

What drives Segregation of Household Municipal Solid Waste? A Case in Powai

Course Project as a part of

US 603 Course

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May, 2018

Abstract

As a part of an academic course, the current study was carried out to learn research methods. The subject chosen was urban household level solid waste management. The question under consideration was what drives the practice of segregation at household level in urban setting. For this, based on primary review of various case studies across cities developing countries was done which gave rise to a hypothesis that the main hindrance to segregation is the knowledge and awareness, while the institutional enforcement is not an important factor. This hypothesis was tested in middle class households in Powai, Mumbai through a household survey which collected data on current segregation practices, willingness to segregate, opinions on role of institutions and tested level of knowledge and awareness through simple questions. A simple model was constructed where composite scores for level of knowledge, awareness, response to institutional enforcement, current level of segregation and willingness to segregate was calculated. Willingness to segregate and current level of segregation were estimated (as the dependent variables) with the other three as independent variables and it was found that the hypothesis that access to knowledge affects segregation fails. On the other hand, as there is no legal enforcement in Mumbai yet to segregate and dispose wet waste (though the Municipal Corporation of Greater Mumbai has served notices to housing societies to that effect recently), response to institutional enforcement is strongly correlated with both the dependent variables. Thus, it is postulated that first the institutional mechanisms will have to be put in place. Also, it was observed that in most houses which practice segregation, it was women who did it. The policy implications of this need to be explored.

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Chapter 1 Introduction

The current study is a part of the ‘Research methods in Urban Sciences’ course (US 603) at the Centre for Urban Studies and Engineering, Indian Institute of Technology Bombay to learn survey-based research methods.

1.1 Background

The main constraints to the study were tied to the course: it was to be a short-term study based in geographical area of Powai, involving household level survey questions and was to be conducted individually. Out of personal interest Solid Waste Management sector was chosen. Being a family focusing on complete at-source waste segregation, I wanted to identify the hindrances which other families face in segregation.

1.1.1 Objective

To understand what the hindrances to adoption of household level waste segregation practices are.

1.1.2 Hypothesis

Waste segregation practices are limited due to limited awareness and knowledge and limited access to facilities and institutional pressures.

Alternatively, the low level of segregation might be due to low enforcement of segregation at the institutional level.

1.1.3 Research Process

This study follows a typical research flow methodology.

After fixing the constraints and area of study, a problem was defined. The primary research problem can be stated as *Why do households (in Powai) not segregate waste?*

Literature review was done on the subject of household municipal solid waste segregation, situation in various cities, MSW collection system in Powai, etc., which is covered in Chapter 2.

Research was designed based on this, a questionnaire was prepared and data collected. An outline of the same is provided in Chapter 3.

The collected data was analysed as detailed in Chapter 4.

Chapter 2 Literature Review

Following keywords were searched for literature review on this topic

- Macro-area: Municipal Solid Waste Management
- Geography: Mumbai, India
- Type of Study/ Method: Survey based
- Focus: Segregation and collection

2.1 Municipal Solid Waste

2.1.1 Definition

The 'What A Waste: A Global Review of Solid Waste Management' report by Urban Development & Local Government Unit of the World Bank published in 2012, a follow up to a 1999 report about Solid Waste Management(SWM) in Asia, compiles basic information about Municipal Solid Waste. The following three definitions, taken from the book put in perspective what comprises municipal solid waste (MSW) (Hoornweg & Bhada-Tata, 2012).

By Organisation for Economic Co-operation and Development: Municipal waste is collected and treated by, or for municipalities. It covers waste from households, including bulky waste, similar waste from commerce and trade, office buildings, institutions and small businesses, yard and garden, street sweepings, contents of litter containers, and market cleansing. Waste from municipal sewage networks and treatment, as well as municipal construction and demolition is excluded.

By Pan American Health Organization: Solid or semi-solid waste generated in population centres including domestic and, commercial wastes, as well as those originated by the small-scale industries and institutions (including hospital and clinics); market street sweeping, and from public cleansing.

By Intergovernmental Panel on Climate Change: The IPCC includes the following in MSW: food waste; garden (yard) and park waste; paper and cardboard; wood; textiles; nappies (disposable diapers); rubber and leather; plastics; metal; glass (and pottery and china); and other (e.g., ash, dirt, dust, soil, electronic waste).

2.1.2 Sources and Types of Municipal solid waste

The “Guidelines for Citizens for Management of Municipal Solid Wastes” by Maharashtra Pollution Control Board mentions domestic, commercial and institutional wastes; as sources of municipal waste and classifies the waste as garbage, rubbish, ashes, bulky wastes, street waste, dead animals, construction and demolition wastes, biomedical and hazardous wastes. (Dhupkar & Nimbarte, 2005)

As the last two are generated from limited sources and collection and disposal processes for them are different, these are generally not grouped with municipal solid waste.

Table 1: Types of municipal solid waste

Types	Materials
Organic	Food scraps, yard (leaves, grass, brush) waste, wood, process residues
Paper	Paper scraps, cardboard, newspapers, magazines, bags, boxes, wrapping paper, telephone books, shredded paper, paper beverage cups. Though organic, unless contaminated by food residue, it is not classified so.
Plastic	Bottles, packaging, containers, bags, lids, cups
Glass	Bottles, broken glassware, light bulbs, coloured glass
Metal	Cans, foil, tins, appliances (white goods), railings, vehicles
e-waste	Batteries, electric and electronic equipment, wires, CFLs, LEDs,
Other	Textiles, leather, rubber, multi-laminates, ash, other inert materials

Source: (Hoornweg & Bhada-Tata, 2012)

2.1.3 Collection of MSW

Waste collection is defined as collection of waste from point of production, to point of disposal. Municipal solid waste is collected in various ways, as listed below (Hoornweg & Bhada-Tata, 2012):

- a. Door-to-door
- b. Community bins
- c. Road-side pickup
- d. Self-delivered
- e. Contractual/delegated services

This collection can be segregated or mixed. Segregation of waste itself may be limited to wet waste and other waste or a more nuanced system might exist (e-waste, paper, glass, metal, plastic, etc. recyclables separated, either at source or at an intermediate level).

2.2 Status of Solid Waste Management in Mumbai

2.2.1 Service Level Benchmarking

To monitor the performance of any Urban Local Body regarding its Service Delivery to the Citizens, Ministry of Urban Development has devised benchmarks for each service delivered. For Solid Waste Management Dept. there are 08 such benchmarks. The benchmarks are elaborated below. (Current achieved values are mentioned in bracket) (CE SWM, MCGM, 2017)

Table 2: Service Level Benchmarking status in SWM of MCGM

Description of service	Target	Achieved
Coverage of SWM services through Door to Door collection	100%	80%
Efficiency of Collection	100%	100%
Extent of Segregation of Municipal Solid Waste	100%	27%
Extent of Municipal Solid Waste Recovered	80%	3%
Extent of Scientific Disposal of Waste at Landfill site	100%	30%
Efficiency in Redressing Customer Complaints	85%	95%
Extent of Cost Recovery in SWM Services	100%	100%
Efficiency in Collection of SWM Charges	90%	100%

As can be seen from this data, the status of segregation of waste is very poor.

2.2.2 Composition of Municipal Solid Waste in Mumbai

The Preparatory Studies for Development Plan 2014-34 for MCGM report gives following statistics of Municipal Solid Waste in Mumbai (DP Section MCGM, 2014).

Table 3: Status of Solid Waste in MCGM, 2017

MUNICIPAL SOLID WASTE GENERATED *	7700 MT/ day
Per Capita generation of Solid waste	630 gm pcd
Construction and Demolition waste (not included above) *	800 MT/ day
MUNICIPAL SOLID WASTE TYPE	
Wet organic material	54%
Dry organic material	15%

Recyclables and paper	19%
Inert material	13%
GARBAGE COLLECTION	
Number of community Collection Points	3,751
Garbage collection from community points	48%
Garbage collection from houses	52%
RECOVERED SOLID WASTE	
Wet organic (manure, vermi-culture)	369 MT/ day
Decentralised segregation of recyclables	250 MT/ day
Dumping Sites in operation in numbers (Deonar, Mulund and Kanjur)	3
Vehicle trips to dumping sites *	1900 per day
Total biomedical waste generated by various municipal and private medical institutions	~ 9 MT/ day
* <i>source</i> : (CE SWM, 2017)	

Other than the recovered waste (619 MT of 7800 MT per day), all waste is dumped in the landfill sites, where some more is segregated by ragpickers. Also, uncollected waste, dumped along nalas, empty plots, sea-side, etc. is also partially reclaimed by ragpickers. Only Kanjurmarg landfill has any treatment, in the form of a bio-reactor.

Current average for South Asia Region is 450 grams pcd, while Mumbai is 630 grams pcd. As expected average of SAR in 2025 is about 775 g (Hoorweg & Bhada-Tata, 2012), the average of Mumbai can be expected to rise to 1 kg per capita per day by 2025.

Under MSWM rules 2016, MCGM asked housing societies and bulk waste generators to segregate waste and dispose wet waste, but these new guidelines are yet to be enforced.

2.2.3 Waste collectors

MCGM employs about 22,000 staff per day in three shifts. 7587 people are deployed by partner NGOs and 9844 individuals through 761 Community Based Organisations work under the Swachh Mumbai Prabodhan Abhiyan for slum cleansing. One individual cover 150 families; 73 lakh population in slum and slum-like areas is covered (CE SWM, 2017).

Over 60,000 street and dumpsite rag pickers (60% women, 20% men & 20% children) work in Mumbai. Further, door-to-door waste collectors and recycling workers total over 100,000 in the city. Therefore, there is already a large section of informal workforce in the entire recycling sector in Mumbai (Mahadevia, Pharate, & Mistry, 2005).

Dry waste collection and sorting centres are being established in collaboration with NGOs. While 32 were already functional in 2017, another 35 sites are being set up. Some centres have baling, shredding, and compressing facilities for paper and plastic. The segregated waste is sent to recycling agencies (CE SWM, 2017).

2.3 Profile of S-ward MCG Mumbai

Powai, Mumbai refers to area in Ward S (Bhandup) of Metropolitan Corporation of Greater Mumbai(MCGM), in the eastern suburbs comprising four revenue villages: Kopri, Powai, Tirandaz and Hariyali-W. On western boundary is the Powai Lake and the other boundary is made by the hills which separate Powai from Ghatkopar and Vikhroli.

The population of S Ward spread over an area of 29.75 km², as per 2011 census is 743,783 and is expected to increase to 899 thousand by 2041 (DP Section MCGM, 2014)

The S ward area is divided into sub-zones by the Development Planning department of MCGM as shown in table below.

Table 4: Geographical area (in Ha) of survey divisions of S Ward, MCGM

S - WARD	S 3.01	IIT Powai, Powai Lake	583
	S 3.02	Hiranandani Powai, Panchkutir Ganesh Nagar	168
	S 3.03	Godrej Colony, HMPL Surya Nagar, Ramabai Nagar Powai	241
	S 3.04	Kaju Tekdi, Kanjurmarg West, Kendriya Vidyalaya Kanjurmarg, Khindipada Bhandup, Panchsheel Nagar Bhandup, Pratap Nagar Kanjurmarg, Shivaji Nagar Bhandup, Sonapur Bhandup, Tembhipada Bhandup, Utkarsh Nagar Bhandup	464
	S 3.05	Bhandup Industrial Area, Govind Nagar Bhandup, Huma Theatre, Vasant Nagar	246
	S 3.06	Gandhi Nagar Powai, Lokmanya Nagar Powai	41
	S 3.07	Kannamwar Nagar, Tagore Nagar	209
	S 3.08	Adarsh Nagar, Friends Colony Nahur, Kanjurmarg E , Nahur E	404
	S 3.09	Kanjurmarg Municipal Dumping Ground	593
	Sanjay Gandhi National Park	-	25
Total		2,975	

Source: (DP Section MCGM, 2014)

The following map from Slum Rehabilitation Authority of Mumbai marks Powai area. It shows the slum pockets concentrate in Tirandaz and Hariyali-W villages and one cluster in Powai, along JVL R. At the ward level, 72% of population in S ward lives in slums.

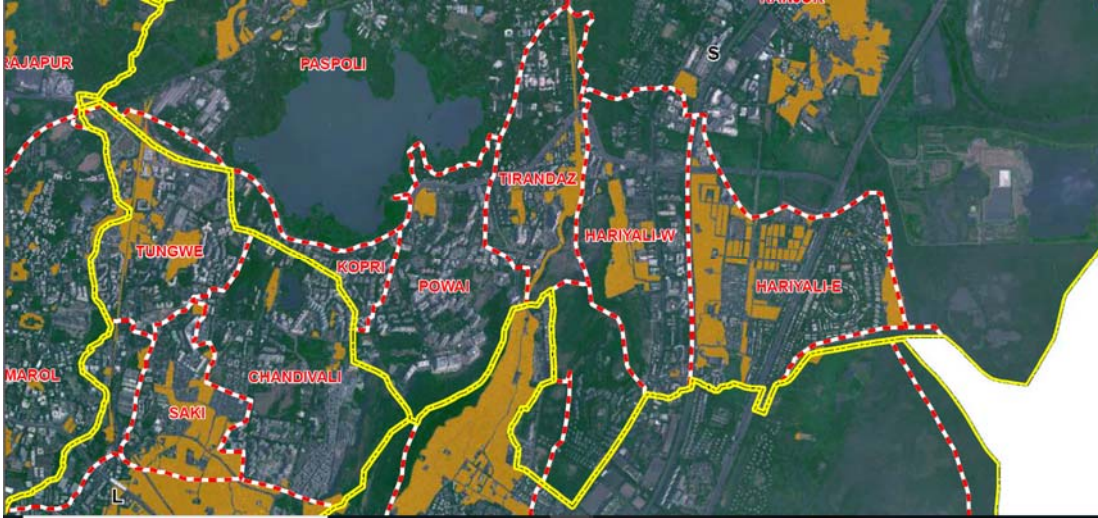


Figure 1: Map of Powai, highlighting Slum pockets

Source: (SRA Mumbai GoM, 2015)

2.3.1 SWM department of S-Ward

The office of Assistant Engineer, Solid Waste Management, S-ward is located near Mangatram petrol pump, Bhandup (W) at the S-ward office and it is the primary responsible institution in the ward for maintaining garbage free, clean and green ward. It has 10 chowkies, of which none is located in Powai. The office has total 1037 posts sanctioned, of which 891 posts are filled (SWM Department, 2015).

There are 2 HYVA compactors installed in S-Ward, one in IIT Bombay and other at Municipal Market, Tagore nagar (CE SWM, 2017).

2.4 Waste Collection

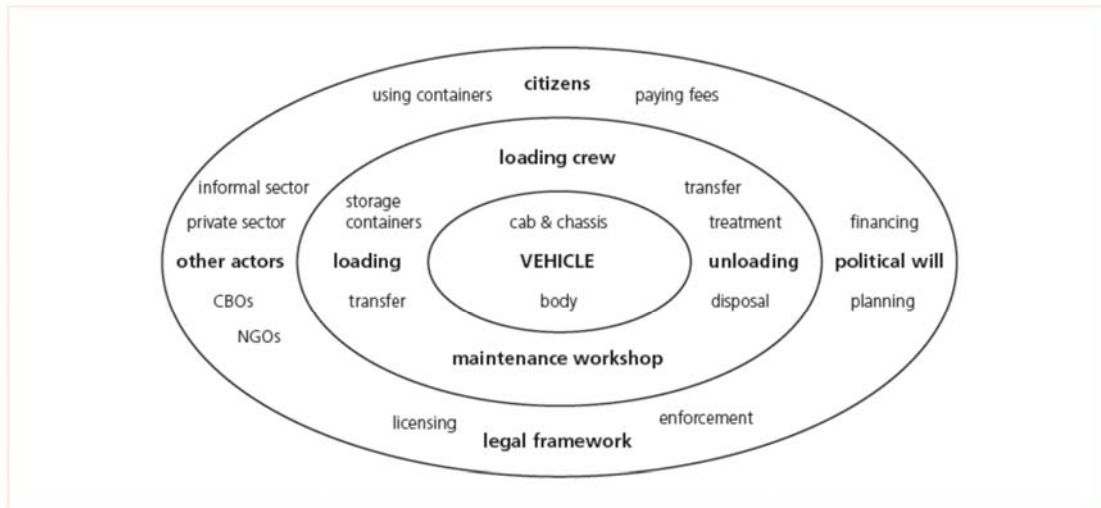


Figure 1.1 The municipal solid waste collection system
The vehicle is the core of the collection system, but there are many other components and aspects that need to be considered. It is not sufficient to select the cab, the chassis (comprising the frame, motor, transmission and wheels) and the load-carrying body without considering the other aspects that are listed in the middle and outer circles. Terms and abbreviations are defined in Annex A7.

Figure 2: Municipal solid waste collection system

Source: (Coffey & Coad, 2010)

While the waste collection system in any municipality primarily depends on the vehicles transporting the waste from generation point to disposal point, a lot of other factors come to play as illustrated in Figure.

Table 5: Comparison of various methods of solid waste collection

Description	Community containers	Block collection	Kerbside collection	From inside the property
Householder co-operation in carrying refuse bins or bags	Yes	Yes	Yes	No
Householder co-operation in emptying refuse bins	Yes	Optional	No	No
Need for scheduled service	No	Optional	Yes	No
Waste pickers' access to waste	Very high	None	High	None
Average crew size (excluding driver)	1-2 (portable) 2-4 (stationary)	1-2	1-4	2-6
Complaints regarding trespassing	No	No	No	Yes
Level of service	Low	Fair	Good	Good
Collection cost per household	Low	Medium	High	Very high

Source: (Coffey & Coad, 2010)

2.4.1 Waste segregation recycling systems from literature

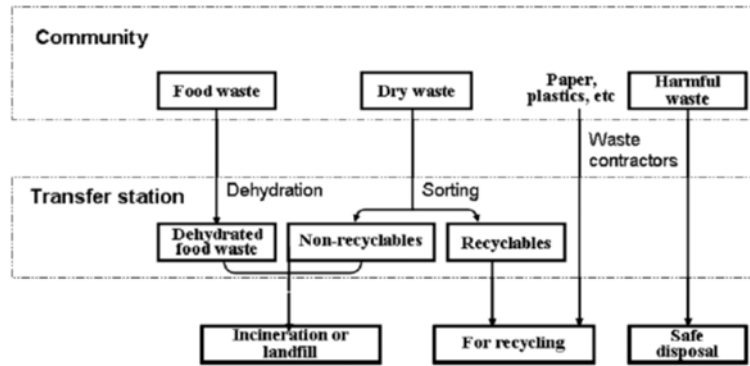


Figure 3: Source separation system of HH waste in Chinese communities

Source: (Zhuang, Wu, Wang, Wu, & Chen, 2008)

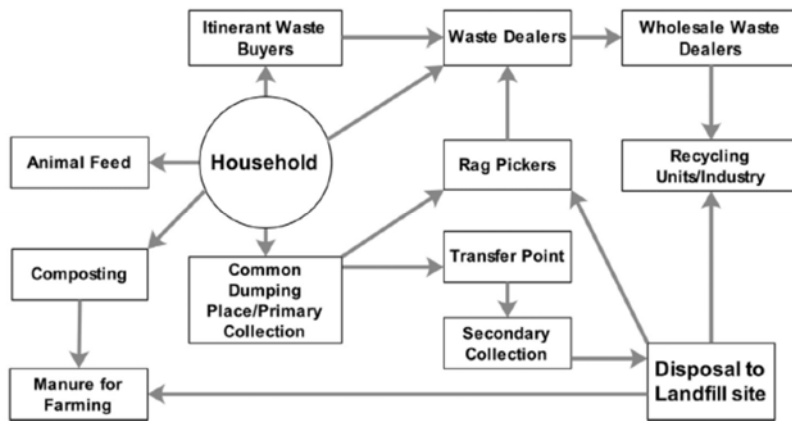


Figure 4: Recycling and chain of waste dealers in India

Source: (Pandey, Surjan, & Kapshe, 2018)

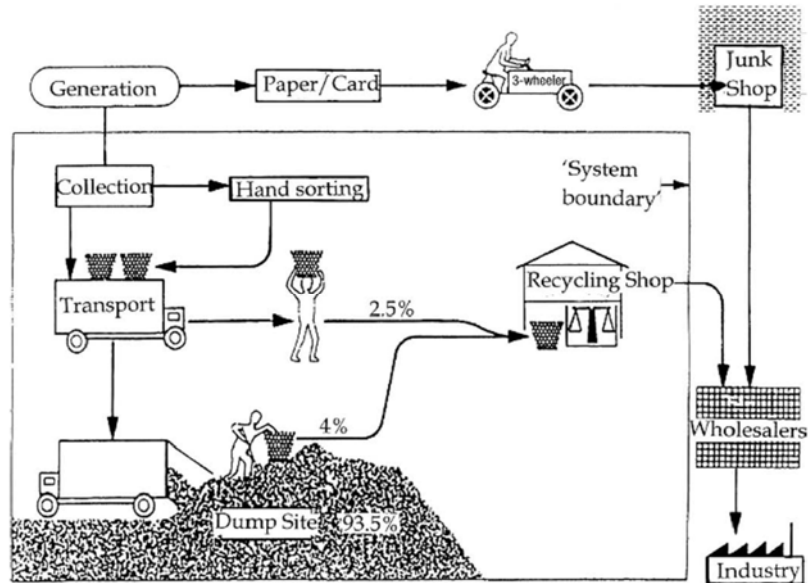


Figure 5: Informal recycling system in Bangkok, in 1987

Source: (Wilson, Bourgeois, & Vicharangsana, 1988)

Table 6: Stakeholder roles and interests

Stakeholder	Role	Interest
Households	Separating their waste	Gain income from selling recyclables
Residential committee	Carrying out environmental education programs to enhance public awareness on waste separation	Earn city-wide reputation from this program
Real estate company	Providing facilities for waste separated collection such as waste containers	Earn city-wide reputation from this program
Recyclers	Recovering recyclable materials from households	Gain a profit by secondary materials deals
Environmental Sanitation Department	Collecting and transporting separated waste, operating of the material recovery facility (MRF)	Reduce transportation costs and gain a profit by waste recovery

Source: (Zhuang, Wu, Wang, Wu, & Chen, 2008)

Table 7: ways of extracting and adding value to recovered waste

Extracting and adding value processes	Explanation and comments
Collection	Identification and picking of items or collecting mixed waste allows the sector to acquire the waste and turn it into a resource. Most primary materials recovered from refuse, such as paper, plastics, rags, metal, glass, and food leftovers, constitute a commodity as they all have a market price
Sorting	Main process that increases the value of the waste recovered. The deeper the sorting differentiation, the higher the value of waste. For instance, if plastic is grouped into one major category, its value is lower than when it is further separated into sub-categories of hard and soft, then HDPE, PET, LDPE, etc. Sorting according to colour, size, shape and potential use or re-use of the materials so as to meet the end-users quality specifications
Accumulation of volume	Additional volume adds value: larger volumes command higher per-unit prices. The greater the quantity, the better bargaining power the trader has. For small quantities, transactions costs, such as checking quality, arranging transport and paying the seller, reduce the profit margin. Industrial feedstocks are massive in volume. It follows that storage space is required
Pre-processing	For instance: washing, changing in shape-cutting, granulating, compacting, baling
Small manufacturing craftsmanship	Creation of micro-enterprises that use the special skills of informal recyclers to transform recyclates into articles traded directly to the community and being affordable by the poor
Market intelligence	Proximity to markets where informal recyclers and traders conduct business allows for the flow of information which allows decisions to be made on accurate market prices, competitors, trading partners, etc
Trading	In informal or formal markets. