers of BGTC&C. Compost fertilizer were applied in vegetable field, flower garden, nursery and leased land cultivator was supplied with compost to use in his paddy field. As a result use of chemical fertilizer was reduced. The economic viability of compost is given in table 24. Here considering standard of compost and packing, price is taken as 8 tk/kg.

Table 6.1: The Economic Benefits of Composting of Waste Materials

Amount of Organic Waste (Kg/year)	Total Amount of Compost (kg)	Price per kg of Compost (Tk)	Total price of Compost (Tk)/yr
328500 (900X365)	82125	8	6,57,000

On the other hand huge amount of cow dung has to be bought every year for gardening purpose by the BGTC&C, the compost generated from the solid waste can replace those cow dung. After meeting the demand of the BGTC&C, additional composts may also be supplied to farmers, or sold in order to recover cost of maintenance of the composting system.

Figure 6.12: Composting Place

Due to corona restrictions, vegetable gardening was encouraged in the vicinity of the residential compounds. So there was demand for lot of fertilizers. Authority had supplied this fertilizer for cultivation. These were initially spread all over the land and mixing was done. After 2/3 days there was no smell at all.

Figure 6.13: Use of Compost Fertilizer

6.3.9 **Provision of Safety and Protective Gears**

The job of a solid waste management worker is tough. Waste workers stick their hands into piles of garbage, trash, and junk to ensure reduce, reuse, recycle. Workers in the waste handling face many occupational health risks and hazards. Segregating reusable and recyclable materials with bare hands is a hazardous task, which puts waste workers to injuries and different kinds of skin and respiratory diseases (Chandan, 2020).The most significant risks are punctures, cuts, lacerations, and abrasions using specialized knives and other tools to sort trash. Workers are also likely to encounter the sharp edges of broken materials. Workers were given waste management PPE, mask, hand gloves, boot, soap, etc. Monthly physical medical checkup was also introduced for workers.

6.3.10 **Awareness Program Undertaken**

A massive awareness raising programs regarding waste disposal and the benefits of recycling and reuse was adopted to educate people. Few awareness boards were fixed in different places and few dustbins were placed in open spaces like near play ground, corner of roads etc. Advertisement about solid waste management in subscribed dish channel was introduced. In

the introductory lecture of courses, all were advised not to litter and to use dustbin. Residential areas are now cleaned once in a month by all households and school students also clean their area monthly. A paper containing necessity of neat and clean environment and habits those pollute environment was pasted in each cookhouse and inside each lifts. Even during cultural program, few violations of waste violation were shown to all to avoid in future. Religious Teacher delivers a motivational lecture in Jumma Prayer on monthly basis. In Srilanka, Schools with an (Adiwiyata Program means waste education) have less solid waste generation (0.25 ton/day) than schools without a waste management training 0.40 ton/day (Arum, 2017). A sample slogan/board is attached at annex D.

6.3.11 **Arrangement of Compulsory Solid Waste Management Training for Workers.** Every staff related with waste collection and management system should have training under a qualified authority. So, that they can perform their tasks properly. Workers involved in solid waste management of BGTC&C do not have formal training and also have no idea about waste management. So a two week on job training program was organized for all workers. The team worked in Chattogram City Corporation for JICA was hired and proper training was imparted.

Figure 6.14 : Awareness Boards

6.3.12 **Decentralized Primary Waste Management System**. Waste management system has been made decentralized by dividing the area and tasking the 3 battalions (Recruit, Advance and Admin) and monitoring their performances. It ensured better accountability. Here Yellow coloured area is under RTB, Purple coloured area is under Advance Trg Bn and Green coloured area is under Admin Bn. The area is distributed considering area of occupation, area of use and proximity of accommodation etc.

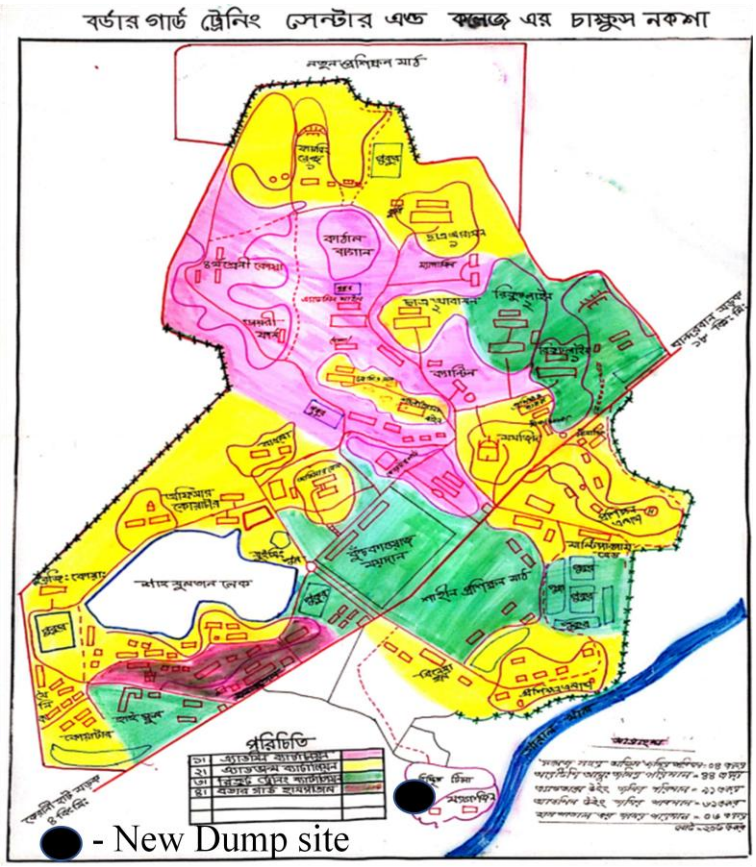


Figure 6.15: Distribution of SWM Responsibilities

6.3.13 **Provision of Incentives for Workers**

Earning coming through selling of paper, plastics, polythene etc were distributed among workers involved in waste management. It works as an incentive to them to collect more recyclable and reusable matters and to get more financial benefit. A new dump truck was issued from Dhaka for solid waste management.

6.3.14 **Provision of Alarm System**

Many informed that an alarm system could be effective since many forget to deposit their waste in time. So a whistle system and horn of vehicle were introduced to warn all stakeholders to deposit their waste. In the past, workers used to collect waste from dustbins as per timing. After introducing alarm system, waste deposition increases.

6.3.15 **Adoption of Waste Reduce, Reuse, Recycle Policy**

Reducing, reusing and recycling waste is important for the environment, and it can also be profitable. Methods of waste reduction include production of less waste at the BGTC&C campus. For example reduction of use of paper in office and classroom by digitalized reporting on routine matters. Initiative was taken to introduce electronic board and taking few

examinations through computer for officer's course. Reuses include the use of waste paper which was one side blank. Reusable cloths were used in car wash and in maintenance of weapons and magazine. Additional clothing item were put in polythene and kept in front of Bus stoppage which were normally taken or collected by poor people or transport drivers. Leaves were transported by Pick up and kept outside. Poor people collect by sack. Plastic, Paper, Electronic waste of the campus was sold as raw materials. These raw materials are then used in the production of new products.

6.3.16 **Strict observance of Policies**

Every individual had to sign a copy of solid waste management instruction before occupying a house. Clear punitive measures are specified for violation of this instruction. There are provisions of punishment for not following the rules. Duty JCO and NCO were instructed to report of any violation of the solid waste management instructions.

6.3.17. **Complain Register and Contact Number**

A complain register is kept inside the canteen so that anyone can report against any unauthorized dumping or problems. The calling number of MT section has been authorized to call for immediate removal of any littering or such activities.

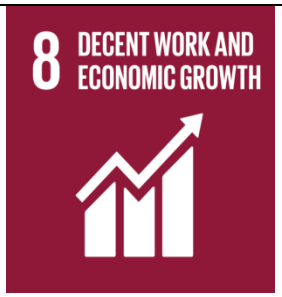
6.3.18 **Utilization of Budget for SWM**

BGB HQ allots adequate budget for SWM. But this budget is not spent for this purpose solely. Rather a lion share is spent for other purposes. Proper utilization of budget is ensured for effective solid waste management system.

6.4 **Reducing Burden of Local Government and Achievement of SDGs**.

Since the waste management of BGTC&C was taken care of by the institution itself, it reduced the burden of local government and contributed to achieve SDG Goals. SDGs encompass as many as 169 targets. In this project, few targets are broadly fulfilled and they are enumerated below:

SL	SDG	THEME	CONTRIBUTIONS
1		Jobs in waste collection and recycling	1. Employed additional 3x Cleaner 2. Few volunteer recycling members joined for their earnings
2		Less Diseases caused by open dumping and burning	1. No open dumping 2. No burning even papers
3		Environmental and health training and awareness	1. All house occupants are info by signing a document regarding waste mgt 2. Signposting 3. Briefing during course/training 4. Waste collectors are given PPE, mask, boot, gloves etc.
4		Women often bear most of the impact of bad waste management	Open dumping site close to accommodation is closed, covered with soil and compacted. Women at house are not expose to bad waste management now
5		Better SWM goes hand in hand with better WASH	1. No littering around houses and other places so comfortable to move and sanitation and hygiene is ensured 2. Due to COVID-19 washing facilities were given all places possible, building's entrance, mosque, office, dining hall etc

6		Waste management is the world's largest industry	1. Selling of papers, polythene, plastic bottles, glass, wood etc started. 2. Compost is produced for agriculture and used against environment killing artificial fertilizer
7		Make Cities and Human Settlements inclusive, safe, resilient and Sustainable	1. BGTC&C community is likely to have less bad impact on environment due to better SWM
8		Ensure sustainable consumption and production pattern	1. 3R policy is followed. 2. Compost is a resource recovery 3. Segregation ensures resource recover like paper, metal, plastic bottle, polythene etc 3. Efforts are taken to reduce waste
9		Reduced methane & CO_2 from dumping & burning	Definitely closing open dumping and no burning of waste has reduced methane gas production
10		Less pollution on the land, healthier environments	1. Eleven dumping places reduced to one. Dumping/ throwing waste indiscriminately are restricted. Again lesser land is used for dumping, so the pollution is less and healthier environment is ensured

6.5 **Budgetary Involvement**

6.5.1 **Expenditure**

Table 6.2: Expenditure Details

SL	**Sector/**	**Expenditure Details**	**Fixed Cost (Tk)**	Monthly Cost (Tk)
1	Collection	Additional 36x Dustbin	28,000	
		Repair of Dustbin	1,000	
2	Transportation	Mechanization of Vans	20,000	
		Provision of Pick Up	30,000	
		Provision of 3 Ton Truck	20,000	
3	Segregation	Employment of 3xNew Employee		30,000
		Purchase of Sacks	1,000	
4	Dumping	Closing of Old Dumping Site	5,000	
		Establishment of New Dumping Site	30,000	
5	Incentives for Exchange Offer			3,000
6	Disposal of Waste	Establishment of Composting Centre and running cost	15,000	3,000
7	Awareness Program	Boards, Panaflex, Tea Break	5,000	
8	Provision of Safety gears	Mask, Hand gloves, Soap,	8000	
9	Training for Workers	Two weeks on job training	20,000	
Total			**183,000**	**4,32,000/ yr**
Grand Total Cost				**6,15,000 tk/yr**

6.5.2 **Earnings**

Table 6.3: Earning Details

SL	**Sector/**	**Profit Details**	**Monthly Earning Tk**	**Yearly Earnings TK**
1	Selling Plastic	Bottle	6,000	72,000
		Polythene	1,000	12,000
2	Selling Paper	Office Paper	2,000	24,000
		Misc Paper	1,000	12,000
3	Misc Item	Wood, tin, Sandal, leather	1,500	18,000
4	Compost Fertilizer	Selling of 82125 Kg	As per table 12	6,57,000
	Grand Total Earnings			**7,95,000**

6.5.3 **Cost Benefit Analysis**

It is clearly evident that earnings are more than expenditure. Annually it can save around 1,35,000 taka . It means it's a beneficial project. It is also saving cost of cow dung and fertilizer purchase which was previously about 1,00,000 taka annually. Due to use of compost it reduces to 30,000 taka only. So, around 70,000 taka was saved here. Moreover, it generated employment opportunity for three persons. Overall, around 1,85,000 Taka is predicted to be saved per year.

There was significant production increase of vegetables and paddy after using compost. Increase in production was not calculated precisely but roughly it was almost 1.5 times more for vegetables and paddy was produced than previous year. Flowers and nursery trees were very healthy than before. Moreover mortality rate of trees were less too.

CHAPTER 7

CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion

BGTC&C is an academic institution of BGB which is located in Satkania UZ of Chattogram district. Total area of the campus is about 206 acres and it houses around 5840 personnel. The institution itself is responsible for managing the solid waste that is produced every day in the campus from different sources. A detail study was conducted to know different aspects of existing solid waste management system of BGTC&C. Firstly present solid waste management system was examined to find out efficiency of its primary waste collection system, transportation and disposal of waste, management of disposal site and its effect on surrounding environment. Secondly segregation or characterization of waste was done to see potentiality for resource recycling and recovery. Then a pilot project was implemented for composting based on characterization of waste. Thirdly a sustainable solid waste management model for BGTC&C was proposed for improvement of primary waste collection system.

Detail research was carried out to develop the sustainable solid waste management model for BGTC&C. Study was conducted from October 2020 to November 2021. Samples were collected and analyzed in three seasons from all sources of waste following proper field and laboratory protocols. Primary data was obtained from various classes of people through KII, questionnaire survey of households and waste workers. Among residential, commercial, institutional and open space/street sweeping waste, residential waste was about 85%. The total solid waste generation and rate of generation was found to be 1253 kg/day and 0.214 kg/capita/day respectively. The solid waste includes kitchen waste, papers, dry leaves, branches of tree, plastics, glass, leather, packets of different commodities etc. It was found that more than 75% of solid waste was organic in nature and mainly food waste. Paper, book etc were second (10.91%) and higher than other educational institutions due to ceremonial parade, cultural programs, competitions and covid protocol when packing materials were used more. About 19% of generated waste was recyclable and 76% was compostable and rest about 5% was inert. Above results were compared with other educational universities like CU, JKKNIU, JU, KUET and found to be compatible. Seasonal variations were found true and rainy season had more solid waste generation. Average bulk density of waste was about 65%. The physical composition and bulk density of solid waste was found suitable for composting.

Solid waste management in BGTC&C is basically controlled and managed by Administration Battalion with the help of Recruit Battalion, Advance Battalion and Headquarters. The solid waste management activities are done mainly by the conservancy group. Wastes are primarily

collected from dustbins as mixed waste by waste collectors every day. There are total 26 personnel employed for cleaning the entire BGTC&C area. Among them 5-6 are employed for the waste disposal on rotation. Collected wastes are transported by open three wheeler vans and dumped in dumping site located in Bishporibar area. No separation or resource recovery is done before disposing to dumping site. Official papers are usually burnt. Kitchen waste and houses waste are polythene packed and put in dustbin. Sometimes these are thrown backyard, in ponds or in open place or even in drain. About 85% of the occupants are not aware about 3R policy and in general populous are not serious about proper disposal of waste. Most of the waste workers also do not have formal training.

Existing solid waste management practice of BGTC&C poses potential risks to health and environment. About 45% inhabitants residing close to dumping site and waste workers experienced different types of diseases like headache, skin disease, diarrhoea etc. Indiscriminate open dumping spread bad smell, caused irritation, gave birth to mosquito, flies etc and ultimately created an unhygienic condition. Broadly waste caused serious threat to water, soil and air of BGTC&C. Through research it was found inadequate number of dustbins and vanes, haphazard dumping, wrong selection of dumping site, lack of awareness, absence of resource recovery practice, fire on waste, lack of supervision, insincerity and shortage of waste workers are the main causes of poor waste management. Overall, it standard was not a pleasant one. It needs major improvement in many aspects including primary collection system. As such, execution of a sustainable solid waste management model for BGTC&C is necessary for ensuring improvement of primary waste collection system. Provision of extra vans, dustbins and waste workers, proper supervision, provision of incentives and punishment, awareness program, relocation of dumping site, briefing in courses/rollcall etc were suggested by Households, Key Informant and waste collectors etc through survey and interview.

A pilot project was executed on composting and found to be economical and viable. About 7,95,000 taka is expected to be earned annually against 6,15,000 taka expense. Compost fertilizers were applied in vegetable field, flower garden, nursery and leased land. It could fertile the land, crops production was more and most importantly use of artificial fertilizer was reduced to a great extent (70%). Roughly production increased by 1.5 times which is very encouraging. Apart from earning it could generate employment opportunity for few persons. Arrangement of adequate dustbins and their maintenance, improvements of transportation moods, employment of segregator, provision of safety gear, incentives and training for workers, decentralization of waste management system, awareness program for residents, relying on 3R policy, closing all unhygienic dumping sites, establishing secondary transfer station and activating alarm system etc has resulted a model for BGTC&C. The model improved the primary waste collection system as well as maximized waste recycling and resource recovery. It has lessened the load of local government, generated source of income, created scope for job opportunity and most importantly ensured hygienic environment by reducing pollutions. Such arrangements was checked against sustainable development goals and found to be broadly addressing most of it ensuring preservation of ecosystem.

Sustainability of the management plan was ensured by safeguarding environment, proper utilization of the institutional capacity, making it within financial capability with economic viability.

7.2 **Recommendations**

Following are the recommendations of this study:

i) Educational institutions may be encouraged to have their own solid waste management system.

ii) A further study can be conducted to establish a composting plant incorporating solid waste of Kernaihat Pouroshouva.

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Annex-A to
Chapter-1

বিজিবি স্থায়ী আদেশ- ১ম খন্ডে উল্লেখিত দায়িত্ব ও কর্তব্যসমূহ

৪০০১। **কমান্ড্যান্ট (অতিরিক্ত মহাপরিচালক)**

ক। অধিনস্থদের প্রশাসন, প্রশিক্ষণ, নিয়মানুবর্তিতা, স্বাস্থ্য ও কল্যাণ এবং সংশ্লিষ্ট ব্যাটালিয়ন/ উইং অধিনায়কদের মাধ্যমে যে সমস্ত কার্যাদি সমাধা করে থাকেন তার জন্য দায়ী থাকবেন।

৪০০৫। **পরিচালক, প্রশাসন (অতিরিক্ত পরিচালক)**

ক-জ। XXXXXXXXXXXXX

ঝ। মৎস খামার, কৃষি, বনজ সম্পদ কিংবা অন্যান্য মুরগীর খামার ইত্যাদি তত্বাবধান এবং নিয়ন্ত্রণ করবেন। ময়লা আবর্জনা ও বর্জ্যের সঠিক ব্যবস্থাপনা নিশ্চিত করবেন।

৪০০৬। **মেডিক্যাল কর্মকর্তা (উপ পরিচালক)**

ক-ঘ। XXXXXXXXXXXXX

ঙ। সামরিক এবং অসামরিক কর্মচারীদের ত্রৈমাসিক মেডিক্যাল চেকআপ করবেন। এলাকার পরিস্কার পরিচ্ছন্নতা নিশ্চিত করবেন।

৪০০৭। **সুবেদার মেজর (জিডি)**

ক-ঢ। XXXXXXXXXXXXX

ণ। অডিটরিয়াম সহ কোয়ার্টার গার্ড, স্কুল, ক্যান্টিন ও মসজিদের যাবতীয় পরিস্কার পরিচ্ছন্নতা, আবর্জনা পরিস্কার, গোপনীয়তা সমূহের প্রতি বিশেষভাবে দৃষ্টি রাখবেন এবং উক্ত স্থাপনাগুলির সৌন্দর্য বৃদ্ধির ব্যাপারে বিশেষভাবে লক্ষ্য রাখবেন।

৪১০০। **উইং কমান্ডার (পরিচালক)**

ক। XXXXXXXXXXXXX

খ। অধীনস্থদের সকল প্রকার প্রশাসনিক কার্যাদি, সুযোগ সুবিধা এবং স্বাস্থ্য সম্পর্কীয় বিষয়াদির ব্যাপারে কমান্ড্যান্টের নিকট দায়ী থাকবেন।

৪১০২। **কোয়ার্টার মাষ্টার (উপ পরিচালক)**

ক-খ। XXXXXXXXXXXXX

গ। স্বাস্থ্যকর ভাবে সৈনিক মেসের খাবার তৈরী ও পরিবেশসনহ সৈনিক মেস ও সংলগ্ন এলাকা পরিস্কার পরিচ্ছন্নতা নিশ্চিত করবেন। বর্জ্যের ব্যবস্থাপনা নিশ্চিত করবেন।

৪১০৩। **সিনিয়র জেসিও (সুবেদার, জিডি)**

ক-ঙ। XXXXXXXXXXXXX

চ। উইংয়ের দায়িত্বপূর্ণ এলাকার (লাইন/কুক হাউজ) ইত্যাদি পরিস্কার পরিচ্ছন্নতা নিশ্চিত করবেন। বর্জ্য ফেলা, সংগ্রহ ও ব্যবস্থাপনা নিশ্চিত করবেন।

৪১১৩। **সিকিউএমএইচ (হাবিলদার, জিডি)**

ক-ট। XXXXXXXXXXXXX

ঠ। সৈনিক লাইনের পরিস্কার পরিচ্ছন্নতা, শৃঙ্খলার তদারকি ও প্রয়োজনীয় প্রতিবেদন দিবেন। বর্জ্য ব্যবস্থাপনার জন্য পরিচ্ছন্ন কর্মী নিয়োগ করবেন।

৪১১৭। **মেডিক্যাল সহকারী (হাবিলদার)**

ক-ঝ। XXXXXXXXXXXXX

ঞ। তিনি নিম্নলিখিত রেজিষ্টার সমূহ রক্ষণাবেক্ষণ করবেন ঃ

(১) বিভিন্ন হাসপাতাল ভর্তি/ত্যাগ রেজিষ্টার।
(২) কেন্দ্রীয় স্যানিটারী পরিদর্শন রেজিষ্টার
(৩) ভিডি রেজিষ্টার।
(৪) ম্যালেরিয়া প্রতিবেদন রেজিষ্টার।
(৫) ফুটরুট রেজিষ্টার।
(৬) ইনকুলেশন ভ্যাকসিনেশন রেজিষ্টার।
(৭) স্থুলতা প্রতিবেদন রেজিষ্টার।
(৮) নিম্ন মেডিক্যাল ক্যাটাগরী রেজিষ্টার।
(৯) ত্রৈমাসিক ডাক্তারী পরীক্ষা রেজিষ্টার।
(১০) রক্তের গ্রুপ রেজিষ্টার।

৪১২৫। **পরিচ্ছন্ন কর্মী (অসামরিক)**

ক-গ। XXXXXXXXXXXXX

ঘ। বিজিটিসিএন্ডসি এর ড্রেন, ময়লার ট্র্যাংকি এবং অন্যান্য যাবতীয় ময়লা আবর্জনা নিয়মিত পরিস্কার পরিচ্ছন্ন করবেন

Annex-B to
Chapter-2

জরিপ প্রশ্নাদি

দৈনিক লেবার, ভ্যান চালনাকারী, ময়লা সংগ্রাহক

১। আর্থ সামাজিক তথ্যাদি

(ক) বয়স (বছর) :

(খ) শিক্ষাগত যোগ্যতা

(গ) আপনি কতদিন যাবৎ বর্জ্য অপসারন কাজ করেছেন ?

(ঘ) বেতন এবং পরিশোধের ধরন (দৈনিক/সাপ্তাহিক/মাসিক)

(ঙ) দৈনিক/মাসিক খরচ/ব্যয়

(চ) অন্য কোন আয়ের উৎস

(ছ) বর্জ্য পুনঃ প্রক্রিয়াজাতকরন রিসাইক্লিং কার্যক্রম থেকে কোন অতিরিক্ত আয় (টাকার পরিমান)

(জ) উৎসব বোনাস (নিয়োগকারী হতে)

(ঝ) আপনার সমাজে বর্জ্য সংগ্রাহক হিসেবে আপনার সামাজিক অবস্থান কি ?

২। দৈনন্দিন কার্যক্রম

(ক) একটি ভ্যান দিয়ে পূর্ণ করে কতগুলি পরিবারের বর্জ্য অপসারন করতে পারেন ?

(খ) দৈনিক কাজের সময় (ঘন্টা) :

(গ) শুরু এবং শেষ সময় :

(ঘ) প্রতি সপ্তাহে কাজের দিন সংখ্যা :

(ঙ) রুট/স্থান সংখ্যা :

(চ) তার দৈনন্দিন কাজে ভবনের সংখ্যা :

(ছ) পরিবারের সংখ্যা এবং মানুষের সংখ্যা :

৩। স্বাস্থ্য

(ক) অসুস্থতার ইতিহাস (বিস্তারিত)

(খ) প্রাথমিক চিকিৎসার জন্য কোন ব্যবস্থা ' আপনার ভ্যানের সাথে সংযুক্ত আছে কি ?

(গ) চাকরি কালীন আঘাত বা অসুস্থতার ক্ষেত্রে, কে চিকিৎসার খরচ বহন করেন ?

৪। সচেতনতা প্রশিক্ষণ কর্মসূচি

(ক) আপনার ব্যক্তিগত স্বাস্থ্য কেমন ? পরিচ্ছন্নতা কি ধরনের ?

(খ) আপনি কি Occupational Health and Safety Organisation স্বাস্থ্যসম্মত নিরাপদ কর্মপরিবেশ সংক্রান্ত কোন শিক্ষা গ্রহন করেছেন ?

(গ) ব্যক্তিগত সুরক্ষা সরঞ্জাম (পিপিই) আপনি কি ব্যবহার করেন ?

৫। উপলব্ধি/ধারনা

(ক) বর্জ্য বিভাজন।

(খ) বর্জ্য পুনঃ প্রক্রিয়াজাতকরণ।

(গ) স্বাস্থ্য এবং নিরাপত্তা।

(ঘ) ভ্যান টানা।

(ঙ) ভ্যান এবং সরঞ্জাম পরিস্কারকরন।

(চ) পিপিই।

(ছ) দুর্গন্ধ হ্রাস।

(জ) বর্জের তরল অংশ নিয়ন্ত্রণ ও ব্যবস্থাপনা।

(ঝ) মধ্যবর্তী/সাময়িক ষ্টেশনে ভ্যান খালিকরন।

৬। সংগ্রাহক যানবাহন এবং সরঞ্জামাদি

(ক) ভ্যান এর আকার।

(খ) ভ্যানের ওজন : ১) খালি, ২) শীতকালে (পূর্ণ অবস্থায়) এবং ৩) বর্ষাকালে (পূর্ণ অবস্থায়)।

(গ) ভ্যানের সাথে অন্যান্য সরঞ্জামাদির বর্ণনা।

(ঘ) ভ্যান এবং সরঞ্জামগুলির মূল্য।

(ঙ) মাসিক রক্ষণাবেক্ষণ খরচ।

(চ) ভ্যান ও সরঞ্জাম পরিস্কারকরণ।

(ছ) পরিস্কার করার জন্য রাসায়নিক দ্রব্যের ব্যবহার এবং ভ্যান এবং সরঞ্জামাদি পরিস্কারে মাসিক খরচ।

৭। অসুবিধা সমূহ

(ক) ভ্যান চালাতে অসুবিধা।

(খ) ভবনগুলিতে আবর্জনার বিন/ডালা খালি করতে অসুবিধা।

(গ) প্রতিকূল আবহাওয়ার সময় অসুবিধা (রোদের দিন ও বৃষ্টির দিন)।

(ঘ) বর্জের তরল অংশের সাথে শরীরের সংস্পর্শ শরীরের যোগাযোগ।

(ঙ) গন্ধের উপদ্রব

Annex-C to
Chapter-2

জরিপ প্রশ্নাদি

মধ্যবর্তী/সাময়িক বর্জ্য ষ্টেশনে কর্মরত ব্যক্তিবর্গ

১। আর্থ সামাজিক তথ্যাদি

(ক) বয়স (বছর) :

(খ) শিক্ষাগত যোগ্যতা

(গ) আপনি কতদিন যাবৎ বর্জ্য অপসারন কাজ করেছেন ?

(ঘ) বেতন এবং পরিশোধের ধরন (দৈনিক/সাপ্তাহিক/মাসিক)

(ঙ) দৈনিক/মাসিক খরচ/ব্যয়

(চ) অন্য কোন আয়ের উৎস

(ছ) বর্জ্য পুনঃ প্রক্রিয়াজাতকরন রিসাইক্লিং কার্যক্রম থেকে কোন অতিরিক্ত আয় (টাকার পরিমান)

(জ) উৎসব বোনাস (নিয়োগকারী হতে)

(ঝ) আপনার সমাজে বর্জ্য সংগ্রাহক হিসেবে আপনার সামাজিক অবস্থান কি ?

২। দৈনন্দিন কার্যক্রম

(ক) আপনি প্রতিদিন কতটি ভ্যান পরিচালনা করেন ?

(খ) দৈনিক কাজের সময়

(গ) শুরু এবং শেষ সময়

(ঘ) প্রতি সপ্তাহে কাজের দিন সংখ্যা

(ঙ) প্রতিটি মধ্যবর্তী/সাময়িক বর্জ্য ষ্টেশনের সাথে সম্পর্কিত বিল্ডিংয়ের সংখ্যা

(চ) বর্জ্য ভ্যানগুলি কখন মধ্যবর্তী/সাময়িক বর্জ্য ষ্টেশনে আসতে শুরু করে ?

(ছ) গৃহের সংখ্যা এবং মানুষের সংখ্যা কত ?

(জ) আপনি কি সেই বর্জ্য আলাদা করেন ?

৩। স্বাস্থ্য

(ক) অসুস্থতার ইতিহাস (বিস্তারিত)

(খ) প্রাথমিক চিকিৎসার জন্য কোন ব্যবস্থা ' আপনার ভ্যানের সাথে সংযুক্ত আছে কি ?

(গ) চাকরি কালীন আঘাত বা অসুস্থতার ক্ষেত্রে, কে চিকিৎসার খরচ বহন করেন ?

৪। সচেতনতা প্রশিক্ষণ কর্মসূচি

(ক) আপনার ব্যক্তিগত স্বাস্থ্য কেমন ? পরিচ্ছন্নতা কি ধরনের ?

(খ) আপনি কি Occupational Health and Safety Organisationস্বাস্থ্যসম্মত নিরাপদ কর্মপরিবেশ সংক্রান্ত কোন শিক্ষা গ্রহন করেছেন ?

(গ) ব্যক্তিগত সুরক্ষা সরঞ্জাম (পিপিই) আপনি কি ব্যবহার করেন ?

৫। উপলব্ধি/ধারনা

(ক) বর্জ্য বিভাজন।

(খ) বর্জ্য পুনঃপ্রক্রিয়াজাতকরণ।

(গ) স্বাস্থ্য এবং নিরাপত্তা।

(ঘ) পিপিই।

(ঘ) দুর্গন্ধ হ্রাস।

(ঙ) লিচেট নিয়ন্ত্রণ ও ব্যবস্থাপনা।

(চ) টিএসএস ভ্যান খালি করা।

(ছ) কম্পেক্টরে বর্জ্য লোড।

জরিপ প্রশ্নাদি

Key Informent Interview (প্রধান তথ্য প্রদানকারী)

১। নিজস্ব পরিচয় ও কার্যাবলী

(ক) বর্তমান অবস্থান/পদ।

(খ) কতদিন যাবৎ এ পদে নিযুক্ত আছেন?

(গ) বর্জ্য ব্যবস্থাপনা সম্পর্কে আপনার কোন প্রাতিষ্ঠানিক শিক্ষা আছে কি?

(ঘ) সরকারীভাবে বরাদ্দকৃত বর্জ্য ব্যবস্থাপনার অর্থ কি যথেষ্ঠ? বরাদ্দকৃত অর্থ কি এই খাতে ব্যয় করা হয়?

(ঙ) বর্জ্য ব্যবহার করে কম্পোষ্ট তৈরী বিষয়ে আপনার মতামত বলুন?

(চ) ক্যাম্পাসে 3R প্রচলনের ব্যাপারে আপনার মতামত।

(ছ) ক্যাম্পাসে কম্পোষ্ট তৈরীতে আপনার মতামত বলুন।

২। **বর্জ্য ব্যবস্থাপনা**

(ক) বর্তমান ব্যবস্থাপনার মান সম্পর্কে আপনার মূল্যায়ন?

(খ) ডাম্পিং এরিয়া/সাইটের অবস্থান, স্বাস্থ্যঝুঁকি ইত্যাদি সম্পর্কে আপনার ধারণা?

(গ) বর্জ্য ব্যবস্থাপনায় ব্যবহৃত গাড়ী/যানবাহন মান সম্মত নয় এবং সংখ্যা অপ্রতুল, এ ব্যাপারে আপনার মন্তব্য?

(ঘ) কি কি কারণে বর্জ্য ব্যবস্থাপনার মান সন্তোষজনক নয়?

(ঙ) আপনার মতে কি কি ব্যবস্থা গ্রহণ করলে বর্জ্য ব্যবস্থাপনার মান উন্নত হবে?

(চ) বর্জ্য অপসারনকারীর সংখ্যা অপ্রতুল-এ ব্যাপারে আপনি কি একমত?

(ছ) বর্জ্য অপসারনে নিযুক্ত ব্যক্তিবর্গের স্বাস্থ্যঝুঁকি কমাতে কি কি ব্যবস্থা নেয়া উচিত বলে আপনি মনে করেন?

৩। **বর্জ্য সচেতনতা শিক্ষা**

(ক) বর্জ্য সচেতনতার শিক্ষার মান সম্পর্কে আপনার মতামত কি?

(খ) কি কি ব্যবস্থাপনার মাধ্যমে সংশ্লিষ্ট সবাইকে সচেতন করা যেতে পারে?

জরিপ প্রশ্নাদি

বাসা ব্যবহারকারী (House Holds)

১। আর্থ সামাজিক তথ্যাদি

(ক) আপনার বয়স সম্পর্কে ধারণা?

(খ) পরিবারের সদস্য সংখ্যা কত?

(গ) গৃহকর্তার চাকুরী?

(ঘ) বর্জ্য ব্যবস্থাপনায় সম্পৃক্ত 3R সম্পর্কে কোন ধারণা আছে কি?

(ঙ) আপনার বাসার অন্যান্য ফ্লাটে বসবাসকারী সবাই কি বর্জ্য সঠিকভাবে ডাষ্টবিনে ফেলেন?

২। **দৈনন্দিন কার্যক্রম ও বর্জ্য ব্যবস্থাপনা**

(ক) দিনে কখন, কোথায় বর্জ্য ফেলেন এবং কিসের মাধ্যমে ফেলেন?

(খ) কেউ কি অনির্ধারিত জায়গায় বর্জ্য ফেলেন?

(গ) বর্জ্য আলাদা করেন নাকি মিশ্রিত অবস্থায় ফেলেন?

(ঘ) ডাষ্টবিনের সংখ্যা কি যথেষ্ট? যথেষ্ট না হলে এতে অসুবিধা সমূহ কি কি হচ্ছে?

(ঙ) বর্জ্য অপসারণকারীদের কাজের মূল্যায়ন করুন।

(চ) সার্বিক বর্জ্য ব্যবস্থাপনায় আপনি কি সন্তুষ্ট? সন্তুষ্ট না হলে কারণ সমূহ কি কি?

(ছ) বর্জ্য ব্যবস্থাপনা উন্নয়নে আপনার মতামত বলুন?

(জ) কম্পোষ্ট তৈরী সম্পর্কে ধারণা থাকলে বলুন।

৩। **স্বাস্থ্য**

(ক) বর্জ্য ফেলতে স্বাস্থ্যগত কোন ঝুঁকি মনে করেন কি?

(খ) বর্জ্যের যথেচ্ছা ফেলার কারণে স্বাস্থ্যগত কোন রোগের কারণ কি?

(গ) বর্জ্য ব্যবস্থাপনা কি পরিবেশ ও স্বাস্থ্যের ক্ষতির কারণ?

(ঘ) ডাম্পিং সাইট কি স্বাস্থ্য সম্মত? এ সম্পর্কে কোন মতামত থাকলে বলুন।

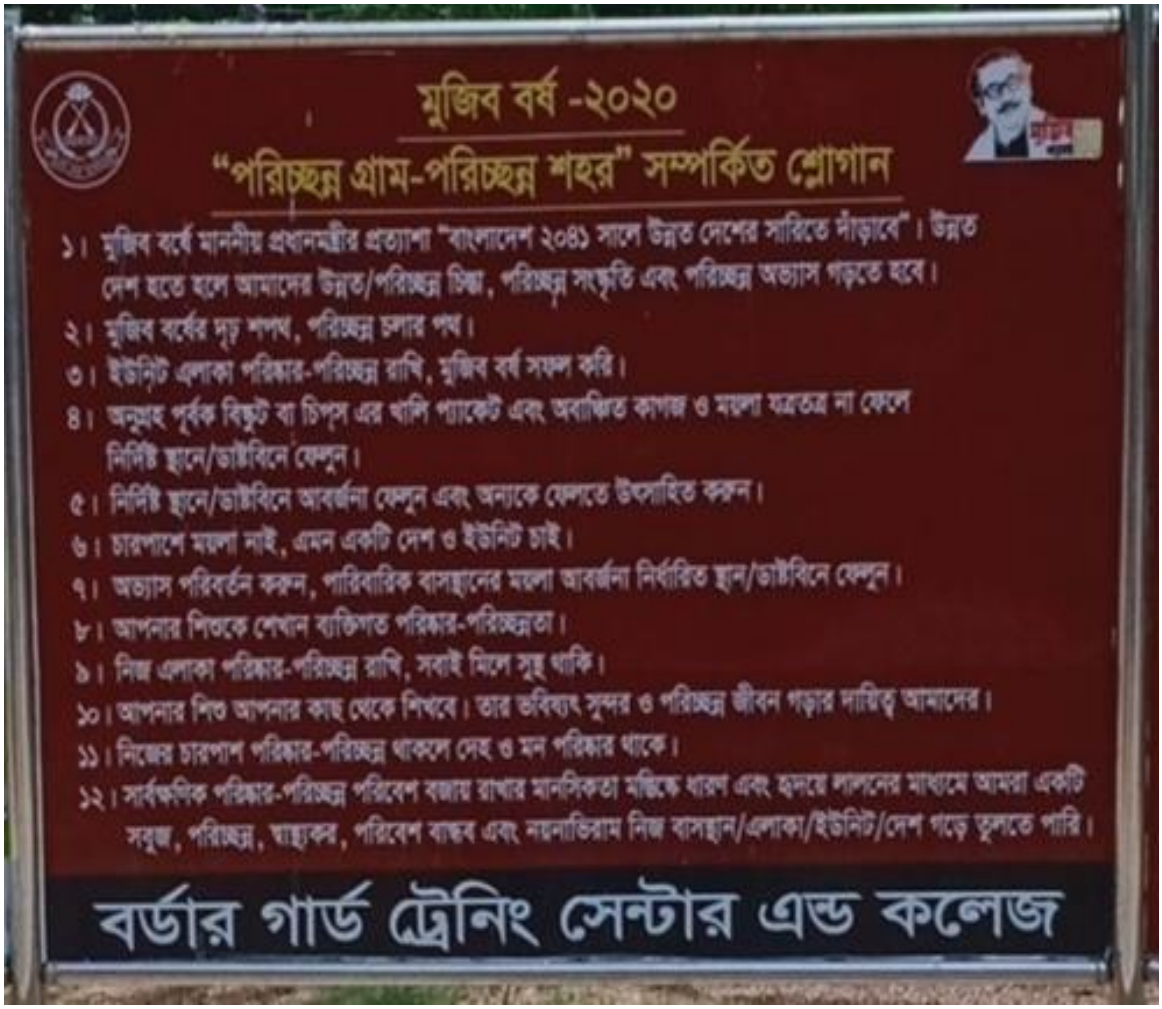
৪। **সচেতনতা প্রশিক্ষণ**

(ক) বর্জ্য সম্পর্কে সবাইকে প্রশিক্ষণ দেয়া প্রয়োজন মনে করেন কি? প্রয়োজন মনে করলে কে কে এই প্রশিক্ষণ পেতে পারে?

(খ) কিভাবে সবাইকে বর্জ্য ব্যবস্থাপনা সম্পর্কে সচেতন করা যেতে পারে?

Annex-G to
Chapter-6

SLOGAN OF WASTE MANAGEMENT BGTC&C



DATA ANNEX

Table 3.5: Occupation of the Respondents

Occupation	Number	Percentage
Housewife	88	37%
Govt Service	96	40%
Private Service	8	3%
Others	48	20%

Table 4.3: Solid Waste Generation in Single Man Mess

Waste Category	Waste Generated by Single Man Mess (Kg/day)					Total
	Officers	JCOs	ORs	Instructors	Recruits	
Total	6.6	8.0	636.8	13.6	161	826
Total Population	30	40	3980	80	700	4830
Per Capita/Day	0.22	0.20	0.16	0.17	0.23	**Avg 0.17 kg/day**

Table 4.4: Compositional Analysis of Solid Waste of Single Man Mess

Waste Composition	Amount Kg/day	Weight %	Remarks
Organic Matter	651.71	78.9	
Paper	81.77	9.5	
Plastics	23.95	3.1	
Textile and Wood	10.74	1.3	
Leather and Rubber	4.13	0.5	
Metal	9.09	1.1	
Glass	4.13	0.5	
Others	40.47	5.1	
Total	826	100	

Table 4.5: Solid Waste Generation in Family Quarters (Kg/day)

Solid Waste Generation in Family Quarters (Kg/day)					
	Officers	Teachers	ORs	3rd/4th Class Employee	Total
Total	27.27	8.75	160.77	47.19	243.98
Population	90	35	690	195	945
Per Capita	0.303	0.25	0.233	0.242	0.242

Table 4.6: Compositional Analysis of Solid Waste of Family Quarters

Waste Composition	Amount Kg/day	Weight %	Remarks
Organic Matter	197.87	81.1	
Paper	17.57	7.2	
Plastics	8.54	3.5	
Textile and Wood	4.54	1.9	
Leather and Rubber	0.24	0.1	
Metal	2.93	1.2	
Glass	1.22	0.5	
Others	10.98	4.5	
Total	243.98	100	

Table 4.7: Solid Waste Generation in Commercial Areas (Kg/day)

Source of Waste	2xDry Canteen	5xWet Canteen	1x Bakery	1xRest House	1x Kabab Ghor	1x Shipoks	1xSlaughter House & Vegetable Store	12xStores (Rations, Clothing etc)	3x Temp Market	Total
Total	3.06	15.5	11.9	1.02	9.9	0.3	15.5	5.75	17.70	80.63

Table 4.8 : Compositional Analysis of Solid Waste of Commercial Areas

Waste Composition	Amount Kg/day	Weight %	Remarks
Organic Matter	67.97	84.3	
Paper	4.76	5.9	
Plastics	1.21	1.5	
Textile and Wood	.89	1.1	
Leather and Rubber	0.48	0.6	
Metal	0.73	0.9	
Glass	0.40	0.5	
Others	4.19	5.2	
Total	80.63	100	

Table 4.9: Summary of Waste in Institutional Areas

Source of Waste	7x Offices	BGB Pub School	Primary School	English School	24x Training Sheds	3xMulti-purpose Sheds	2x Clinics	2xFiring Range	Total
Total	11.95	9.65	4.24	4.75	11.98	5.1	2.58	4.8	55.05

Table 4.10: Composition Analysis of Solid Waste in Institutional Areas

Waste Composition	Amount Kg/day	Weight %	Remarks
Organic Matter	8.11	12.09	
Paper	35.74	53.3	
Plastics	6.99	10.43	
Textile and Wood	6.40	9.54	
Leather and Rubber	1.35	2.02	
Metal	1.37	2.05	
Glass	0.65	0.97	
Others	6.44	9.6	
Total	55.05	100	

Table 4.11: Composition Analysis of Solid Waste Open Areas/Street Sweeping

Waste Composition	Amount Kg/day	Weight %	Remarks
Organic Matter	22.00	37.93	Maximum Leaves
Paper	4.00	6.90	
Plastics	6.35	10.95	
Textile and Wood	3.00	5.17	
Leather and Rubber	0.90	1.55	
Metal	0.75	1.29	
Glass	0.40	0.69	
Others	20.60	35.52	
Total	48.00	100.00	

Table 4.12 : Contribution of different sources in total Solid Waste Generation

Waste Source	Amount Kg/day	Weight %	Remarks
Residential	1069.98	85.35	Highest
Commercial	80.63	6.43	
Institutional	55.05	4.39	
Open/Road Sweeping	48.00	3.83	
Total	1253.66	100.00	Per capita 0.214 kg/day

Table 4.13 : Physical Composition of Solid Waste Generated

Composition of Total Solid Waste of BGTC&C		
Waste Composition	Amount Kg/day	Weight %
Organic Matter	942.41	75.17
Paper	136.75	10.91
Plastics	44.69	3.56
Textile and Wood	23.99	1.91
Leather and Rubber	6.71	0.54
Metal	14.49	1.16
Glass & Ceramics	6.62	0.53
Others	77.98	6.22
Total	1253.64	100.00

Table 4.14 : Recyclable and Non Recyclable Component in Solid Waste of BGTC&C

Recyclability of Total Solid Waste of BGTC&C			
Recyclable		**Non Recyclable**	
Waste Category	Weight kg/day	Waste Category	Weight kg/day
Paper	136.75	Organic Matter	942.41
Plastics	44.69	Others (dirt, stone etc)	77.98
Textile and Wood	23.99		
Leather and Rubber	6.71		
Metal	14.49		
Glass	6.62		
Total	233.26		1020.40
Grand Total %	**18.61**		**81.39**

Table 4.15: Mean weight fractions of the various components of MSW in different seasons

Seasons	Mean weight fraction							
	Organic matter	Paper	Plastic	Textile and wood	Leather and rubber	Metal	Glass	Other
Summer (May-Jun)	0.761	0.105	0.035	0.018	0.006	0.012	0.005	0.059
Monsoon (Jul-Aug)	0.792	0.101	0.031	0.012	0.005	0.007	0.005	0.052
Winter (Nov-Jan)	0.716	0.116	0.041	0.025	0.006	0.015	0.006	0.074
Annual mean	0.755	0.106	0.036	0.018	0.005	0.011	0.005	0.063

Table 4.16: Bulk Density of Few Samples

Category of Waste	**Wt of Can (gm)**	**Wt Can+Wet Sample (gm)**	**Wt of Can+Dry Sample (gm)**	**Wt of sample (gm)**	**Wt of Water (gm)**	**Moisture Content (%) Dry Basis**	**Moisture Content (%) Wet Basis**
Food Waste-1	50.30	148.80	67.00	16.70	81.80	489.82	83.05
Food Waste-2	50.10	225.30	64.40	14.30	160.90	1125.17	91.84
Food Waste-3	71.50	220.10	102.00	30.50	118.10	387.21	79.48
Food Waste-4	65.00	221.90	73.90	8.90	148.00	1662.92	94.33
Bones /Shell	55.00	124.80	96.00	41.00	28.80	70.24	41.26
Paper	65.60	138.40	111.20	45.60	27.20	59.65	37.36
Other Papers	50.50	107.80	74.00	23.50	33.80	143.83	58.99
Textile	71.70	204.20	201.10	129.40	3.10	2.40	2.34
Glass/Wood	92.50	230.30	135.90	43.40	94.40	217.51	68.51

Table 5.1: Details of Personnel related to Solid Waste Management of BGTC&C

S/N	Appointment	Number	Service Length range	Educational Background	Health Condition	Salaries Tk	Responsibilities
1	Admin Bn Comd	1	14-20 yrs	Masters	Good	75,000	Overall monitoring and management of conservancy activities
2	Assistant Dir	1	10-14	BA/HSC	Good	40,000	Monitoring and supervision of conservancy activities
3	Conservancy Group Comd - Havilder		14-30	SCC/HSC	Good	35,000	Employ and Supervise conservancy group
	Assistant Conservancy Group Comd - Naik	1	14-30	SCC/HSC	Good	30,000	Assist Conservancy group commander in discharging his duties
4	Waste Collector	5	2-20	SSC	Good	15000-20,000	Deal with collection, transportation, segregation and dumping in to Dumpsite
5	Cleaner/ Sweeper	15	2-20	SSC	Good		
6	NC (E)	5	2-20	SSC	Good		