ASSESSMENT OF PLASTIC WASTE AND ITS MANAGEMENT AT AIRPORTS AND RAILWAY STATIONS IN DELHI

CENTRAL POLLUTION CONTROL BOARD

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FOREWORD

Disposal of plastics waste has drawn attention of environmentalist due to their non-biodegradability and unaesthetic views since these are not disposed scientifically and possibilities to contaminate soil and sub-soil water because of leachates. Plastic packagings are extensively used in the Railways and Airport's catering services, resulting into significant quantity of plastic waste. In view of problems posed due to littering of plastic waste on the railway stations and along the tracks due to lack of their proper facilities/systems, the Central Pollution Control Board (CPCB) sponsored a study through RITES Ltd, Gurgaon relating to "Assessment of Plastic Waste Generation and its Management at 02 Airports and 03 Railway Stations in Delhi".

The present study envisages data on Plastics Waste generated at three Railway Stations and two Airports in Delhi. About 6758 kg/day of Plastics Waste is Generated in these 03 Railway Stations and about 3662 kg/day at the 02 Airports. The per capita Plastics Waste Generation is approximately 9 gm/day at Railway Station and 69 gm/day at Airport, which is many times higher than the Railways. While the value added plastics waste is collected by informal sectors (rag-pickers), whereas, the non-recyclable plastic carry bags and multilayer and metalized pouches are left at site.

I acknowledge special thanks to Dr. Kishan Pal, Group General Manager, RITES Ltd. and his team members for timely completion and submission of the Report. I would also like to appreciate efforts made by our colleagues Dr. S.K. Nigam, Senior Scientist for coordination during study period and compilation of the report and to Dr. A.B. Akolkar, Additional Director and Shri J.S. Kamyotra, Member Secretary for their supervision during the study. I hope, the recommendations of the study will help in improving the Plastic Waste Management in Railway Stations and Airports.

(S.P. Gautam)
Chairman

CONTENTS

EXECUTIVE SUMMARY

BACKGROUND

The rapid rate of urbanization and development has led to increasing plastic waste generation. The quantum of plastic waste in Municipal Solid Waste (MSW) is increasing due to increase in population, development activities and changes in the life style. Recently, plastic waste has attracted widespread attention in India, particularly in the last five years, due to widespread littering on the landscape. As plastic is non biodegradable in nature, it remains in environment for several years and disposing plastic wastes at landfill are unsafe since toxic chemicals leach out into the soil, and under-ground water and pollute the water bodies. Due to littering habits, inadequate waste management system / infrastructure, plastic waste disposal continue to be a major problem for the civic authorities, especially in the urban areas. It has been observed that due to an inefficient waste collection and transit system, a large amount of plastic wastes are not disposed off completely or fails to reach the recycling/reuse chains.

Over the years little scientific data is available on quantification, analysis and management of plastic waste at developers/establishments like airports and railway stations. The Central Pollution Control Board (CPCB), Delhi has understood the problems associated with plastics waste Management in Railways/Airports, and sponsored a project on "*Assessment of Plastics Wastes and its management at Airport and Railway Stations in Delhi*" to CIPET, Chennai. The scope of work comprises assessment and quantification of plastic waste from sources of generation, present practice of collection, transportation and its disposal.

OVERVIEW AND METHODOLOGY

Various literatures concerned with the subject are reviewed to understand the present percentage of plastic waste in MSW and the recent practice of recycling. The plastic constitutes two major category of plastics; (i) Thermoplastics and (ii) Thermoset plastics. The Thermoplastics, constitutes 80% and Thermoset constitutes approximately 20% of total post-consumer plastics waste generated. The plastic materials are categorized in seven types based on properties and applications. To make sorting and thus recycling easier, the universally accepted standards marking code has been developed to help consumers identify and sort the main types of plastic. It will also help in identifying whether the material used on the end product is virgin, recycled or a blend of virgin and recycled. The symbols defined by society of the Plastic Industry (SPI) USA and available in the IS 14534:1998 of BIS are as follows:

PET HDPE PVC LDPE PP PS OTHER

Presently, for manufacturing usage & management of Plastic Waste, Plastic Manufacture and Usage Rules 1999, as amended in 2003 is existing. This Rule empowers reduction of use of poly-bags and alleviates the problem of littering in the country. The Rule attempts to attain these objectives by not allowing to manufacture and use of plastics bags < 20µ and also restriction on use of recycled & coloured bags in food applications. However, the existing Rules are not effective in mitigating littering and its associated problems. In India,

the per capita plastic consumption is 6-7 kg per annum as compared to the developed countries where, the per capita consumption is in the range of 15 to 22 kg/annum.

The methodology adopted for assessment of plastic waste and its management at airports and railway stations in Delhi was achieved by the standard approach for desk research, field studies, data collection through questionnaire, analysis and interpretations. The acts, legislations and standards were also consulted. Meetings were organized with individual, organizations and stakeholders involved in the plastic sector. An effort has been made to study the present practices of plastics waste and its management at airports and railway stations in Delhi and its management.

FIELD STUDIES

Delhi has three major railway stations (H.Nizmuddin, Old Delhi and New Delhi Railway Stations), which cater maximum commuters of National capital. In all about 522 trains are originating from Delhi stations. The total number of passenger served at these three stations are 7,25,000 per day i.e. the passengers served annually are about one fourth of India's population. There are about 42 platforms, 146 vendors at these stations to meet the passenger's requirement. The solid waste generated at H.Nizmuddin, Old Delhi and New Delhi Railway Station is 4 tones, 8 tones and 11.25 tones respectively. There are 460 dustbins to store the waste at stations. The various segments of study i.e. Platform Vendors, Offices at station, Pantry cars, Waiting / Retiring Rooms, Dustbins, Rag-pickers, and Kabadis are decided depending upon the channel of supply i.e. source, distribution of plastic packaging materials and informal collection system of plastic waste. During the study, it is has been that unauthorized rag-pickers playing an important role in collection, transportation of plastic waste from railway stations. The rag-pickers collect only value added products like drinking and soft drink bottles from tracks and platform for their daily earnings. There are about 235 to 260 rag-pickers which are actively involved in the collection of value added plastic products. The rag-pickers sale the collected plastic wastes to the Kabadis. There are 19 kabadis near railway stations and which contacted to generate the exact quantity of plastic waste collected per day.

The domestic airport has three terminals, i.e. Terminal 1A and Terminal 1B and Domestic arrival terminal 1C. Terminal 1A caters to domestic flights of the Indian Airlines and its subsidiary Airlines. The International Terminal or Terminal II of Indira Gandhi International Airport (IGIA), where 35 international airlines flying at regular intervals to the major cities across the world. The various segment required for the study area at the airport were finalized after the consultation and meeting with the officers of Delhi International Airport Limited (DIAL). The study area includes, Terminal Vendors, Restaurants, Dustbins, Air Caterers, and Waste collectors. The maximum quantity of plastic waste is being generated by air caterers as compared to other sources. The four air caterers who are providing catering services to both domestic as well as international flights are: Tajsats Air Catering, Sky Gourmet, Oberoi Group, and The Ambassador. The quantity of solid waste generated per day is about 14 tones. There are 283 dustbins to store the waste at airport.

QUANTIFICATION

In order to select representative sample for physical and chemical analysis, reconnaissance survey of the area under study was carried out for locations of samples. Thus, sampling locations were selected for analysis from three main collection yards for railway stations and at segregation point for airport. Results of samples analyzed, indicate that an average of

20% plastic waste is generated in Municipal Solid Waste (MSW) excluding water and soft drink bottles at three railway stations, whereas contribution of plastic waste at Airports including water and soft drink bottles is 30 %.

Quantity of Plastic Waste at Railway Stations

The informations collected from various sources were analyzed and the present quantities of plastic waste generated are worked out. The quantity of plastic waste generated per day at H. Nizamuddin, Old Delhi and New Delhi railway station is 972 kg, 1,428 kg and 4,358 kg respectively. Out of these total quantities, the value added plastics (water and soft drink bottles) reported at H. Nizamuddin, Old Delhi and New Delhi railway stations is about 20%, 20% and 32% respectively. The per capita plastic waste generation at H. Nizamuddin, Old Delhi and New Delhi is 7.8 gm, 9.5 gm and 9.7 gm respectively. The plastic waste generated from sources like unauthorized vendors, passengers, and passing trains are improbable to quantify as all these factors are variable. However, the quantities generated from these sources are reflected in the total plastic waste generated from collection yard.

Quantity of Plastic Waste at Airports

The total quantity of plastic waste generated at airport (domestic and International) is 4,130 kg per day. Out of which, 2,666 kg/day is generated at domestic airport and 1,523 kg/day at International airport. The contribution of plastic bottles alone is 80% i.e 3,370 kg. The maximum quantity of plastic waste is being generated by air caterers. The per capita plastic waste generation at Domestic and International airport is 70 gm and 68 gm respectively.

COLLECTION, TRANSPORTATION AND RECYCLING

The waste management system at railway stations in Delhi is with the Public Health Department. The District Medical Officer of railway is the incharge of the waste management system at railway stations. The collection of waste is being done by railway employees along with private contractors at New Delhi and H. Nizamuddin railway station; however no private contractor is employed at Old Delhi railway station. There are about 512 workers are posted at three railway station. The waste management system is well managed at airport as compared to railway stations. At Airport the waste is being managed by a private agency, M/s Subhash Projects & Marketing Limited (SPML), who is responsible for managing the overall operation including collection, transportation and its disposal. The collected waste from airport is being segregated at a site located at Gitorni and segregated materials are disposed off to the authorized recycling units.

The technology employed is mechanical recycling is based on traditionally grinding extrusion to obtain granules. Mechanical recycling is the most preferred and widely used method of recycling and it recycles particular type of polymers used in water and soft drink bottles. As it requires selected plastic waste, the cost for sorting, cleaning and separating selected polymers increases the operating cost. The existing mechanical recycling process may emit harmful gases due to its old design components and not having provision for pollution control. The plastic waste including laminated plastics and carry bags are still remains the challenge for the process.

DISPOSAL TECHNOLOGIES

Various literatures are reviewed which indicate that, recycling of waste plastics is not the only solution for the post consumer plastic, as it remains in the environment after the third/fourth recycling process and ultimately unfit for reuse and hence it ends up in land filling. Hence recycling is not the complete solution for disposal of the waste plastics. The complete solution to the disposal of waste plastics is realized in the energy recovery and can be achieved in the blast furnace and in cement kiln by effectively utilizing the calorific value of plastics waste. The calorific value of plastic wastes can be utilized effectively by replacing coal. The use of plastic waste as alternative fuel will help to reduce the energy cost along with reduction in the CO_2 emissions. During co-incineration of plastic waste in blast furnace and cement kilns, it is completely burnt at high temperature and slag which remain as waste, can further utilized as cement and road construction. There is no risk of generation of toxic emission due to the burning of plastics waste in the process and the process is safe as per environmental norms. The establishment like Airport and Railways required to develop environmental friendly waste management system for disposal of plastic waste generated from their premises.

To reduce the burden of littered/discarded plastics, there is an urgent need for increase public awareness as people are responsible for the pollution caused by plastics. Keeping this in mind, few recommendations have been made, which may assist in formulating future policies for plastic waste management. Furthermore it is most important, to upgrade the technology for plastics waste disposal. The virgin plastic products shall be labeled with the plastic identification code to help in sorting and segregating as per IS 14535: 1998.

CHAPTER-1
INTRODUCTION

1.1 BACKGROUND

TABLE 1.1
MUNICIPAL SOLID WASTE IN INDIAN CITIES

POPULATION RANGE (MILLIONS)	AVERAGE PER CAPITA VALUE KG/CAPITA/DAY
0.1 - 0.5	0.21
0.5 - 1.0	0.25
1.0 - 2.0	0.27
2.0 - 5.0	0.35
>5	0.50

Source: CPHEEO Manual on MSW Management

The term "plastics" includes materials composed of various elements such as carbon, hydrogen, oxygen, nitrogen, chlorine, and sulfur. Plastics typically have high molecular weight, meaning each molecule can have thousands of atoms bound together. In other words plastics are macromolecules, formed by polymerization and having the ability to be shaped by the application of reasonable amount of heat and pressure or any other form of forces. This great human creation changed the world and brought comfort to our lifestyle. Now plastics are in all human activity ranging from clothing to shelter, infrastructure to communication, agriculture to construction, hardware to packaging and entertainment to health care. Its attractive properties, lightweight and high strength meets a large share of the materials needs of man and that too at a comparatively lesser cost. Increasing urbanization and industrialization have contributed for increased plastic generation. This increase has been rapid since the middle of the 19th century which has affected the quality of environment. The urban population has grown at a rate of 19.9% to 34.41% during the last two decades. The growth of urban and rural population is 2.1 % and 1.5% respectively during 1991-2001. One among the reasons for urban population growth is migration of rural population to cities. Rapid population growth, urbanization and industrial growth have led to severe problem of waste generation in urban centers. India is the second fastest growing major economy in the World with GDP growth rate 9.1 % for the fiscal year 2006-07. The airports and railway stations are contributing significantly for waste generation due to large handling of passenger at a point. The characteristics of waste depend on various factors such as food habits, traditions, lifestyle, climate etc. The waste generated due to urban activities is known as municipal solid waste (MSW). As per 2001 census the urban population accounts about 27.8 % of overall population (1027 million). Among the states Tamilnadu is the most urbanized State with 43.9% of population living in urban areas and Himachal Pradesh is lowest urbanized with 9.8% population. 35 Metro-cities have population more than one million with total population of about 1078.8 million. Number of cities in classes include; class-I: 393; class-II: 401; class-III: 151; class-IV: 1344; class-V: 8881[1]. Global experience shows that when a country's urban population reaches almost 25% of overall population the pace of urbanization accelerates. **Table 1.1** describes the average municipal solid waste production from 0.21 to 0.50 Kg per capita per day in India. The present urban population is expected 341 million in 2010. The waste quantities are expected to increase from 46 million tones in 2001 to 65 million tones in 2010[2]. It is also reported that per capita per day production will increase to 0.7 kg in 2050[3].**Table 1.2** represents the municipal solid waste characteristic during last three decades in the country and also in developed countries. From the analysis of the table it could be concluded that

[1] Website : http//india.gov.in//urbanindex.nic.in/
[2] Kumar, S and Gaikwad, SA "Municipal Solid Waste Management in Indian Urban Centres" (2004)
[3] Manual on Municipal Solid Waste Management (2000), Table 3.6

there is an increasing trend of paper, plastics, metals, glass and calorific value in solid waste over the years. This change is due to change in lifestyle of people and increase in computerization. Plastic waste in municipal urban waste is comparable with the developed countries[4].

TABLE 1.2
CHARACTERISTIC OF MUNICIPAL SOLID WASTE

S No	COMPONENT	WET WEIGHT IN INDIA (%)			DEVELOPED COUNTRIES
		1971-72[5]	1996[6]	2005[7]	
1	Paper	4.14	2.91-6.43	8.13	28-60
2	Plastics	0.69	0.28-0.78	9.22	2-8
3	Metals	0.50	0.32-0.80	0.50	3-13
4	Glass	0.40	0.35-0.94	1.01	4-16
5	Inert	3.83	44-54	25.16	-
6	Ash and fine earth	49.20	30-40	--	0-10
7	Compostable Matter	41.24	31-57	40-60	6-26
8	Calorific Value	800-1100	<1500	800-1000	1500-3000
9	C/N Ratio	20-30	20-30	20-40	--

Source: CPHEEO Manual on MSW Management

1.2 AIMS AND OBJECTIVES

Due to large benefits of plastics in different applications, its use is increasing at a galloping rate all around the world industry in India. The Plastic products namely carry bags, blood bags, colored plastics pots are fast becoming popular both in rural and urban areas of India. Plastic waste has attracted attention in India particularly in the last five years due to the widespread littering of plastics on the land. Most common method of disposing of wastes is to dump them in low lying areas on the outskirts of towns which is unhealthy and unscientific. Over the years little scientific data is available on quantification, analysis and management of plastic waste on airports and railway stations. This has serious environmental impacts on water and air pollution and soil degradation. The main aims and objectives of the study are briefly summarized as follows:

- Compilation of data on plastic waste from railway stations and airports in Delhi,
- Analysis of plastic waste to understand its utilization/disposal,
- Methods for waste collection, transportation and disposal as available for municipal solid waste,
- Scientific ways for plastic waste management,
- Guidelines for Infrastructure Development for waste management, and
- Monitoring, disposal methodologies/ techniques and training needs.

1.3 SCOPE OF WORK

The Central Pollution Control Board (CPCB), Delhi has signed a MoU on the project with RITES, Gurgaon with the following scope of work for Assessment of Plastics Waste and its Management in Railway stations and Airports.

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[4] Report on Solid Waste Management in India by Sunil Kumar: WWW. db.org/document/events/2005/sanitation

[5] Bhide & Sunderesan, 1983

[6] Manual on MSW, NEERI,1996

[7] http://www.cpcb.nic.in

- Assessment of Plastic Waste (PW) at Delhi Airports (National & International) and Delhi Railway Stations (New Delhi, Delhi and Nizamuddin),
- Quantification of Plastic Waste from different sources at Railway Stations and Airports, Categorization of Plastic Waste as per BIS standards,
- Present practices for collection, transportation, treatment and disposal of plastics waste, and
- Proposed disposal techniques and recommendations for plastics waste management.

1.4 ACTS, LEGISLATION AND STANDARDS

The Ministry of Environment and Forests (MoEF), Government of India (GoI) formulate and evolves Environmental Acts, Legislation, Guidelines and Standards in India. There is no direct Act to check, monitor and management of plastic waste in the country, however, the existing Plastic Manufacture Sale & Usage Rules 1999, as amended in 2003 is limited to manufacture, sale & use of plastics bags and containers. At present, there are no guidelines or codes of practices for collection, sorting and recycling of plastic waste. However it is considered along with solid waste management guidelines prepared by Central Public Health and Environmental Engineering Organization (CPHEEO), Ministry of Urban Development, Government of India[8]. The Rule attempts to attain these objectives by increasing the thickness of virgin plastic bags and restricting the use of colored recycled plastic bags. The analysis of the Rules have revealed that it has not been effective in mitigating littering and its associated problems.

[8] Manual on Solid waste management (2001), CPHEEO, Ministry of Urban development, GoI, New Delhi.

CHAPTER-2
OVERVIEW AND METHODOLOGY OF STUDY

2.1 LITERATURE REVIEW

The increased used of plastics products as packaging application in the recent years have increased the quantity of plastics in the solid waste stream to a great extent. The quantum of solid waste is ever increasing due to increase in population, development activities, changes in life style, and socio-economic conditions. It is estimated that approximately 15722 tones per day (TPD) of plastic waste is generated on the basis of per capita consumption based on population of India.

Plastic waste has a significant portion in total municipal solid waste (MSW). Hence, there is a formal system of waste collection in urban areas, however, informal sectors i.e. rag-pickers, collect only value added plastics waste such as pet bottles etc. However, plastic carry bags and low quality plastic less than 20 micron do not figure in their priorities, because collecting them is not profitable. This is primarily because the rewards are not much than efforts required for collection, and this leads to plastic bags and other packaging materials continuing to pose a major threat to the environment[9]. More over the major concern for this waste stream is that these are non-biodegradable and remains in the environment for several years. Clogging of drains by plastic waste is a common problem.

TABLE - 2.1
PLASTICS CONSUMPTION IN INDIA

S.NO	YEAR	CONSUMPTION (Tones)
1	1996	61,000
2	2000	3,00,000
3	2001	4,00,000
4	2007	8,500,000

With the formal and informal sector failing to collect plastic waste. The packaging and poly vinyl chloride (PVC) pipe industry are growing at 16-18% per year. The demand of plastics goods is increasing from house hold use to industrial applications. It is growing at an annual rate of 22% annually. The polymers production has reached to 8.5 million tones in 2007. **Table 2.1** provides the total plastics waste consumption in India during last decade. National plastic waste management task force in 1997 projected the polymers demand in the country. **Table 2.2** documents the demand of different polymers in India during years 1995-96, 2001-02 and 2006-07. The comparison of demand and consumption from **Table 2.1** and **Table 2.2** indicates that projections are correct. More than one fourth of the consumption in India is that of PVC which is being phased out in many countries. Poly bags and other plastic items except PET in particular have been a focus, because it has contributed to host of problems in India such as choked sewers, animal deaths and clogged soils.

TABLE 2.2
POLYMERS DEMANDS IN INDIA (Million Tones)

S.NO	TYPE OF POLYMER	1995-96	2001-02	2006-07
1	Polyethylene	0.83	1.83	3.27
2	Polypropylene	0.34	0.88	1.79
3	Poly vinyl chloride	0.49	0.87	1.29
4	Poly Ethylene Tetrephthalate	0.03	0.14	0.29

Source: National Plastic Waste Management Task Force (1997)

[9] Analysing Plastic Waste Management in India, Priya Narayan, sept.2001.

India recycles about 60% of its plastics, compared to world's average of 22%. Plastic waste contains the calorific value equal to fuel[10]. India has among the lowest per capita consumption of plastics and consequently the plastic waste generation is very low as seen from the **Table 2.3**[11]. The comparison of per capita plastic consumption with rest of the word is presented in **Table 2.4**.

