Final Report

Sustainable Bioenergy Solutions for Tomorrow (BEST) – Case India: Madhya Pradesh, Maharashtra and Tamil Nadu

Deliverable 3.1.5

Plan for bioenergy and biomaterial loops in the future Indian cities

Key Activity: Design of Bioenergy Systems for Indian Cities

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1.1 Background

Bioenergy Solutions for Tomorrow (BEST) – India is a joint research program of Cluster for Energy and Environment (CLEEN) and Finnish Bio-economy Cluster (FIBIC) aiming at cooperation across traditional business area boundaries. The overall target of BEST is to build a solid common understanding of the future bioenergy business opportunities as well as the necessary know-how and capabilities for seizing them. Bioenergy is a key element of bio-economy, which plays a central role in shifting towards truly sustainable society. Bioenergy can also be considered one essential element in the future sustainable energy system. Based on these drivers, the BEST program builds on the world-class strengths of the Finnish forest, energy and technology sectors.

The concepts and technological solutions developed in this program will provide the participating companies tools for increasing their competitiveness and creating new business opportunities. The built common intelligence will facilitate the program partners to cooperate as a bioenergy ecosystem, and as one central outcome, a roadmap for successful Finnish bioenergy business will be created. This is expected to create global opportunities for exporting complete concepts or technological solutions as well as to enhance the capability of Finnish actors to influence the discussion on e.g. the sustainability and regulation of bioenergy.

The University of Eastern Finland (UEF) partnered with TERI to conduct feasibility study for urban waste based Combined Heat and Power (CHP) plants in 6 cities of India.

1.2 Objectives of the Study

- To conduct feasibility analysis for urban waste based CHP plants in Thane and Pune districts of Maharashtra; Indore and Bhopal of Madhya Pradesh; and Chennai and Coimbatore of Tamil Nadu.
- To understand volume of urban waste generation from different sources in each of the cities
- To collect data related to municipal solid waste management from municipal authorities

1.3 Study Details

1.3.1 Methodology

In accordance with the objectives, field surveys were conducted to collect primary data. A synthesis approach was adopted for the study in addition to field surveys to validate the primary data. A substantial amount of secondary data and information from reliable sources

such as government departments, agencies and research papers or reports were used to prepare this report.

Quantitative surveys with urban households, key informant at whole sale markets, restaurant managers, transporters and municipal authorities were conducted at each of the study cities.

1.3.2 Target Groups

- **Households:** Multi-storied residential building, Single storied residential building, Semi-structured building, Wooden or metal railing house and Hut
- **Market:** Vegetable or fruit market, Meat or chicken market, and Fish market
- **Restaurant:** Large, Medium and Small size restaurants
- **Waste transporters**
- **Municipal authority**

1.3.3 Selection of Respondents

Different approaches were adopted for selection of respondents in each target group of respondents.

From North, South, East and West directions of each of the study cities a few localities were randomly selected for the household survey. After reaching the selected locality, the Supervisor of the field team first used to collected information about approximate number of households in the locality based snowballing technique. Then Investigators were used to be provided the sample quota for the day by the Supervisor. Investigators used to approach households based on convenience for interview in the selected locality.

Market survey component was conducted at randomly selected shops in whole sale markets. From city dwellers, information was collected about restaurants before the survey. Category wise names were collated. Randomly selected restaurants were approached for the survey as per convenience.

Apart from discussion with officials at municipalities of the study cities, secondary sources such as Urban Local Body websites, City Development Plans, important government reports published under Jawaharlal Nehru National Urban Renewal Mission (JNNURM), etc. were frequently referred.

1.3.4 Research Instruments

Structured questionnaires were developed for each of the target groups. Tools were translated into Hindi, Marathi and Tamil to conduct the pen-paper based survey. Before finalising the tools, pre-testing was conducted in rural areas of Uttar Pradesh. In each state, bilingual tools were used for the survey.

1.3.5 Summary of Coverage

In the survey 3 states were covered namely, Maharashtra, Madhya Pradesh and Tamil Nadu. From each state, 2 cities were selected for the survey. The target group wise sample size was different. The table below shows target group wise sample size (targeted) for each study city. Due to some field level challenges, non-response, no consent or non-availability achieved sample size was less in a few cases. In the sub-sequent chapters along with analysis the number of respondents (N) is given for each table or chart.

Table 1.1 Target group wise sample size

S. No.	Sample Size	Madhya Pradesh		Sub Total	Maharashtra		Sub Total	Tamil Nadu		Sub Total	Total
		Bhopal	**Indore**		**Mumbai**	**Pune**		**Chennai**	**Coimbatore**		
A.	**H.H Survey**										
1	Multi-storied building with flat system	50	50	100	50	50	100	50	50	100	300
2	Single-storied building	25	25	50	25	25	50	25	25	50	150
3	Semi-structured building (brick wall without concrete roof)	25	25	50	25	25	50	25	25	50	150
4	Wooden/Metal railing house	10	10	20	10	10	20	10	10	20	60
5	Hut (slum house)	5	5	10	5	5	10	5	5	10	30
	Sub – Total	**115**	**115**	**230**	**115**	**115**	**230**	**115**	**115**	**230**	**690**
B	**Market Survey**										
1	Vegetable/ Fruits Mandies	3	3	6	3	3	6	3	3	6	18
2	Meat / Chicken Markets	3	3	6	3	3	6	3	3	6	18
3	Fish Market	2	2	4	2	2	4	2	2	4	12
	Sub – Total	**8**	**8**	**16**	**8**	**8**	**16**	**8**	**8**	**16**	**48**
C	**Restaurant**										
1	Large	2	2	4	2	2	4	2	2	4	12
2	Medium	2	2	4	2	2	4	2	2	4	12
3	Small	4	4	8	4	4	8	4	4	8	24
	Sub – Total	8	8	16	8	8	16	8	8	16	48
D	**Transporters**	**2**	**2**	**4**	**2**	**2**	**4**	**2**	**2**	**4**	**12**
E	**Municipal Authority**	**10**	**10**	**20**	**10**	**10**	**20**	**10**	**10**	**20**	**60**
	Sub – Total	**12**	**12**	**24**	**12**	**12**	**24**	**12**	**12**	**24**	**72**

Total	**143**	**143**	**286**	**143**	**143**	**286**	**143**	**143**	**286**	**858**

1.4 Field Work and Data Processing

1.4.1 Team Composition and Duration

With a target to complete the fieldwork within 10 days in each district, the survey agency deployed 6 field staff. Each field team consisted of 5 Investigators and 1 Supervisor. The Supervisor's role was to supervise the Investigators and perform random spot checks for ensuring accuracy and data quality. Each field team was managed by a local Field Manager.

During the initial days of fieldwork the field teams faced severe challenges as many households were not able to respond properly in the quantified way. In many cases such as data about fallen leaves, approximate figures were given by the respondents. The survey timing was between 9 AM to 5 PM. Survey teams used public transport to reach at the selected study areas.

1.4.2 Recruitment and Training

Field personnel from Madhya Pradesh, Maharashtra and Tamil Nadu, who were well conversant with the local dialect, were recruited for conducting the survey. Investigators who were at least graduates with the experience of conducting social and market research studies were selected for this survey.

Training of 2 days was organized by at each state. Besides the study tools, investigators were also informed about the study objective and the right way of capturing data. Besides, field investigators were also given hands on training to operate GPS devices for capturing geo-coordinates during the fieldwork. In addition to classroom lectures by researchers, training participants were trained using mock calls and role plays.

1.4.3 Quality Control Mechanism

The quality control mechanism followed during the study comprised of the following:

- Proper and adequate training to all the field investigators and supervisors irrespective of their prior experience
- 50 % back check by supervisors
- Daily team de-briefing meeting after the day's field work to decide any course corrections, if required
- Random field visits by the Research Manager and Field Managers of survey agency also by the researchers of TERI or UEF

1.4.4 Data Processing

Filled in questionnaires from the study sites were dispatched to the survey agency Headquarters in Delhi for data entry using CS Pro, cleaning and analysis. While entering the collected data, double data entry of at least 20 % of the collected data was ensured.

Final analysis was done using SPSS. Cross-tabs were generated from the quantitative data. Charts were prepared with the help of the collected quantitative data for graphical representation of some of the findings in the report.

1.5 Urban Waste Assessment in Maharashtra

1.5.1 State Profile

The state of Maharashtra is widely known for its capital Mumbai (erstwhile Bombay) which is not only the commercial capital of India and one of the most populous cities in the world. Maharahtra is located in western part of the country and it lies in between $15^0 35'$ N to $22^0 02'$ N latitude and $72^0 36'$ E to $80^0 54'$ E longitude. It spreads over 307,713 km^2, which is about 9.4% of the total geographical area of the country.

The state shares its boundaries with Gujarat and Madhya Pradesh in the north, Chhattisgarh in the northeast; Karnataka and Andhra Pradesh to its south. Besides, the state also shares a long cost line along the Arabian Sea.

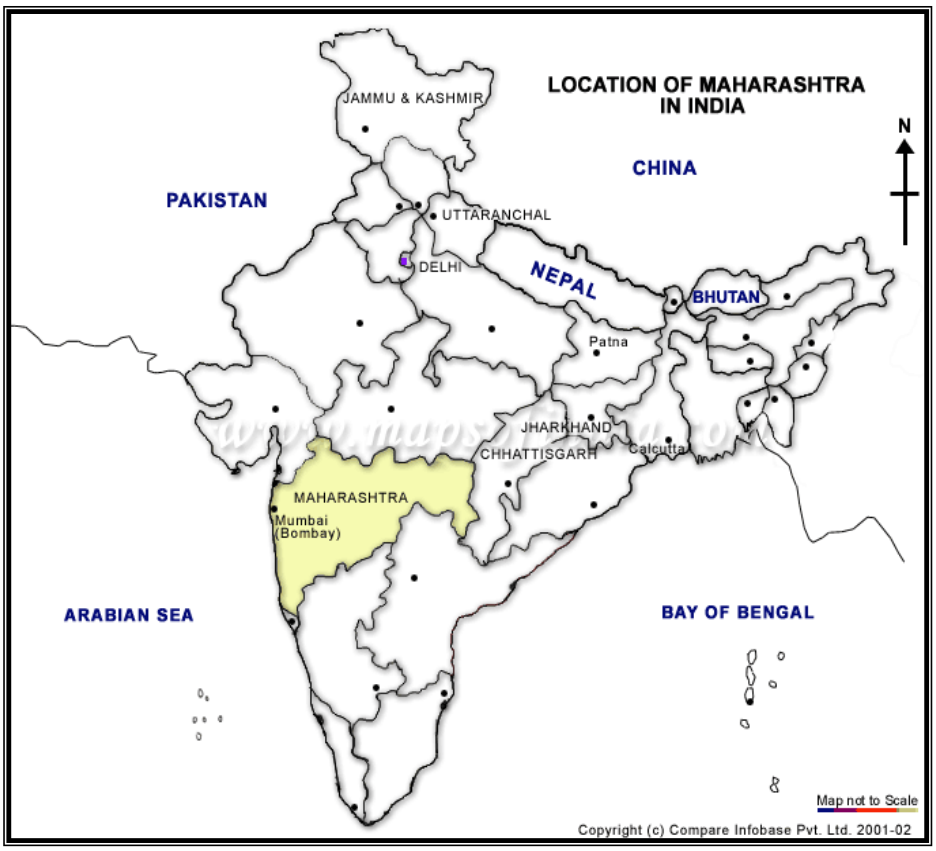


Figure 1.1 Location of Maharashtra

Source: http://www.beachesofindia.com/images/maharashtra-location-map.gif

Maharashtra is the second largest state of India both in terms of geographical area and population. It has 35 districts divided into six divisions. Maharashtra is a highly urbanized state with 45.2 percent of the population residing in urban areas. The state can be divided into 5 distinct regions in terms of its geography and topography, namely Deccan Plateau, Central Highlands, Eastern Chhotanagpur Plateau, Western Ghats and Coastal Plains. Major rivers of the state are Krishna, Godavari, Bhima, Tapi-Purna, Wardha-Wainganga. The state has a tropical monsoon climate with mean annual temperature ranging between 25^0 C and 27.5^0 C, and mean annual rainfall between 1600 mm and 2000 mm.

The table 1.2 below shows that geographic area of Maharashtra is around 30,771,000 hectare, whereas forests cover around 5,214,000 hectare land and net sown area is around 17,475,000 hectare. Around 16% and 57% are covered by forests and net sown area respectively.

Table 1.2 Demographic and economic indicators in Maharashtra (year 2011)

Sl. No.	Indicators	Unit	Maharashtra
1	Geographical Area	Thousand Hectare	30,771
2	Forests	Thousand Hectare	5,214
3	Net Sown Area	Thousand Hectare	17,475
4	Population	Crore	11.23
5	Decadal Growth Rate	Percentage	16.00
6	Density of Population	Population/Sq. Km.	365
7	Gross State Domestic Product (GSDP)	Crore Rupees (current prices 2011-12)	1,199,548
8	Per Capita Income	Rupees	95,339

(Source: Economic Survey 2012-13, Maharashtra)

The state boasts of one of the best infrastructure in India *(Source: Economic Survey 2012-13, Maharashtra)*:

- **Roads:** Total road length in the state, as on March 2012, was approx. 2.45 lakh km. More than 99 percent of the villages are connected by all-weather roads and fair-weather roads.
- **Railways:** Total length of the rail network in the state, as on March 2012, was 5,984 km.
- **Water Transport:** The state has a 720 km long coast line having two major ports i.e. Mumbai Port Trust and Jawaharlal Nehru Port Trust.
- **Airports:** There are four international airports in the state in Mumbai, Nagpur, Pune and Aurangabad and five domestic airports.

- **Power:** State has highest installed capacity and generation of electricity in the country. The installed capacity as on March 2012 was 32,505.98[1] MW, with thermal power contributing to more than 50% of the total capacity.

[1] http://www.cea.nic.in/reports/monthly/inst_capacity/dec13.pdf

1.5.2 Profile of Pune City

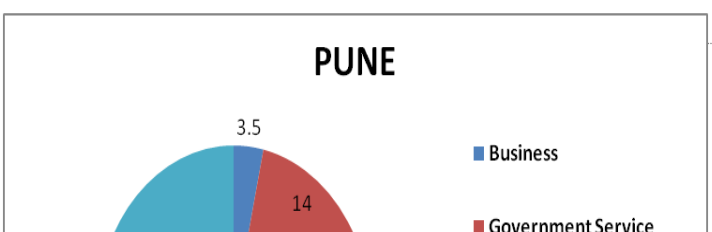
Pune is one of the most renowned places in Maharashtra. Over the years it has emerged as a major hub of business and economic activity. Pune boasts of a number of quality educational institutions and industries. In 1987, the urban area of Pune was 138.36 sq. km. with an addition of 23 villages in 2001; the area has increased to 243.84 Sq. Km.

The population of Pune city as per Census 2011 is more than 3 million which has grown by more than six times in the last 60 years. Migration has increased almost double from 370,000 in 2001 to 660,000 in 2011. Population density has increased from 10405.28 person per sq. km in 2001 to 12,770.25 person per sq. km. in 2011.

In the urban household survey, 12 localities in Pune city were covered and total number of households covered was 115 as shown in the table below (Table 1.3). Around 18.3% respondents in the household survey were from Vadgao and 17.4% were from Shivaji Nagar area of Pune. *(Source: City Development Plan for 2041, 2012)*

Table 1.3 Coverage of household survey in Pune city

Locality	Coverage
Vadgao	21
Budhavarpeth	13
Khadka Road	10
Sangamwadi (Tadiwala Road)	7
Shukrawaripeth	6
Ladkwadi	14
Shivaji Nagar	20
Gokhale Nagar	14
Indiralok Society	7
Hingnekarwada	1
Jogeshwari Society	1
Shandi vishnu Krupa Nagar	1
TOTAL (N)	**115**



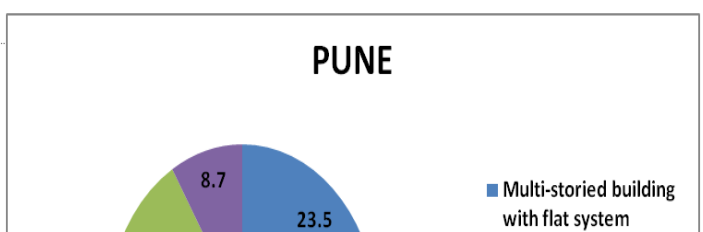


Figure 1.2 Percentage of respondents by occupation in Pune (N=115)

Figure 1.3 Distribution of type of households covered in Pune (N=115)

During the household survey in Pune, all the urban households reported to have electricity connection, LPG connection or supply, water supply, connection with waste water outlet and dust bin in the locality. However, only 20% reported that municipality had provided baskets for waste disposal at household level. LPG is the primary cooking fuel for all the urban households in Pune city covered in the survey. All the respondents in the household survey said that generating power from waste is the right option to tackle urban waste challenges.

1.5.3 Waste Generation and Management in Pune City

In Pune city, the total bulk of solid waste generation per day is estimated to be 1,374.3 MT. At present, different types of waste in the city (such as municipal waste, biomedical waste, construction debris, industrial waste, hotel waste, etc.) generated and disposed as per Municipal Solid Waste (Management and Handling) Rules, 2000. But Pune Municipal Corporation (PMC) does not follow any scientific disposal for e-waste and Construction & Demolition waste. Waste from different parts of the city is transported to landfill site located about 20 km away from Pune at Devachi Uruli. Extent of segregation of waste is only 27.96% against the Ministry of Urban Development's benchmark of 100%; while the household level coverage of SWM services is 52.7%. *(Source: City Development Plan for 2041, 2012)* .
According to the municipal staff, there is waste management committee existing at ward level. There are 1200 bins placed in municipal area for primary collection of waste. The interview of PMC regarding waste transportation revealed that it uses hired 40 tonnes capacity trucks for waste transportation. Total cost spent on waste transportation is around Rs 4000-5000 per trip which is comprised of Rs 500 per trip as cost for driver and cleaner and Rs 500-800 per trip as cost for loading and unloading the waste. Rs 1000 per trip being the variable cost average fuel (diesel) consumption being 4 litres per km for transporting 40 tonnes of waste. Productivity of the trucks is reported to be 10 tonnes per hour. Reported diesel consumption is 30 litres per hour and transportation generates 400 hours of employment. On an average these trucks make 150-180 trips on annual basis. The staff at PMC agreed that present waste management needs improvement and there is important challenge for municipal authority. There is role

NGOs/private sector to improve waste management services. They also agreed that waste to energy projects can improve solid waste management in the city and government should provide support to promote such projects.

According to the primary survey, per household daily waste generation is estimated at 690 gm of biomass (wet/ fresh) and 250 gm of non biomass based waste.

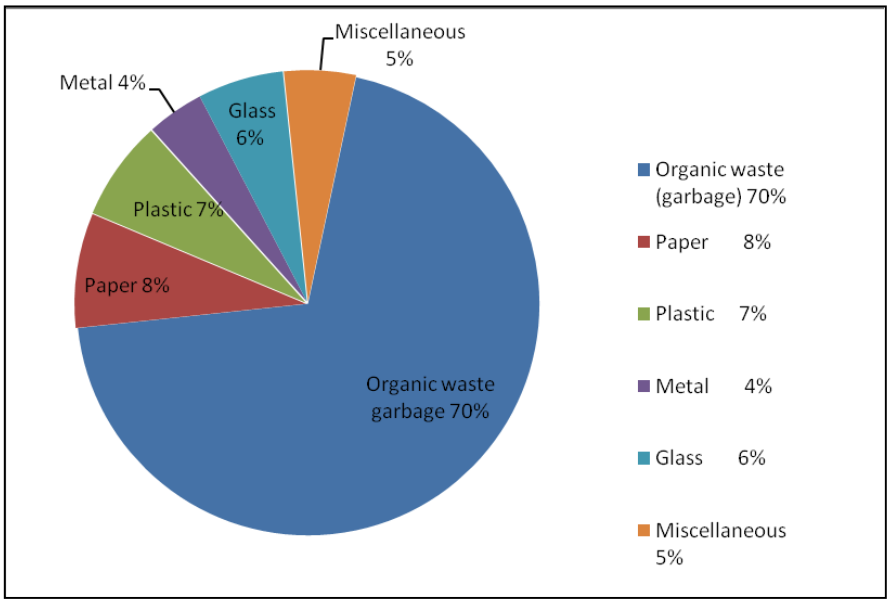


Figure 1.4 Waste characteristics in Pune city[2]

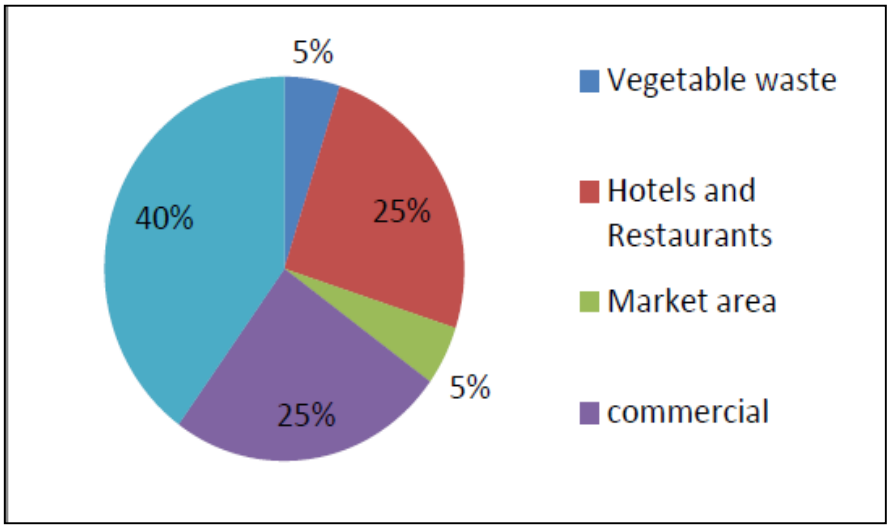


Figure 1.5 Source wise waste generation in Pune[2]

[2] and [2] Mane T T, Hemlata N. (2012). Existing Situation of Solid Waste Management in Pune City, India

1.5.4 Status of waste-to-energy projects in Pune

As per the information provided by PMC, its pioneering initiative has been to set up 20 biomethanation-cum-power generation plants with total capacity of 98 tonnes per day (TPD)~~:~~ of which 13 plants have the ~~of~~ capacity of 5 TPD, 3 of the capacity of 10 TPD and 1 of the capacity of 3 TPD. The technologies were selected on the basis of competitive bidding, and operation and maintenance contracts for five years were granted to successful bidders. Transporting bio-waste is carried out to the decentralised biomethanation plants which are not too far from the location of the generation of waste. Municipal Corporation is responsible for transporting bio-waste from secondary terminals to the plant sites.

Given the waste collection efficiency of 80-90 per cent, of which 45 per cent is segregated, the PMC has allotted separate vehicles for the collection of wet waste. The wet waste to be transported to all the biomethanation plants in their decentralized locations, totals to about 300-350 tonnes per day. For each such plant, the Corporation provides 600 sq metre of land, 5000 litres daily water supply and a connection at site for electricity; both water and electricity are provided free of cost.

The waste is treated in a two-stage biomethanation process by using closed vessels where, in the absence of oxygen, micro-organisms break down the organic matter into a stable residue, and generate a methane-rich biogas in the process. This gas can then be used as a source of renewable energy to produce electricity (net surplus after own requirement) of 400 KWh per day. This is being used for street lights in the surrounding area. The solid residue is used as manure, and the aqueous liquor is a nutrient-rich fertiliser which can be used to recycle nutrients back to agricultural land.

Besides the biomethanation plants, there is provision for processing unsegregated waste.

Hanjer Biotech is operating a processing plant for 1,000 TPD of mixed waste producing RDF, manure and fuel at the old dumping site at Urali and Fursungi. The inert waste (about 20 per cent of the total waste received at these sites) is being disposed of in a scientific landfill developed by the company.

At the high end of the technology spectrum is the "non-incineration based thermal waste to energy" plant set up in a public-private partnership (PPP) model in the Ramtekdi Industrial Area. The investment of Rs 140 crore was made by Rochem Separation Systems India Pvt. Ltd, based on the patented Concord Blue gasification technology on the 2.5 acre land. The land was provided by Pune Municipal Corporation to the company on a lease-rental basis. This state-of-the-art technology processes unsegregated waste to produce energy, fulfilling the requirements of the US EPA and European standards with regard to emissions.

Syngas (synthesised gas) is produced from unsegregated waste, which is a combination of biodegradable and non-biodegradable components. This is done by a thermal process of heating in complete absence of oxygen followed by reformation of the produced gas, which leads to a clean hydrogen rich gas that is being utilised for power generation.). Unlike biogas which is produced from a biological activity of bacteria breaking down only the biodegradable component of the waste, syngas is produced from a thermal process and hence is a solution

for the complete spectrum of solid waste not including inerts. Also, syngas is rich in hydrogen, making it one of the cleanest fuels, unlike biogas which constitutes about 50% methane.

Looking at capacities already allocated to waste-to-energy projects in Pune, there is no additional capacity requirement if all these projects are successful in long run.

1.5.5 Profile of Thane City

Thane is located adjacent to southern Mumbai. The name comes from an anglicization of Shri Sthanak, its earlier name based on a temple of Ganesha. Thane city also known as 'the city of lakes' is the administrative headquarters of Thane district. Thane covers an area of 147 km^2 and has a population of more than 1.8 million within its municipal limits, according to the 2011 census. Thane comes under Mumbai Metropolitan Region and also the proximity with Mumbai has made it culturally a part of it.

In the urban household survey, 13 localities in Thane city were covered and total number of households covered was 117 as shown in the table below (Table 1.4). Around 19% respondents (22 households) in the survey were from Parashwadi (Kopri Colony).

Table 1.4 Coverage of household survey in Thane city

Locality	Coverage
Kisan Nagar	14
Wagle Estate	7
Shastri Nagar	14
Samar Khar	5
Maytri Park	6
Shivai Nagar	7
Gulmohar Apartment (Vartak Nagar)	7
Nehru Nagar (Vartak Nagar)	8
Vinayak Society(Vartak Nagar)	10
Sharam Vihar Society (Vartak Nagar)	2
Kodiyar Apartment (Vartak Nagar)	1
Parashwadi (Kopri Colony)	22
Dhobighat (Kopri Colony)	14
TOTAL (N)	117

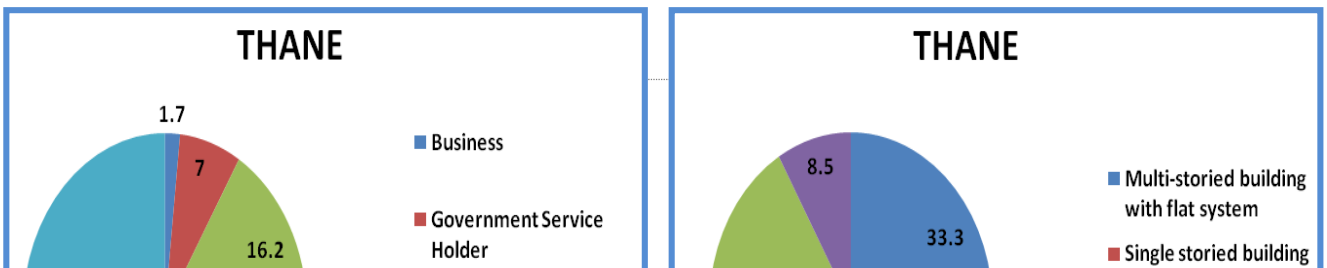


Figure 1.6 Percentage of respondents by occupation in Thane (N=117)

Figure 1.7 Distribution of type of households covered in Thane (N=117)

In Thane primary survey, all the urban households reported to have electricity connection, LPG connection or supply, water supply, connection with waste water outlet and dust bin in the locality. However, no respondent reported that municipality had provided baskets of waste disposal at household level. LPG is the primary cooking fuel for 95% households covered in Thane city. Remaining 5% reported to kerosene to be the primary cooking fuel. All the respondents in the household survey reported that energy generation from waste is a good option.

1.5.6 Waste Management in Thane City

According to Thane Municipal Corporation (TMC), waste collection efficiency of the municipality is around 96%. Total daily solid waste generated in TMC territory is around 704 metric tonnes, with a per capita generation of 380 gm. Whereas the waste dumped is 679 metric tonnes (MT) per day.

For solid waste collection TMC has deployed vehicles like dumper placers, ghanta gadi (vehicle with a bell) and rickshaws (tricycles). The solid waste from each collection point is brought to the dumper placers and other collection vehicles. From here the waste is moved to specified areas, weighed and lastly disposed at open dumping site. As per the City Sanitation Plan report for the city, around 90% households are covered with solid waste related services.

Wet waste from vegetables-fruit market, hotels and segregated wet waste from municipal solid waste accounting to 20 MT per day is treated by TMC by bio-methanation process. It is proposed to create a scientifically designed landfill site at Diaghar. *(Source: Environmental Status Report for TMC, 2012).* In addition, 4 projects with the capacity of 2 TPD each are also planned in different parts of the city. Thus additional capacity of generation of 2 MW of power still exists with the city's waste. Preferred option as indicated by residents to Municipal Corporation would be biomethanation.

Based on the primary household survey it can be said that in Thane city each household on an average generates around 670 gm of biomass (wet/ fresh basis) based waste and approximately 240 gm of non-biomass based waste daily. According to municipal staff, TMC uses hired

trucks/dumper placers with a capacity to carry 2 to 2.5 tonnes of waste per trip. Reported average distance covered by garbage vehicles on daily basis is around 5 to 8 km and average trips made on yearly basis are 111,600. The annual transport contract signed by TMC with the contractor for last year was Rs 93,726,420. In addition to this tonnage, there is larger trucks also used handling around 36 and 45 tonnes of waste to haul it finally to disposal point. They make 10 and 20 collection trips every month covering average distance of 25 km and 50 km respectively. Number of trips undertaken on annual basis is reported to be 120 and 240, respectively. Daily expenses on these trucks are Rs 6000 and Rs 3500 per trip which included driver/cleaner costs (Rs 650) and loading and unloading cost (Rs 1000 and Rs 550). Variable cost for waste transportation is estimated at Rs 1200 and Rs 35 per tonnes of waste hauled and average diesel consumption is reported at 5 litres per hour. Per day wages paid for the purpose come to round Rs 400 with an average productivity of around 20 tonnes per hour. The tonnage productivity is reported at 35 tonnes per litre diesel. Loading of waste in 155 belled trucks is done manually and around 600-650 tonnes of waste is handled on the daily basis. Wages pain on daily basis is reported at Rs 277.66.

The staff at TMC agreed that present waste management needs improvement and there is important challenge for municipal authority. There is role NGOs/private sector to improve waste management services. They also agreed that waste to energy projects can improve solid waste management in the city and government should provide support to promote such projects.

1.6 Urban Waste Assessment in Madhya Pradesh

1.6.1 State Profile

The state of Madhya Pradesh is called the heart of India. The state is located exactly at the centre of the country. It is the one of the largest states in terms of area with coverage of 3,08,245 sq. km., around 9.4% of geographic area of the country. Its geographic coverage lies in between $21^0$17′ N to $26^0$52′ N latitude and $74^0$08′ E to $82^0$49′ E longitude.

The state shares its boundaries with Rajasthan and Uttar Pradesh in the north; Chhattisgarh in the east; Maharashtra in the south and Gujarat in the west.

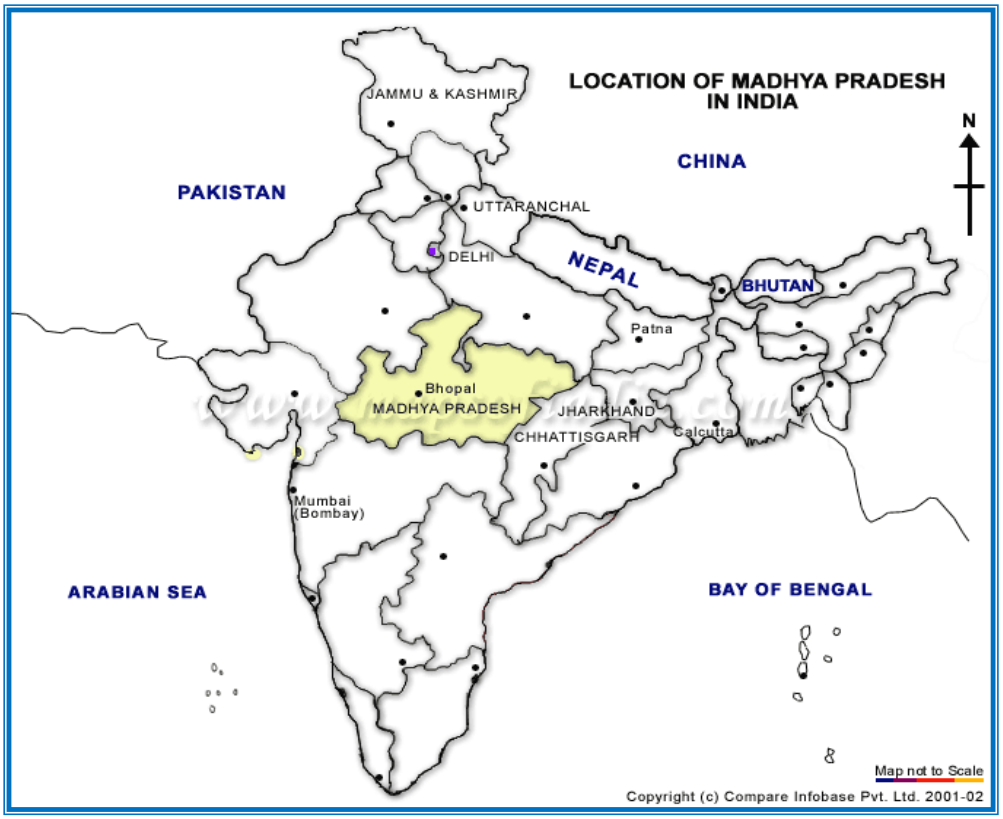


Figure 1.8 Location of Madhya Pradesh

Source: http://www.rainbowskill.com/wp-content/uploads/2008/10/madhyapradesh-location-map.gif

Madhya Pradesh is divided into 10 divisions and 50 districts for administrative purpose. The capital of the state is Bhopal. The economy of the state mainly depends on agriculture with more than 70% of the population involved in agricultural activities. The share of primary sector in the GDP of state has declined sharply from 32.5% in 2004-05 to 14.1% in 2011-12. During the year 2011-12, growth of primary sector in Madhya Pradesh is about 18% as compared to 3.08 % at all India level. Some key economic indicators for the state are given in the table 1.5 below:

Table 1.5 Demographic and economic indicators in Madhya Pradesh (year 2011)

Sl. No.	Indicators	Unit	Madhya Pradesh	India
1	Geographical Area	Thousand Hectare	30,825	3,28,710
2	Forests	Thousand Hectare	8,699	
3	Net Sown Area	Thousand Hectare	14,735	
4	Population	Crore	7.26	121.02
5	Decadal Growth Rate	Percentage	20.3	17.64
6	Density of Population	Population/Sq. Km.	236	382
7	Gross State Domestic Product (GSDP)	Crore Rupees (current prices 2011-12)	309687	
8	Per Capita Income	Rupees	37994	

(Source: Economic Survey 2012-13, Madhya Pradesh)

Madhya Pradesh has a subtropical climate. It has a hot dry summer (April–June), followed by monsoon rains (July–September) and a cool and relatively dry winter. The average rainfall is about 1,370 mm (53.9 in). It decreases from west to east because monsoon wind moves from west to east and drained clouds in western part takes less quantity of water vapours with them to eastern part. The south-western districts have the heaviest rainfall, some places receiving as much as 2,150 mm (84.6 in), while the western and north-western districts receive 1,000 mm (39.4 in) or less. Madhya Pradesh weather is markedly different in the following zones - Northern Plains, Hilly Region of the Vindhyas, Narmada Valley, Malwa Plateau, Plains of Chhattisgarh and mountainous region of Bastar.

In summer days, the mean maximum temperature rises to about 42.5°C in northern Madhya Pradesh especially at places like Gwalior. The maximum mean temperature is 40°-42.5 °C in regions around Bhopal, Sagar, Rewa, Bilaspur as well as Raigarh. The days in the month of May are usually hotter than those of June. The monsoon is a relief to the utterly hot weather in Madhya Pradesh. Temperature remains moderate till September-October. Thereafter it starts declining. This indicates the arrival of winter. Madhya Pradesh weather gets chilled in winter which attains its height in the month of December and January. The average temperature during winters is as low as 10 °C in the north, while in the south it varies from 10°-15°C.

Infrastructure in the state can be summarised below *(Source: Economic Survey 2012-13, Maharashtra)*:

- **Roads:** The state has a total road length of about 99000 km.
- **Railways:** The total length of the rail routes passing through the state is around 4950 km.
- **Airports:** There are five operational airports in the state at Indore, Bhopal, Jabalpur, Gwalior and Khajuraho.
- **Power:** The total installed power generation capacity in the state is about 12902.35 MW. Out of this, about 5572.32 MW is obtained from state sources, about 4306.81 3023.22 MW from central government facilities and the remaining 240 MW is produced by private sector.[3]

1.6.2 Profile of Bhopal City

Bhopal is the capital of Madhya Pradesh and the administrative headquarters of Bhopal district. Bhopal is known as the *City of Lakes* for its various natural as well as artificial lakes and is also one of the greenest cities in India. Area of Bhopal city is around 837.24 km^2 and according to the 2011 census its population is 1,795,648. Bhopal's population density stands at 2,575 per sq. km. The total effective literacy rate was 85.24%. *(Source: Census 2011).*

In the household survey, 14 localities of Bhopal city were covered. Although in total 130 respondents took part in the survey, around 23% were from Harshwardhan Nagar and 20% were from R.K. Colony area.

[3] http://www.cea.nic.in/reports/monthly/inst_capacity/dec13.pdf

Table 1.6 Coverage of household survey in Bhopal city

Locality	Coverage
Aradhana Nagar	4
R K Colony	26
Harshwardhan Nagar	30
Kotra	2
Naya Basera	6
Professor Colony	10
Sahjanabad	10
Sakat Nagar	10
Sanjay Nagar	6
Sarswati Nagar	2
Sewa Sadan	11
Sudama Nagar	5
T.V. Nagar	7
Vajpey Nagar	1
TOTAL	130

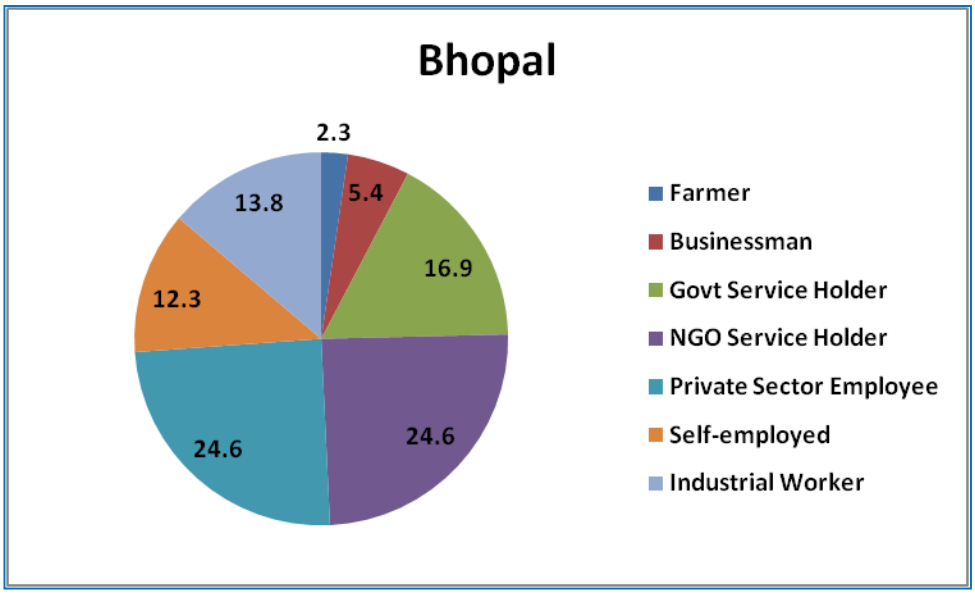


Figure 1.9 Percentage of respondents by occupation in Bhopal (N=130)

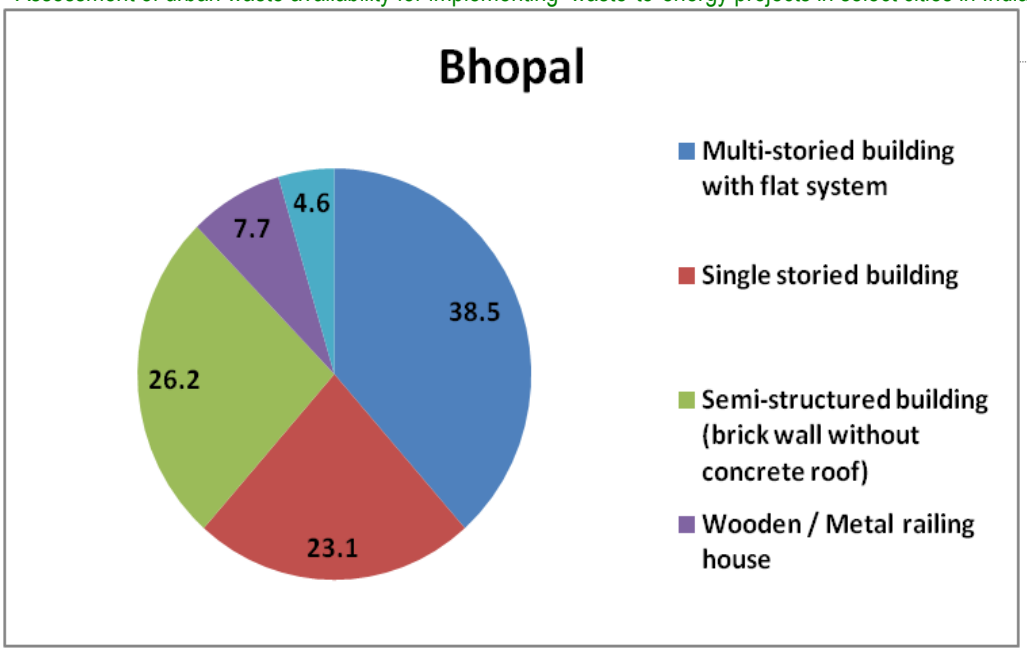


Figure 1.10 Distribution of type of households covered in Bhopal (N=130)

From the primary survey in Bhopal, it was understood that all the urban households have electricity connection or LPG connection (legally or illegally). However, around 31% reported not to get municipality water supply, 25.4% not connected with waste water outlet and around 27% reported no dust bin was provided in the locality by the municipal authority. It is interesting to note that about 17% of the respondents mentioned that municipality had provided baskets of waste disposal at household level. For around 90% households LPG is the primary cooking fuel. However, remaining 10% reported to use traditional cookstove. These are mainly from slum areas of the city. All the respondents in the household survey reported that energy generation from waste is a good option.

1.6.3 Waste Management in Bhopal City

Bhopal Municipal corporation (BMC) reported that 550MT of solid waste is generated per day in the urban area. Most waste dumped on open land or outside the containers. The BMC reports that 60% of the city area is cleaned and swept daily, 30% twice per week and 10% fortnightly. The characteristics of municipal solid waste as done in ADB assisted project is presented in table 7 below. The table suggests around 54-55% organic waste generation on an average. Waste collected from city is disposed at Bhanpura trenching ground existing landfill site that is 15 km away from New Bhopal. Almost 230 to 280 trips are made to land fill site by 77 Vehicles every day. The disposal site at Bhanpur has a waste processing plant which has been commission and run by M.P. Agro. Installed capacity of bio-fertilizer plant is 100 MT of compost per day. There is no proper access and most of the vehicles do not reach the disposal site. *(Source: Bhopal City Development Plan under JNNURM)*

As per the primary survey, in Bhopal each household generates 1181 gm of biomass (wet/ fresh) based waste and 233 gm of non-biomass based waste. As per response from Municipal Authorities, the Transport Department informed that 500 waste collection trips are made on monthly basis with average distance covered being 40 km. Average cost incurred on driver and cleaner of transport vehicles is around Rs 15000 to 20000 per month and diesel

consumption equivalent to Rs 50,500 per month. Rs 180 per day is paid as wages to contract workers.

The staff at BMC agreed that present waste management needs improvement and there is important challenge for municipal authority. There is role NGOs/private sector to improve waste management services. They also agreed that waste to energy projects can improve solid waste management in the city and government should provide support to promote such projects.

Table 1.7 Characteristics of solid waste in Bhopal

Sl No	Name of the Test	Site I Jehangirabad (Resi/ Coml)	Site II Fatehgarh (Resi)	Site III Bairagarh (Sabji Mandi)
PHYSICAL				
1	Compostable material	28%	63%	72%
2	Paper	2.9%	16%	6%
3	Plastics	2.9%	10%	6%
4	Glass and Ceramics	2.4%	1.2%	Nil
5	Earth, Stones, Bricks	30%	10%	7%
6	Moisture Content	25%	46%	58%
7	Volatile Substances	36%	44%	53%
8	Non Volatile Substances	64%	56%	47%
CHEMICAL				
9	Carbon Content	26%	27%	29%
10	Total Nitrogen	0.8%	0.65%	0.7%
11	pH	6.0	6.2	6.4
12	Potassium (K2O)	0.41%	0.48%	0.68%
13	Phosphorus (P2O5)	0.7%	0.65%	0.45%
14	HCV in Kcal/Kg	1252	1024	821
15	C/N Ratio	32.5	41.5	41.4

(Source: Integrated Urban Development in Madhya Pradesh 2011, Bhopal, ADB)

1.6.4 Status of waste-to-energy project in Bhopal

As on date, there is no waste-to-energy project operational in Bhopal. Pre-qualification bid has been floated for waste-to-energy project. The project would involve MSW collection and transportation system, waste-to-energy plant of 8 MW capacity, scientific closure of existing dump site and development of new sanitary land fill site, at an estimated project cost 350 crores. A Design, Build, Finance and Operate and Transfer (DBFOT) model would be followed for this purpose. The Concession may be for an initial period of 20 years, to be extended by another 10 at the option of the Concessionaire.

1.6.5 Profile of Indore City

Indore is not only the commercial capital of Madhya Pradesh, but also the largest city of the state. It serves as the headquarters of both Indore District and Indore Division. A central power city, Indore exerts a significant impact upon commerce, finance, media, art, fashion, research, technology, education, and entertainment and has been described as the commercial capital of the state.

Located on the southern edge of Malwa Plateau, the city is located 190 km west of the state capital of Bhopal. With a Census-estimated 2011 population of 2,167,447 distributed over a land area of just (526 km2), Indore's population density stands at 3,727 per sq. km. *(Source: Census 2011)*

In the household survey, 14 localities in Indore city were covered. Out of 126 households, about 9% were from Malwa Mill area. The table 1.8 below shows locality wise coverage in the household survey.

Table 1.8 Coverage of household survey in Indore city

Locality	Coverage
Arjun Pur	10
Chardra Bhaga	10
Jabran Colony	12
Jansewa Nagar	8
Jawhar Nagar	10
Kanchan Vihar	10
Karbala Maidan	10
Mahawar Nagar	8
Malwa Mill	11
Professor Colony	2
Rajeev Awash Vikash	10
Samajwad Nagar	9
Sekhar Pur	10
Vijay Nagar	6
TOTAL	126

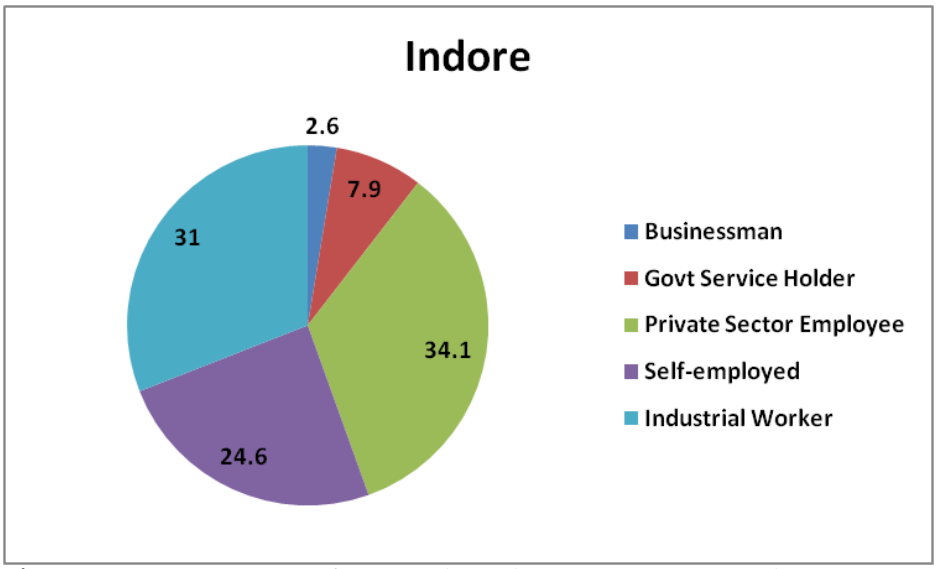


Figure 1.11 Percentage of respondents by occupation in Indore (N=126)

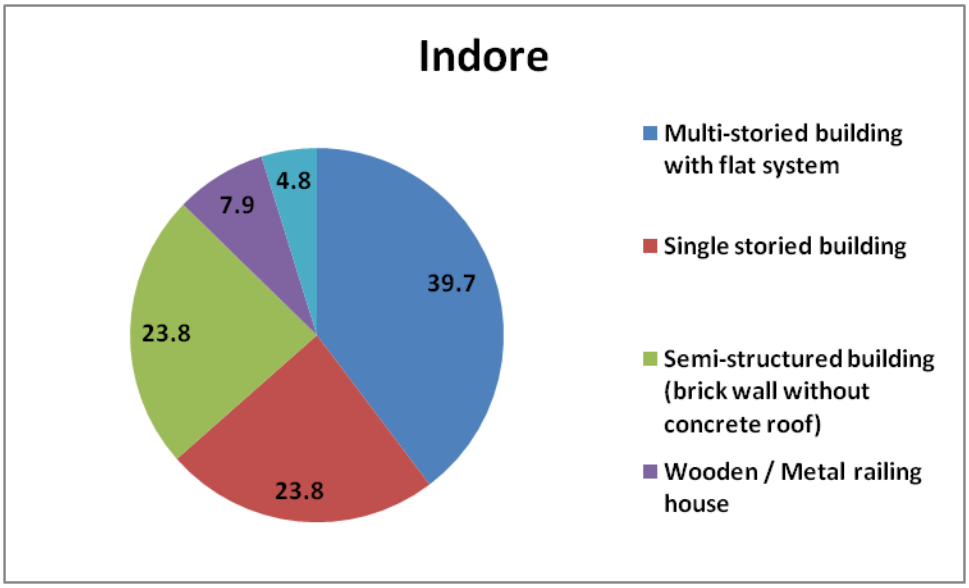


Figure 1.12 Distribution of type of households covered in Indore (N=126)

During the household survey in Indore, it was found out that all the urban households have electricity connection or LPG connection (legally or illegally). However, around 37% reported no to municipality water supply, 36% not connected with waste water outlet and around 62.7% reported no dust bin was provided in the locality by the municipal authority. No household reported about provision of household level waste bin facility by municipality. For around 80% households LPG is the primary cooking fuel. However, remaining 20% reported to use traditional or kerosene cookstove for cooking. All the respondents in the household survey reported that energy generation from waste is a good option. Interaction with Municipal Authorities indicated that on average waste transport vehicles travel around 10 km in the city.

Indore Municipal Corporation opined that present waste management needs improvement and there is important challenge for municipal authority. There is role NGOs/private sector to improve waste management services. They also agreed that waste to energy projects can

improve solid waste management in the city and government should provide support to promote such projects.

1.6.6 Waste Management in Indore City

In Indore the quantum of solid waste generated daily is 600 MT. Approximately 325 MT (54%) reaches landfill site. Indore Municipal Corporation crudely removes solid waste and dumps at Devguradia trenching ground around 7 km away from the main city. *(Source: Survey on the Current Status of Municipal Solid Waste Management in Indian Cities and the Potential of Landfill Gas to Energy Projects in India, FICCI, 2009)*

Municipal Solid Waste is collected from various residential and commercial establishments, industrial establishments, hotels, restaurants, guest houses, slaughter houses, etc. Therefore it is heterogeneous in nature. It comprises of about 51.25% organic waste, 15.30% recyclable waste, and 33.45% as mixed waste, including silt, construction waste, etc. *(Source: Project Design Document for Integrated Municipal Solid Waste Processing Complex in Indore, A2Z Infrastructure Ltd., 2012).* As per report of CPCB in 2005 covering the State Capitals in India, the composition of MSW in Indore was – 49% compostable, 12.6% recyclable, moisture content 31%, C/N ration 29.3% and calorific value of 1437 Kcal/Kg.

Assuming that 50% of this waste would be organic in nature around 250 MT/day of waste can be processed into energy which is again roughly around 2 MW of power like Bhopal.

The primary survey of households says that per household generation is estimated to be 1027 gm per day for biomass based (wet/ fresh) waste and 157 gm per day for non-biomass based waste.

1.6.7 Status of waste-to-energy projects in Indore

As of now there is no waste-to-energy project operational in Indore. As per the PDD submitted by A2Z Infrastructure Ltd in 2012 to United Nations Framework Convention on Climate Change (UNFCCC), it proposes to process 600 TPD MSW in Integrated Waste Management complex. The proposed project includes processing the waste to produce compost, Refuse Derived Fuel (RDF), bricks and recovery of recyclable material. The annual RDF production is estimated to be 37685 MT.

1.7 Urban Waste Assessment in Tamil Nadu

1.7.1 State Profile

The state of Tamil Nadu is located at southern part of India. It has a huge geographic area spanning over 130,058 sq. km., around 3.96% geographic area of the country. The state lies in between $8^0$05′ N to $13^0$35′ N latitude and $76^0$15′ E to $80^0$20′ E longitude. The state shares its boundaries with Andhra Pradesh and Karnataka in the north; and Kerala in the west. The state has a lengthy east coastline along the Bay of Bengal.

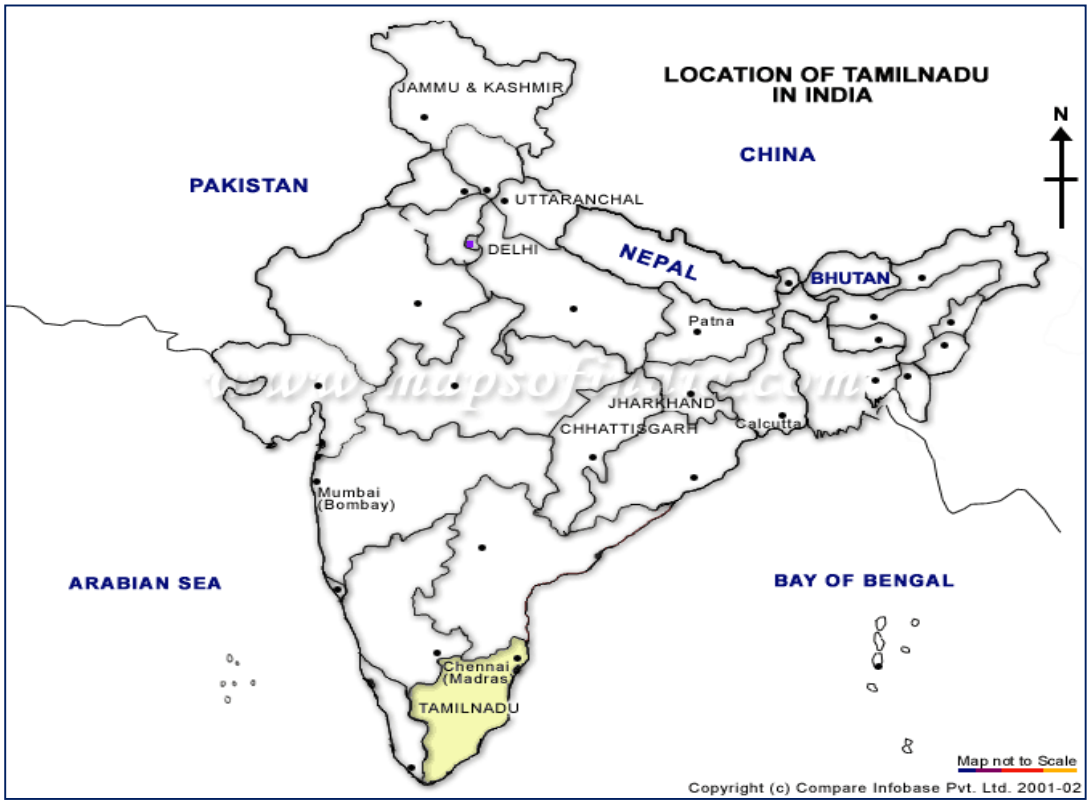


Figure 1.13 Location of Tamil Nadu

Source: http://lyberty.com/encyc/articles/images/india-tamilnadu-map.gif

In terms of its topography the state is divided into four regions namely, Coastal Plains, Eastern Ghats, Central Plateau and Higher Elevation Mountains. Main rivers flowing through the state are Cauvery, Pennaiyar and Vaigai. *(Source: Forest Survey of Tamil Nadu)*

Tamil Nadu has 32 district and 208 talukas. It is India's second most industrialized state. The economy of the state is dominated by service sector and manufacturing. Agriculture contributes only 21% of the state GDP. Some key economic indicators for the state are given in the table 1.9 below:

Table 1.9 Demographic and economic indicators for Tamil Nadu

Sl. No.	Indicators	Unit	Tamil Nadu
1	Geographical Area	Thousand Hectare	13026.64
2	Forests	Thousand Hectare	2105.82
3	Net Sown Area	Thousand Hectare	5061.92
4	Population	Crore	7.21
5	Decadal Growth Rate	Percentage	15.6
6	Density of Population	Population/Sq. Km.	555
7	Gross State Domestic Product (GSDP)	Crore Rupees (current prices 2011-12)	428109
8	Per Capita Income	Rupees	72993

(Source: Economic Survey 2012-13, Tamil Nadu)

Tamil Nadu's geographic area is covered by two different agro-climatic zones namely – (1) semiarid and (2) tropic wet and dry. Due to its proximity to sea, the temperature level in plain and plateau areas does not fall below 18^0C and does not go beyond 43^0C. The average rainfall ranges from 925 mm to 1,170 mm.

Infrastructure in the state can be summarized below (Source: Tamil Nadu, April 2011, Indian Brand Equity Forum):

- **Roads:** The state has a total road length of about 45000 km with National Highway and State Highway coverage of 4,500 km and 9,264 km respectively.
- **Railways:** The total length of the rail routes passing through the state is around 5911 km with track density of 32.2 km per 1000 sq. km.
- **Airports:** Tamil Nadu has international airports at Chennai and Trichy; and it has domestic airports are at Coimbatore, Tuticorin and Madurai.
- **Power:** The installed power capacity in Tamil Nadu is 20,716.52 MW during 2012-13

1.7.2 Profile of Chennai City

Chennai (formerly, Madras) is the capital city of Tamil Nadu, and it is located on the Coromandel coast off the Bay of Bengal. It is the biggest industrial and commercial centre in South India, and a major cultural, economic and educational centre.

Chennai city has 4.68 million residents, making it the sixth most populous city in India. The area of Chennai was expanded in 2011 from 176 Sq Km to 426 Sq Km

The urban agglomeration, which comprises the city and its suburbs, is home to approximately 8.9 million, making it the fourth most populous metropolitan area in the country and 31st largest urban area in the world. *(Source: Census 2011)*

Chennai has a sound economy with broad industrial base in automobile, computer, technology, hardware manufacturing and healthcare sectors. As of 2012, the city is India's second largest exporter of information technology (IT) and business process outsourcing (BPO) services. A major part of India's automobile industry is based in and around the city thus earning it the nickname "Detroit of India".

In the urban household survey in Chennai city, 12 localities were covered and total number of households covered was 114 as shown in the table below (Table 1.10). Around 28% and 20% respondents were from Anna Nagar and Tripli Lane respectively.

Table 1.10 Coverage of household survey in Chennai city

Locality	Coverage
Anna Nagar	32
Tripli Lane	23
T. Nagar	18
Mullai Nagar	9
Chepauk	8
Thiruvallivar Nagar	8
Elil Nagar	5
Saida Pet	4
Muthu Tamil Nagar	3
Saithapatai	2
Kanesh Nagar	1
Ayyanavaram	1
TOTAL (N)	**114**

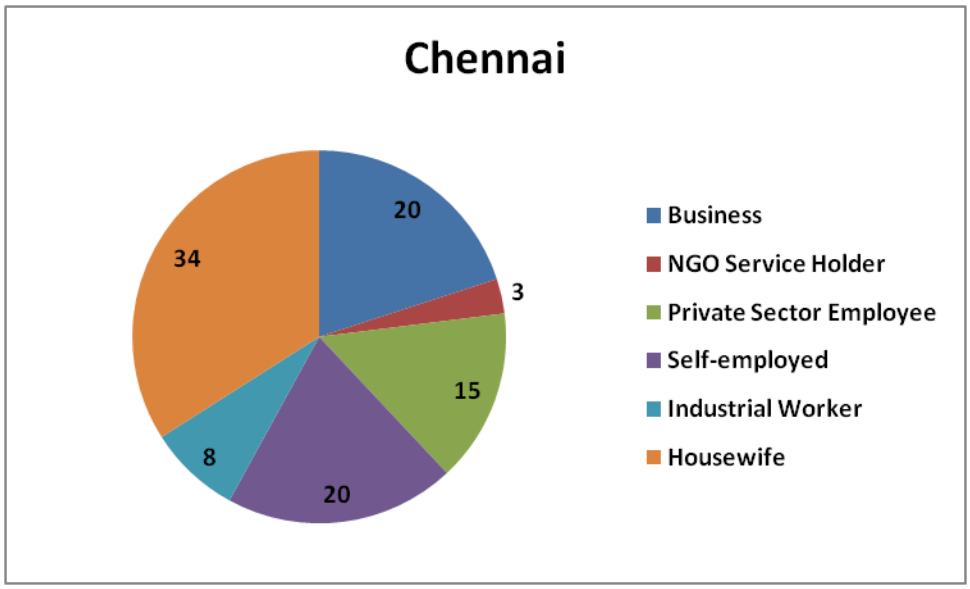


Figure 1.14 Percentage of respondents by occupation in Chennai (N=114)

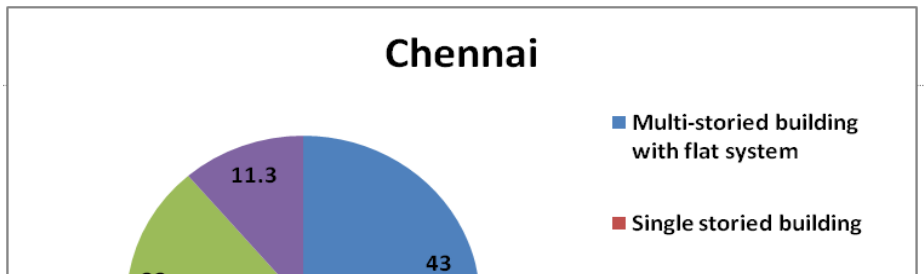


Figure 1.15 Distribution of type of households covered in Chennai (N=114)

During the household survey in Chennai city, all the urban households reported to have electricity connection, LPG connection or supply, water supply, connection with waste water outlet and dust bin in the locality. However, it was found out that municipality or the city authority does not provide dustbin at the household level. LPG is the primary cooking fuel for all the households covered in Chennai city. The staff at Chennai Municipal Corporation refused to meet survey team as they sad that the city is at advanced stage of bidding waste processing and waste-to-energy projects and they would not like to share this information with anyone at this stage.

1.7.3 Waste Management in Chennai City

Chennai Municipal Corporation and the respective Urban Local Bodies (ULBs) are the responsible agency for solid waste management in their jurisdiction. Average per capita solid waste generation within the city area is estimated at about 782 gm. It has been estimated that the city 3400 MT of solid waste is generated daily.

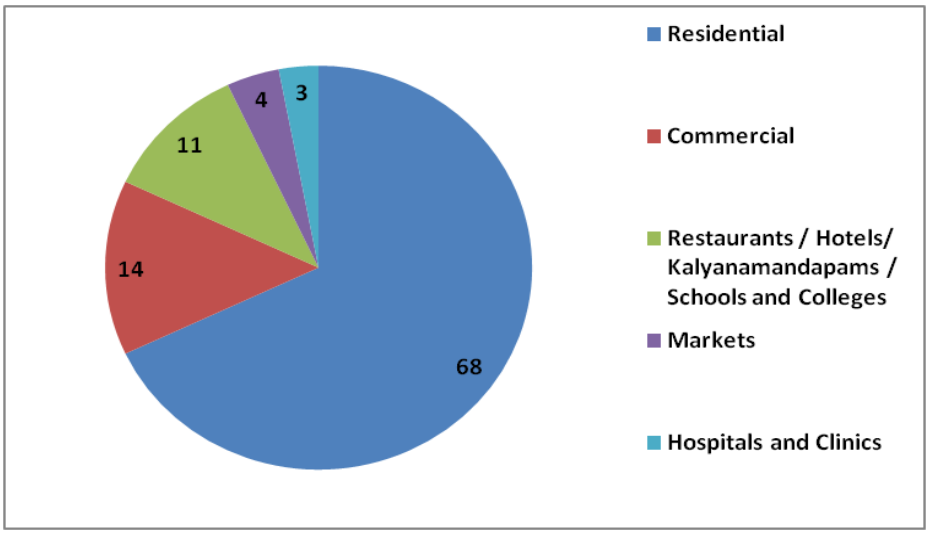


Figure 1.16 Sources of solid waste in Chennai city [3]

[3] and [4] Development Plan for Chennai Metropolitan Area (2006)

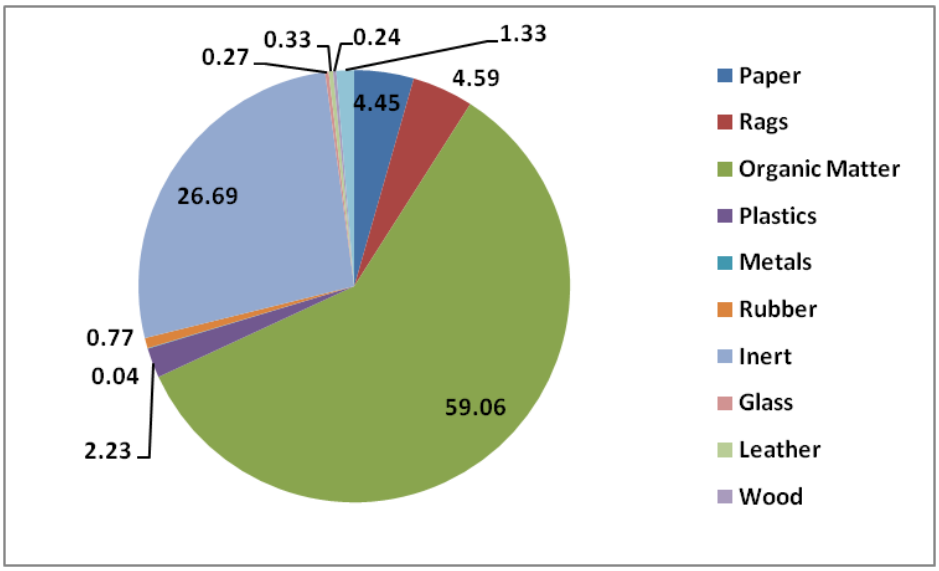


Figure 1.17 Characteristics of solid waste in Chennai city [4]

The Municipal Corporation and some NGOs like Exnora are engaged in solid waste management in the city. The Municipal Corporation provides street sweepings and scientific collection throughout the city.

In Chennai Metropolitan area small, medium and large enterprises (secondary raw material) are involved in the recycling industry. The enterprises get the supplies from dealers who specialize in waste papers, glass, plastic, metals and other reusable material and are in turn supported by vast network of dealers and small traders. Scavengers, rag pickers, including those at the landfill site, transfer stations and street level, together with itinerant buyers who collect, separate materials from door to door, provide dealers with regular supply of waste. It has been estimated that they recover about 400 tonnes per day of these material.

At present the Chennai Corporation and Onyx are the two agencies responsible for entire solid waste collection and transportation. The Corporation claims that the collection efficiency is around 95% in the city.

Solid Waste is taken to the transfer stations and is finally disposed at two designated disposal sites viz. Kodungaiyur located at Northern part of City and Perungudi in the south. The extent of the Kodungaiyur landfill site is 182 hectares and the Perungudi land site is 142 hectares. About 45% of the total solid waste generated is disposed at Kodungaiyur site and the remaining at Perungudi site. *(Source: Development Plan for Chennai Metropolitan Area, 2006)*

1.7.4 Status of waste-to-energy projects in Chennai

As per the interactions with Commissioner, Corporation of Chennai, there is no operational project on waste-to-energy in the city. Though a biomethanation based project for processing with a capacity of 30 TPD of vegetable market waste was installed in 2005 but it became dysfunctional in 2009 due to technical reasons as cited by Corporation. As of now tenders are in final stages of negotiations for implementing future waste-to-energy projects (*also see http://www.methanetomarketsindia.com/htm/case-study/4.htm*).

1.8 Coimbatore city

Coimbatore also known as Kovai, is a one of the popular cities in southern India. It is the second largest city and urban agglomeration in Tamil Nadu, after Chennai and the sixteenth largest urban agglomeration of India. It is one of the fastest growing Tier-II cities in India and a major textile, industrial, commercial, educational, information technology, healthcare and manufacturing hub of Tamil Nadu.

Coimbatore is the fourth largest metropolis in South India and the administrative capital of Coimbatore district. Coimbatore has been ranked 4th among Indian cities in investment climate by Confederation of Indian Industries (CII) and ranked 17th among the top global outsourcing cities by Tholons. Its city area is around 247 km^2 and population is around 1 million. Population density of the city stands at 10,052 per sq. km. *(Source: Census 2011)*

In the urban household survey in Coimbatore city, 21 localities were covered and total number of households covered was 115 as shown in the table below (Table 1.11). Around 11% respondents were from Railway Colony and 10% respondents were from Classic Garden area.

Table 1.11 Coverage of household survey in Coimbatore city

Locality	Coverage
Railway Colony	13
GKD Nagar	10
Sriram Avenue	2
GKS Nagar	5
Lakshmanna Puram	6
Classic Garden	12
Ramakrishna Nagar	1
Indira Nagar	1
Rajeswar Nagar (Selva Puram)	11
New Damu Nagar	5
Maha Lakshmi Nagar	7
Papa Nayakan Palem	1
Aman Nagar	6
Gurunchi Garden	1
LG	2
KTP Nagar	1
Arunthathiyar Street (Colony)	3
GH Colony	4
Govinda Swami Pattai (Selva Puram)	3
SH Road	9
Ukka Dan (Dobi colony)	10
TOTAL (N)	115

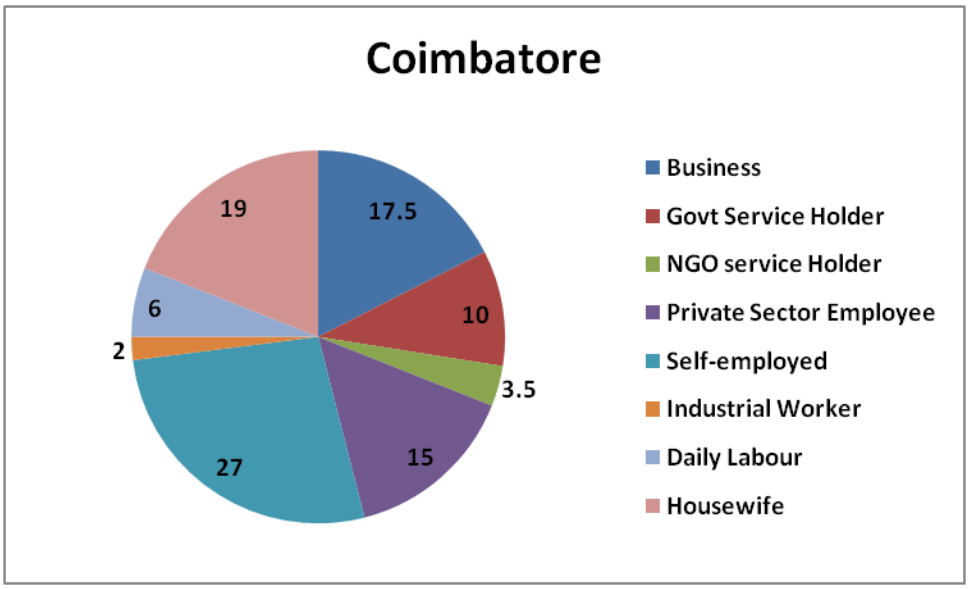


Figure 1.18 Percentage of respondents by occupation in Coimbatore (N=114)

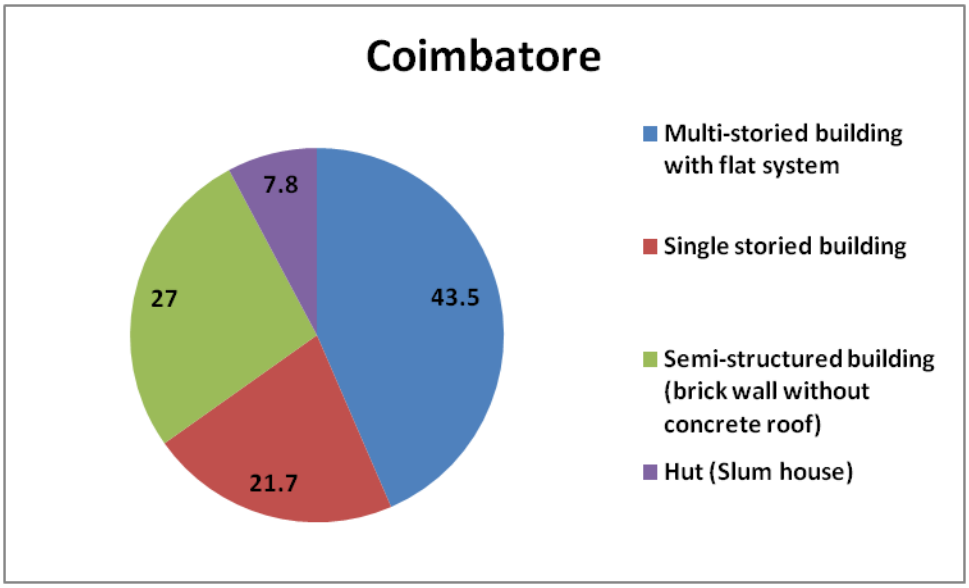


Figure 1.19 Distribution of type of households covered in Coimbatore (N=114)

During the household survey in Coimbatore city, all the urban households reported to have electricity connection, LPG connection or supply, water supply, connection with waste water outlet and dust bin in the locality. However, it was found out that municipality or the city authority does not provide dustbin at the household level. LPG is the primary cooking fuel for 97% of the households covered in Coimbatore city, but for remaining 3% kerosene is the primary cooking fuel.

1.8.1 Waste Management in Coimbatore City

In terms of solid waste generation, 885 MT per day is generated in Coimbatore city. According to the Coimbatore Municipal Corporation, waste from the waste storage points were transported to the dump sites located in various parts of the city (i.e., Ondipur, Kavundampalayam, and Vellalore) in open tippers and involved unhealthy practices. *(Source: Coimbatore Solid Waste Management Report, JNNURM, July 2013)*

Door-to-Door collection of segregated solid waste is practiced for primary collections with 287 pushcarts. Road sweeping and mopping is also carried out with 12 road sweeping flipper machines to clean the roads. The usage of bullock carts is slowly being phased out. There are about 100 containers of 2 MT capacities, which are placed at important locations in the town. About 36 private tractors are being used for collection of waste from the bins. About 288 MT of waste are collected and disposed at the secondary collection points by these tractors on daily basis. Per capita per day waste generation is about 606 gm. *(Source: City Development Plan, Coimbatore, 2006)*

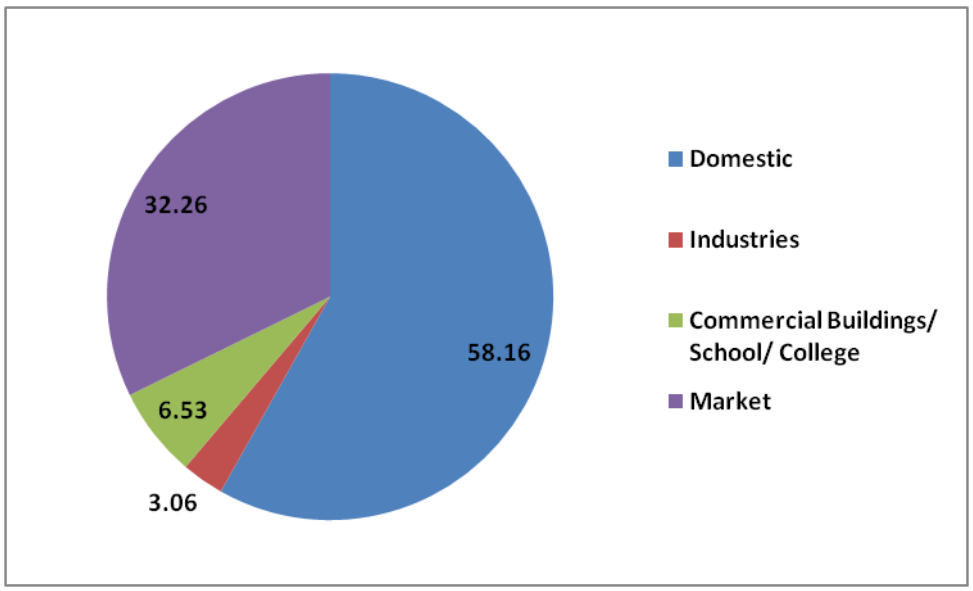


Figure 1.20 Sources of solid waste in Coimbatore city

Central Pollution Control Board (CPCB) carried out a study on the waste characteristics in Coimbatore city in 2005. As per the CPCB 50% of the waste is compostable and 15.5% recyclable. The moisture content of the waste was reported to be 54%, the C/N ration is reported at 45.8 and calorific value 2361 Kcal/Kg. At this stage of the survey it was quite difficult to get information from Chennai Municipal Corporation about the future plan on waste-to-energy projects.

1.8.2 Status of waste-to-energy projects in Coimbatore

To data, no waste-to-energy project has been observed in operational stage in the city. However, there is a composting project is currently being operating with a capacity of 100 TPD.

1.9 Results of surveys conducted in six cities

The sections below present discussion on surveys conducted in six cities to assess present situation of solid waste management and its perception among the users and practitioners for the services. The methodology for conducting the survey has been discussed in earlier sections of the chapter.

Section I: Information and electricity supply and demand

The first section of the questionnaire focuses on collecting information on electricity supply and demand in the each of the survey cities based on perception of household respondents and comprises of five questions. On the issue of regularity of electricity supply, the compiled data for six cities is shown in figures 1.21 and 1.22 below.

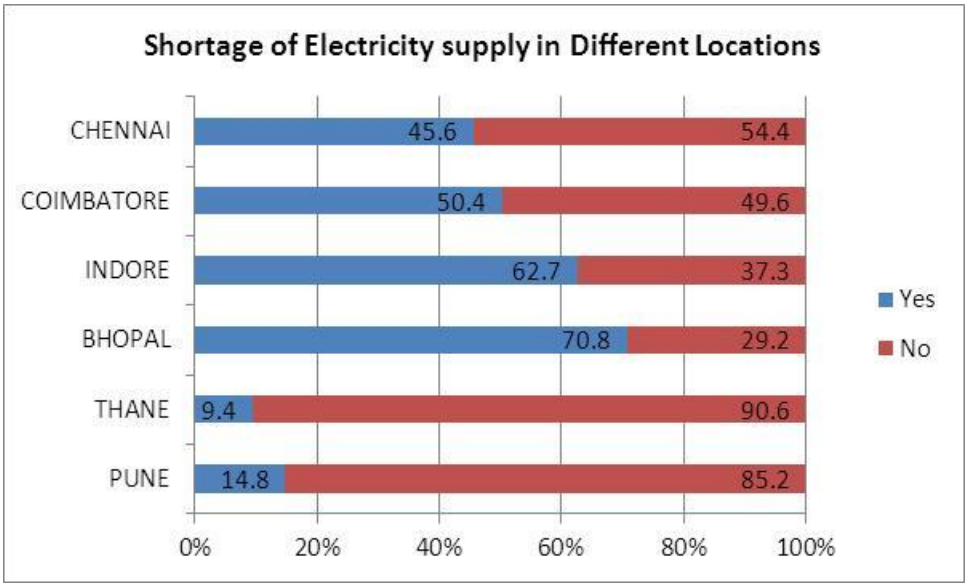


Figure 1.21 Respondents' perceptions on shortage of electricity supply (Yes: there is shortage: No: no shortage)

The cities with most consistent power supply are Thane and Pune where only 9.4% and 14.8% of residents face power cuts respectively. The situation is 50-50 in the case of Chennai and Coimbatore while worse in Indore and Bhopal where 62.7% and 70.8% of the respondents face power shortage.

The trend is more or less similar of the issue of load shedding in the market places. Markets in Thane and Pune are facing least load shedding while markets Indore and Bhopal and Coimbatore and Chennai falling in between.

These observations are consistent with level of development in these states where Maharashtra is most industrially developed followed by Tamil Nadu and Madhya Pradesh in that sequence.

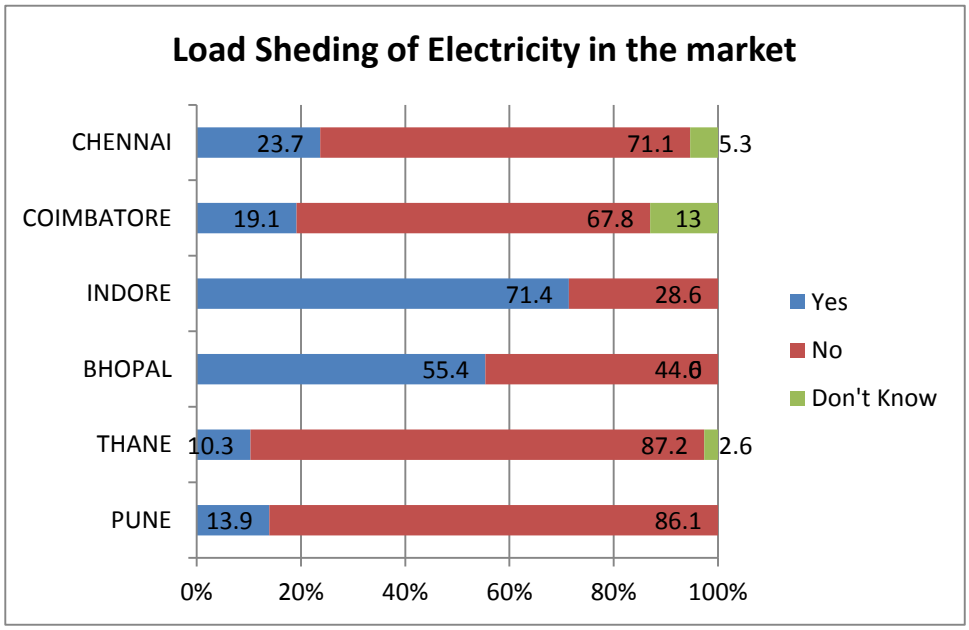


Figure 1.22 Respondents' perceptions on load shedding situation in market areas

On the question if the present electricity supply will be adequate to meet the power demand in the city, the response of the stakeholders are shown in Figure 1.23 below.

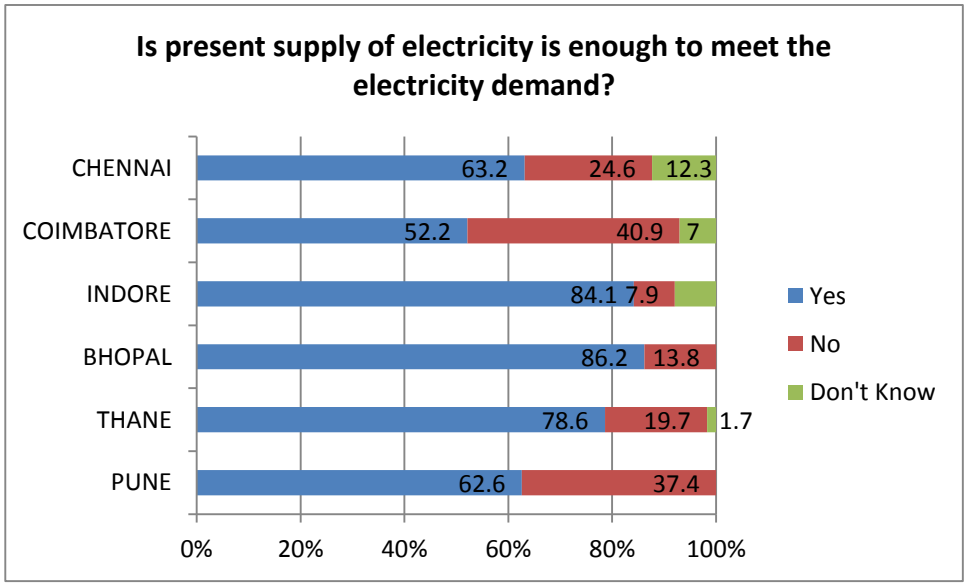


Figure 1.23 Respondents' perceptions on adequacy of electricity supply to meet demand

Interestingly, around 85% respondents in Bhopal and Indore confirmed to the fact that present supply should be able to meet the power demand of these cities. While 78.6% of respondents say that its possible for the city of Thane. For Coimbatore only 52.2% of the respondents and 62.6% and 63.2% respondents in Pune and Chennai feel the same way.

The respondents' perception on whether the utilities would be able to meet cities power demand is presented in Figure 1.24 below.

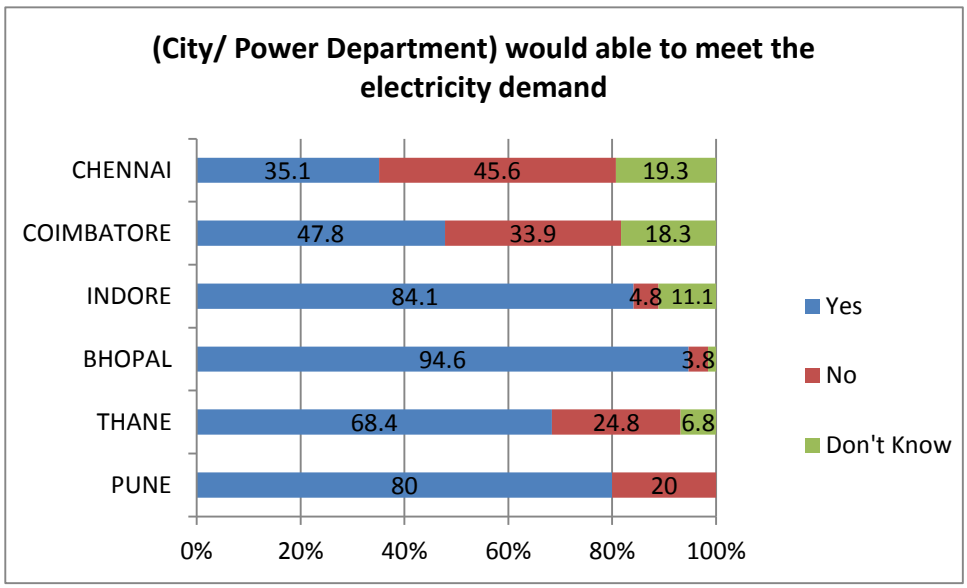


Figure 1.24 Respondents' perceptions on ability of authorities to meet the power demand

The respondents here reflect mixed unexpected response compared to other questions. While majority of the respondents in most cities (94.6% in Bhopal, 84.1% in Indore, 80% in Pune, 68.4% in Thane and 47.8% in Coimbatore with 18.3% choosing do not know) believed that utilities will be able meet power demand. Unlikely, in Chennai majority of the respondents' believed that utilities would not able to meet the power demand (Figure 1.24). The negative perception on utilization of waste to energy was may be due to lack of knowledge on energy technology, lack of good faith on societal development i.e. lack of initiatives for waste to energy plants.

The last question in this section was focussed on if the respondents support development of renewable resources such as MSW or biomass as an alternative source of power to fill the present gap in supply and demand for power in the cities. In this regard, the participants' response is shown in Figure 1.25 below.

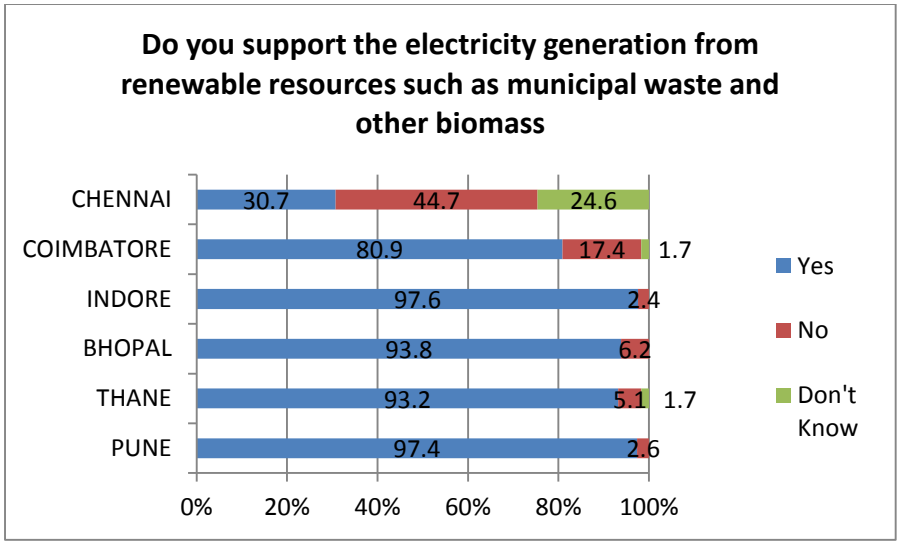


Figure 1.25 Respondents' perceptions on support for renewable sources for power generation at city level

In this case, majority of the respondents in all cities except Chennai (97.6% in Indore, 97.4% in Pune, 93.8% in Bhopal, 93.2% in Thane and 80.9% in Coimbatore) felt that MSW and biomass residues can play important role in the meeting the deficit demand for power in these cities. In Chennai only 30.7% respondents felt so with 44.7% saying no and 24.6% saying do not know. The reason for respondents in majority Chennai saying no might be their historical failure with waste-to-energy projects.

Section II: Respondents' perception of sale of recyclable materials

The second section of the questionnaire focussed on collecting information on generation of recyclable waste at the household level in the survey cities and comprises of eleven yes/no questions.

The response to question dealing with whether respondents purchase the daily newspaper is presented in Figure 1.26 below.

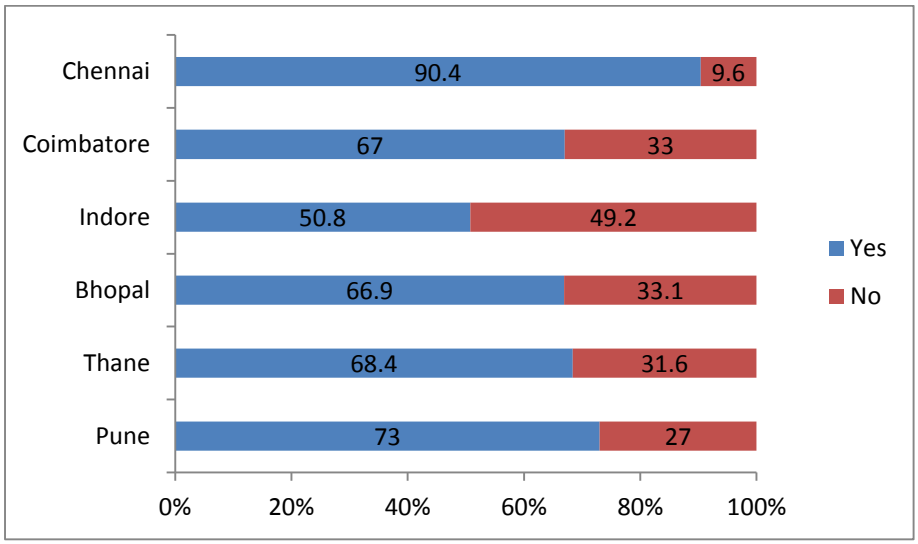


Figure 1.26 survey on purchase of newspaper

Majority of the respondents in the survey cities said that they purchase newspapers (ranging from 50.8% in Indore to 90.4% in Chennai). In Indore equal number responded that they do not purchase the newspaper.

The response to frequency of purchase of newspapers is presented in Figure 1.27 below.

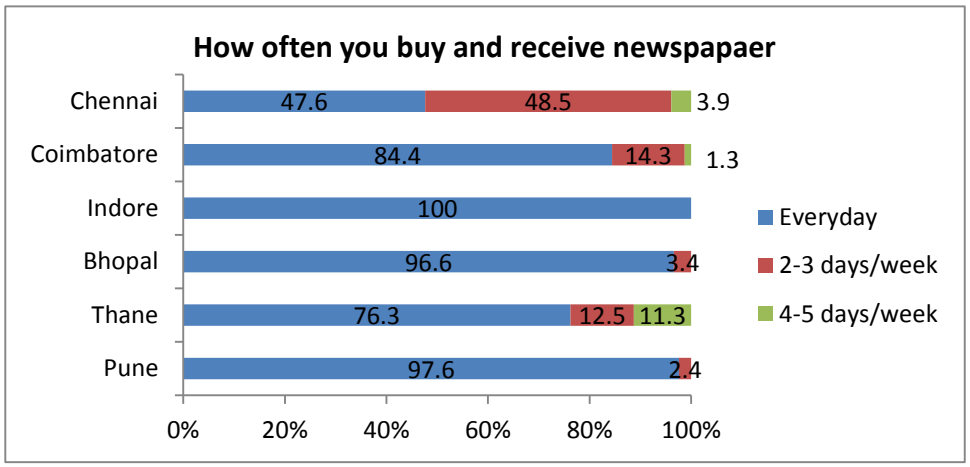


Figure 1.27 Frequency of purchase of newspaper

Here again majority of respondents except for Chennai purchase the newspaper on daily basis. In Chennai 47.6% purchase it on daily basis, 48.5% on frequency of 2-3 days a week and balance minor percentage on 4-5 days a week.

Response to question on anyone purchasing newspaper for recycling or any other use is presented in Figure 1.28 below.

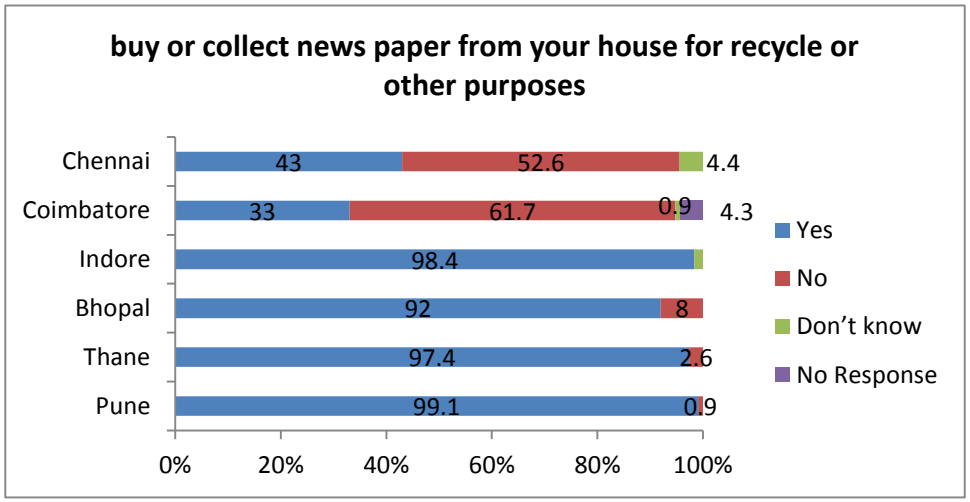


Figure 1.28 Purchase of newspapers from households

The responses on purchase of newspapers provide interesting insights. While the majority respondents in Pune, Thane, Bhopal and Indore sell or give away the newspapers after use, its only 33% in Coimbatore and 43% in Chennai who sell or give away their newspapers after use.

The response is similar on issue of respondents selling their other recyclable items like polythene, plastic, rubber, etc. as presented in Figure 1.29 below.

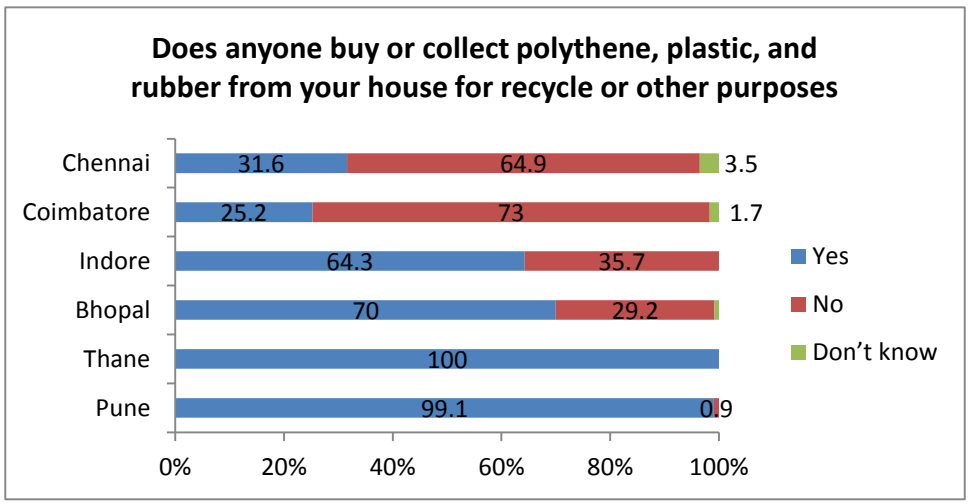


Figure 1.29 Sale/collection of other recyclables from households

In this case, also majority of respondents in Pune, Thane, Bhopal and Indore (ranging from 64.3% in Indore to 100% in Thane) sell/give away other recyclables. While in Chennai and Coimbatore only 31.6% and 25.2%, respectively sell/give way the other recyclables.

The response for sale/collection of waste textile materials is shown in Figure 1.30 below.

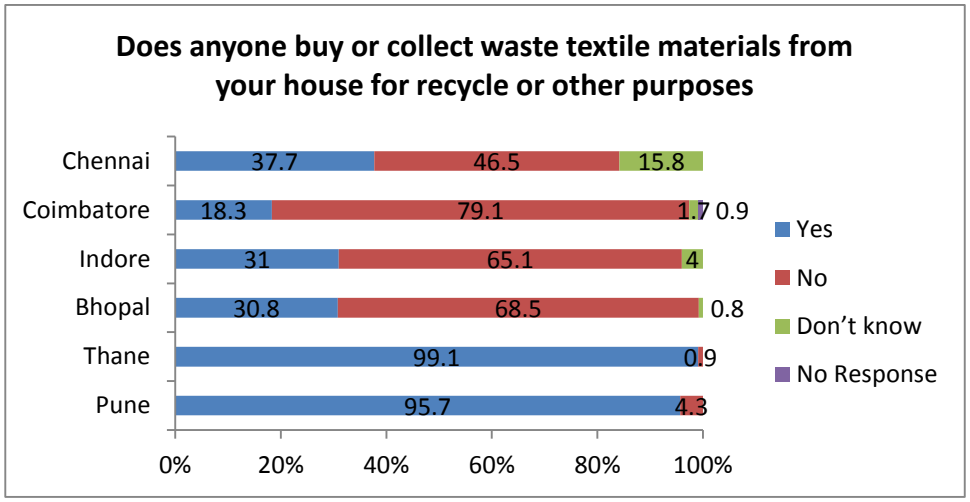


Figure 1.30 Sale/collection of waste textile materials from households

In Thane and Pune almost entire quantity of waste textiles materials is collected from houses. In other cities less than 50% is collected ranging from 18% in Coimbatore to 37.7% in Chennai.

The response on collection/sale of waste leather materials is presented in Figure 1.31 below.

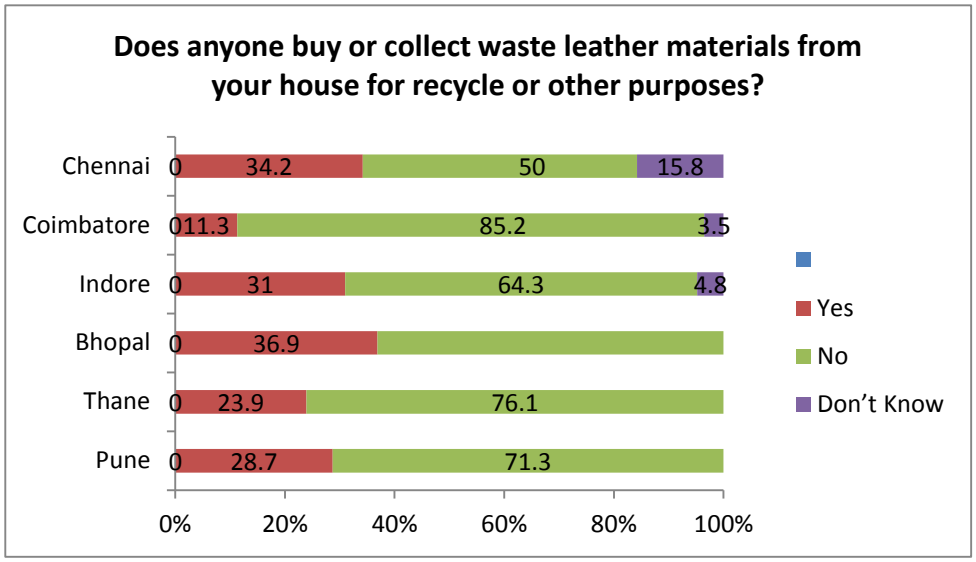


Figure 1.31 Collection/sale of waste leather materials from households

It is evident that collection of waste leather materials is carried out for respondents ranging from 11.3% in Coimbatore to 34.2% in Chennai. The majority of the households in all cities reported that no agency picks up this waste from houses.

Response to collection of waste wood materials in presented in Figure 1.32 below. Here also responses range from 11.3% for Coimbatore to 37.6% in Thane in affirmative and majority in all cities in negative.

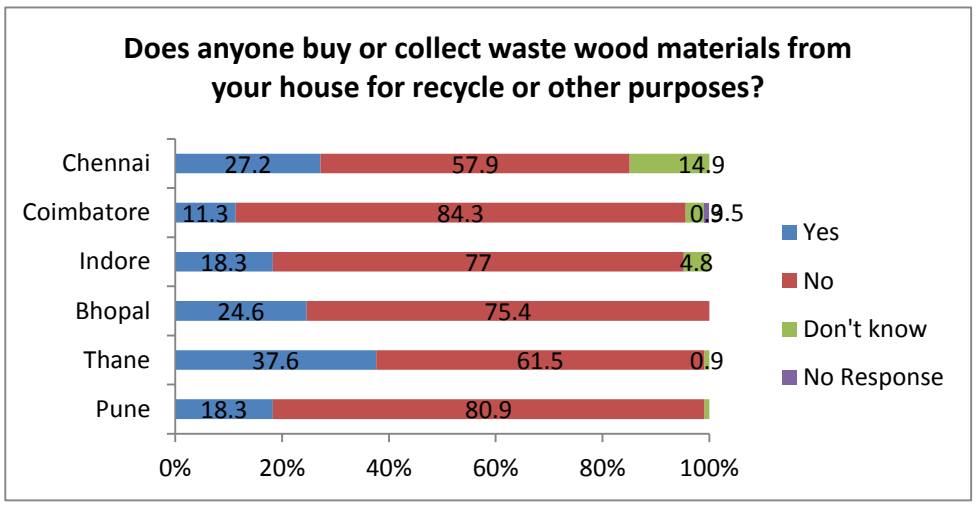


Figure 1.32 Collection of wood waste materials from households

Response to collection of glass and ceramic waste is presented in Figure 1.33 below.

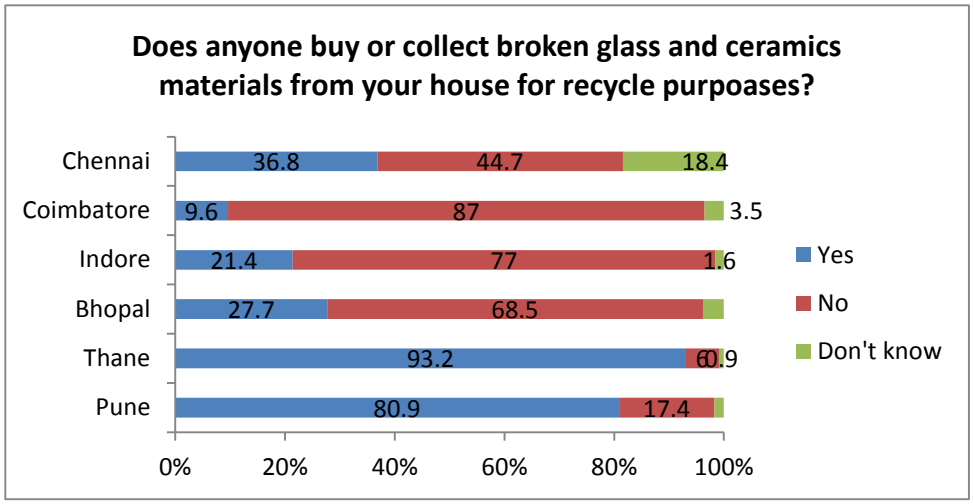


Figure 1.33 Collection of glass and ceramic waste from households

The response in this case provides a varied picture. While majority collection was done for households in Thane and Pune (93.2% and 80.9%, respectively), collection in other cities ranged from 9.6% in Coimbatore to 36.8% in Chennai.

The response to sale/collection of aluminium cans is presented in Figure 1.34 below. In this case again cans are collected from around 100% respondents in Pune and Thane and around 50% and 62% respondents from Bhopal and Indore while it is collected from only 17.4% and 29%respondents from Coimbatore and Chennai respectively.

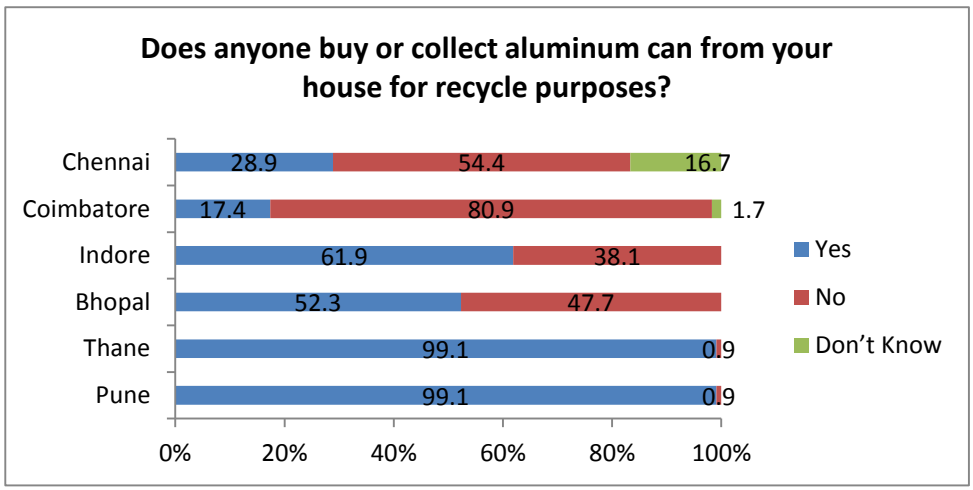


Figure 1.34 Sale/collection of aluminium cans from households

The response related to the question on collection of other metal wastes like tin, copper, iron, steel and lead is presented in Figure 1.35 below.

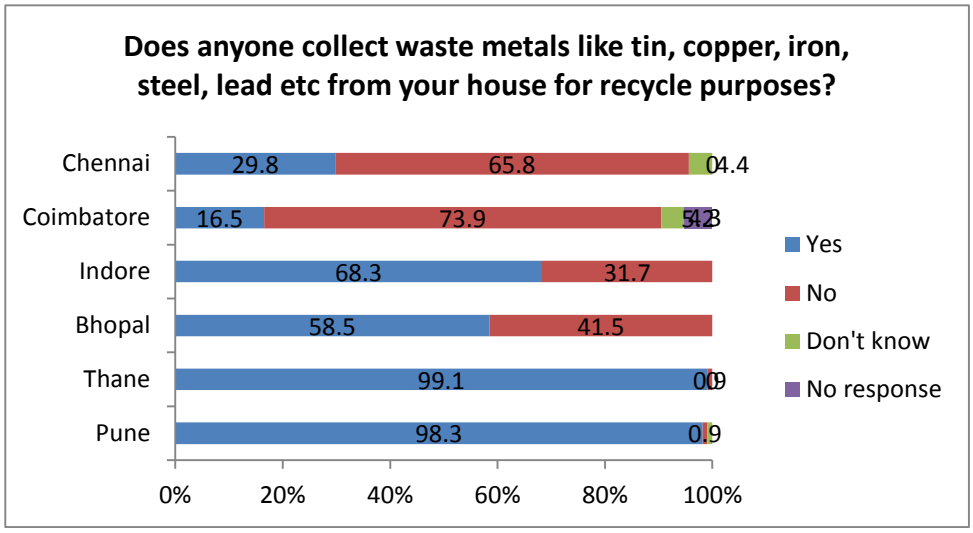


Figure 1.35 Collection of metal waste from households

The response for collection of waste metals present similar picture as that of Aluminium cans. Almost all the metal waste is collected in Thane and Pune and 58.5% and 68.3% of metal wastes are collected in Bhopal and Indore, respectively. Only 16.5% in Coimbatore and 29.8% in Chennai were affirmative on sale/collection of metal wastes from households.

Response to use of pesticides in the households is presented in Figure 1.36 below. Around 65.4% households in Bhopal and 47% households in Thane and Indore reported that they use pesticide at household level. Only 28.7% households in Pune, 15% in Chennai and 13% in Coimbatore use pesticides.

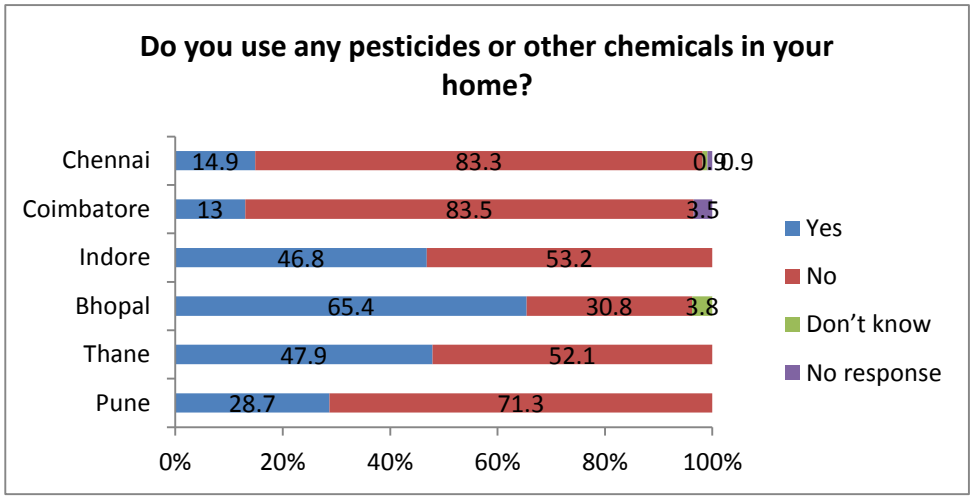


Figure 1.36 Use of pesticides at household level

Response to type of pesticide used at household level is presented in Figure 1.37 below.

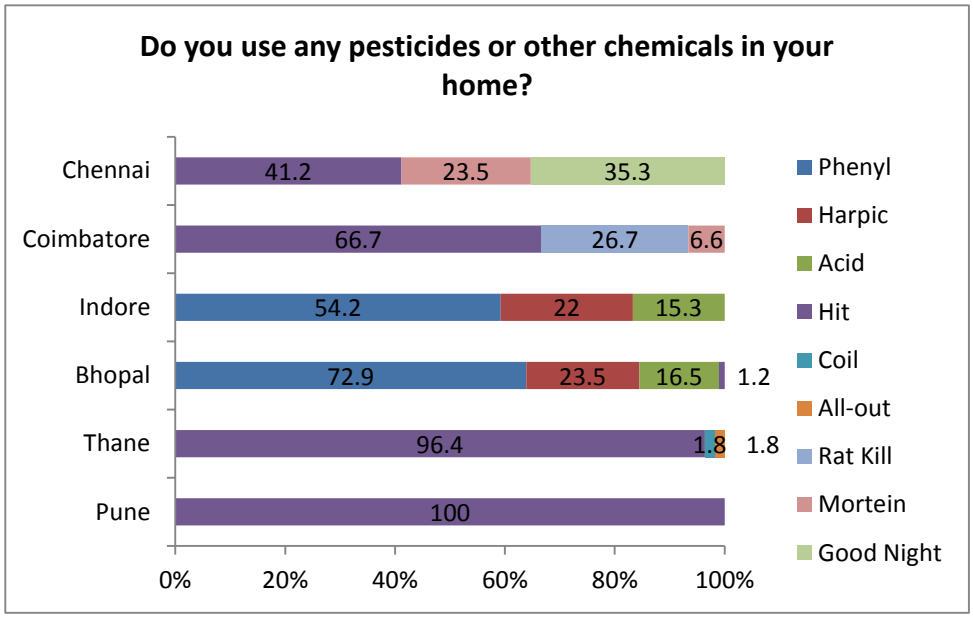


Figure 1.37 Type of pesticide used at household level

Majority of the respondents in Thane and Pune (96.4% and 100%) and 66.7% in Coimbatore use Hit. While in Chennai only 41.2% of respondents use Hit. 73% of respondents in Bhopal and 54.2% respondents in Indore use Phenyl.

Section III: Waste disposal practices among the households

The third section of questionnaire focuses on waste disposal practices adopted/prevalent at the household level. The purpose of this section is gauge level waste segregation presently practices and tools to achieve it.

The first question dealt with type of basket/bin/ bag used for storage of waste at the household level. The result of survey in presented in Figure 1.38 below.

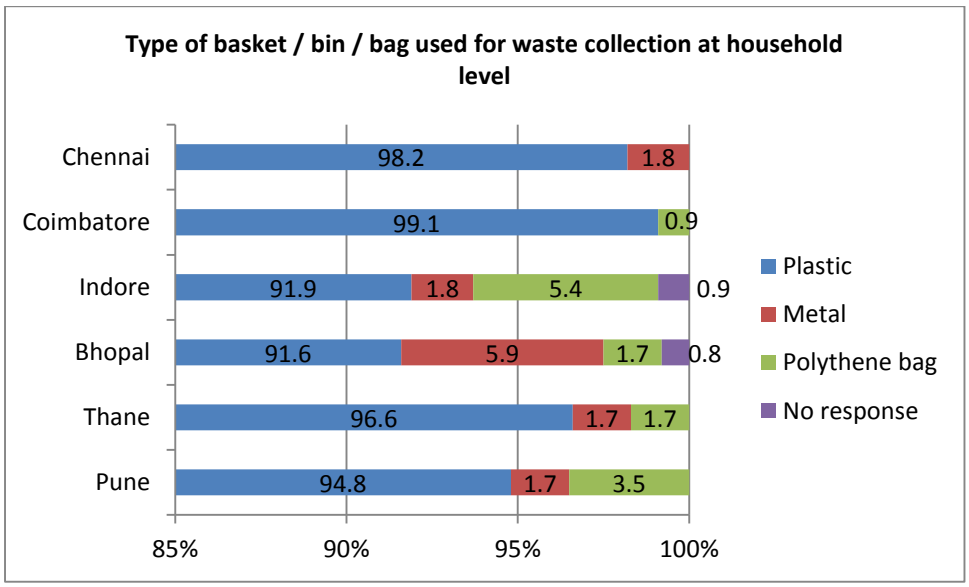


Figure 1.38 Type of basket/bin/bag provided at household level

The results clearly indicate that majority of the households in all cities (> 90%) used plastic bins/bags for collection of household waste. Rest of the households used either metal bins or polythene bags for collection of household waste.

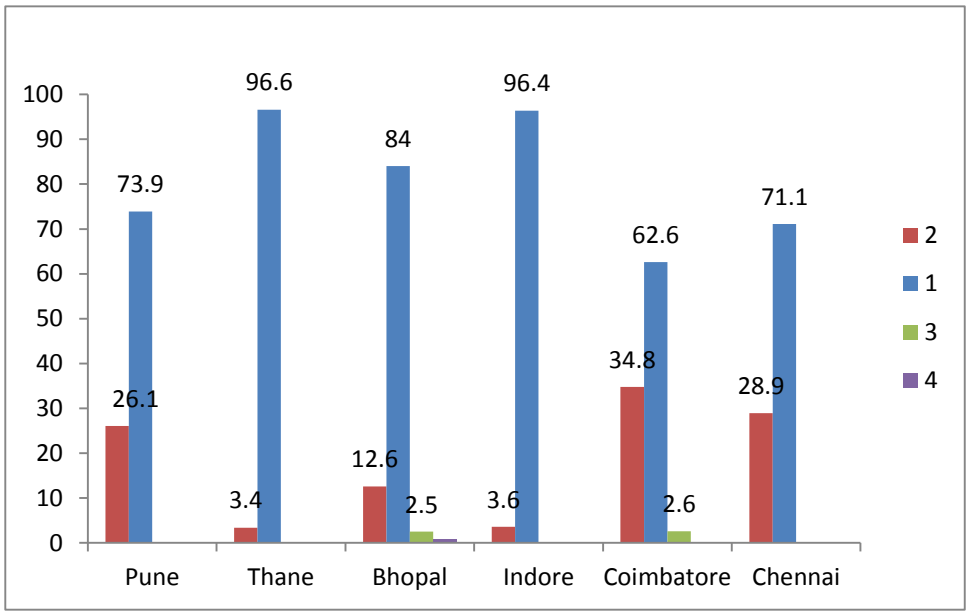


Figure 1.39 No. of bins used in households for waste collection

The majority of the households ranging from 62.6% in Coimbatore to 96.6% in Thane used only one bin for collection of waste at the household level. Some households ranging from 3.4% in Thane to 34.8% in Coimbatore used 2 bins (one for wet waste and other for dry waste) as introduced by Municipal Corporation on pilot basis. Interestingly, some households in Bhopal (even 4 bins) and Coimbatore reported using three bins for collection of daily waste as in most Indian cities the emphasis is to segregate waste into wet and dry categories.

Response to the question related to use of information regarding requirement of different types for bins for storage of bio and non-bio based waste is presented in Figure 1.40 below.

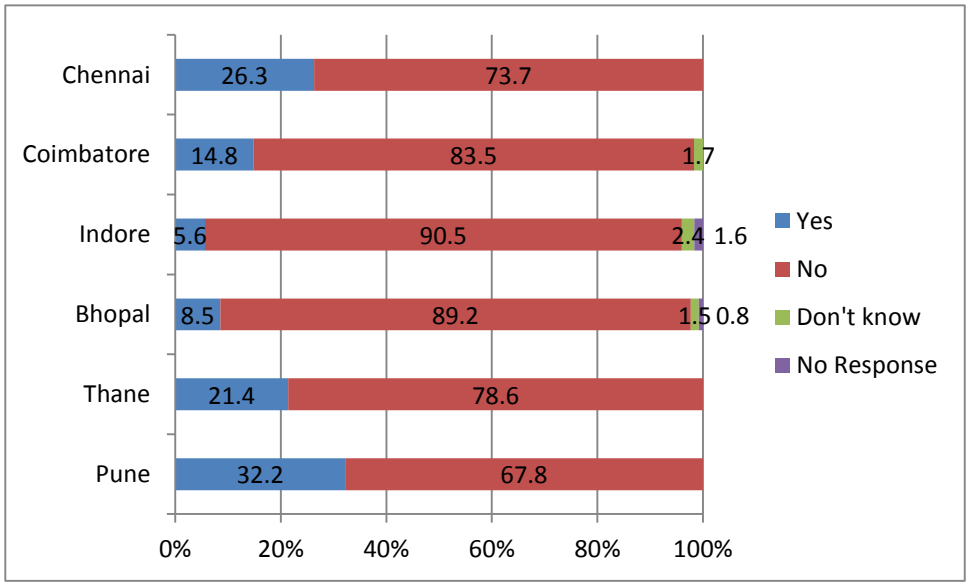


Figure 1.40 Perception on different types of bins to be used for bio and non-bio waste

Respondents ranging from 5.6% in Indore to 32.2% in Pune knew the purpose of two bins was to store bio and non-bio based wastes separately but surprisingly majority of the respondents in all cities did not now the purpose of having two bins in the house.

Response to the question whether waste is collected in segregated manner at the household level is presented in Figure 1.41 below.

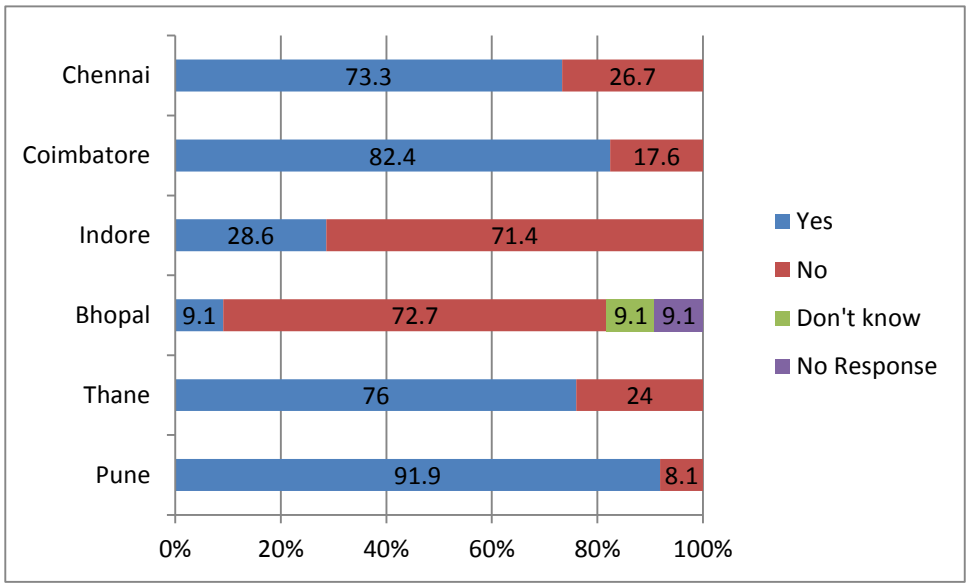


Figure 1.41 Collection of waste in segregated manner

Majority of the respondents were provided with two bins in Chennai, Thane, Coimbatore and Pune to store waste in segregated manner while only 9.1% in Bhopal and 28.6% in Indore stored waste in segregated manner.

Response to question gauging awareness of households on where the waste is taken for disposed after collection at the household level is presented in Figure 1.42 below.

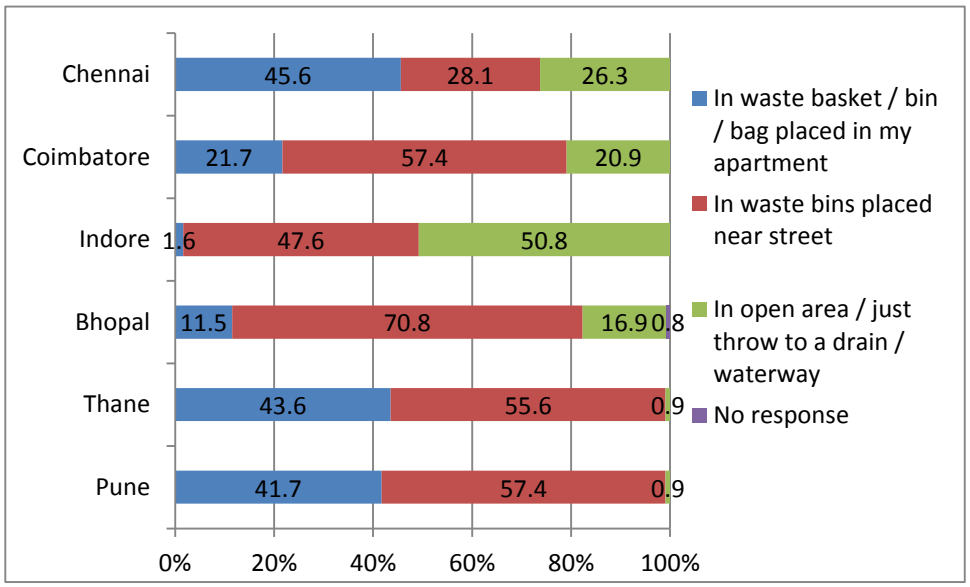


Figure 1.42– Secondary points for urban household waste disposal

In Indore only (1%) and Bhopal (11.5%) placed their waste in the bins provided at the apartment level. Respondents ranging from 21.7% in Coimbatore to 45.6% in Chennai placed their waste in apartment bins. Majority on most cities except Indore placed their waste in nearby street. In Indore 50.8% of respondents threw their waste in open areas/drains/waterways due to lack of proper disposal facility.

The response to question on frequency of waste disposal from household level in presented in Figure 1.43 below.

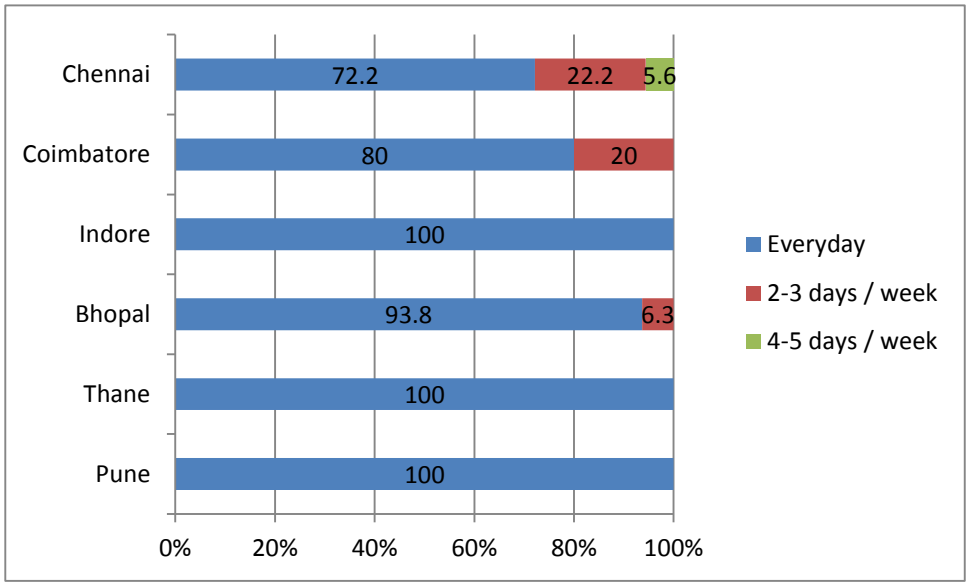


Figure 1.43 Frequency of waste disposal at household level

Majority of the households ranging from 72.2% in Chennai to 100% in Pune dispose waste on daily basis which is consistent with the observation that food waste cannot be stored beyond a day in temperate climate. Interestingly around 5.6% in Chennai dispose it at frequency of 4-5 days a week and 20% in Coimbatore and 22% in Chennai dispose waste at a frequency of 2-3 days a week as they do not generate much food waste and waste can be stored at household level for longer time.

Response to question on mechanism of waste disposal from households is presented in Figure 1.44 below.

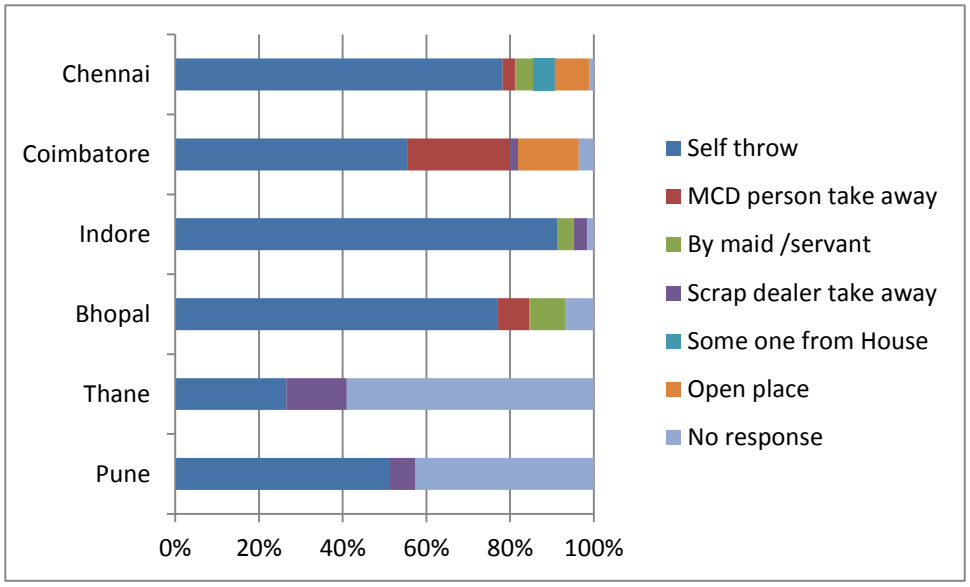


Figure 1.44 Mechanism of waste disposal from household

In majority of households in Chennai, Coimbatore, Indore, Bhopal and Pune the respondents themselves dispose the waste. Large percentage of respondents in Thane gave no response to the question. In Coimbatore, Bhopal and to a lesser extent in Chennai some portion of waste is also picked up by municipal staff. In Coimbatore and Chennai some waste is also disposed in open places.

Response to question on existence of collection of waste from households is presented in Figure 1.45 below.

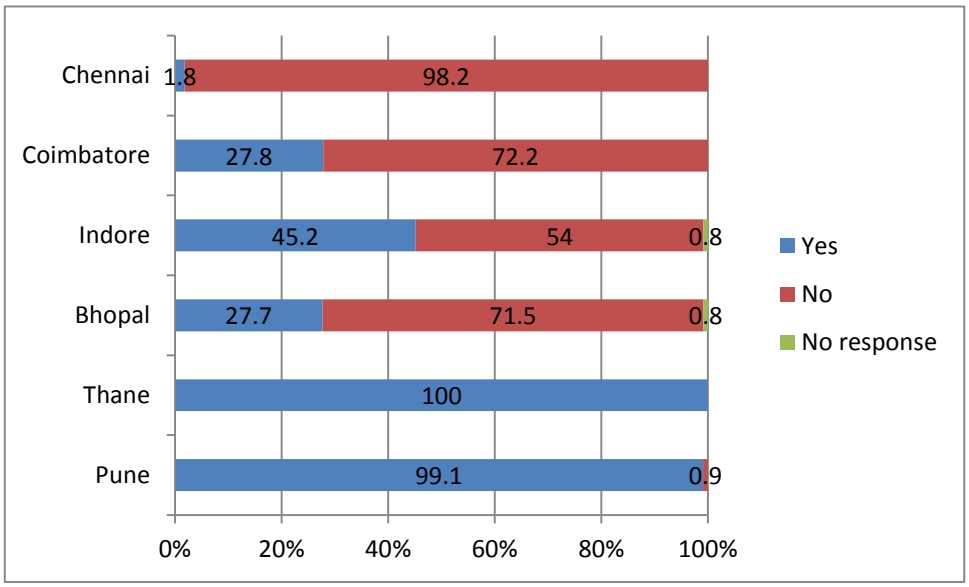


Figure 1.45 Existence collection of waste from households

In Pune and Thane almost entire quantity of household waste is picked by external agency. Whereas on the contrary, in Chennai 98.2% of household waste in not picked up by any agency. In Coimbatore and Bhopal around 27% and in Indore around 45% of household waste is picked by external agency.

Response to question on which agency picks up the waste collected at household level is presented in Figure 1.46 below.

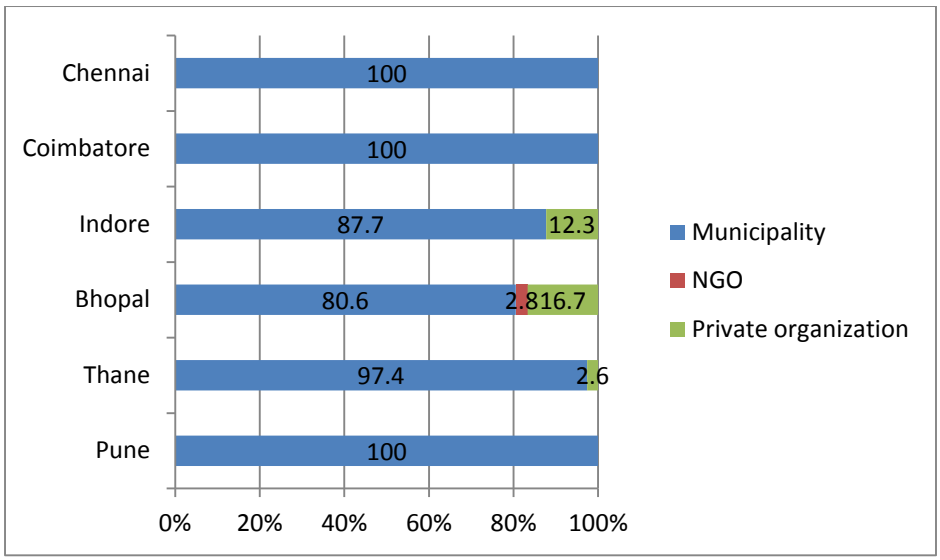


Figure 1.46 Household waste collection by different agencies

It is clear from the figure that-the Municipal Corporations are the main agency responsible for picking up waste. NGOs picks up around 2.8% of waste in Bhopal and private agency pick up waste from 2.6 to 16.7% households in Thane, Bhopal and Indore.

The response to question on awareness of households on frequency of waste removal from primary waste collection points after they dispose the waste is presented in Figure 1.47 below.

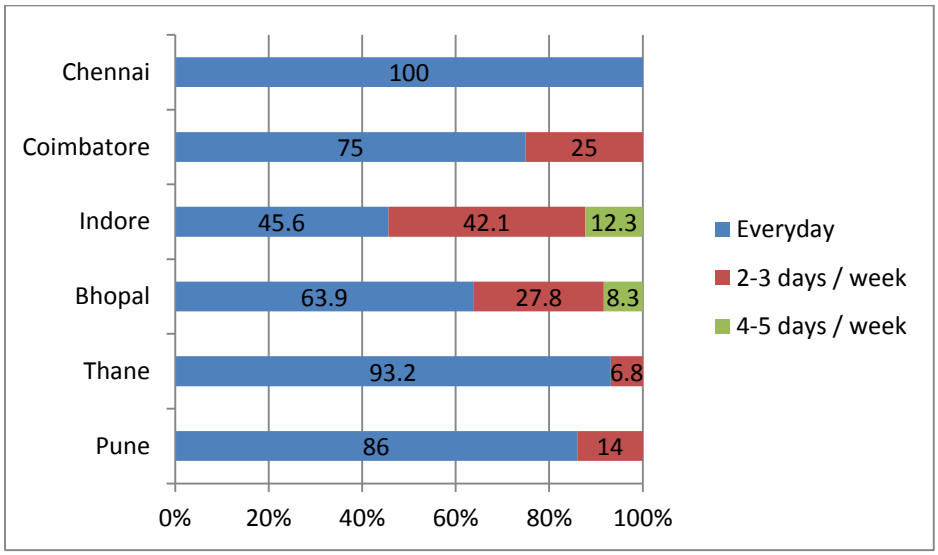


Figure 1.47 Frequency of waste removal from primary collection points

It is reported that the majority of the waste in all cities except Indore is picked up every day. In Indore 45.6% of waste is picked up every day while 42.1% waste is picked up at a frequency of 2-3 days a week. Some amount of waste in Bhopal and Indore is picked up at 4-5 days a week.

Response to question on payment of user charges for waste collection and transportation is presented in Figure 1.48 below.

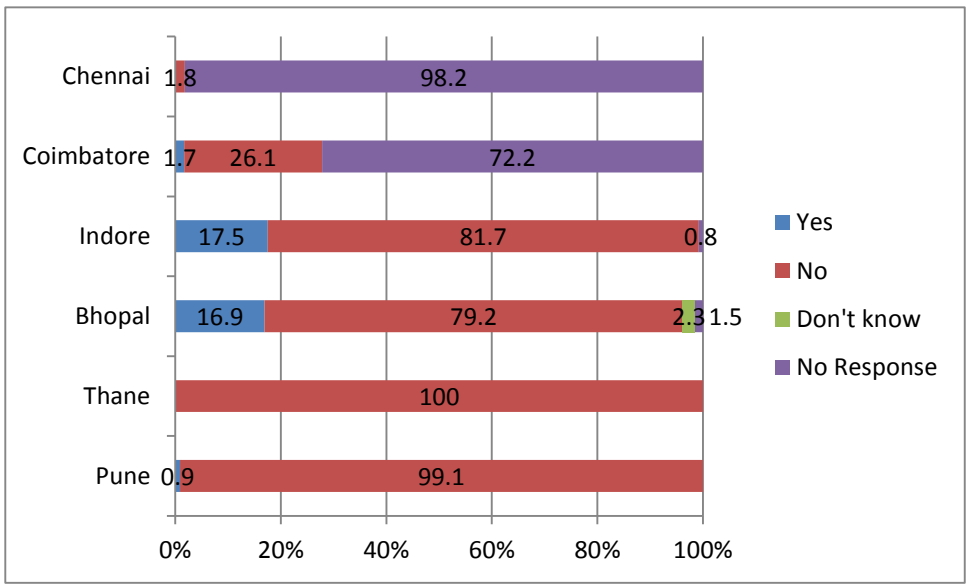


Figure 1.48 Payment of user charges by households for waste collection and transportation

Households in Pune and Indore pay no user charges while in Chennai majority gave no response with 1% saying that they don't pay user charges. Similar was response for Coimbatore where 1% admitted that they pay user charges while rest either didn't pay or did not respond. Around 17% of households in Bhopal and Indore paid user charges.

Fourth section of the questionnaire dealt with perception of respondents on existing practices on solid waste management in each of the case study cities.

The response to question on the need to for improvement in existing waste management services in cities is presented in Figure 1.49 below.

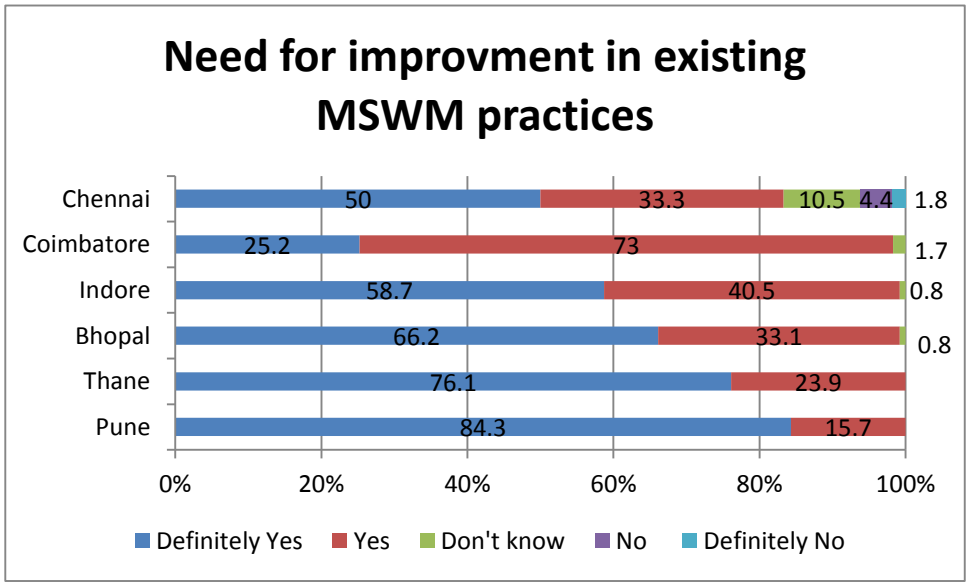


Figure 1.49 Need for improvement in existing MSWM services

Almost all of the respondents in all the cities expressed that the present waste management system needs to improve indicating low satisfaction with present level of services. Majority in Pune, Thane, Bhopal and Indore responded as definitely yes for need to improve the existing solid waste management services.

Response to question on whether the waste management is a challenge to Municipal Authorities is presented in Figure 1.50 below.

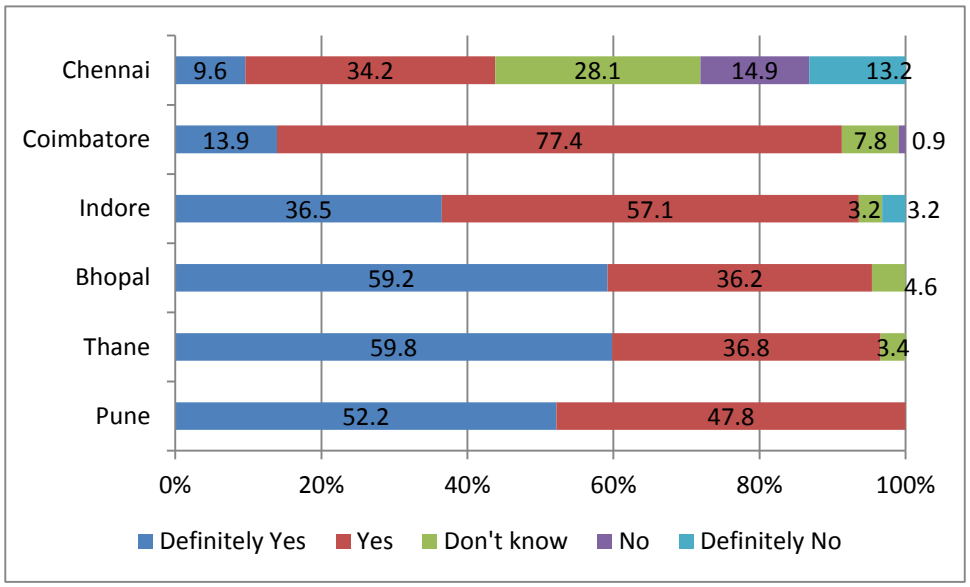


Figure 1.50 Perception on whether the waste management to challenge to Municipal Authorities

The majority respondents in Pune, Thane, Bhopal, Indore and Coimbatore expressed that waste management is a challenge to municipal authorities while around 44% in Chennai expressed that it is a challenge to municipal authorities and 28.1% expressed that they don't know if it is a challenge and 15% expressed it as not being challenge.

2. Assessing the waste segregation practices for waste-to-energy option(s) and its improvement

The surveys carried out in six cities indicate that majority of the households in Chennai, Thane, Coimbatore and Pune store the waste in segregated manner while very few (9.1% in Bhopal and 28.6% in Indore) store waste in segregated manner (refer to figure 1.41). Segregated MSW is generally not available in most Indian cities due to a low level of compliance of Municipal Solid Waste (Management and Handling) Rules, 2000. The Rules require waste to be segregated into organics, recyclables and inert. Mixing of the waste at the point of generation makes it costly affair for waste-to-energy projects to process and segregate this waste to separate out organic fraction of the waste and constituent having net calorific value thus increasing the cost of the waste-to-energy project.

Discussion with municipal authorities revealed that provision of two-bin system to separately store wet and dry waste at the household level has been recently introduced on pilot basis in some cities and has reached varying levels. As per the Figure 1.39, some households in Bhopal and Coimbatore reported using four and three bins for collection of daily waste, respectively.

The cities which have been successful in segregating household waste at source and transporting it in segregated manner have been successful in implementing waste-to-energy projects. For instance, discussion with municipal officials in Pune revealed that PMC has been able to implement 20 decentralised biomethanation projects. However, even PMC which is one the better performing municipal body in the country has not been able to ensure 100% source segregation of waste. Still around 1000 tonnnes per day of mixed waste is processed into RDF and another 700 tonnes per day of mixed waste is used for producing power through gasification route. In Chennai, a 30 TPD biomethanantion project was installed in 2005 for vegetable market waste but is not currently functional due to technical reasons. Other selected cities are presently in process of implementing waste-toenergy projects. Processing mixed waste makes it costly affair for waste-to-energy projects to segregate organic fraction thus increasing the cost of the project. In these projects, there is no mechanical facility provided other than screening machine, which cannot effectively separate wet and dry waste components of MSW. Because of the very high cost of facilities for the sorting, separation and recycling of waste, it is uneconomical for the developer to operate such projects. The unsegregated waste and generally higher moisture content in Indian MSW also cause rapid deterioration of plants and machinery causing their frequent breakdown and higher O&M (Operation and Management) costs.

To achieve source segregation of municipal waste, Ministry of Urban Development, Government of India has prescribed Service Level Benchmarks (SLBs). SLBs are performance indicators for urban local bodies in the country which include 100% coverage of households for SWM services and 100% waste segregation. To implement these SLBs, the local governments need to prescribe municipal bylaws to make the waste segregation and segregated storage at household level mandatory and intense Information, Education and Communication (IEC) campaign need to be carried out to sensitize citizen regarding the same.

3. Analysis of present barriers for implementation of waste-to-energy projects

3.1 Operational barriers

Among the study cities, most progress in adopting waste-to-energy options for city solid waste has been made in city of Pune in Maharashtra. The municipal authorities have achieved waste collection efficiency of 80-90% of which 45% is collected in segregated manner. The segregated wet waste is transported by dedicated vehicles so that they don't get mixed with other waste streams. The total wet waste transported to decentralized biomethanation facilities totals to about 300-350 tonnes per day. In addition, 1000 tonnes per day of mixed waste is processed to produce RDF for power generation and a gasification plant based on German technology to process 700 tonnes per day mixed waste to produce power. The gasification project is supposed to produce around 10 MW of power but is presently running at around 2 – 2.5 MW capacity. According to plant operators, access to segregated waste will not only reduce the waste transportation cost but also improve the power generation from this facility. In other cities, the waste-to-energy projects as indicated in previous sections are in planning phase so it is premature to comment on their operation.

Another non-technical barrier to waste-to-energy projects is vibrant recycling sector[5] in the country which takes care of most of the plastic waste, wood based waste and waste paper. It is estimated that overall waste recycling rates are as high as 70% for total recyclable waste (*Source: Management of Municipal Solid Waste, Central Pollution Control Board, 2005)*.

Other non-technical barriers/issues specific to operation of such projects in India include:

- The urban local bodies often seek royalty for land allotted for setting up waste-to-energy projects instead of giving tipping fee to the project developer. Managing MSW is one of the services rendered by the local bodies and for that they charge tax from the generators.
- Land is leased only for setting up MSW treatment plant and not for the power plant as in the case of Hyderabad plant. Hence the cost for setting power module of the waste-to-energy projects goes up.
- Energy Service Companies (ESCOs) perceive failure to set up projects/time payment of loan as risks for the project developers interested in setting up waste-to-energy projects and therefore are not willing to take up municipal projects for financial considerations.

[5] Waste recycling is also preferred option as per waste management hierarchy

3.2 Technical barriers

The survey and interaction with municipal officials and waste-to-energy technology operators indicated prevalence and preference for following technology options:

- Bioemethanation projects as have been running successfully in Pune, executed in Chennai and planned for Thane
- RDF based power generation as has been practiced in Pune and planned for Indore
- Gasification based power generation project as has been functional in Pune

Among other waste-to-energy options, harvesting landfill gas does not hold promise for these cities as existing waste disposal sites are actually unlined waste dumps and landfill gas yield on a sustained basis from these disposal sites remains uncertain. Further, disposal of organic waste in future scientific landfills built as per the provisions of Municipal Solid Waste (Management and Handling) Rules of 2000 is banned as such waste is to be processed either centrally or in decentralized manner. So future landfills will not be a significant source of landfill gas.

Incineration, though functioning well in various countries in Europe, Japan and China has found little support in India. Several reasons for this are – failed project in 1970s in Delhi, relatively lower calorific value (1421 to 2594 Kcal/kg) and higher moisture content (31% to 63%), presence of construction debris and high amount inerts in mixed waste. As a result, the incineration system requires costly waste sorting system (as in Pune gasification unit) and hence higher operating cost. Also there is always concern regarding emission of dioxins and furans if incinerator is not operated properly.

4. Assessment of feasibility of different waste-to-energy technologies

As stated in section above, the survey in six cities revealed that various operational waste-to-energy technologies include:

- Decentralized biomethanation projects
- RDF based power projects
- Gasification based power project

The sections below therefore would restrict to discussion on these technology options.

Biomethanation is anaerobic digestion of organic materials which is converted into biogas, a gaseous combustible mixture, of methane (CH_4). Biomethanation is a biological treatment method that can be used to recover both nutrients and energy contained in biodegradable municipal waste. Biomethanation of organic wastes is accomplished by a series of biochemical transformations - which include in the first stage hydrolysis, acidification and liquefaction followed by a second stage where acetate, hydrogen and carbon dioxide are transformed into methane. The process generates biogas with high content of methane (55–70%) which can directly be used as fuel and by employing gas engines can also generate electricity[6].

Apart from methane (55-75%), biogas contains significant amounts of carbon dioxide CO_2, (30-45%), which is non-combustible, along with smaller quantities and traces of Nitrogen (0-5%), Oxygen(<1%), Hydrogen sulphide (0-0.5%) hydrocarbon (<1%), Ammonia (0-0.05%) , water vapour (1-5%) and Siloxanes (CnH2n+1SiO, 0-50 mg/m^3). [7]

The complete combustion of 1m3 of CH4 (methane gas) provides about 9000 kcal of heat and after proper pre-treatment, in internal combustion engines electric energy can be produced (or both heat and electricity if a cogeneration engine is used).

This technology can be conveniently employed in a decentralized manner for biodegradation of segregated organic wet wastes such as wastes from kitchens, canteens, institutions, hotels, and slaughter houses and vegetables markets. Our study suggested that the such type of technology can also be applied to manage MSW in a centralized manner in small towns and decentralized manner in large cities provided the municipal authorities collect segregated biodegradable wet wastes from households and establishments.

Commercially available digesters range from 70 m3 to 2000 m3 reactor capacity. The smaller digesters make use of the generated biogas (i.e. mixture of CH4 and CO2) for heating the digester while larger units generate up to 2 MW of electricity (*Verma, S. 2002. Anaerobic Digestion of Biodegradable Organics in Municipal Solid Wastes*). Biogas produced through biomethanation technology can be upgraded into biomethane which can also be used as a transportation fuel. Alternatively, upgraded biomethane can substitute natural gas (a non-renewable fuel) in variety of domestic and industrial applications. Carbon dioxide is typically removed from biogas only when the target is to upgrade it into biomethane.

[6] http://planningcommission.nic.in/reports/genrep/rep_wte1205.pdf
[7] http://www.iosrjournals.org/iosr-jestft/papers/vol3-issue2/H0323644.pdf

Refuse Derived Fuel (RDF) is a segregated combustible fraction of MSW. The combustible fraction of the waste is transformed into fuel pellets by the compaction of waste or shredded and converted into fluff, enriched in its organic content by the removal of inorganic materials and moisture. Due to reduction in fuel particle size non-combustible material, RDF fuels are more homogeneous and easier to burn than the gross MSW feedstock. The RDF burning technology includes spreader stoker fired boiler, suspension fired boilers, fluidized bed units, and cyclone furnace units. In order to derive optimum advantage from RDF towards saving fossil fuel; secondary fuel like biomass, rice husk and other agro wastes can be used in small proportions for co-burning to generate energy.

Combustion of the RDF from MSW is technically sound and is capable of generating power. RDF can be fired at temperature above 900° C along with the conventional fuels like coal without any ill effects for generating heat. Operation of the thermal treatment systems involves higher costs and a relatively higher degree of expertise.

Gasification is the main technology for biomass conversion to energy and an attractive alternative for the thermal treatment of solid waste. Gasification produces combustible gas such as hydrogen, synthetic fuels and is a process that converts dry organic or fossil based carbonaceous materials into carbon monoxide, hydrogen and carbon dioxide at elevated temperature (500-1800°C). The syngas can be used as a feedstock for the chemical industry (through some reforming processes, or as a fuel for efficient production of electricity and/or heat. The number of different uses of gas shows the flexibility of gasification and therefore allows it to be integrated with several industrial processes, as well as power generation systems. Air gasification produces a low-energy gas (4-7 MJ Nm-3 net calorific value), while oxygen gasification produces a medium-energy gas (10-18 MJ Nm-3 NCV). The purpose of gasification of waste is to generate power more efficiently at lower power level (< 2MW) and also to minimize emissions. [8]

MSW is segregated in gasification process to remove non-combustible materials. Biomass, agro-residues and RDF pellets can be added to the gasifier to enhance the heat generation. Gasification is normally followed by combustion of the produced gases in a furnace and in internal combustion engines or in single gas turbines after comprehensive cleaning of the product gas. The process produces residual waste, as well as waste from cleaning of the gases, which have to be deposited at a controlled landfill. Wastewater is also normally produced and treated before it is discharged to the sewage system or evaporated in cooling towers.

The residue or ash that has to be landfilled is similar to that of incineration process. The gas can be used for thermal or power generation purposes. Internal combustion engines can be used for power generation with heat recovery. Typical efficiency of these systems is higher than that of incineration and is in excess of 25% at < 1 MW capacity. [9]The engine exhaust can be treated to meet the environmental norms. Based on several fundamental studies, it is evident that the emissions from gasification process using MSW is lower and even the treatment, if required, will be for less than one third of the volume of combustion products.

The purpose of gasification of waste is to minimize emissions and to maximize the gain and quality of recyclable products.

[8] http://planningcommission.nic.in/reports/genrep/rep_wte1205.pdf
[9] http://planningcommission.nic.in/reports/genrep/rep_wte1205.pdf

5. Developing strategies for implementation of municipal waste-to-energy projects

Waste-to-energy projects are useful for surveyed cities especially the Chennai, Coimbatore, Indore and Bhopal as these cities suffer from shortage of power (refer Figure 1.21). Majority of the respondents also recognise that MSW and biomass can be important renewable source of energy for these cities as shown in Figure 1.25 earlier. However, among the surveyed cities, it is clear that Pune and Chennai have already gone ahead for either implementation or at advanced stage of tendering waste to energy projects. So there is no scope for developing further waste-to-energy projects in these cities. However, scope exists in other cities namely Thane, Coimbatore, Bhopal and Indore. The proposed strategies for implementing waste to energy projects in these cities include:

- Segregation of wastes at source and involvement of all stakeholder's in effectively managing MSW and minimizing waste going to landfills in Bhopal and Indore. Avoidance of waste to landfills will mean that more and more waste will be processed for energy or resource recovery
- Separation of four streams of MSW at source, namely, 1) construction and demolition wastes, 2) street sweepings and silt from drains, 3) wet bio-degradable and recyclable fraction separated at source in households, institutions and commercial establishments and, 4) single-source bulk wastes collected from market yards, restaurants and canteens, slaughter houses, etc. by the municipality. This will ensure that only segregated organic fraction of waste is processed for energy recovery. As discussed with gasification plant operators at Pune, they indicated that the project viability and power generation capacity can be increased from present 2-3 MW to rated 10 MW if they have access to segregated waste.
- Implementation of technological options which are feasible, financially affordable, and environmentally sound for processing and scientific disposal of MSW along with the financial mechanisms and institutional arrangements to set up treatment plants to recover maximum possible resources and energy from the wastes. This is exemplified in Pune where they have been able to collect segregated waste from households, use it in decentralised manner to produce power and manure. As discussed earlier, the municipal authorities have been able to set up 20 decentralised biomethanation plants to process around 98 tonnes of segregated waste every day.
- Municipal authority may allot suitable parcel of land as per yardstick that may be prescribed on a token lease rent / license fee of Rs. 1/- per sq. meter /year to the concessionaire / private developer (big or small) willing to make investments in processing of municipal solid waste
- Municipal authority may deliver MSW at the plant site / transfer station free of cost and may not insist on getting royalty on the income derived by the concessionaire. The residual waste from all the processing facilities needs to be sent to sanitary landfills.
- Municipal authority should be willing to purchase power from the concessionaire if offered at a rate approved by the regulatory authority.