TABLE 2.3
PLASTIC WASTE CONSUMPTION

S.NO	DESCRIPTION	WORLD	INDIA
1	Per capita per year consumption of plastic (kg)	24	6-7
2	Recycling (%)	15-20	60
3	Plastic in Solid Waste (%)	7	9

TABLE 2.4
PLASTIC WASTE CONSUMPTION (P/C/YEAR)

S.NO	COUNTRY/CONTINENT	PER YEAR CONSUMPTION (Kg)
1	India	6.0
2	East Europe	10.0
3	South East Asia	10.0
4	China	24.0
5	West Europe	65.0
6	North America	90.0
7	World Average	25.0

Source: Plastindia

A study conducted by the National Environmental Engineering Research Institute (NEERI) for the Brihan Mumbai Muncipal Corporation, which handles more than 5,500 metric tones MSW per day shows that plastic waste is 0.75 %. In Europe and U.S.A, plastic waste makes up 8 % of total MSW. The rest is made up of organic materials (33%), paper and paperboards (30%), glass and metals (16%) and others (13%)[12]. The methods of recycling and the technology used for the same at present are quite outmoded and are in need of upgradation. It has also been observed that some of industries even recycle the plastic waste/scrap which is totally unhygienic and such is a health hazard for persons who use items made from such plastics and even used at times for packaging of foodstuff and medicines[13].

2.2 PLASTICS AND ITS CLASSIFICATIONS

Plastic is the general term for a wide range of synthetic or semi synthetic polymerization products. They are composed of organic condensation or addition polymers and may contain other substances to improve performance or economics. There are few natural polymers

generally considered to be "plastics". Plastics can be formed into objects or films or fibers. Their name is derived from the fact that many are malleable, having the property of plasticity.

Plastics can be classified in many ways, but most commonly by their physical properties. Plastics may be classified also according to their chemical sources. The twenty or more known basic types fall into four general groups: Cellulose Plastics, Synthetic Resin Plastics, Protein Plastics and Natural Resins. Plastics, depending on their physical properties, may be classified as thermoplastic or thermosetting materials. Thermoplastic materials can be formed into desired shapes under heat and pressure and become solids on cooling. If they are subjected to the same conditions of heat and pressure, they can be remolded.

[10] ICPE Newsletter Vol. 7, issue 4, Oct-Dec 2006
[11] Plastics for Environment and Sustainable Development, ICPE, Vol. 8, Issue 1, Jan- Mar 2007.
[12] ICPE, Vol. 6, Issue 2, Apr- Jan 2005.
[13] IS 14534:1998, Guidelines for recycling of plastics.

Thermosetting materials which once shaped cannot be softened /remolded by the application of heat. The examples of some typical Thermoplastic and Thermosetting materials are tabulated in **Table 2.5**. Out of total uses of plastic, 80% are Thermoplastic and 20% are Thermosetting. Each Thermoplastic resins are versatile in nature and hence most suitable for a wide range of packaging applications.

TABLE - 2.5
TYPICAL THERMOPLASTIC AND THERMOSETTING RESINS

S.NO	THERMO PLASTIC	S No	THERMOSET PLASTIC
1	Polyethylene Tetraphthalate (PET)	1	Bakelite
2	Polypropylene (PP)	2	Epoxy
3	Poly Vinyl Acetate (PVA)	3	Melamine
4	Poly Vinyl Chloride (PVC)	4	Polyester
5	Polystyrene (PS)	5	Polyurethane
6	Low Density Polyethylene (LDPE)	6	Urea - Formaldehyde
7	High Density Polyethylene (HDPE)		

Source: Central Pollution Control Board

2.2.1 Categorization of Plastics

The plastic waste is categorized in 7 types based on properties and applications. These are summarized in **Table 2.6** along with recycled products. This categorization helps to the manufactures of plastic products with regard to the marking to be used on the finished product in order to facilitate identification of the basic raw material. To make sorting and thus recycling easier, the universally accepted standards marking code has been developed to

help consumers identify and sort the main types of plastic. It will also help in identifying whether the material used on the end product is virgin, recycled or a blend of virgin and recycled.

TABLE 2.6
CATEGORIZATION OF PLASTICS

Codes	Properties	Packaging Applications	Recycled Products
1 PET	Clarity, strength, toughness, barrier to gas and moisture, resistance to heat	Packaged drinking bottles and soft drink bottles	Fiber fill for sleeping bags, carpet fibers, ropes, pillows etc
2 HDPE	Stiffness, strength, toughness, resistance to chemicals and moisture, permeability to gas, ease of processing	Raffia bags, knitted fabrics, water, gas and sewer pipes, small volume bottles to large barrels, house wares, storage bins, caps and closures, shopping bags, etc.	Flower pots, trash cans, traffic cones, detergent bottles, soap cases, other household items, etc.
3 V	Versatility, clarity, eases of blending, strength, toughness, resistance to grease, oil and chemicals.	pharmaceutical tablet packaging, potable water pipes and irrigation pipes and fittings, door and window profiles, cables, floorings, medical products like blood bags, footwear, etc.	Footwear, irrigation and other drainage pipes, mats, etc.

Codes	Properties	Packaging Applications	Recycled Products
	Ease of processing, strength, toughness, flexibility, ease of sealing, barrier to moisture.	Wide width films, agriculture films and pipes, heavy duty bags, shrink films, cable insulation and sheathing, extrusion coating, liquid packaging, etc.	Grocery bags, shelter films, household items, etc.
	Strength, toughness, resistance to heat, chemicals, grease and oil, versatile, barrier to moisture.	Raffia, monofilaments, strapping, automobile batteries and automobile components, luggage and furniture, combs, ball pens, injection syringe, etc.	Plastic lumber, household goods, luggage, etc.
	Versatility, insulation, clarity, easily formed	Disposable cups, packaging materials, meat trays, audio visual cassettes, etc.	Plastic lumber, cassette tape boxes, flower pots, etc.
	Dependent on resin or combination of resins	The category includes other plastics like nylon, ABS, Poly Acetals, Polycarbonate,	Recycling of these high value plastics are special in nature.

Source: IS 14535: 1998 & ICPE Newsletter, Vol. 6, Issue 2, Apr- Jan 2005.

2.3 METHODOLOGY

The methodology adopted for assessment of plastic waste and its management at airports and railways stations in Delhi was achieved by following the standard approach for desk research, field studies, data collection, analysis and interpretations. The acts, legislations and standards were also consulted. Meetings were conducted with individuals and organizations involved in the plastic sector. The approach and methodology adopted is discussed in subsequent sections.

2.3.1 Approach

The approach for the present study is presented in **Figure 2.1**. Based on desk research, the parameters such as source and type of plastic used/consumed were identified for data collection and surveys at Railway stations and Airports. The quantification and categorization were conducted for each site/ station. The method of plastic waste collection, transportation and disposal were studies at/from sites. The recommendations were made based on study.

2.3.2 Study Methodology

Thermo plastics are re-usable and recyclable, and hence there is no problem of disposal of the plastic waste, however due to poor littering habits inadequate waste management system / infrastructure, plastic waste management/ disposal continue to be a major problem for the civic authorities, especially in the urban areas. The quantity of actual plastic waste generated from source and reaching to dumping site for final disposal is not same and It depends on efficiency of collection and transportation of plastic waste along with MSW, picking of recyclable material by rag-pickers at different level are other factors. For assessment of plastic waste generation at railway station, four sources are identified for the study. These are platform vendors, canteens, waiting room/retiring room and pantry trains. Out of these the platform vendors and pantry's are the major contributors towards waste generation. The field team has conducted the vendor's survey at each stations and

platforms. In addition, surveys were also conducted for rag-pickers and kabadis for actual quantification of plastic waste generation from the station. At railway station, major part of plastic waste generated at platform has been channeled by informal system. It has been noted that rag-pickers are picking only water and soft drink bottles from the track and dustbins of the platform. The total amount of plastic waste generated is considerably less than the amount of plastic produced. This is attributed to those applications in which plastic meet long term requirements before their disposal and therefore do not yet occur in the waste stream in big quantities. Railways have adopted collection system through department and private contractor. Samples were also collected for analysis from collection yard. Similarly at Airport the plastic waste is generated at four locations namely: terminals (arrival/ departure), canteens/restaurants; air caterers and offices (generally at Airports) waste being channeled through properly managed system. The methodology has been adopted for the assessment of plastic waste at railway stations and airport is presented in **Figure 2.2**.

The data was generated through questionnaire and actual measurements at site. The questionnaire were handed over to each vendor/ involved in plastic waste generation. They were verified through sample checks to validate the quantities/ values.

FIGURE 2.1

APPROACH FOR THE STUDY

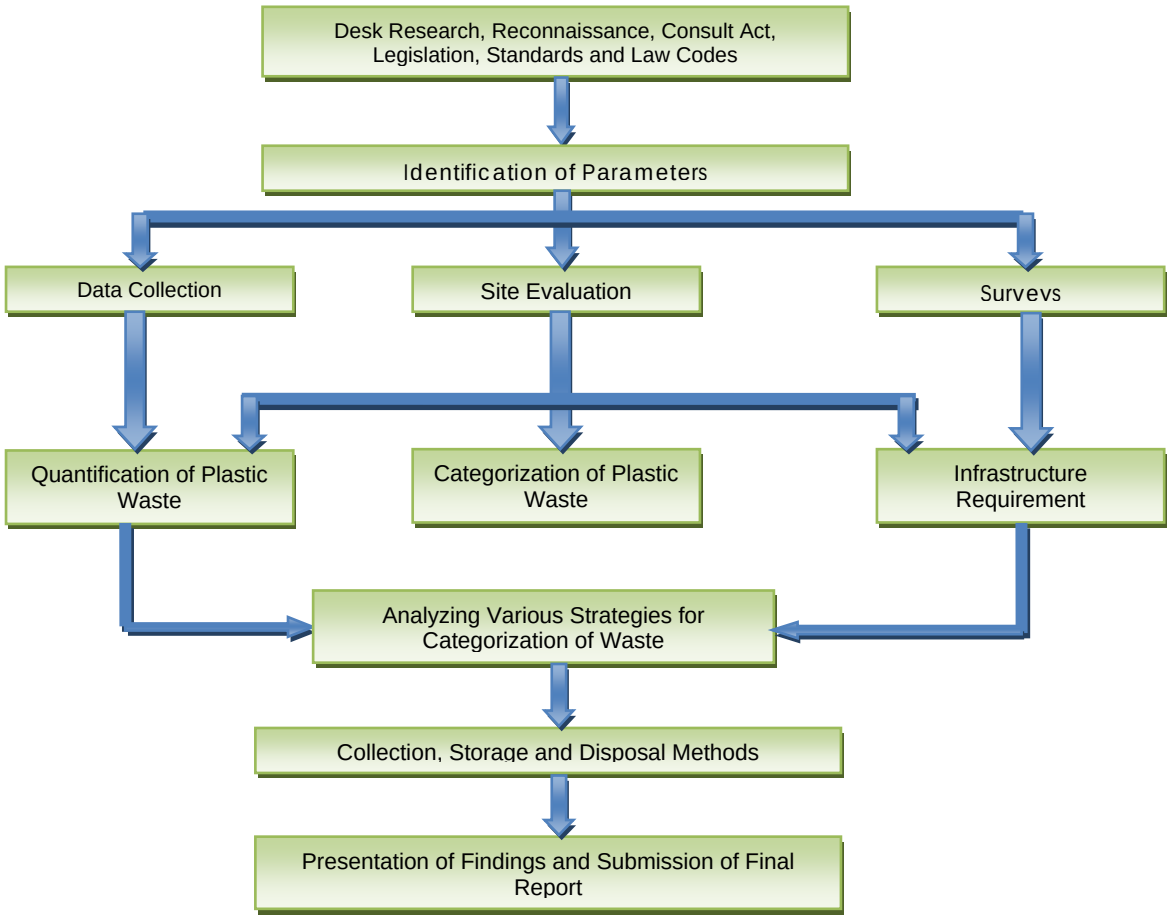
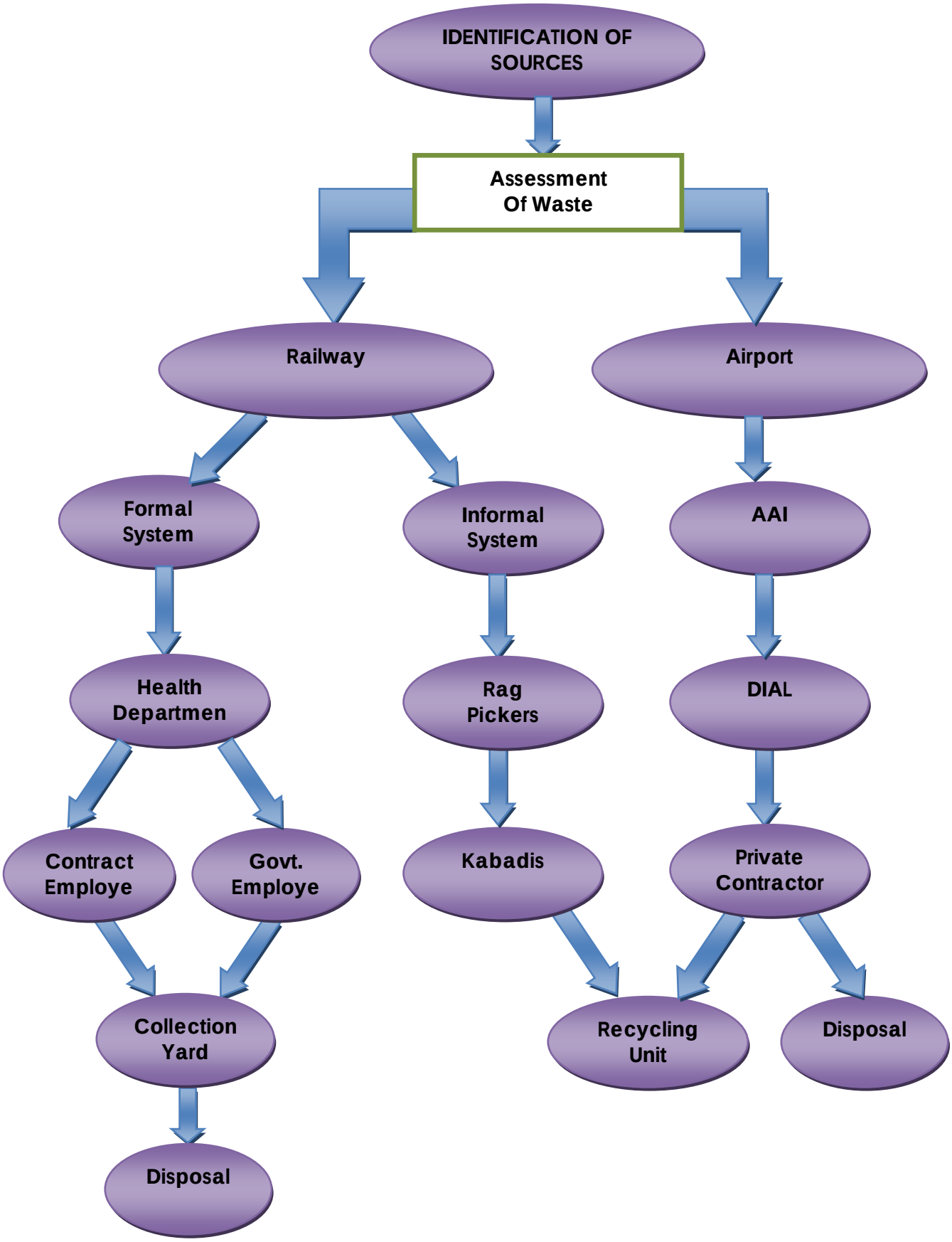


FIGURE 2.2

FIGURE 2.2
STUDY METHODOLOGY



CHAPTER-3
FIELD STUDY

3.1 SECTORS OF STUDY

Plastic wastes are being generated at rapid rate of urbanization in India. Waste generation rates are often affected by socio-economic development, degree of industrialization, sector of operation and climatic conditions. Generally greater the economic prosperity and high percentage of urban population, the greater the amount of plastic waste produced. During the phase of this study following sectors in urban area/ Delhi city have been selected;

- Railways (H. Nizamuddin, Old Delhi and New Delhi)
- Airports (National and International).

Railways stations and Airports generate different composition of solid wastes. Hence an effort has been made to study plastic waste and its management at airports and railway stations separately in a year. Location of field studies, study area, sources of waste and classification are discussed in subsequent sections.

3.2 RAILWAYS

Indian Railways has been serving the people of India for over 150 years and handles nearly 6,000 million passengers every year, which is equivalent to carrying almost the entire population of the country more than four times annually[14]. Indian Railways (IR) not only enjoys the monopoly over India's rail transport, but it is also one of the largest and busiest rail networks in the world. This widespread network is classified into sixteen zones for administrative purposes[15]. Each and every zonal railway further comprises several divisions. The Northern Railway (NR) is one amongst the nine older zones of Indian Railways. Delhi, the capital city of India, serves as the headquarters of Northern Railway. The whole zone is divided into five divisions namely Delhi, Ferozpur, Ambala, Lucknow and Moradabad for smooth administration. New Delhi is well connected with other parts of the country through Rajdhani, Shatabdi and Express trains. Due to the wide network of trains, the stations experiences the huge quantity of waste and it mostly depends upon the numbers of trains originating and passing through the station and numbers of passengers handled. The details of the numbers of trains originating and passing through the station and numbers of passengers at three stations are summarized in **Table-3.1**. In all about 522 trains are originating from Delhi stations and about 206 trains passing through. The total number of passenger served at these three stations are 725,000 per day i.e. the passengers served annually are about one fourth of India's population.

TABLE 3.1
NUMBER OF TRAINS IN DELHI

S. No	STATIONS	TOTAL NUMBER OF TRAINS	ORIGINATING TRAINS	PASSING TRAINS	PASSENGER PER DAY
1	H. Nizamuddin	222	94	128	1,25,000
2	Old Delhi	206	172	34	1,50,000
3	New Delhi	300	256	44	4,50,000
	Total	**728**	**522**	**206**	**7,25,000**

[14] Journal of centre for transportation research and management. (Indian Railway Traffic Service Association)
[15] Northern Indian Railway web site

Source: Data collected from Railway stations records

The Indian Railways are practicing various types of plastic packaging to the platform vendors and pantry's through Indian Railway Catering and Tourism Corporation (IRCTC). Thermoplastics are used as packaging material. Thermoplastics along with its packaging applications are summarized in **Table - 3.2**.

TABLE - 3.2
PLASTIC USE IN PACKAGING APPLICATION

S No	THERMOPLASTIC MATERIALS	PACKAGING APPLICATION
1	Polyethylene Terephthalate (PET)	Drinking bottles, microwavable packaging, soft drink bottles, food jars for butter, jelly & pickles, plastic films
2	Polypropylene (PP)	Drinking bottles, bottles for milk, juice, grocery bags
3	Poly Vinyl Acetate (PVA)	Food packaging, plastic toys, wire, cable, insulation, flexible packaging
4	Poly Vinyl Chloride (PVC)	Plastic bags, frozen foods, stretch films, container lid
5	Polystyrene (PS)	Food container, bottle caps, medicine bottles, straws
6	Low Density Polyethylene (LDPE)	Disposal cups, glasses, plates, spoon. CD & cassette boxes
7	High Density Polyethylene (HDPE)	Custom packaging

Indian Railways are the largest source of PET bottles generation (drinking water), food packaging, tumblers, multilayer metalized plastic, plastic carry bags and cups. Generally, PET bottles are collected by rag-pickers and sold at waste collection system (Kabadis). The kabadi sale these to recycle material users. The remaining large amount of plastic waste gets strewn/ littered on the rails/tracks in and around the railway stations.

3.2.1 Locations/ stations

Delhi having three major railway stations (New Delhi, Old Delhi and H.Nizmuddin Railway Stations), which cater maximum commuters in Northern Zones. The brief descriptions of railway stations are given in subsequent paragraphs.

I) H. Nizamuddin Railway Station: H. Nizamuddin Railway Station is located in South Delhi and named after a Sufi saint Nizamuddin Aulia. All the south-bound (South India) trains either originate from here or pass through this. It is the third largest railway station in Delhi after Delhi and New Delhi railway stations. This station is having seven platforms, out of which six platforms are for the use of passenger trains while seventh one is for parcel/ goods trains. Washing line for the trains is located one kilometer away from the main station.

II) Old Delhi Railway Station: Delhi station (popularly known as Old Delhi Station) is the oldest railway station of Delhi city. It was built by the Britishers, before independence. Many important trains are originating and passing through this railway station. This station is having 18 platforms, which is largest in the Delhi division. Washing lines are located parallel in between these platforms.

III) New Delhi Railway Station: New Delhi Railway station is the main railway station in Delhi division. New Delhi Station is the busiest, and one of the largest in India. The New

Delhi station holds the record for the largest route interlock system in the world. Most eastbound and northbound trains originate here and it handles over 300 trains each day, from 16 platforms.

3.2.2 Study Area

The plastic wastes generated from the railway stations is lacking proper collection, segregation, transportation, treatment, reuse and disposal of plastic waste. Railways are the major transport sector in India, hence it becomes essential to generate the plastic data for Railway sector. The various segments of study are decided depending upon the channel of waste processing from source to disposal. The source, packaging materials, formal and informal collection system of plastic waste are important components/ segments. The project for the study area finalized after time to time consultation with Railway Authorities are:

- Platform & Vendors,
- Offices at station,
- Pantry cars,
- Waiting / Retiring Rooms,
- Dustbins,
- Rag-pickers, and
- Kabadis.

i) Platform & Vendors: Platform vendors are the major users for the plastic packaging containers for supply of feed materials to the passengers at platform. Passengers purchase the needful items from vendors in plastic containers. On consumption/ utilization of needful items, the plastic containers in the form of plastic waste are thrown either in the designated dustbins or on platforms/ rails. The survey was carried out at each platform of the station with the objective to know the type and average quantity of plastic packing materials in use. The survey was conducted at three railway station i.e., H. Nizamuddin, Old Delhi and New Delhi railway stations. There are 42 platforms and 146 vendors available in three Delhi railway stations. The distribution of platforms and vendors are summarized in **Table 3.3.**

TABLE 3.3
NUMBER OF PLATFORMS AND VENDORS

S NO.	STATIONS	PLATFORMS	VENDORS
1	H. Nizamuddin	8	20
2	Old Delhi	18	79
3	New Delhi	16	47
	Total	**42**	**146**

ii) Offices at station: Offices located at platform or station building also contributes in the system for generation of plastic waste. The study was carried out to know the exact locations of dustbin and quantity of plastic waste generated from offices. It was observed that at present the numbers of dustbin are negligible at all the stations, hence it could be concluded that no plastic waste is being generated from offices. Therefore plastic waste from offices is not considered as a part of plastic waste generating source in the report.

iii) Pantry cars: The Indian Railway Catering and Tourism Corporation (IRCTC) is responsible for managing and supplying the entire catering services for the railways. The IRCTC has been using various types of plastic for packaging food items to the passengers. Trains like Rajdhani and Shatabdi have well maintained pantry and waste collection system within the trains. However, other trains (express trains) do not have proper collection system. This is because of non AC coaches, which results in the throw away culture of refuse from the open windows. The remaining plastic waste is found lying scattered all over the floor of train and lifted by rag-pickers as train reaches the final destination station. These trains stand at stations for passengers de-boarding and leave the station to washing line for cleaning purpose. At washing line, the collected plastic waste in dustbins from pantry cars gets collected and cleaned by the railway employees. Wastes collected from the washing line are disposed at the collection yard located within the washing line area. The Survey was conducted at washing line of each station to understand the process of waste collection and disposal. The numbers of panty cars running from three station are shown in **Table 3.4**. In all there are 36 trains (6%) with pantry car and proper waste collection system.

TABLE 3.4
NUMBER OF PANTRY CARS

S NO.	STATION	PANTRY CAR OF RAJDHANI	PANTRY CAR OF SHATABDI
1	H. Nizamuddin	02	--
2	Old Delhi	--	--
3	New Delhi	22	12
	Total	**24**	**12**

iv) Waiting/Retiring Rooms: Each railway station is having waiting rooms and retiring rooms for passenger and officers refreshment. Two types of waiting rooms are provided for passenger services, in which one is AC type and another is Non-AC type. During field study it is observed that, dustbins are provided in each waiting and retiring rooms but the generation of plastic wastes found to be practically negligible and cannot be considered as the source.

v) Dustbins: The primary collection points are the dustbins. There are two types of dustbins i) railway departmental dustbins located at some specified distance on the platform and cleaned by the railway employee at the designated interval ii) the second type of dustbins are placed close to the vendor shops and cleaned by vendors only. The Railway departmental dustbins are of fixed size and open whereas vendor's dustbins are of varying size and shape. The waste from these dustbins is emptied/ disposed at the railway collection centre located within the station area. The distribution of dustbins on each railway station platforms is available in **Annexure 3.1.** About 460 dustbins are available on stations in Delhi. The numbers of dustbins at each railway station are reported in **Table 3.5**. On an average 12 dustbins are available on each platform. However the number of dustbins per platform at H. Nizamuddin, Old Delhi and New Delhi are 9, 6 and 18 respectively.

TABLE 3.5
NUMBER OF DUSTBINS AT EACH RAILWAY STATION

S NO.	STATIONS	RAILWAY DUSTBINS	VENDOR DUSTBINS	TOTAL
1	H. Nizamuddin	36	20	56
2	Old Delhi	45	69	114
3	New Delhi	250	40	290
	Total	**331**	**129**	**460**

vi) Rag-pickers: It has been observed that rag-pickers are involved in collection, transportation and disposal of plastic waste from railway stations. The rag-pickers found all over the rail/track in search of plastic bottles in railway station area. The majority of rag-pickers are child labour and in the age group 10 to 15. The rag-pickers collect drinking and soft drinks bottles from tracks and platform for their daily earnings. These rag-pickers sold their daily collected plastic bottles to the nearby Kabadis. About 20 % of the rag-pickers from each station have been selected for survey to assess/ calculate an average quantity of plastic waste (Bottles) being collected by them. It has been reported that rag-pickers collect only value added products like drinking water and soft drink bottles. About 235 to 260 rag-pickers are reported to work on different railway stations. The distribution of rag-pickers at each railway station is summarized in **Table 3.6**.

TABLE 3.6
RAG-PICKERS AT STATIONS

S NO.	STATIONS	NUMBERS
1	H. Nizamuddin	35-40
2	Old Delhi	50-60
3	New Delhi	150-160
	Total	**235-260**

vii) Kabadis: Each railway station has specific and well established Kabadis and they deals in post consumer collection of plastic waste. Hence, Kabadis are the important link between collection and disposal of plastic waste from railway stations. Sometimes the sorting of plastic material is done at the location of Kabadis itself. Kabadis sale sorted/ crushed plastic material (bottles) to the bulk buyers or recycled units. There are 19 Kabadis near railway stations, out of these 12 are near New Delhi; 5 near Old Delhi and 3 near H. Nizamuddin railway station.

viii) Recyclers: The recycling sector in India is dispersed between the formal and informal sector. Formal recycling units are registered, pay taxes and municipality has an account of them. However informal units are characterized as those who are not registered with municipality. The PET recycling unit is the part of formal sector and receives most of the plastic waste (water and soft drink bottles) collected by kabadis from railway stations. The interviews with recyclers help to understand the complexity of problem associated with plastic waste management in India. A site visit was also undertaken to recycling unit to understand the procurement of raw materials for recycling, process techniques and quality of finish product. The more detail in processing of plastic waste at recycling units are described in the **Chapter-7.**

3.3 AIRPORT

At present, there are 454 airport/ airstrips in the country. These include operational, non-operational, abandoned and disused airports. Airport authority of India (AAI) manages 133 airports including 8 custom airports, 24 civil enclaves and 82 domestic airports. Out of these 44 airports are non-operational and closed airports. About 96.36 million passengers are reported to travel by air in the country. Out of these 85.55 million (88.8) traffic is at International 4.46 million (4.6%) at customs and 5.40 million (5.6%) at domestic airports. Among country's international airports Delhi traffic contribution is about 24%. It is also reported that the annual growth of passenger traffic is over 25%. The passenger traffic at Delhi airport is reported in **Table 3.7**.

TABLE 3.7
PASSENGER TRAFFIC IN DELHI AIRPORT

YEAR	PASSENGER(MILLION)		TOTAL
	DOMESTIC	INTERNATIONAL	
2005-06	10.47	5.77	16.24
2006-07	13.79	6.65	20.44

Source: Feasibility Study of Non-operational Airports, RITES study (2008)

The total freight traffic in 2006-07 was 1.55 million tones, more than 10% growth over the previous year. Out of this 0.39 million tones freight traffic is reported at Delhi airports. The details of these are summarized in **Table 3.8**.

TABLE 3.8
FREIGHT TRAFFIC AT DELHI AIRPORT

YEAR	PASSENGER(MILLION)		TOTAL
	DOMESTIC	INTERNATIONAL	
2005-06	0.109	0.273	0.382
2006-07	0.116	0.273	0.389

Source: Feasibility Study of Non-operational Airports, RITES study (2008)

The total aircraft movement was over 1,075,000 representing 28.28% growth over 2005-06. The domestic region aircraft movement accounts 0.86 million (80%) and International 0.21 million (20%). About 81% aircraft movement is through International Airports. Domestic Airports accounts 10.44%, customs airports (5.42%) and the other airports comprise the balance. The aircraft movement in Delhi airport is reported in **Table 3.9** which is 21% of International airports and 17% of all airports in the country.

TABLE 3.9
AIRCRAFT MOVEMENT IN DELHI (NUMBERS)

YEAR	DOMESTIC	INTERNATIONAL	TOTAL
2005-06	104,420	46,700	151,120
2006-07	132,600	52,570	185,170
2007-08	170,868	61,680	232,956

Source: Feasibility Study of Non-operational Airports, RITES study (2008)

3.3.1 Locations

There has been a revolution in air travel in India in the last decade. Ever since the Government launched its open sky policy and allowed private players to enter the arena there has been a sea change in the airline industry in India. Air travel has become cheaper and more affordable and the number of people traveling by air has gone up drastically. The New Delhi, the capital of India is having two major airports (Domestic and International) and is the major gateway for foreign visitors to India. The airport is located 23 km south-west of the city centre. The New Delhi airport caters to both domestic and international travelers and their brief description is given in the subsequent paragraph:

i) Domestic Airport**:** The domestic airport has three terminals, i.e. Terminal 1A and Terminal 1B and Domestic arrival terminal 1C. Terminal 1A caters to domestic flights of the national Indian Airlines and its subsidiary, Alliance Air. Flights of other scheduled private airlines operate from the terminal 1B. The domestic airport currently handles about 13,100 passengers daily on an average.

ii) International Airport**:** It links the entire world with North India. In the International Terminal or Terminal II of Indira Gandhi International Airport (IGIA) there are 35 international airlines flying at regular intervals around the major cities of the world. In the year 2005-2006, the recorded traffic was about 16.2 million passengers per annum making it the busiest airport of south Asia. An International airport currently handles about 9,500 international passengers daily on an average.

3.3.2 Study Area

The various segment required for the study area at the airport were finalized after the consultation and meeting with officers of Delhi International Airport Limited (DIAL). The study area includes:

- Terminal Vendors,
- Restaurants,
- Dustbins,
- Air Caterers, and
- Waste collectors.

i) Terminal Vendors: The survey was carried out at each terminal to know the types of plastic materials and average quantity of generation. During the survey it was noticed that the quantity of plastic material is depend upon the habit and culture of the users visiting the airport. The data of plastic waste generation was collected from the three domestic terminals and one international airport. The summary of terminal vendors at each terminal is given in **Table 3.10.** There are 33 vendors at airport.

TABLE 3.10
NUMBER OF TERMINALS AND VENDORS

S No	AIRPORT	TERMINALS	TERMINAL VENDORS
1	Domestic	Terminal 1A	7
		Terminal 1B	9
		Terminal 1C	1
2	International	Terminal 2	16*

*Including 3 outside vendors, near gate.

ii) Restaurant: The luxurious restaurant like ITC and Ashoka group of hotels are located within the terminal area. These restaurants are largely depending upon the self waste collection system which ends in big container placed outside the premise of terminal. The per day generation of plastic waste from these hotels are minimal and observed about 5 kg/day.

iii) Dustbins: The location and numbers of dustbins plays an important role in the waste management system. Further, the frequency of collected waste from dustbins is also an important factor. The role of dustbin is to avoid the spreading of waste in the surrounding. The entire dustbin placed at both the airport is being managed by private contractor M/s Subhash Projects and Marketing Limited (SPML). The number of dustbins and their locations at both the airport are tabulated in **Table 3.11.** Beside terminal dustbin, the big waste container is also found placed in apron area and outside the terminal area. In all, there are 283 dustbins to collect the waste, of these 133 are at domestic and 150 dustbins are at International terminal. The waste from terminal dustbins are collected and transported to big waste container.

TABLE 3.11
NUMBER OF DUSTBINS WITH LOCATIONS

S No	AIRPORT	TERMINALS	TERMINAL VENDORS
1	Domestic	Terminal 1A	48
		Terminal 1B	70
		Terminal 1C	15
2	International	Terminal 2 (Departure)	70
		Terminal 2 (Arrival)	45
3	Visitor lounge		25
4	Aero Bridge		10
		Total	**283**

Source: M/s Subhash Projects and Marketing Limited (SPML)

iv) Air Caterers: The maximum quantity of plastic waste is being generated through air caterers as compared to other sources. The four air caterers who are providing catering services to both domestic as well as international flights are:

- Tajsats Air Catering
- Sky Gourmet,
- Oberoi Group, and
- The Ambassador

3.4 WASTE COLLECTOR

M/s Subhash Projects & Marketing Limited (SPML) is engaged in managing solid waste along with plastic waste collection at both airports as per the agreement with DIAL. SPML has the responsibility for managing the overall operation including collection, transportation and disposal of waste including plastic. The collected waste from airport is being segregated at well planned segregation facility site located at Gitorni. The recyclable segregated materials are disposed off to authorized recycling units.

SPML is an ISO 9001-2000 certified Engineering and Construction Company in India involved in Solid Waste Management projects. SPML has offices in Delhi, Kolkatta, Bangalore, Chennai, Hyderabad, Mumbai, Bhopal, Patna and Jaipur. SPML is engaged in handling Solid Waste Management of 3 zones in Delhi covering 370 sq.km of area. The organization has developed requisition facilities by adopting safety and pollution control measures.

CHAPTER-4
QUANTIFICATION OF PLASTIC WASTE AT RAILWAY STATIONS

4.1 METHODOLOGY

The information on the nature of waste, its composition and the quantities are essential basic needs for the planning of a waste management system. The quantification of plastic waste was done through field studies. The method employed was through questionnaire and actual measurement of plastic waste at site. Questionnaire was given to each vendor and was asked to fill the plastic waste generation on each day. Each component was weight to reach on total plastic waste generated at source. This process has helped in calculating the loss in transit. The quantity of plastic waste depends upon:

- Efficiency of waste collection and transportation,
- Picking up of recyclable material by informal sector, and
- Habit of users to dispose in the bins.

Finally the data has been utilized to work out different interferences. This quantification of plastic waste at each station is discussed in subsequent sections. RITES has assessed present quantity of plastic waste generated from each three railway station namely H. Nizamuddin, Delhi and New Delhi based on the sources of waste and its collection process. The quantification of waste is essential due to the following reasons:

- Basic plastic data helps in planning, design operation and management of system
- The changes in composition and quantities over a period of time, helps in future planning.
- It provides the information for selection of equipment, suitable technology, and future needs.
- Indicates the amount and type of material suitable for processing, recovery and recycling.

4.2 H. NIZAMUDDIN STATION

Based on above methodology, the plastic waste generations at stations were carried out. The field data was compiled by sorting of waste into predermined components in numbers, weighing and finally determine the weight of each component by multiplying unit weight with component numbers. The distribution of plastic in weight and components were also carried out. The methodology was adopted at all the three railway stations. The total quantity of plastic waste generated from platform vendors and pantry are summarized in **Table 4.1** and **Table 4.2** and graphically presented in **Figure 4.1** and **Figure 4.2**. The present quantity of plastic waste generated per day through platform vendors and pantry at H. Nizamuddin railway station is about 1607 kg of which, about 130 kg is mixed plastic waste and remaining 37 kg include multilayered and metalized plastic waste. The quantity of water bottles and soft drink bottles that is value added product is 119 kg.

TABLE 4.1
PLASTIC WASTE AT H. NIZAMUDDIN RAILWAY STATION

Sources	Units	Water Bottles (1 Ltr)	Soft Drink Bottles	Plastic Glass	Ice Cream Cups	Food Stuff Box	Carry Bags	Sandwich	Bread Loaf	Total
Platform Vendors	Numbers	1,547	874	165	--	60	125	--	--	74.03
Pantry (Rajdhani)	Numbers	800	75	--	750	--	--	750	60	55.97
Number of Rajdhani	Numbers	02	02	02	02	02	02	02	02	--
Unit weight	gram	27.98	30.25	12.66	3.98	12.00	2.27	1.18	1.18	--
Total (Kg)	**Kilogram**	**88.05**	**30.98**	**2.09**	**5.97**	**0.72**	**0.28**	**1.77**	**0.14**	**130.00**

TABLE 4.2
MULTILAYERED METALYZED PLASTIC WASTE AT H. NIZAMUDDIN RAILWAY STATION

Sources	Units	Sauce & Dairy Whitener	Pickle Sachet	Biscuit Packet	Kurkure/ Namkeen	Tetra Pack	Chocolate	Total
Platform Vendors	Numbers	--	--	520	1072	--	--	4.23
Pantry (Rajdhani)	Numbers	1600	750	750	750	750	1500	32.49
Number of Rajdhani	Numbers	02	02	02	02	02	02	--
Unit weight	gram	1.82	1.09	1.73	3.12	11.82	0.008	--
Total (Kg)	**Kilogram**	**5.82**	**1.64**	**3.49**	**8.02**	**17.73**	**0.02**	**36.72**

During survey, it has been observed that plastic waste generated at source is picked up by Rag-pickers. About 35-40 rag-pickers have been actively involved at H. Nizamuddin Railway Station for plastic waste collection. About of 20% of rag-pickers were randomly selected for survey. Questionnaire used in the survey for rag-pickers is enclosed as **Annexure-4.2.** The survey conducted at station reveal the fact that the value added plastic wastes (water and soft drink bottles) are not generated at platforms and track because as soon as it generates, it is lifted by the informal sectors i.e. rag-pickers. Survey has indicated that about 167 kg of plastic waste is collected and sold to kabadis. However, the kabadis daily plastic waste purchase about 190 kg per day. Approximately, 71 kg is generated through unauthorized vendors, passengers, outside vendors and passing trains. The distribution of plastic waste based on sources is presented in **table 4.3.**

FIGURE 4.1
PLASTIC WASTE AT H. NIZAMUDDIN STATION

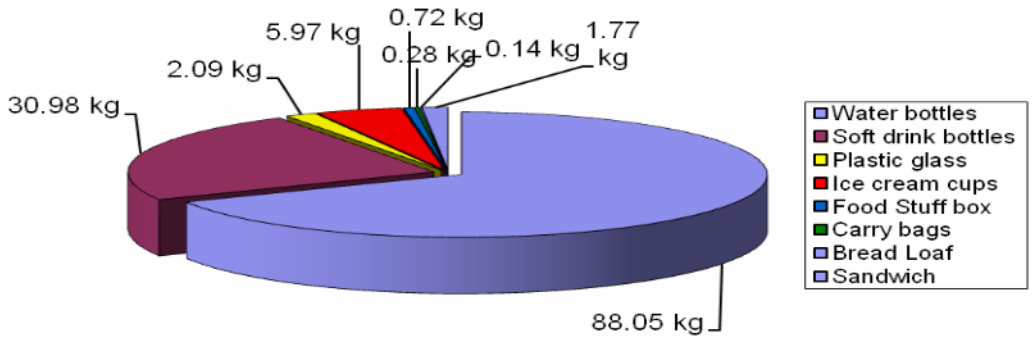


FIGURE 4.2
MULTILAYRED METALIZED PLASTIC AT H. NIZAMUDDIN STATION

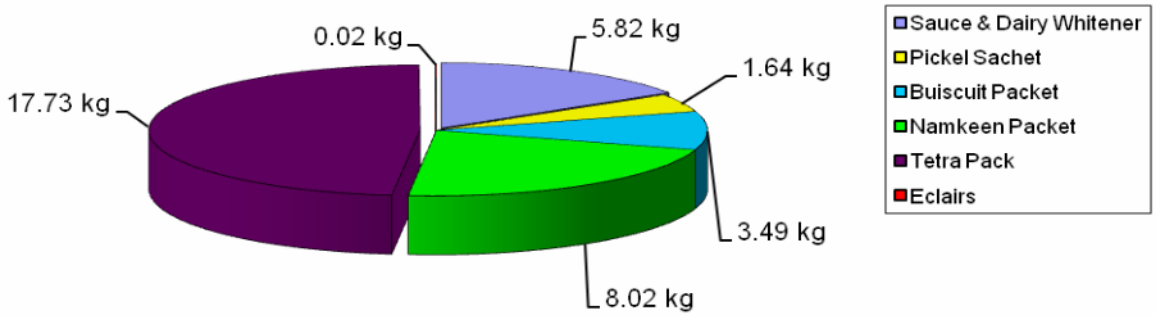


TABLE 4.3
VALUE ADDED PLASTIC WASTE GENERATION

S. No.	PLASTIC WASTE SOURCE	QUANTITY (Kg)	PERCENTAGE (%)
1	Platform Vendors/ Rajdhani	119	73
2	Passengers/ Unauthorized Vendors/ Passing trains and offices	71	37
	Total	**190**	**100**

4.3 OLD DELHI STATION

The methodology adopted for data collection is the same as discussed in section **4.2** for H. Nizamuddin railway station. The total quantity of plastic waste generated from platform vendors and pantry are tabulated in **Table 4.4** and **Table 4.5**. The quantity of plastic waste generated per day through platform vendors and pantry at Delhi railway station is 346 kg. The quantity of water bottles and soft drink bottles which is value added product is 337 kg. The quantity of multilayered metalized plastic is 9 kg. The **Figure 4.3** shows the contribution of various types of plastic waste at Delhi railway station. About 50-60 rag-pickers are actively involved with the rag picking at Delhi Railway Station. The quantity of water and soft drink

bottles collected by rag-pickers is about 4 to 5 kg per person per day. The average quantity collected by rag-pickers and kabadis are 250 kg and 280 kg respectively. With the analysis of above data it could be concluded that about 30 kg (10%) is reaching to kabadis from other sources than railway station.

FIGURE 4.3
PLASTIC AND MULTILAYRED METALYZED PLASTIC AT OLD DELHI STATION

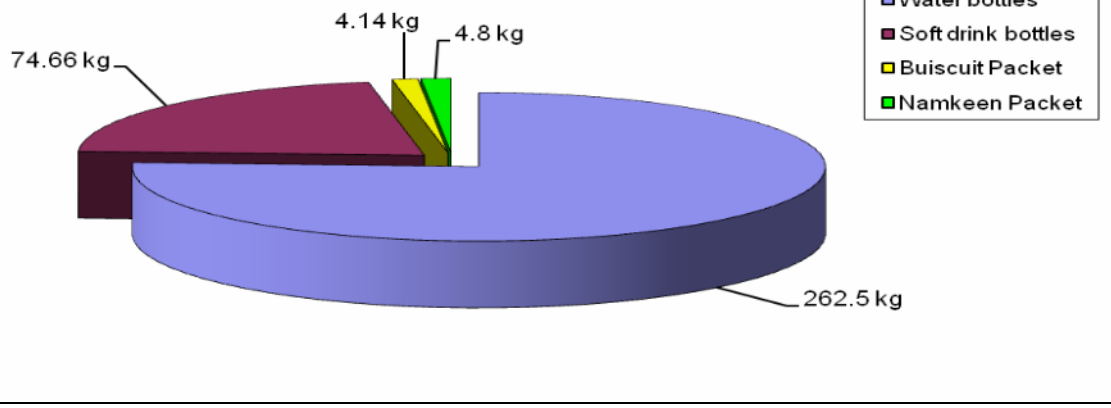


TABLE 4.4
PLASTIC WASTE AT DELHI RAILWAY STATION

Sources	Units	Water Bottles (1 Ltr)	Soft Drink Bottles	Plastic glass	Ice cream cups	Food stuff box	Carry bags	Sandwich	Bread Loaf	Total
Platform Vendors	Numbers	9382	2468	--	--	--	--	--	--	337.16
Pantry (Rajdhani)	Numbers	--	--	--	--	--	--	--	--	--
Number of Rajdhani	Numbers	--	--	--	--	--	--	--	--	--
Unit weight	gram	27.98	30.25	12.66	3.98	12.00	2.27	1.18	1.18	
Total (Kg)	**Kilogram**	**262.5**	**74.66**	**--**	**--**	**--**	**--**	**--**	**--**	**337.16**

TABLE 4.5
MULTILAYERED METALYZED PLASTIC WASTE AT DELHI RAILWAY STATION

Sources	Units	Sauce & dairy whitener	Pickle sachet	Biscuit packet	Kurkure/ Namkeen	Tetra pack	Chocolate	Total
Platform Vendors	Numbers	--	--	2396	1541	--	--	8.94
Pantry (Rajdhani)	Numbers	--	--	--	--	--	--	--
Number of Rajdhani	Numbers	--	--	--	--	--	--	--
Unit weight	gram	1.82	1.09	1.73	3.12	11.82	0.008	
Total (Kg)	**Kilogram**	**--**	**--**	**4.14**	**4.8**	**--**	**--**	**8.94**

4.4 NEW DELHI STATION

The packed items at New Delhi Railway station are distributed by Indian Railway Catering and Tourism Corporation (IRCTC). Hence, the quantity of plastic packaging materials at various sources are worked out from the data of IRCTC. Total quantity of plastic waste from platform vendors and pantry are tabulated in **Table 4.6** and **Table 4.7.** The total quantity of plastic waste generated per day through platform vendors and pantry at New Delhi station is 2,315 kg. The quantity of water and soft drink bottles is 1,508 kg. The quantity of multilayered metalized plastic is 670 kg. The **Figure 4.4** and **Figure 4.5** shows the contribution various types of plastic waste at New Delhi railway station. It is communicated that about 155 rag-pickers are actively involved in the waste picking. The average collection per rag-pickers per day is about 9 kg. The quantity of plastic waste (water bottles and soft drink bottles) workout from the data collected through rag-pickers is 1,395 kg. However the data collected from Kabadis indicates that plastic waste from the rag-pickers is 1,400 kg per day.

FIGURE 4.4
PLASTIC WASTE AT NEW DELHI STATION

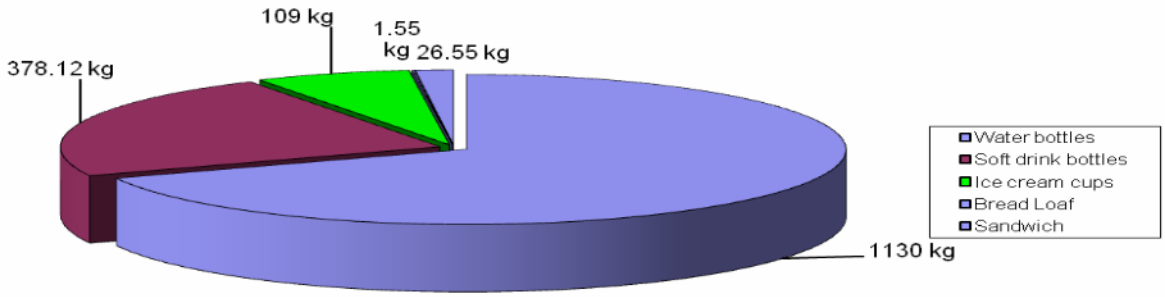


FIGURE 4.5
MULTILAYRED METALIZED PLASTIC WASTE AT NEW DELHI STATION

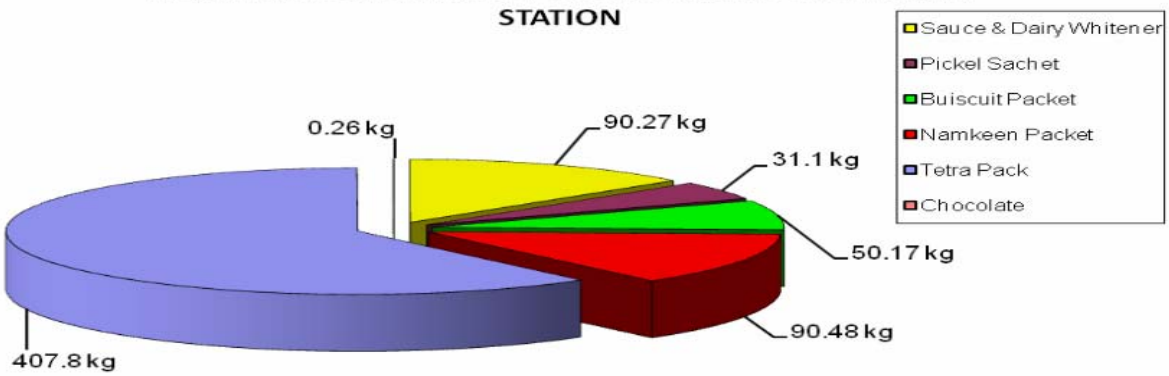


TABLE 4.6
PLASTIC WASTE AT NEW DELHI RAILWAY STATION

Sources	Units	Water Bottles (1 Ltr)	Soft Drink Bottles	Plastic glass	Ice cream cups	Food stuff box	Carry bags	Sandwich	Bread Loaf	Total
Platform Vendors	Numbers	10800	500	--	--	--	--	--	--	317.40
Pantry (Rajdhani)	Numbers	800	--	--	700	--	--	750	60	574.42
Pantry (Shatabdi)	Numbers	1000	1000	--	1000	--	--	500	--	753.40
Number of Rajdhani	Numbers	22	22	22	22	22	22	22	22	--
Number of Rajdhani	Numbers	12	12	12	12	12	12	12	12	--
Unit weight	gram	27.98	30.25	12.66	3.98	12.00	2.27	1.18	1.18	--
Total (Kg)	**Kilogram**	**1130**	**378.12**	**--**	**109**	**--**	**--**	**26.55**	**1.55**	**1645.22**

TABLE 4.7
MULTILAYERED METALYZED PLASTIC WASTE AT NEW DELHI RAILWAY STATION

Sources	Units	Sauce & dairy whitener	Pickle sachet	Biscuit packet	Kurkure/ Namkeen	Tetra pack	Chocolate	Total
Platform Vendors	Numbers	--	--	500	500	--	--	2.43
Pantry (Rajdhani)	Numbers	1600	750	750	750	750	1500	357.38
Pantry (Shatabdi)	Numbers	1200	1000	1000	1000	1500	--	310.26
Number of Rajdhani	Numbers	22	22	22	22	22	22	--
Number of Rajdhani	Numbers	12	12	12	12	12	12	--
Unit weight	gram	1.82	1.09	1.73	3.12	11.82	0.008	--
Total (Kg)	**Kilogram**	**90.27**	**31.1**	**50.17**	**90.48**	**407.79**	**0.26**	**670.07**

The following sources are fluctuating time to time, therefore, exact quantification of plastic waste by these sources could not be done. These sources are;

i) Unauthorized illegal vendors;
ii) Passengers; and
iii) Passing trains.

i) **Unauthorized vendors:** The movement of unauthorized vendors at station is a common scene. These vendors are selling variety of plastic packaging materials. The movements of these vendors are not limited to platforms but also in halted trains (passing trains). Entry for unauthorized vendors is possible because boundary of station is not sealed.

ii) **Passengers:** Passengers or visitors brings plastic packaging materials from home or outside vendors and discard at platform or at tracks. The plastic waste generated from passengers and visitors are impossible to quantify due to unidentified source.

iii) **Passing trains**: Passing trains which halt at station for a moment could discard the waste. Also passengers throw unwanted waste at halted station and it could be possible that the plastic materials purchased on some other station are discarded at halted station.

4.5 CHARACTERIZATION OF MUNICIPAL SOLID WASTE

The samples from three stations were collected and analyzed. In order to have a representative sample, reconnaissance survey of the area under study was carried out for sample locations. Samples were collected from main collection yard for railway station. Thus, 3 sampling locations were selected for physical and chemical analysis. Photograph of sample collection sites are shown in **Figure 4.6**.

FIGURE 4.6
PHOTOGRAPHS OF SAMPLING LOCATIONS

Sample from H. Nizamuddin station

Sample from Delhi station

Method of Sampling: Samples for physical and chemical analysis was collected as per the standard methods described in IS 9234-1979. Crude waste to be analyzed was mixed properly to make it homogenous. Representative samples of 100 kg from each location was collected, mixed thoroughly and divided in four equal parts. Two diagonally opposite parts were retained and the other two parts were discarded. The retained portion of the waste were properly mixed and further subjected to quartering. This time the other two diagonal parts were retained from which samples of 100 kg each were taken for physical and chemical analysis.

Physical Analysis: The inorganic materials include Fine earth, Earthware (Stones and bricks), Glass /ceramics, Metals (ferrous and non ferrous), paper and card boards, Plastic carry bags, Plastic cups, Multilayred Metalised Plastic pouches, Aluminium foil for food packaging, Others(wooden matters, grass leaves, rubber, leather etc.) and compostable matter like food items were segregated manually. These organic and inorganic components were weighted on wet weight basis and recorded as percentage of total mass. Results of average composition of MSW at four locations are reported in **Table 4.8**.

Moisture Content: The collected sample is weighted and dried at 105^{o}C in a hot air oven for about two hours. After drying the samples crucible is reweighed and the moisture content is calculated in percentage (%).

Wet Density: Density of each item has been taken as on received basis.

Chemical Analysis: The samples collected from three stations were taken for chemical analysis. The parameters analyzed for chemical analysis are calorific value and carbon contents.

Carbon Content and Calorific Value: A known amount of sample is burnt in a sealed chamber in the presence of known quantity of oxygen. The sample is ignited electrically and the heat is produced. As the amount of heat produced the rise in temperature is determined.

The calorific value is determined by bomb calorimeter in kcal/kg. The calorific value vary from 4070 kcal/kg to 6620 kcal/kg. The material weighed and burnt through oxidative combustion and the carbon content is measure by gas Chromatography using TCD detector. The carbon content vary from 47.8 % to 69.10 %. On an average the carbon content and calorific value in plastic waste is 66.3 % and 5517 kcal/kg respectively. The values are presented in **Table 4.9.**

Discussion on Results: Analysis of results show that average plastic waste of 20% of total waste excluding water and soft drink bottles are generated at three railway stations. The total quantity of solid waste generated per day at H. Nizamuddin, Delhi and New Delhi station are 4 tones, 8 tones and 11.25 tones respectively. The increased use of plastics products, about 50% of which go for packaging application alone and hence are discarded

TABLE 4.8
COMPOSITION OF MUNICIPAL SOLID WASTE

Particulars	NEW DELHI			OLD DELHI			H NIZAMUDDIN		
	Material (%)	Wet Density (kg/cum)	Moisture (%)	Material (%)	Wet Density (kg/cum)	Moisture (%)	Material (%)	Wet Density (kg/cum)	Moisture (%)
Fine Earth	6.9	1080	2.6	4.6	1100	1.6	6.1	1050	2
Earth ware	8.5	1160	3.1	5.8	1200	4.2	8.3	1230	4.5
Glass/ Ceramic	6.0	1150	4.7	6.5	1160	8.1	7.0 7.01	1200	
Metals	4.8	1030	6.8	4.2	1170	3.8	1.9	1100	10.6
Food items	14.2	620	18.9	23.6	620	19.2	19.3	650	17.8
Papers/boards	7.6	550	16.5	17.4	560	18.5	19.9	540	18.2
Plastic bags	8.2	510	8.3	5.7	500	8.9	8.9	540	14.0
Plastic cups	6.3	490	11.4	1.9	510	10.2	3.3	480	10.4
MMP*	11.8	470	9.6	6.5	430	3.6	7.1	420	4.8
Aluminium foil	2.8	650	4.4	2.1	630	6.8	2.4	610	10.5
Others	22.9	820	13.2	21.7	780	2.1	15.8	740	3.6

*__MMP__- Multilayered Metalized Plastic

TABLE 4.9
CARBON CONTENT AND CALORIFIC VALUE OF PLASTIC WASTE

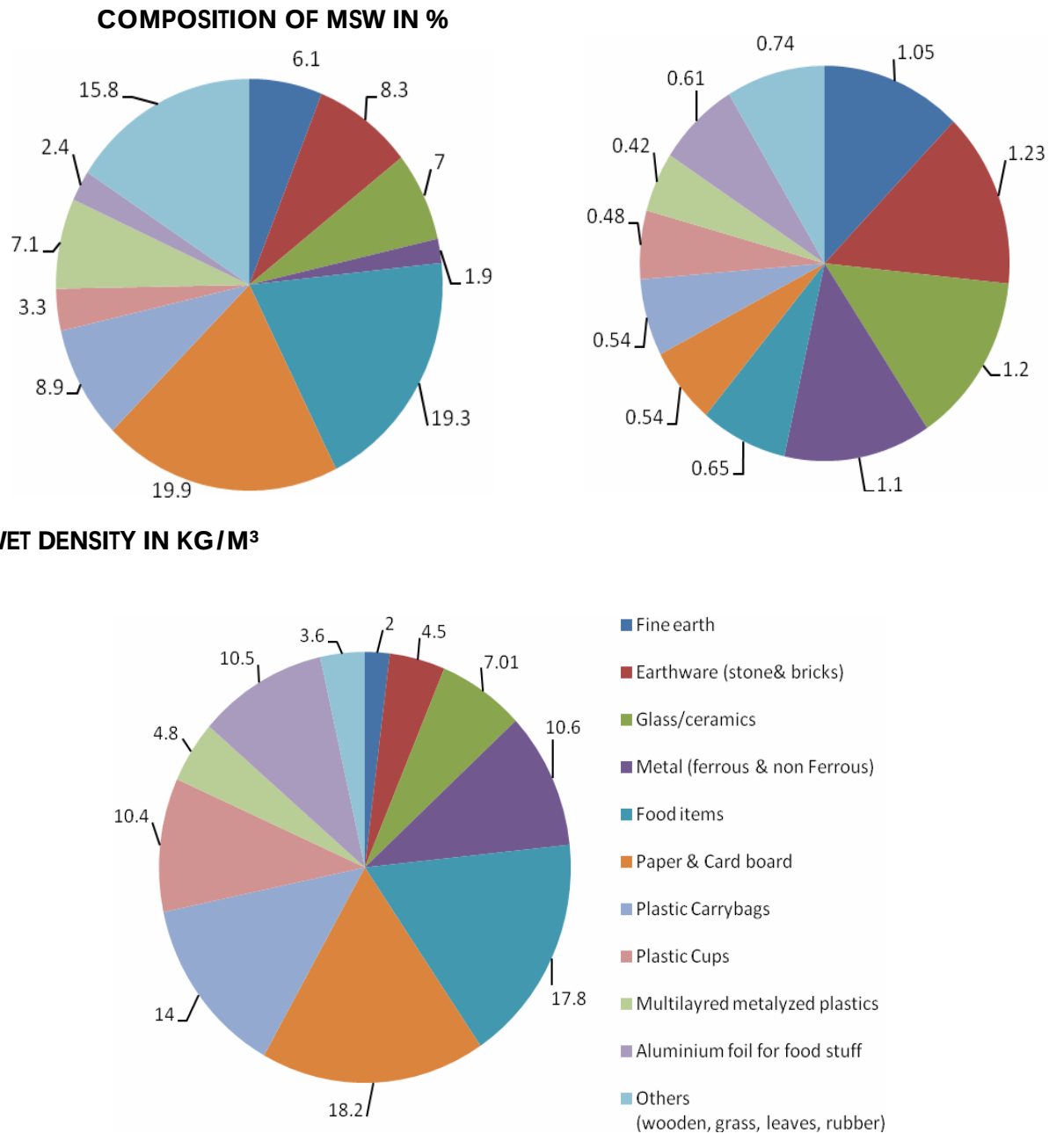
Particulars	NEW DELHI		OLD DELHI		H NIZAMUDDIN	
	Carbon Content (%)	Calorific Value (kcal/kg)	Carbon Content (%)	Calorific Value (kcal/kg)	Carbon Content Value (%)	Calorific (kcal/kg)
Plastic bags	66.7	6023	66.3	5910	69.10	6052
Plastic cups	47.8	4093	47.7	4070	49.10	4162
MMP*	67.2	6406	67.1	6319	70.4	6620

*__MMP__- Multilayered Metalized Plastic

immediately after using the content has increased the quantity of plastics in the solid waste stream to a great extent[16].

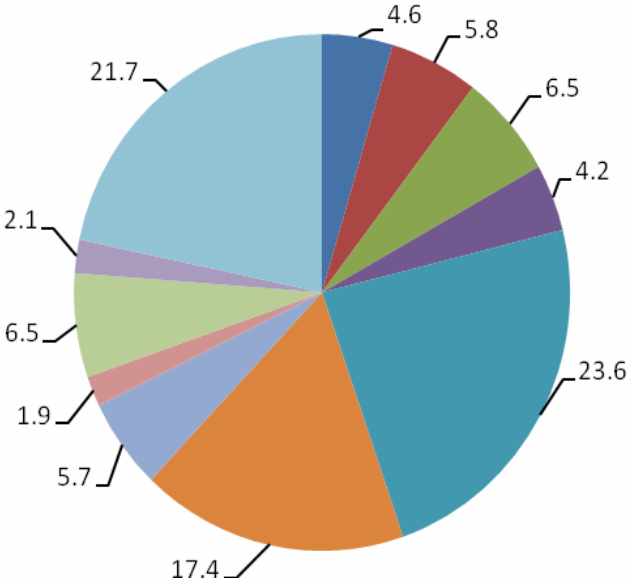
The composition of municipal solid waste in percentage along with wet density and moisture content are analyzed and graphically presented in **Figures 4.7, 4.8** and **4.9** respectively. The mass flow chart for solid waste is presented in **Figure 4.10**.

FIGURE 4.7
COMPOSITION OF MUNICIPAL SOLID WASTE AT H.NIZAMUDDIN

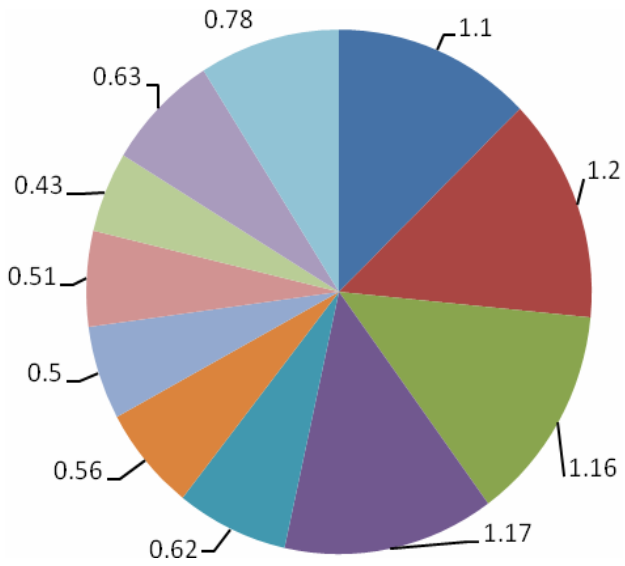


[16] ICPE Newsletter Vol.7, Issue 4, Oct-Dec 2006.

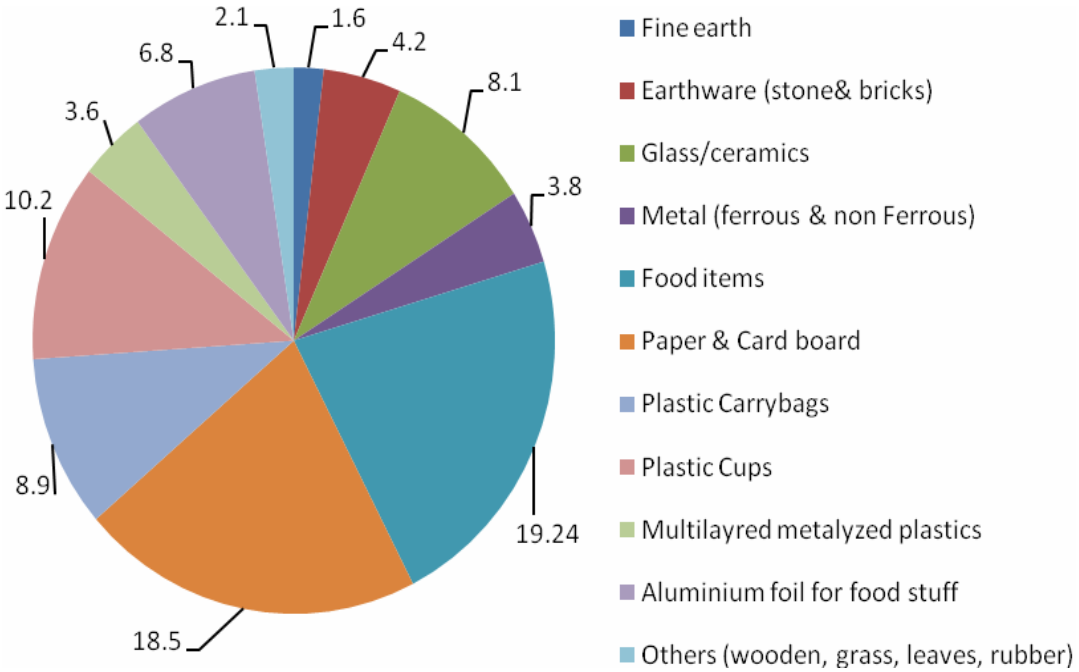
FIGURE 4.8
WET DENSITY OF MUNICIPAL SOLID WASTE AT DELHI



COMPOSITION OF MSW IN %

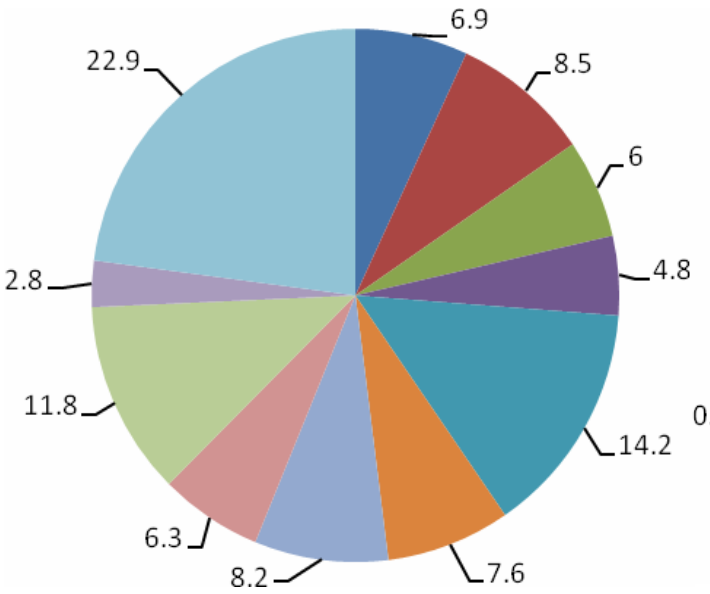


WET DENSITY IN KG/M³

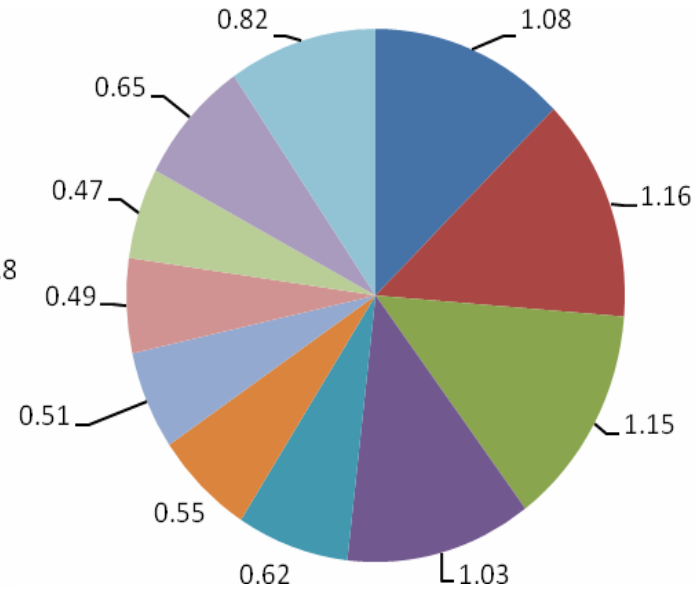


MOISTURE CONTENT IN %

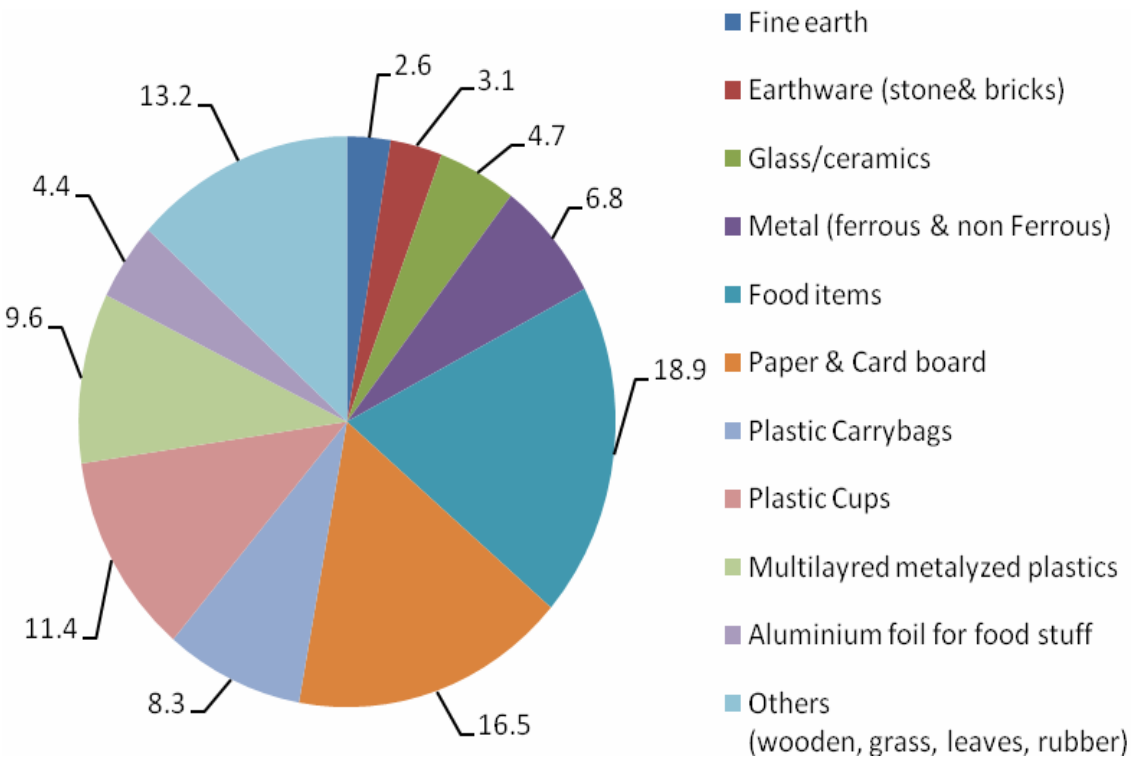
FIGURE 4.9
MOISTURE CONTENT OF MUNICIPAL SOLID WASTE AT NEW DELHI



COMPOSITION OF MSW IN %

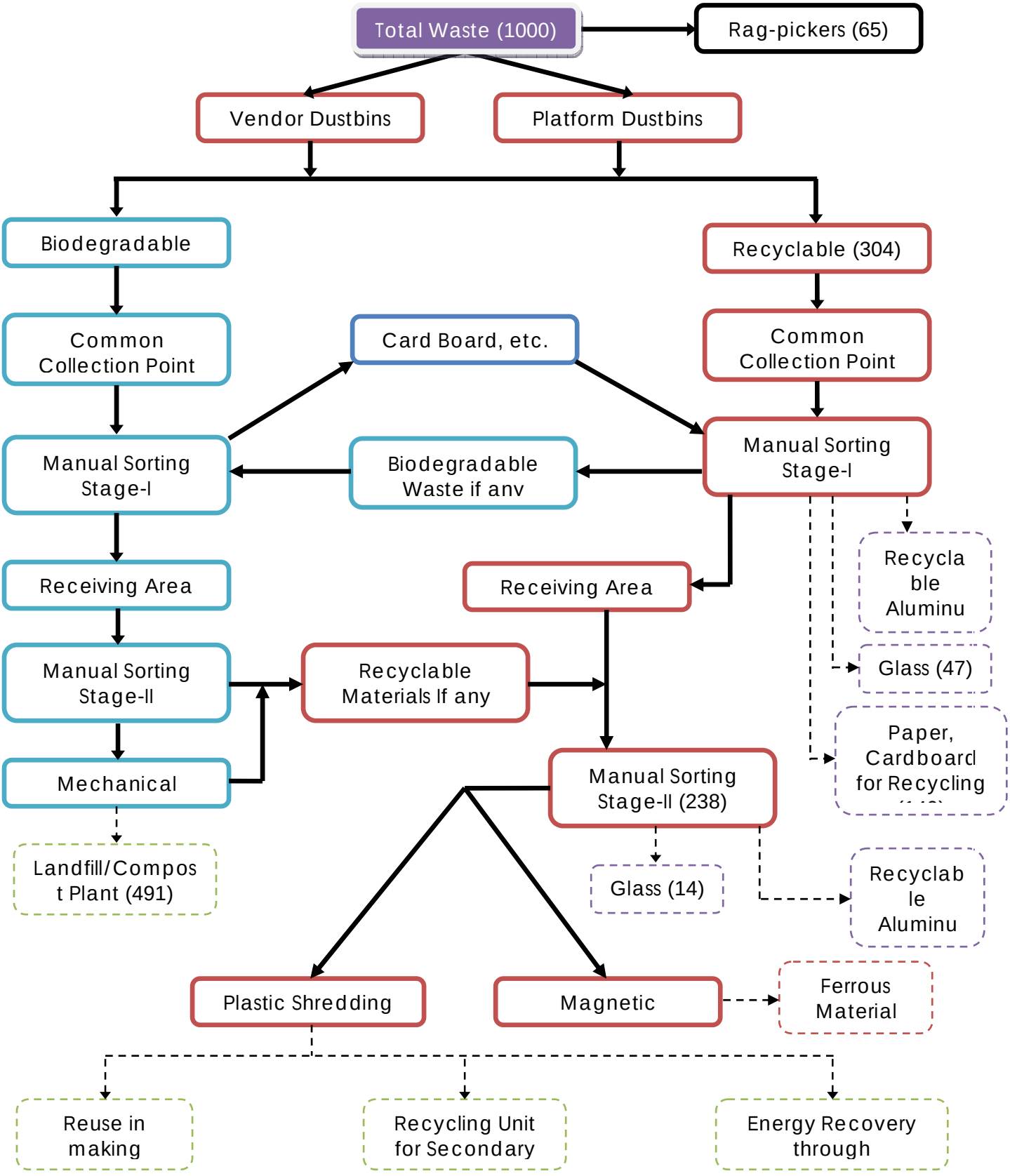


WET DENSITY IN KG/M³



MOISTURE CONTENT IN %

FIGURE 4.10
MASS FLOW CHART FOR SOLID WASTE



Figures in Bracket indicates weight

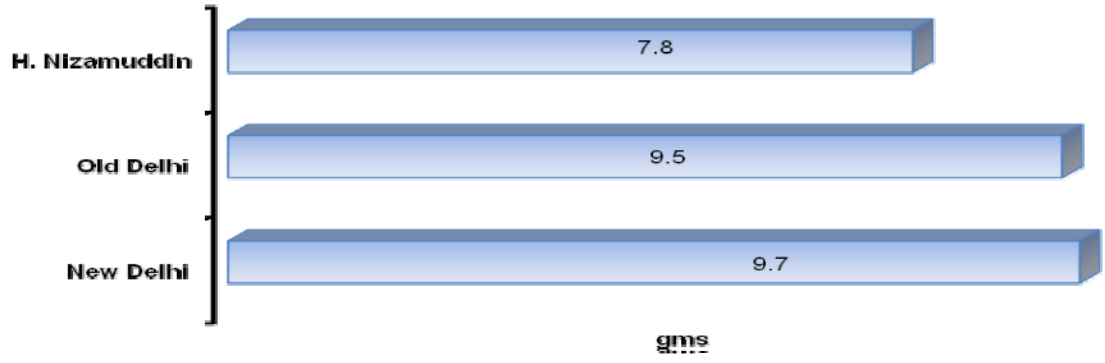
4.6 PLASTIC WASTE GENERATION AT RAILWAY STATIONS

During the survey it has been observed that plastic waste is following the route of solid waste or kabadis for reuse or disposal. The quantity of plastic waste generated at railway stations are summarized in **Table 4.10.** The quantities at stations vary from 972 kg to 3,358 kg per day. The plastic waste generation per capita is calculated based on the ratio of the total quantity of plastic waste generated to total number of passengers per day. The details of per capita plastic waste generation from railway stations are summarized graphically in **Figure 4.11**. The per capita plastic wastes at railway stations vary from 7.5 gm to 9.7 gms per person per day. The analysis of data has concluded that the average plastic waste generation at Delhi railway stations is about 9.00 gm per person per day.

TABLE 4.10
TOTAL QUANTITY OF PLASTIC WASTE AT RAILWAY STATIONS

Location	Number of Passenger (Numbers)	Quantity of MSW Per Day (Kg)	% Of Plastic waste in Sample	Quantity of Plastic waste In Sample (kg)	Quantity of Plastic waste From Kabadis (Kg)	Total Quantity of Plastic waste (Kg)	Plastic waste per capita (gms)
H. Nizamuddin	1,25,000	4,000	19.3	772	200	972	7.8
Delhi	1,50,000	8,000	14.1	1,128	300	1,428	9.5
New Delhi	4,50,000	11,250	26.3	2,958	1,400	4,358	9.7
Total	**7,25,000**	**23,250**	**--**	**4,858**	**1,900**	**6758**	**-**

FIGURE 4.11
PER CAPITA PLASTIC WASTE GENERATION AT RAILWAY STATIONS (GMS)



4.7 EPILOGUE

It has been observed that the major part of value added plastic generated at railway stations in Delhi is being collected by rag-pickers and channeled to local recycling units, however the plastic waste like carry bags and multilayered metalized plastics which left behind and goes to the landfill along with municipal solid waste. To mitigate the environmental hazards

caused due to littering of plastic waste, the recycling & reuse technology are described at **Chapter “6”.**

CHAPTER-5

QUANTIFICATION OF PLASTIC WASTE AT AIRPORT

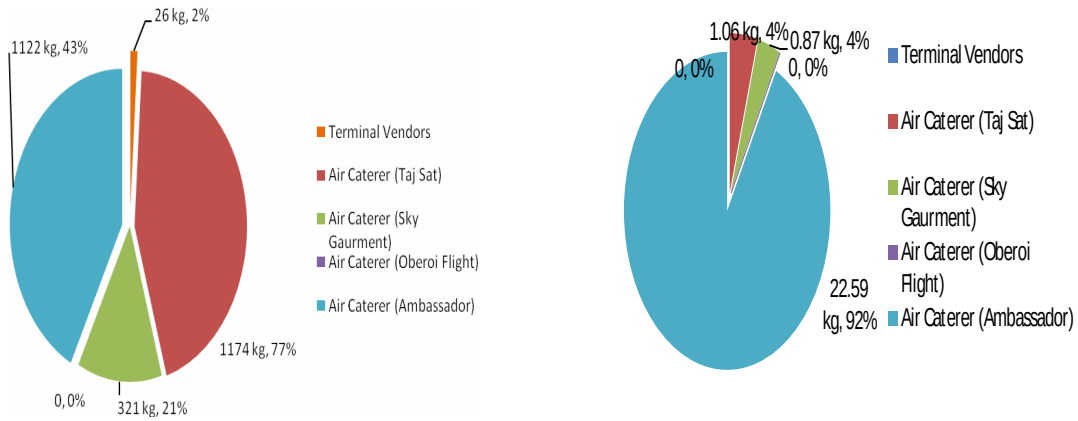
5.1 METHODOLOGY

The methodology adopted for quantification of plastic waste from airport was same as described in **chapter-4** for railway stations. The analysis of data is presented in subsequent section. The waste management system at Airport is different as compared to railway stations. At railway station the waste management is by Railways while at Airport the waste is being managed by a private agency. Similar to Railways the waste generation sources at airport are: terminal vendors, restaurant and air caterers.

5.1.1 Domestic Airport

The plastic waste generated from terminal vendors, restaurants and air caterers is 2,666 kg per day, out of which multilayered metalized plastic is 24.5 kg per day. The quantity of plastic bottles coming from the vendors, restaurants and air caterers is 2,139 kg per day (80%). The type and quantity of plastic waste materials generated at sources like terminal vendors, restaurant and air caterers at domestic airport are shown in the **Table 5.1 and Table 5.2** respectively and shown in **Figure 5.1.**

FIGURE 5.1
PLASTIC WASTE AT DOMESTIC AIRPORT



Value added plastic **Multilayered Metalized plastic**

TABLE 5.1
PLASTIC WASTE AT DOMESTIC AIRPORT

Sources	Units	Water Bottles (1 Ltr)	Water Bottles (500ml)	Water Bottles (200ml)	Soft Drink Bottles	Plastic glass	Ice cream cups	Food stuff box	Food stuff box (Thin plastic)	Carry bags	Total
Terminal Vendors	Numbers	515	145	--	210	25	95	95	115	80	27.79
Air Caterers											
Taj Sat	Numbers	38x76*	--	580x76	32x76	360x76	--	--	--	18x76	1174.30
Sky Gaurment	Numbers	21x10*	--	980x10	835	1010x10	45x10	80x10	--	110x10	316.67
Ambassador	Numbers	20x65*	10x65	1000x65	35x65	15x65	--	--	--	--	1122.45
Oberoi Flight	Numbers	--	--	--	--	--	--	--	--	--	--
Unit weight	gram	27.98	25.03	15.21	30.25	12.66	3.98	12.00		2.27	--
Total (Kg)	**Kilogram**	**137.00**	**19.89**	**1808.16**	**174.00**	**486.90**	**2.17**	**10.74**	**0.13**	**2.50**	**2641.5**

***** Average number of flights serves per day by caterers.

TABLE 5.2
MULTILAYERED METALYZED PLASTIC WASTE AT DOMESTIC AIRPORT

Sources	Units	Biscuit packet	Chocolate	Total
Terminal Vendors	Numbers	--	--	--
Air Caterers				
Taj Sat	Numbers	600	3200	1.06
Sky Gaurment	Numbers	50x10	55X10	0.87
Ambassador	Numbers	200x65	200x65	22.59

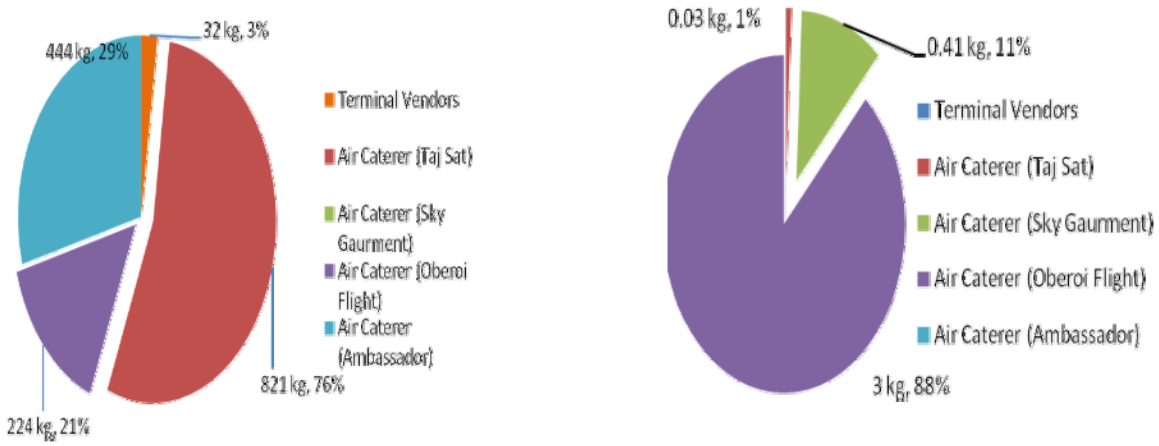
Oberoi Flight	Numbers	--	--	--
Unit weight	gram	1.73	0.008	--
Total (Kg)	**Kilogram**	**24.39**	**0.13**	**24.52**

***** Average number of flights serves per day by caterers.

5.1.2 International Airport

The total quantity of plastic generated form terminal vendors, restaurant and air caterers at International Airport is estimated as 1,523 Kg per day. The distribution of plastic waste is summarized in **Table 5.3**. Out of total quantity, the plastic bottles and soft drink bottles are 1,231 kg and multilayered metalized plastic wastes are 3.72 kg. The type and quantity of multilayered metalized plastic waste generated at international airport is shown in **Table 5.4**. The graphical representation of plastic waste generated at International airport is shown in **Figure 5.2**.

FIGURE 5.2
PLASTIC WASTE AT INTERNATIONAL AIRPORT



Value Added plastic **Multilayered Metalized plastic**

The total quantity of plastic waste collected per day for recycling is 1,600 kg and breakup of plastic waste material is shown in **Table-5.5**.

5.2 CHARACTERIZATION OF MUNICIPAL SOLID WASTE

Analysis of samples was done in the similar fashion as in case of railway station discussed in **chapter-4**. The samples were collected from SPML waste collection yard at Gitorni. The waste was leveled and mixed and then it was divided in 8 segments. One kg of waste was collected from each segment and thoroughly mixed and about one kg was taken for analysis. The composition of Municipal Solid Wastes is given at **Figure 5.3 and Table 5.6**. Analysis of results indicates that on an average about 30% of plastic waste is generated at airport (domestic and International airport). At airport, the total quantity of solid waste generated, is 14 tones with calorific value of 5,455 kcal/kg **(Table 5.7)**.

TABLE 5.3
PLASTIC WASTE AT INTERNATIONAL AIRPORT

Sources	Units	Water Bottles (1 Ltr)	Water Bottles (500ml)	Water Bottles (200ml)	Soft Drink Bottles	Plastic glass	Ice cream cups	Food stuff box	Food stuff box (Thin plastic)	Carry bags	Total
Terminal Vendors	Numbers	455	452	--	170	55	120	183	--	--	32.53
Air Caterers											
Taj Sat	Numbers	550x15*	--	1900x15	178x15	6000	--	--	--	250	822.56
Sky Gaurment	Numbers	--	--	--	--	--	--	--	--	--	--
Ambassador	Numbers	--	--	2000x9*	--	1500x9	--	--	--	--	444.67
Oberoi Flight	Numbers	25x14*	40x14	500x14	125x14	100x14	250x14	50x14		30x14	222.21
Unit weight	gram	27.98	25.03	15.21	30.25	12.66	3.98	12.00		2.27	--
Total (Kg)	**Kilogram**	**253.36**	**25.33**	**813.74**	**138.85**	**265.29**	**14.41**	**10.59**	**--**	**1.52**	**1520.57**

***** Average number of flights serves per day by caterers.

TABLE 5.4
MULTILAYERED METALYZED PLASTIC WASTE AT INTERNATIONAL AIRPORT

Sources	Units	Biscuit packet	Wafers/ Cakes	Chocolate	Total
Terminal Vendors	Numbers	--		--	
Air Caterers					
Taj Sat	Numbers	--		3200	0.03
Sky Gaurment	Numbers	232		1400	0.42
Ambassador	Numbers	--		--	--
Oberoi Flight	Numbers	--	75X14	75X14	3.27
Unit weight	gram	1.73	3.12	0.008	--
Total (Kg)	**Kilogram**	**0.40**	**3.27**	**0.045**	**3.72**

***** Average number of flights serves per day by caterers.

TABLE 5.5
PLASTICS WASTE COLLECTION AT SPML

S No	Type of Plastic *materials*	Avg. Quantity From both Airport per day (Kg)	Remarks
1	Water drinking Bottles	400	Including both mineral & soft drink bottles
2	Plastic Glass	600	Including ice cream cups, plastic glass, food stuff plastic
3	Plastic carry bags	600	Including carry bags, Multilayered metalized plastic
	Total	**1,600**	**--**

Source: M/s Subhash Projects and Marketing Limited (SPML)

TABLE 5.6
COMPOSITION OF MUNICIPAL SOLID WASTE

Particulars	SEGREGATION UNIT, AIRPORT		
	Material	Wet Density	Moisture
	(%)	(gm/cucm)	(%)
Fine Earth	4.2	1.04	2.6
Earth ware	5.1	1.15	3.1
Glass/ Ceramic	4.5	1.18	4.7
Metals	2.4	1.13	6.8
Food items	16.6	0.64	18.9
Papers/boards	5.5	0.46	16.5
Plastic bags	11.7	0.65	12.6
Plastic cups	5.2	0.62	11.7
MMP*	12.6	0.44	9.3
Aluminium foil	9.5	0.63	4.4
Others	22.7	0.75	13.2

***MMP**- Multilayered Metalized Plastic

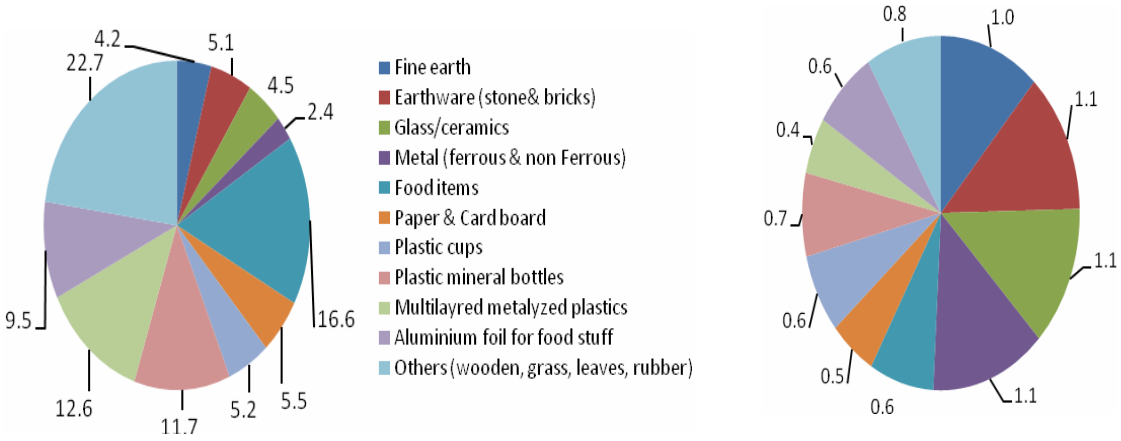
TABLE 5.7
CARBON CONTENT AND CALORIFIC VALUE OF PLASTIC WASTE

Particulars	Carbon Content	Calorific Value
	(%)	(kcal/kg)
Plastic bags	66.2	5995
Plastic cups	47.8	4127
MMP*	67.0	6245

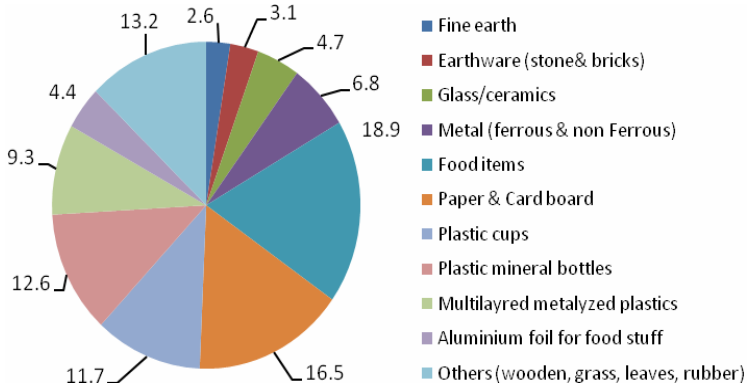
***MMP**- Multilayered Metalized Plastic

FIGURE 5.3

COMPOSITION OF MUNICIPAL SOLID WASTE AT AIRPORT



Composition of MSW (%) **Wet Density (gm/cucm)**



Moisture Content (%)

5.3 PLASTIC WASTE GENERATION AT AIRPORT

The total quantity of plastic waste generated at Domestic Airport is 2,666 kg per day and at International Airport is 1,523 kg per day, totaling to 4,189 kg per day. The actual quantity of plastic waste worked out from survey conducted at airport and sample analyzed from segregation unit is nearly matching, it means the total quantity of plastic waste generated at both the airport are reaching the segregation unit without any transit loss. The per capita plastic waste generation at Domestic and International airport is 70 gm and 68 gm respectively. The quantity of plastic waste generated at domestic and International airport is summarized in **Table 5.8**

TABLE 5.8
TOTAL QUANTITY OF PLASTIC WASTE AT AIRPORT

Location	Passenger Per day (Numbers)	Quantity of MSW Per Day (Kg)	% of Plastic waste in Sample	Quantity of Plastic waste (Kg)	Plastic waste per capita (gms)
Domestic	37,968	14,000	29.5	2,666	70
International	22,358			1,523	68
Total	**60,326**	**14,000**	**29.5**	**4,130**	**--**

5.4 EPILOGUE

It has been observed that the quantities of plastic waste observed through actual survey are almost equal to the analysis done on the sample collected from the segregation unit for airport. It means the total quantity of plastic waste generated at airport is channeled properly to segregation unit without any littering. The generation of multilayered metalized plastic is quite low due to better social habit/culture of passengers. However due attention is required to mitigate the environmental hazard caused due to multilayered plastics at airport.

CHAPTER – 6

COLLECTION AND TRANSPORTATION OF PLASTIC WASTE AT RAILWAY STATIONS

6.1 COLLECTION

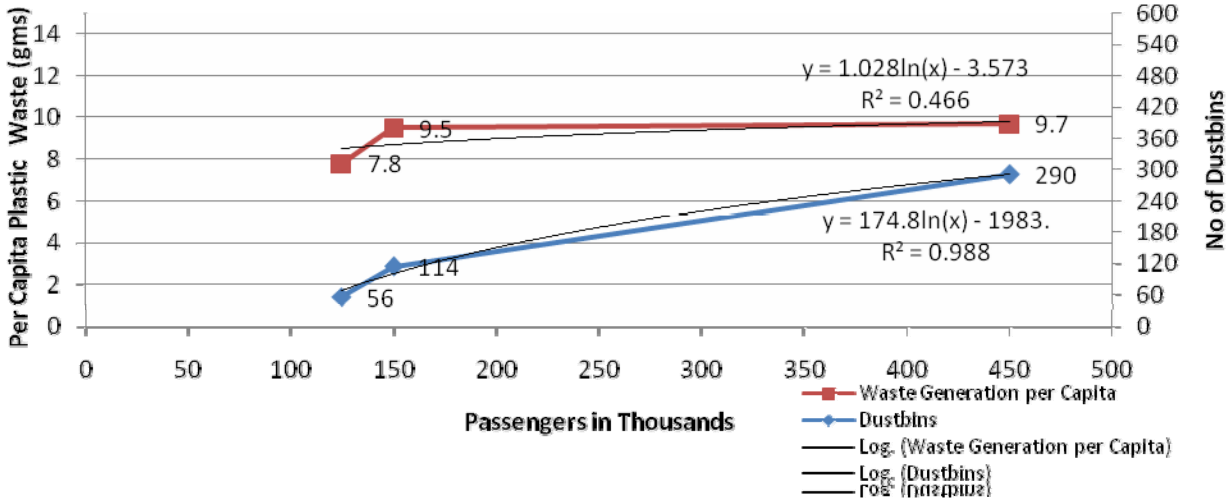
The collected waste from the source has been taken to the processing or disposal sites. The cost effective system are designed to ensure that all the waste collected from source is temporarily stored at a common collection bin/yard and then transported in bulk to the processing or disposal site. Plastic waste also finds their way to disposal along with MSW. Departments like railways and airports are operating and maintaining their own waste management system. The proper and scientific disposal of waste requires good and healthy waste management system and an organization setup.

The system is under the management of the railway's public health department. In addition, rag-pickers are also involved, however, entry for the rag-pickers in railway station is illegal. The rag-pickers, pickup value added plastic (VAP) and litter other plastic items. The plastic items other than PET bottles do not figure in their priorities because collecting them is not profitable. The sizes of collection bins at railway stations vary from 75 litres to 100 litres. The bins are made of either steel or plastic. The steel bins are fixed and emptied by turning while plastic bins can be lifted and emptied. The logarithmic graph between number of passenger, number of dustbin and per capita plastic waste at railway stations in Delhi is plotted. The requirement of dustbin at platform is a factor of number of passenger. Hence the require number of dustbin at railway station in Metro cities can be worked out from best fit logarithmic graph has been developed from the collected data at station and presented. This logarithmic graph is given in **Figure 6.1**. Based on the curve the number of dustbins required and waste generated can be estimated for planning purpose.

6.1.1 Existing Organization Setup

Indian Railway is the second biggest employer in the world. At every Railway station, the wastes have been managed by public health department of Railways. The Railway is among the biggest generator of waste in transport sector due to large number of visitors, compared to Airport and Ports. The District Medical Officer of Railways is the incharge of the city railway stations in Delhi. The Chief Health Inspector is the head and responsible for maintaining cleanliness at particular station. An existing general organization setup at H. Nizamuddin, Old Delhi and New Delhi station is shown in the **Figure-6.2.**

FIGURE 6.1
LOGARITHMIC GRAPH



The waste collection and transportation responsibilities are summarized in **Table 6.1 and 6.2**.

FIGURE 6.2
EXISTING ORGANIZATION SETUP AT STATION

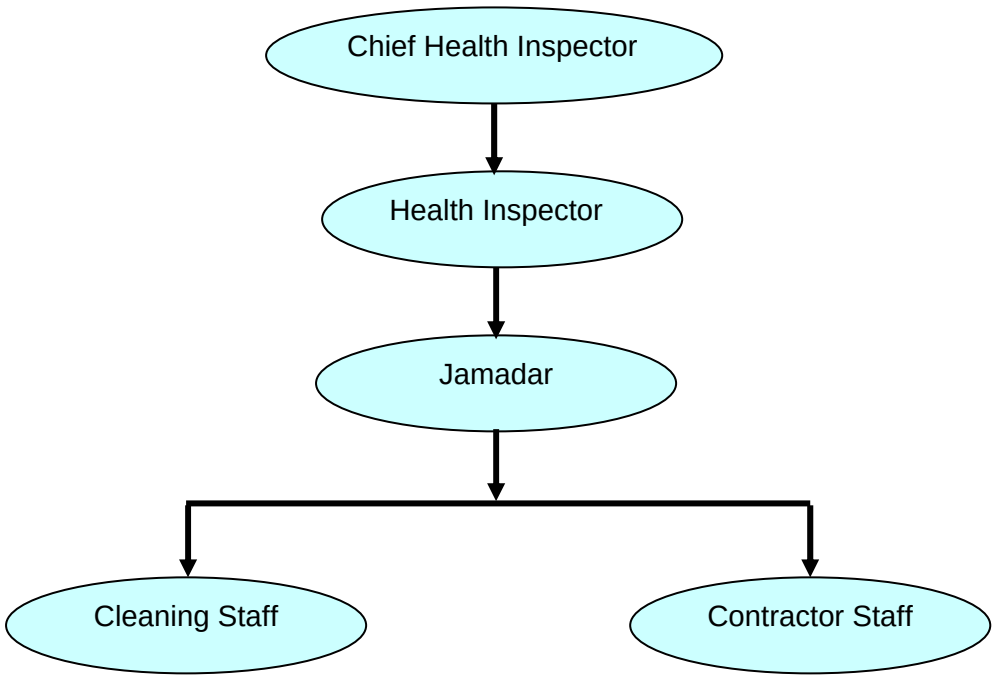


TABLE 6.1
SHIFTWISE NUMBER OF EMPLOYEES AND THEIR RESPOSIBILITY

S. No.	Stations	Employee	Morning (0600-1400hrs)	Evening (1400-2200hrs	Night (2200-0600hrs)	Responsibility
1	H. Nizamuddin	Chief Health Inspector(CHI)	1			Operational and maintenance head
		Health Inspector	2			Assisting the CHI
		Jamadar	1	--	--	Supervision
		Railway staff	29	10	4	Collecting waste from all platforms except Pl. No.1
		Contractor staff	48			Cleaning and Collecting waste from Pl. 1, track, circulating area and FOB.
2	Old Delhi	Chief Health Inspector	1			Operational and maintenance head
		Health Inspector	4			Assisting the CHI
		Jamadar	1	--	--	Supervision
		Railway staff	80	56	43	Cleaning and Collecting waste from track, circulating area & all platforms
3	New Delhi	Chief Health Inspector	1			Operational and maintenance head
		Health Inspector	6			Assisting the CHI
		Jamadar	3	--	--	Supervision
		Railway staff	89	54	38	Cleaning and Collecting waste from platforms, FOB's, offices at first floor.
		Contractor staff	56			Cleaning and collection of waste from pl. no. 1 & 16, waiting rooms, offices, circulating area, all tracks, washable apron, open drains.

TABLE 6.2
COLLECTION AND TRANSPORTATION RESPONSIBILITY

Stations	Area			
	Platform	Track	Circulating area	Rest of area
H. Nizamuddin	Private	Private	Private	Railways
New Delhi	Private	Private	Private	Railways
Old Delhi	Private	Railways	Railways	Railways

At railway stations, passengers dump the solid waste into dustbins placed for the purpose at platforms. There are about 56, 114 and 290 dustbins observed during survey at H. Nizamuddin, Old Delhi and New Delhi station respectively. The dustbins are cleared and cleaned by safai karmachari. Since, no separate dustbins are kept for degradable and non degradable waste at railway stations, the solid waste at the first collection point is not segregated, however, it will be appropriate to segregate the solid waste at this point. An informal system also actively involved in the waste picking at railway stations in addition to formal system. Photographs of waste collection by formal and informal system at railway

station are shown in **Figure 6.3**. The collected waste from the formal system finally goes to the municipal landfill for disposal whereas waste from informal sectors to the chain of recycling system.

FIGURE 6.3
PHOTOGRAPHS OF FORMAL AND INFORMAL SYSTEM

Formal System

Informal System

6.2 TRANSPORTATION

FIGURE 6.4
COLLECTION VEHICLE AT STATION

The waste from the dustbins is collected in the four wheel metal trolley and transported or cleaned to the common collection yard located within the station area. Not only the wastes collected from dustbins but also from tracks, waiting rooms and offices etc, are pickup in trolley and transported to the collection yard. The waste from dustbins is not segregated while transporting to collection yard. The waste from the collection yard is lifted by the private contractor and dumped in to the Municipal landfill in one shift every day. Each railway station i.e, H. Nizamuddin, Old Delhi and New Delhi have same type of waste storage with transportation system. The waste at dumping yard is of mixed in nature and goes to the Municipal landfill without any segregation. The waste collected by the informal sectors does not figure in this channel. The vehicle used for the transport of waste from collection yard to the Municipal landfill is shown in **Figure 6.4**.

The requirement/ vehicles used in waste collection are:

1) **Dumper Placer:** Dumper placer system is developed on LCV, MCV and HCV truck chasis depending upon the container capacity. The available container capacities are 7 cum, 5 cum, 4.5 cum, 3.5 cum, 2.5 cum and 1.5 cum. It has many advantages such as high productivity, easy operation, low maintenance and flexible method of handing.

2) **Hydraulic Compactor vehicle:** The packer consists of a body mounted tailgate on a chassis with compression mechanism, an ejection plate inside the body, the hydraulic installation and control mechanism. These vehicles compacted waste from an initial low density to higher density. Hydraulic compactor vehicles are of two types: the hydraulically operated pressure plate type and the mechanically driven screw impeller type. The cost of these vehicles is 2 to 3 times that of common open body trucks. The vehicles are available in 7 cum, 10 cum, 15 cum and 24 cum capacities.

3) **Tipper:** These trucks are available in various sizes from 3 to 7 tonnes capacities. The main disadvantage of Tipper vehicle is the spilling of waste due to uncovered trolley.

The transportation of waste from collection yard to disposal point should be so managed as to ensure the availability of the vehicles in the adequate numbers and in such a condition which will result in their most efficient and cost-effective utilization. The various transportation facilities available with cost per tones per kilometers for average lead of 50 km are summarized in **Table 6.3** which is being commonly used in the waste management system in India. As seen from the table cost per ton per km for Hydraulic Lifter & Compactor, Dumper Placer and Tipper are Rs. 7.29, 5.43 and 5.06 respectively.

6.3 STORAGE

During field study it was noticed that the railway stations in Delhi are not having separate storage system for plastic waste. As there is no facility to store plastic waste separately it is being collected along with MSW. This collected waste is then dumped to the open collection yards located inside or nearby railway station. The segregation of waste has not been done at collection yard. H. Nizamuddin and Old Delhi railway station have two collection yards. Waste from tracks and platform is collected in main collection yard while waste generated from washing line is stored at temporary collection yard located near the washing line. This waste from washing line is ultimately goes to the main collection yard. While at New Delhi railway station is having seven collection yards including one main collection yard. All the collection yards observed during study where open structure except one at New Delhi station.

TABLE 6.3
COMPARISION OF TRANSPORTATION SYSTEM

S No	Type of Vehicle	Cost of Vehicle (10 ton capacity) (Lacs)	No. of Vehicle	Annualised cost over 7 years (Lacs)	Manpower cost/Year (Lacs)	Fuel cost per Year per Vehicle (Lacs)	Total cost/Year (Lacs)	Waste transported Ton/Year	Average Lead (Km)	Cost Rs/T/Km
1	Hydraulic Lifter & Compactor	40	1	5.71	2.19	1.22	9.12	2504	50	7.29
2	Dumper Placer	25	1	3.57	2.19	1.04	6.80	2504	50	5.43
3	Tipper	15	1	2.14	3.29	0.91	6.34	2504	50	5.06

6.4 CLOGGING OF SEWER AND DRAINS

The present practices of collection by formal and informal system with existing policies on plastic waste have not been able to solve the problem of littering. The main reason for scattering of the plastic packaging materials is due to throw-away culture of passengers. Passengers from trains throw waste on tracks which creates littering of waste especially at halting stations. The dumping of plastic waste materials in the sewer/ drain system can be observed during study at each railway station. The littering of plastic waste materials in and around the railway premises are clogging the drains due to negligence of safai karmacharis and these materials not picked by rag-pickers.

6.5 DISPOSAL

The plastic wastes generated at dumping sites are collected by private contractors employed for disposal of waste to Municipal landfill site. The value added plastics picked up by rag-pickers are channeled to recycling units. The recycling units and the process adopted are described in section **7.3** of **Chapter-7**. While other non value added plastics like multilayered and metalized plastics and carry bags etc. are disposed off to municipal landfill along with MSW.

CHAPTER-7

COLLECTION AND TRANSPORTATION OF PLASTIC WASTE AT AIRPORT

7.1 COLLECTION

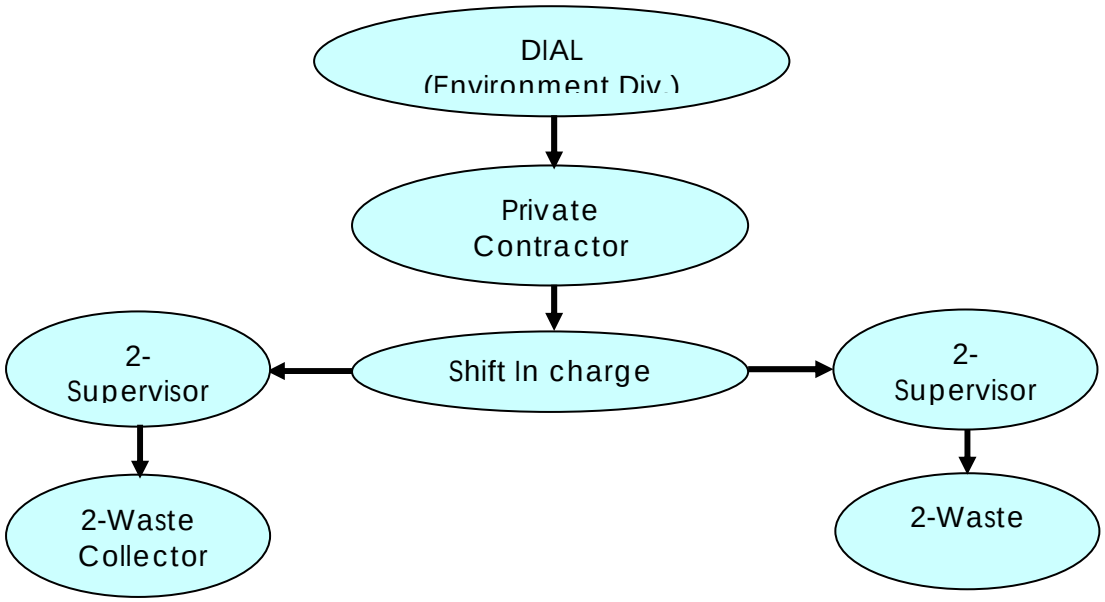
At present all the functions of Delhi Airport (Domestic and International) are handling by Delhi International Airport (P) Limited (DIAL). DIAL is a Public Private Partnership Initiative that has been awarded the mandate for modernization and restructuring of the Indira Gandhi International Airport in New Delhi. DIAL comprises the GMR Group, Airports Authority of India, Fraport AG, Eraman Malaysia and India Development Fund. The mandate is to finance, design, build, operate and maintain the airport for a period of 30 years till 2036. Indira Gandhi International Airport is a major gateway to India, located in the National capital of Delhi. It is vital link between India and rest of the globe. The International Terminal (Terminal II) has 35 airlines flying to major cities across the world. The domestic terminal has three terminals (1A, 1B and Arrival). The airport is equipped with state of art category- III A landing system making it operational even during dense foggy weather. Airport currently handle 13,100 domestic and 9,500 International passengers daily as on average.

The waste is being managed by formal sector of airport authorities in control way at all over India. The Delhi International Airport (P) Limited (DIAL) is responsible for the operation and maintenance of the entire airport system. The DIAL has given the contract for collection, transportation and disposal of solid/ plastic waste to M/s Subhash Project & Mktg. Ltd, (SPML) Delhi for 3 years i.e. from February 2007 to February 2010. M/s. Subhash Projects and Marketing Limited (SPML) has provided manpower, organized a network of waste collection and its transportation from the areas within airport.

7.1.1 Existing Organization Setup

The details regarding the existing organization setup at airport is collected from the respective airport department. The Airport Authority of India (AAI) had adopted hierarchy chart followed by DIAL. The DIAL appointed the private contractor who is responsible for entire waste management system at airports in Delhi. The detail of organization chart shown in **Figure 7.1**. The waste generated at both the Airports is primarily collected in Dustbins. There are 283 dustbins placed in an entire airport area (domestic and International). The placement or location of dustbins should depend upon the type of area. The dustbins are cleaned as soon as it gets full and the entire staff is working on the ground round the clock for cleaning purpose. All the dustbins kept in the Airport is having same dimensions and features. The capacity of these containers is about 100 litres. The wastes in the Dustbins are frequently removed by the staff of SPML to the big waste container, located outside the airport building.

FIGURE 7.1
HIERARCHY OF ORGANIZATION AT AIRPORT



7.2 Transportation

The waste from terminals is transported through four wheel trolley while the waste from apron and hanger are moved by the hydraulic dumper. The waste collected in the trolley is then moved to the big container kept within the apron and at city side area. No segregation is carried out during transportation of the waste. The collected wastes at big waste containers are stored temporarily. The Hydraulic remover trucks transport the disposable waste materials at Okhla landfills while recyclable waste materials to segregation facility of SPML at Ghitorni. At present, the following machinery/ vehicles have been used in the airport 24 x 7 (365 days) along with hydraulic remover trucks:

Hydraulic Compactors with a capacity to lift 12 tonnes	-- 2 nos
Dumper Placers with a capacity of 8 tonnes	-- 3 nos
Top loading closed truck	-- 1 no

The cost of transportation is estimated about Rs. 5.06 to 7.29 per ton per km as discussed and calculated in **Table 6.3**.

7.3 RECYCLABLE PLASTIC PROCESSING

The plastic waste from airport is transport to SPML waste handling site for segregation. The segregation is carried out manually where recyclable and non-recyclable were separated. The plastic bottles collected are sold to recycling units located outside Delhi.

During visit it was observed that plastic waste like water and soft drink bottles, waste from plastic industry and wiry plastic waste are recycled. The non-recyclable waste from both the sectors is ultimately disposed at the Municipal landfills. The plastic bottles collected from railways and airport are inspected and sorted according to the requirement at recycled unit.

These segregated wastes is then washed and crushed in small pieces. These crushed plastic raw wastes are then weighted at receiving platform and are processed in batches. The wetted plastic waste pieces is dried and lifted at first floor where it is passed through the melting process in closed reactors/ vessels. The melting temperature required for the process is kept as 260^0C. The material from the reactor is then cooled and wind in fibers around the bobbin. The fibers from bobbins are stretched and streamed with oil bath for smoothen the fibers. These plastic fibers are then dried and cut in to pieces. The cut fibers are then inspected and tested for the quality. The bailing of the inspected fibers is done by bailing machine and the fibers are finally ready for the packing process. These finished plastic fibers are the final product of plastic recycled units but it is raw material for the other plastic industries. The plastic industries used this fiber in making various kinds of commercial products like plastic carpet and filling in cushions etc.

CHAPTER-8

PLASTIC WASTE MANAGEMENT AND DISPOSAL TECHNOLOGIES

8.1 PLASTIC WASTE MANAGEMENT APPROACH

Plastic waste is continuously produced as a result of human activities at airports and railway stations. The volume of plastics in Municipal Solid Waste (MSW) has increased phenomenally in recent years. The percentage of plastic waste at stations and airport is ranging between 20-30% (refer **Table 4.8** and **Table 5.6**) as compared to 5-9% in Municipal areas (refer **Table 1.2**). In order to control littering efficient plastic waste management along with scientific disposal is required. Waste management involves activities associated with generation, storage, collection, transportation, processing and disposal. Plastic waste disposal in an environmentally sustainable manner should be achieved by adopting principles of economy, aesthetics, energy conservation and pollution control. It encompasses planning, organization, administration, financial, legal and engineering aspects involving interdisciplinary relationships. The unsanitary conditions prevalent in big establishment in metro cities, indicate the necessity of providing services that are properly designed and adopted. India as a developing country needs simpler, low cost technology keeping in view of maximum resource recovery in environmental friendly manner. An advanced technological solution for plastic waste disposal available in developed countries but cannot be directly adopted in developing countries due to difference in waste characteristics, financial constraints and socio-cultural aspects. With the aim of restrain littering and have proper disposal process for plastic waste, following activities are required to enforce in plastic waste management.

8.1.1 Two-Bin System

The plastic waste management needs to be optimized from concept to project management. In order to follow appropriate plastic disposal technologies, segregation at source is essential. The recyclable waste material should be separated from food waste and other biodegradable waste, in a separate bin at the source of waste generation, by having a two-bin system for waste storage. The bins are clearly labeled/marked on them “Recyclable Waste” and “Bio-degradable Waste”. The plastic waste are separated out easily from other recyclable materials. The bio-degradable waste goes to the Municipal landfill for energy recovery or bio-fertilizer and recyclable waste can be handed over for further reuse. The reuse of recyclable waste material will reduce land fill requirement and environment pollution.

8.1.2 Collection and transportation

The collection and transportation of plastic waste on a daily basis is an imperative step. Since the waste cannot be removed as fast as it is produced, it is stored and transported as soon as possible at specific pre-defined frequencies. At railway stations in Delhi, the collection and transportation is carried out partially through departmental work-force and private contractors. In this dual function it is impossible to fix responsibility and accountability on either side. It is, therefore, advisable to clearly define areas for departmental and contract collection and transportation. The capacity available of manpower and transportation are summarized in **sections 6.2** and **sections 6.3** are underutilized, and hence, needs

improvement. The system of storage and types of vehicles are often compatible. Mechanical lifting bins are required to minimize the cost of manually collection.

8.1.3 Organization setup

The basic objectives of sound organization for waste management system is be to collect, process and dispose of plastic waste effectively at least cost in an environmentally sustainable manner. At present, Health Inspectors has been assigned at station to manage this activity. The organization has to seek help from other specialized agencies for executing relevant task, if needed. The broad principles to be considered are:

- The authority and responsibility should be clearly laid down and authority should be commensurate with responsibilities.
- Responsibility should be so distributed as to avoid overlapping, duplication and duel accountability.
- The division of responsibility should be so made as to serve the basic function of the whole system in the best professional manner.
- The work should be divided into different groups, each containing positions requiring similar abilities and facilities.
- Rewards for good work should be initiated so as to keep the good workers satisfied.

8.1.4 Micro Planning

An efficient and cost beneficiary system of waste management requires micro planning for collection, storage, transportation processing and disposal of plastic waste. This should also ensure an effective participation of the Government, citizens and NGO's in planning and waste management system. More attention and micro planning is required at railway station rather than airport. Mumbai central station is practicing the compactor machine having a cost of about Rs. 1.75 lakhs with a capacity of 6-8 bales of PET bottles per hour. This device reduces the volume of plastic waste by compacting, so that storage and transportation becomes relatively easier. Based on the success of project at Mumbai central station, the Railway authorities should consider such compactors at Delhi to reduce volume and transportation cost.

8.1.5 Role of NGO's

Non - Governmental Organizations (NGOs) are one of the most effective media to reach the people and can play a significant role in the management of plastic waste through mass awareness programs in public and at project sites. The Government of India through Central and State Pollution Control Boards should provide full co-operation through financial assistance for conducting mass awareness programs in the area of plastic waste management. In addition, NGO's may develop R&D projects, participate in policy making and organizing rag-pickers as "Waste collectors" by motivating and bring them in the main stream of waste management. NGO's may be provided tools and equipment for efficient performance of their work in the informal sector.

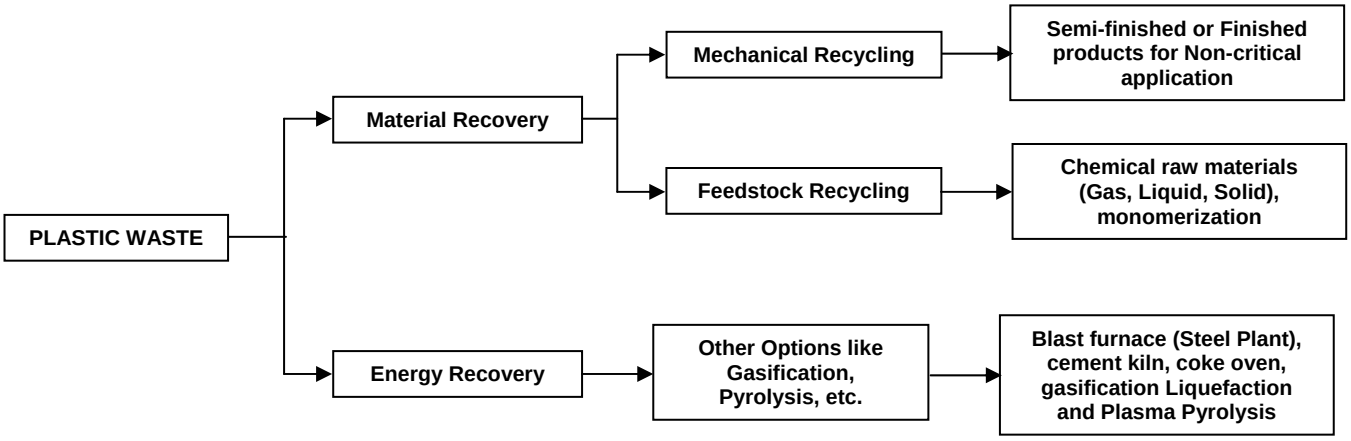
8.2 RECYCLING OF PLASTIC WASTE

The recycling of plastic is possible through different methods discussed in **Section 8.3**. The compacted bales of plastic waste from stations and airport should reach the recycling unit on daily basis. Recycling of plastics waste should be carried with a view to:

- Minimize the pollution level during the process
- Enhance the efficiency of the process, and
- Conserve the energy.

The practice of recycling post-manufacturing plastic waste has been in vogue since the last many years. But problems are encountered in case of post consumption of plastic. The incompatibilities of the components mixed are generally chemically different polymers and hence pose difficulties in processing. Many a time the in homogeneity of polymers will lead to inferior material properties. The collected plastic water and soft drink bottles from stations and airport have been channeled properly to recycle unit, but the multilayered metalized plastic which is littering the area is not recycled. This is because these wastes are not segregated anywhere in the channel of waste disposal and find its way in the landfill along with MSW. The selection of technological options to recycle/reuse of plastic wastes are depends upon the quality and quantity of waste. While determining the methodologies of recovery system, it is required to make a distinction between different recovery options namely: **Primary Recycling** (Conversion of waste plastic into products having performance level comparable to that of original products made from virgin plastics); **Secondary Recycling** (Conversion of waste plastics into products having less demanding performance requirements than the original material); **Tertiary Recycling** (The process of producing chemicals/ fuels/ similar products from waste plastics); and **Quaternary Recycling** (The process of recovering energy from waste plastics by incineration). However, International Standards like ISO refers Plastics Recycling as a Recovery Process. The recovery has been divided into two categories namely MATERIAL RECOVERY and ENERGY RECOVERY. The process flow chart for recovery process is depicted in **Figure 8.1**.

FIGURE 8.1
SCHEMATIC DIAGRAM OF PLASTIC RECOVRY OPTIONS



8.2.1 Mechanical Recycling:

Mechanical recycling involves processing of waste in to a product with characteristics similar to those of original product. This is the most preferred and widely used recycling process due to its cost effectiveness and ease of conversion to useful products of daily use. The limitation of this process is that the process requires homogenous and clean input. The process of mechanical recycling of waste plastics into products of varying usefulness mostly involves the essential steps namely:

Collection/ Segregation (Plastic wastes are separated/segregated by Flotation Process in which varying density property of plastic waste is made use for segregating plastics); **Cleaning & Drying** (Post consumer plastic wastes require cleaning and drying than industrial waste. The wastes generated during these processes require proper treatment and disposal methods); **Sizing/ Chipping** (Cleaned plastic waste products should be sized/chipped to fed into the extruders for processing and palletizing and these operations depends upon the type and size of the plastic waste); **Agglomeration/Coloring** (Depending upon the end product, sized plastic waste is mixed with color master batch in high speed mixers/ agglomerators); **Extrusion/ Pelletisation** (Chipped plastics are plasticized and re-granulated to make the plastic material ready for fabrication) **Fabrication into End Product** (Reprocessed plastic granules used as raw materials for producing end products using fabrication machines)

8.3 TECHNOLOGICAL DISPOSAL OPTIONS

The selection of appropriate technology for plastic waste disposal and its processes for the management of plastic wastes are available in literature. Several processes and technologies have been explored and developed for plastic waste management. Some of these are:

- Chemical recycling of pet bottles into fibers
- Processing of plastic waste in Blast Furnace
- Co-incineration of plastic waste in cement kilns
- Utilization of plastic waste in road construction with bitumen
- Plasma Pyrolysis Technology for disposal of plastic waste and
- Gasification,

8.3.1 Chemical recycling of pet bottles into fibers

This method of plastic recycling, involves the breaking down of polymer chain in to their basic components, which can then be used in various industries. The feedstock plastic recycling process is flexible and more forbearing to the plastic additives, as compared to the mechanical plastic recycling. This is the most costly method of recycling. The varying end products are obtained by using following process:

Monomerization: The waste plastics are initially broken down into their constituent monomers by chemical reaction (depolymerization). These monomers are then extracted for use as the raw material in new plastic products. Monomerization produces higher quality plastic raw materials than material recycling. Which in turn enables the production of high-quality plastic products with the same (or almost the same) quality as virgin raw material. Among other products, this enables the recycling of waste PET bottles into new PET bottles, which is not possible with other recycling technologies. About 50% recovery is possible

through this process. The limitations of this process is that, the large scale process setup along with clean and single resin plastic waste as input is required[17].

8.3.2 Processing of plastic waste in Blast Furnace

Plastic waste can be co-incinerated as fuel in the iron and steel industry. This will reduce coal consumption and hence in reduction in the consumption of energy. The proportion of waste plastic added to coal should be about 1% by mass. Increased addition of waste plastic will reduce the heating strength of the coal/coke[18]. The use of plastic in coke ovens-a typical high-temperature process in the iron and steel industry was put in practice in the year 2000 at Nippon Steel Corporation, Japan. In this process, the collected and baled plastic waste that has been agglomerated by pre-treatment is mixed together with coal and charged into coke oven. The mixed plastic waste and coal are carbonized in an oxygen-free reducing atmosphere at about 1,100 to 1,200^{0}C. As a result, the waste plastic is thermally decomposed into coke (about 20%), tar/light oil (about 40%) and coke oven gas (about 40%). These products obtained by the carbonization of waste plastics have their own uses. When plastics are used together with coke, CO_2 emission is significantly less. The excessive reducing gases are also used for blast furnace stove and power generation.

Blast Furnace: Plastics waste can be used as an alternative raw material in blast furnaces to generate energy for manufacturing of iron. Plastic waste can be successfully used as a reducing agent in blast furnaces for the manufacturing of iron from its ore. Use of coke in blast furnace provides only one type of reducing agent- carbon Monoxide. In contrast, use of plastic waste provides one additional type of reducing agent – Hydrogen. Advantage of this process includes use of all types of plastics including laminated plastics without creating any environmental pollution[19]. The high temperature inside the blast furnace around 2000^{0}C ensures that there is no possibility of any dioxins formation even if PVC is processed. Furthermore, as the reducing atmosphere in the low- temperature region at the top of the furnace contains no oxygen, no dioxins are produced or resynthesized in the lower temperature zone also.

The plastics waste is first formed into suitable size either by crushing or pellatising as necessary, and subsequently injected into the blast furnace from the tuyeres at the base of the furnace with hot air. The injected plastic waste material is broken down to form reducer gas- Carbon Monoxide (CO) and Hydrogen (H_2). The reducer gas rises through the raw material layers in the blast furnace and reacts with iron ore to produce pig iron. The gas, after the reduction reaction, is recovered at the top of the blast furnace which has energy content to the tune of 800 kcal/NM^3 and is reused as a fuel gas in heating furnaces within the steel plant. The reactions involved in the process are:

i) In the Presence of Coke only

Coke or pulverized coal is burnt rapidly in the first stage of operation when, in the presence of oxygen, carbon-dioxide is produced.

$$C + O_2 = CO_2$$

[17] ICPE Newsletter Vol.7, issue 1, Jan-March 2008
[18] Nippon Steel Technical Report No. 94 July 2006.
[19] ICPE Newsletter Vol. 6, Issue 1, Jan-March 2008.

When the oxygen in the passage area is fully consumed, carbon monoxide is produced by the reaction of freshly produced carbon-dioxide with the coke.

$C + CO_2 = 2CO$

The carbon monoxide reduces the iron ore into pig iron.

$Fe_2O_3 + 3CO = 2Fe + 3CO_2$

ii) In the Presence of Plastic Waste along with Coke

Plastics materials break down to CO and Hydrogen. This presence of hydrogen, produced by burning of plastics, contributes to the reduction reaction thus reducing the amount of CO_2 generated by coke.

$½\ C_2H_4 + CO_2 = 2CO + H_2$

$Fe_2O_3 + 2CO + H_2 = 2Fe + 2CO_2 + H_2O$

The blast furnace temperature reaches up to around 2000^0C. Plastics may replace coke or coal for the reduction reaction. However, coke has a special function in the blast furnace in moving the gases, liquids and solids within the blast furnace. Plastics and pulverized coal cannot perform this specific function and hence the substitution of coke is possible only up to a certain limit, which has been established at approximately 40% (compared to coke).

As cost of waste plastics is less than coke, use of plastics waste reduces the raw material cost. Use of plastics waste also reduces the ash generation, ensuring cleaner operation. There are varieties of low-end plastics waste, whose cost is lower than coke. Basically, these low-end create waste management problems as the waste pickers find it unviable to pick up those for normal mechanical recycling. With the utilization of all types of low-end plastics waste in the blast furnace, the waste management problems can be solved to a great extent. When plastics are used together with coke, CO_2 emission is significantly less (30%) than when only using coke. Furthermore the blast furnace slag can be used as cement and road material. Also the excessive reducing gases are also used for blast furnace stove and power generation.

8.3.3 Co-incineration of Plastics Waste in Cement Kilns

Keeping in view the problems associated with the disposal of plastic waste, CPCB initiated a study on “Co-incineration of plastic waste in cement kiln” in collaboration with Indian Centre for Plastics in the Environment (ICPE), MP Pollution Control Board and ACC Ltd. Co-incineration refers to the usage of waste materials as alternative fuels to recover energy and material value from them. The temperature in the cement kiln process is about 1400^0C. Excess level of oxygen and counter flow operation with the flue gases moving in a direction opposite to the materials lends a high degree of turbulence to the process. The presence of an alkaline reducing environment (lime) and the pre-heating of the raw materials by a pre-heater tower (>100 meter tall) acts as an ideal scrubber for hot flue gases before they are emitted into the atmosphere. The 3Ts- Time, Temperature and Turbulence in cement kilns provides extremely high destruction removal efficiency (DRE) for the plastic wastes. Co-incineration leaves no residue as the incombustible, inorganic content of the waste materials are incorporated in the clinker matrix. Therefore, after the waste is co-incinerated, it becomes a part of the product. Co-incineration ranks higher on the waste disposal hierarchy and eliminates the need for landfills and incineration.

At ACC Ltd, Kymore trial run of plastic waste was carried out in association with stakeholders. During the trial run 1.5% plastic waste was used as alternate fuel along with the coal. The average caloric value of plastic waste used was 34.34 MJ/Kg. The emission monitoring during the trial burn was carried out. The trial burn has proved to be an innocuous and ideal mode of disposal. Various parameters monitored in the trial burn also included heavy metals, dioxins and furans concentration measurements in the kiln stack. The dioxins and furans were analyzed in the reputed SGS Laboratory at Belgium. No appreciable change was observed in emissions of various pollutants when plastic waste was co-incinerated in the cement kiln. It is expected that the plastic menace of neighboring cities of Kymore plant would be put to an end by co-incineration of the same in Kymore Works.

8.3.4 Utilization of plastic waste in road construction

To address the plastics waste disposal issue, an attempt has been made to describe the possibilities of reusing the plastics waste (post-consumer plastics waste) in road construction. Central Pollution Control Board (CPCB) Delhi has published "Indicative Operational Guidelines on Construction of Polymer – Bitumen Roads for reuse of waste plastics (PROBES/101/2005-06). The document explains the method of collection, cleaning process, shredding, sieving and then mixing with bitumen for road laying. This studies was carried out by Thiagarajar college of Engineering, Madurai and the report was circulated to all the State Pollution Control Boards / Pollution Control Committees and other road laying agencies for reference.

By using this technology (plastics waste coated aggregate bitumen mix), several roads have been laid in the States of Tamil Nadu, Maharashtra , Puducherry, Kerala ,Andhra Pradesh and Goa. To evaluate the performance of the built roads using plastics waste coated aggregate (PCA) bitumen mix and also to generate data base for evolving Standards by Indian Road Congress (IRC), CPCB has instituted a study on "Performance Studies of Polymer Coated Bitumen Built Roads during 2002-2007" to Thigarajar college of Engineering, Madurai . In this report parameters suggested by Central Road Research Institute (CRRI) and Indian Road Congress (IRC) have been incorporated. Further details of each test and its comparison with the IRC Standards have also been given in this report.

Process Details

Mini Hot Mix Plant

Step. I
Plastics waste (bags, cups , thermocole) made out of PE,PP,and PS cut into a size between 1.18 mm and 4.36mm using shredding machine, (PVC waste should be eliminated)

Step II a:
The aggregate mix is heated to 165^0c (as per the HRS specification) and transferred to mixing chamber.

Step II b
Similarly the bitumen is to be heated up to a maximum of 160^0c(HRS Specification) to have good binding and to prevent weak bonding. (Monitoring the temperature is very important)

Step III:
At the mixing chamber, the shredded plastics waste is to be added over the hot aggregate. It gets coated uniformly over the aggregate within 30 to 45 secs, giving an look of oily coated aggregate.
Step IV:

The plastics waste coated aggregate is mixed with hot bitumen and the resulted mix is used for road construction. The road laying temperature is between 110^0c to 120^0c. The roller used is 8-ton capacity

Central Mixing Plant
The modified process can also be carried out using *central mixing plant*. The shredded plastics are added along the aggregate in the conveyor belt. A special mechanical device is developed which will spray the plastics inside the chamber to coat the plastics effectively. This also can be used as an alternative method
CMP helps to have better control of temperature and better mixing of this material thus helping to have a uniform coating.

8.3.5 Plasma Pyrolysis Technology (PPT)

Plasma pyrolysis is a state of the art technology, which integrates the thermo-chemical properties of plasma with the pyrolysis process. The intense and versatile heat generation capabilities of Plasma Pyrolysis technology enable it to dispose of all types of plastic waste including polymeric, biomedical and hazardous waste in a safe and reliable manner. Plasma Pyrolysis is the thermal disintegration of carbonaceous material in oxygen-starved atmosphere. When optimized, the most likely compounds formed are methane, carbon monoxide, hydrogen carbon dioxide and water molecules.

Process Technology: In Plasma Pyrolysis, the plastics waste is fed in to primary chamber at 850^0C through a feeder. The waste material dissociates into carbon monoxide, hydrogen, methane, higher hydrocarbons etc. Induced draft fan drains the pyrolysis gases as well as plastic waste into the secondary chamber where these gases are combusted in the presence of excess air. The inflammable gases are ignited with high voltage spark. The secondary chamber temperature is maintained at 1050^0C. The hydrocarbon, CO and hydrogen are combusted into safe carbon dioxide and water. The process conditions are maintained such that it eliminates the possibility of formation of toxic dioxins and furans molecules (in case of chlorinated waste). The conversion of organic waste into non toxic gases (CO_2, H_2O) is more than 99%. The extreme conditions of plasma kill stable bacteria such as bacillus sterio-thermophilus and bacillus subtilis immediately. Segregation of waste is not necessary, as the very high temperatures ensure treatment of all types of waste without discrimination.

8.3.6 Gasification

Gasification is a recycling method where waste plastics are processed into gases such as carbon monoxide, hydrogen and hydrogen chloride. These gases are then used as the chemical raw material for the production of chemicals such as methanol and ammonia. Almost all types of plastics, including those containing chlorine, can be recycled under the gasification method. This method is therefore suitable for miscellaneous plastics or plastics that are hard to sort.

In this process, the long polymer chains are broken down into small molecules, for example, into synthesis gas. The process may be fixed bed or fluidized bed gasification. In the fluidized process sand is heated to 600~800^0C at first- stage low temperature gasification furnace and plastic introduced into the furnace. Waste plastic break down on contact with the sand to form hydrocarbon, carbon monoxide and hydrogen. The gas from the low-stage

gasification furnace is allowed to pass in second-stage high temperature gasification furnace with a steam at a temperature of 1.300~1,500^{0}C to produce a gas composed primarily of carbon monoxide and hydrogen. At the furnace outlet, the gas is rapidly cooled to below 200^{0}C to prevent the formation of dioxins. The gas then passes through a gas scrubber, and any remaining hydrogen chloride is neutralized by alkalis and removed from synthetic gas. Slag is produced as a by-product, which can be utilized as raw material for civil engineering works and construction materials. There are problems in controlling the combustion temperature and the quantity of unburned gases.

8.4 SELECTION OF TECHNOLOGY

The most environmentally friendly alternative for plastic waste disposal is the process by which we can re-utilize the energy content of the polymer in an ecologically acceptable way. Presently, only plastic water and soft drink bottles are recycled by using mechanical process as presented in **Section 8.3**. The mixed plastic wastes like multi-layer plastic laminates used for packaging wafers, ghutkas (pan masala pouches), etc. with different polymer structure are not recyclable, hence, littered around the cities/towns and keep piling up on garbage heaps and become eyesore, which often chokes the sewage pipes and drains. Ultimately, it leads unhygienic conditions inside and surrounding the station area. It has been observed that these coloured laminated wastes are not lifted by rag-pickers, because collecting them is not profitable and non-recyclable therefore, lettered/thrown on the surroundings.

Based on literature survey, the various technological options for plastic waste recycling are presented in **Table 8.1**. Even though, mechanical recycling is the most preferred and accepted method for the plastic waste recycling, it only recycled the selected waste.

TABLE 8.1
COMPARISON OF VARIOUS TECHNOLOGICAL OPTIONS

Category	Method of Disposal	Merits	Demerits
Chemical Recycling	Degradation of Monomer	- About 50% recovery is possible.	- Only PET flakes are required for process. - Large scale process.
Furnaces	Blast furnace	- Process includes use of all types of plastics including laminated plastic - 30% less CO_2 emission compared to coal - Slag can be used as cement & road construction	- Substitution of plastic waste with coke is limited to 40% - The process is commercially used in developed countries - Process is in initial stage in India
Others	Gasification	- production of Synthetic gas used in chemical industry	- Release of unburned toxic gases - High initial and operating cost - Used in developed countries.
	Plasma Pyrolysis	- Cost is depend on capacity - No harmful emission	- Requires controlled conditions
	Cement Kiln	- Process all types of plastics including laminated plastic - Less CO_2 emission compared to coal	- Can replace only 15% of coal - process is on initial stage in India
	Road	- Saving of bitumen	Nil

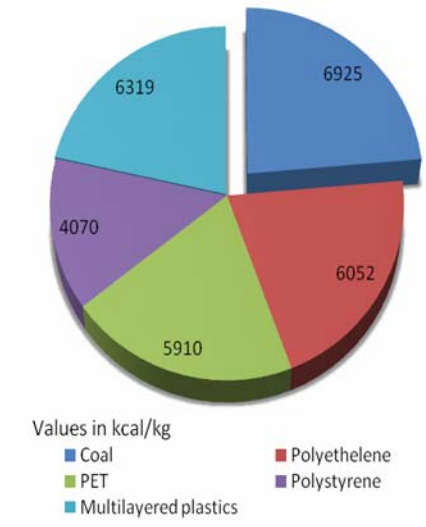
	Construction	-Better roads -Best for coastal & hilly regions	

The cost of sorting, cleaning and separating selected polymers increases the operating cost of the process. The existing mechanical recycling process may emit harmful gases such as carbon monoxide (CO), gaseous formaldehyde (HCHO), gaseous hydrochloric acid (HCL), suspended particulate matter (SPM) and respiratory suspended particulate matter (RSPM) etc. The extruders used are of old design, locally made and not have provision for pollution control. The plastic waste like laminated and carry bag are still remains the challenge for the process.

Recycling is not the complete solution for disposal of the waste plastics. After the third/fourth recycling process, the plastic is totally unfit for reuse and hence ultimately it ends up in land filling. Some types of the plastics are not suitable for recycling. However, recycling methods are only suitable for processing segregated plastic materials and is not suitable for assorted municipal waste plastic. The problems associated with the recycling process are as follows:

- Many types of plastics are used hence it is difficult to segregate them for specific purpose.
- Plastics contain a wide range of fillers & additives.
- Sorting of plastic is technically difficult as well as expensive.
- Recycling of plastic degrades the quality of the end product.

FIGURE 8.3
COMPARISON OF CALORIES



Plastic waste contains high calorific value and thus a valuable energy resource. The calorific values of different polymers meet the standards required for injection fuel in blast furnace and cement kiln industries. The comparison of the calorific values of different plastics waste is given in the **Figure 8.3** along with coal. The calorific value of plastic wastes can be utilized effectively by replacing coal. The use of plastic waste as alternative fuel will help to reduce the energy cost along with reduction in the CO_2 emission. Production for 1 ton of cement produces 0.6 to 1 ton of CO_2. With the use of plastic waste of 11 tons generated from the Airport and Railway station can reduce same amount of the CO_2 emission. 1 million tons capacity cement plant can consume about 10,000 MTs to 30,000 MTs of plastics waste annually[20]. Also 3 million tons per annum capacity steel plant can use up to 0.6 million tons of plastics waste per annum[21]. Furthermore, with replacing plastic wastes as auxiliary fuel with coal in blast and cement kiln also saves the natures valuable resources. Hence, they are two viable options for disposal of plastics waste as mentioned below :

(i) Utilization of Plastic Waste in road construction;
(ii) Co-incineration of Plastic Waste in Cement Kiln.

[20] ICPE Newsletter Vol. 4, Issue 2, April-June 2006.
[21] ICPE Newsletter Vol. 6, Issue 1, Jan-March 2008.

8.5 EXTENDED PRODUCER RESPONSIBILITY (EPR)

A new waste management policy is gaining popularity in Europe because it saves tax payers money and is significantly better for the environment and public health. Extended Producer Responsibility (EPR) also called “Producer Takeback” is a product and waste management system in which manufacturers take the responsibility for environmentally safe management of their product when it is no longer useful or discarded. This is an absolutely essential policy whereby the producers of products must be made financially, physically and legally responsible for their products. The principle of “Extended producer responsibility” requires continuing accountability on producers over the entire life-cycle of their products. The aim of EPR is to encourage producers to prevent pollution and reduce resource and energy use at each stage of the product life cycle through changes in product design and technology. Producers will thus have a financial incentive to design their products with less hazardous and more recyclable material. The successful example of EPR implementation is in Germany which shows reduction in consumption of packaging fell from 40% (by volume) to 27% by reducing the use of plastic packaging, significant design changes in the process and development of new technologies[22].

8.6 EPILOGUE

A comparison of the various technological options as described in **Table 8.1** reveals that the plastics recycling concept is not so far acceptable option because it cannot give complete solution to disposal. Hence, the complete solution to the 100% disposal of plastics waste can be achieved through burning of plastics waste in blast furnace and cement kiln as alternative fuel. The high flame temperature in cement kiln and blast furnaces ensures complete destruction of harmful pollutants. Furthermore, processes shall be useful for all types of plastic resins (unique/mixed polymer) and hence sorting of plastic waste is not required, which will reduce the operation cost of process. The above prefer technological options succeed only if an efficient plastic waste collection system has been work properly at first instant. The scientific disposal of plastic waste requires healthy management, for which some recommendations based on the observations made during the study are presented in **Chapter 9**.

[22] Clean Production Action, Beverley Thorpe (www.zerowaste.org)

CHAPTER-9

CONCLUSION AND RECOMMENDATIONS

9.1 CONCLUSIONS

Due to rapid pace of urbanization there is an increasing demand of transport specially in railways and airport sectors. In these sectors passengers are handled at Railway stations and Airports. There are several environmental challenges; one of these is waste management specifically plastic waste management at these sectors. Environment issues regarding plastic waste arise predominately due to the throwaway culture and lack of waste management system. Inadequate resources, in-appropriate technologies, management apathy and low efficiency of system are unable to give fruitful results. Undoubtedly, it is the habit of people and lack of infrastructure for management of solid waste. Problems have been identified in the collection, transportation and disposal system along with the quantified plastic waste at railway stations and airport. The existing policies have not been able to provide any respite solution for associated problems. RITES, has identified various sources along with assessed quantities of plastic waste at Railway and Airport and suggested the following recommendation:-

9.1.1 Railway Stations

The sources of plastic waste generation at stations are identified and these are: Platform Vendors, Offices at station, Pantry cars, waiting/ retiring rooms, Dustbins, Rag-pickers/ Kabadis. The existing waste management system at railway station has several short-comings, hence the waste management system needs complete reorganization, with a clear definition of roles and responsibilities. Some of the conclusion drawn from experienced gain and lesson learned are as follows for railways.

- Indian Railways is carrying about 6,000 million passengers every year in the country. In Delhi 522 trains are originating from the three stations under study namely Hazarat Nizamuddin, Old Delhi and New Delhi. The total number of passenger served at these stations are about 7,25,000 per day. There are 42 platforms and 146 vendors at these stations to meet the passenger's requirements. 36 trains on these stations have pantry cars. The solid waste generation at these stations is about 4 tones, 8 tones and 11.25 tones respectively. There are 460 dustbins to store the waste at stations.

- The quantity of plastic waste generation at Hazarat Nizamuddin station is 972 kg, at Old Delhi station is 1428 kg and at New Delhi station is 4,358 kg. Out of total quantity the value added plastic is 119 kg, 337 kg and 1508 kg respectively. The per capita plastic waste generation at H. Nizamuddin, Old Delhi and New Delhi is 7.8 gm, 9.5 gm and 9.7 gm respectively.

- The plastics waste has been collected by both formal and informal system but an informal system (rag-pickers) is also collecting illegally the value added plastic waste i.e., water bottles and soft drink bottles. However plastic carry bags and multilayered metalized plastic pouches are not collected by them.

- No separate dustbins for biodegradable and recyclable waste have been provided, therefore non value added plastic waste like packaging materials and multilayered metalized plastics finds their way to landfill along with garbage without getting segregated at any point upto disposal.

- The percentage of plastic in solid waste is ranging between 20%-30% with respective locations as compared to 5-9% in Municipal Solid Waste, in general. This variation in percentage is due to present social culture of the people and increasing use of plastic packaging products at stations.

- The value added plastics (water and soft drink bottles) collected by informal sector and being recycled in PET recycling units. At recycle unit, plastic bottles are shredded, melted in reactors at 260^{o}C and baled in to the final product. The final products in the form of fibers are going by carpet manufacturers.

- The various technological options reuse/recycle/disposal of plastics waste are reviewed and most environment friendly and economical viable disposal processes are suggested. The existing laws, legislations and standards prescribed only for the segregation and processing.

9.1.2 Airport

The present practices of plastic waste disposal at airport include terminal vendors, air caterers, restaurants and dustbins. The plastic waste including solid waste is collected by SPML. Based on study the conclusions are

- Indira Gandhi International Airport (IGIA), New Delhi is the busiest airport in South Asia and carrying 60,326 passengers per day. There are three terminals (1A, 1B and 1C) at domestic airport and one terminal (Terminal II) at International airport. The quantity of solid waste generated per day is about 14 tones. There are 283 dustbins to store the waste at Airport.

- Recyclable and non recyclable Municipal solid waste at airport has been collected by private contractor having responsibility of manage all waste from its generation to disposal. And hence, the generated waste finds way in the chain of waste management system.

- Domestic airport is generating about 2,666 kg, out of which 2,139 kg is value added plastics generating from various sources. The quantity of plastic waste generated at International airport is 1,523 kg. Out of quantity 1,231 kg is value added plastic generated from the sources. Hence total quantity of value added plastic is 3,370 kg. However the per capita plastic waste generation at domestic and International airport is 70 gm and 68 gm respectively.

9.2 RECOMMANDATIONS

It can be said that waste management shall not be the sole responsibility of local government and developers, infact it requires the involvement of all concerned stakeholders. Based on the observations made during the study, recommendations have been made which will help in formulating policy making, planning and management of plastic waste at railway stations and airports across the country.

9.2.1 Railway Stations

1) The entry of rag-pickers at railway stations shall be restricted, however, They can be included in the main stream of waste management system as per norms of railway authorities. The waste collection, segregation transport and disposal shall be privatized to some specialized agency.

2) Separate dustbins system should be adopted for biodegradable and non-biodegradable waste. Railways may keep vigil on waste generating/managing organizations and consider penalties for plastic littering.

3) Plastic recycling industry is needed to upgrade the technology for better products and the products should be labeled with the plastic identification code to help in sorting and collection as per IS 14535: 1998.

4) Reuse of plastic as in cement kilns and utilization in road construction could be the best option, as it is free from pollution and mixed plastic waste can be processed easily.

5) Massive public awareness programs with the help of NGO's will have to be launched on war footing against littering, segregation and disposal of plastic waste.

6) There is need to use biodegradable plastic bags in place of plastic bags, thus. Use of plastics products can be reduced.

7) An independent Waste Management Cell (WMC) could be set-up to look-after solid and plastic waste management.

9.2.2 Airport

- Recyclable waste material should be separated from food waste and other biodegradable waste at source itself by adopting two bin systems. The maximum quantity of plastic waste is being generated by air caterers; hence use of plastics as packaging material should be reduced.
- Plastic wastes should be disposed in cement industry or utilized in road construction. Training programs may be initiated for optimum management of plastic waste collection, transportation and disposal systems.

- The existing laws, legislations and standards are for processing and segregation. Law shall be acted for plastic waste overall management and fines on improper disposal.

Annexure 3.1

Distribution of Dustbins at Railway station

Sl No	Railway station	Platform	Number of Dustbins	Remarks
1	H. Nizamuddin	Platform-1	07	
		Platform-2&3	12	
		Platform-4&5	13	
		Platform-6&7	10	
		FOB	09	
		Offices	05	
		Total	**56**	
2	Old Delhi	Platform-1&2	11	
		Platform-3,4,5&6	22	
		Platform-7,8,9&10	35	
		Platform-11,12,13&15	20	
		Platform-14,,16&17	14	
		Platform-18	9	
		Near Comsume Hotel	3	
		Total	**114**	
3	New Delhi	All Platforms	290	During field study in the month of October 2008, the dustbins were lifted for security purpose. Hence the exact locations of dustbins had not been identified.
		Total	**460**	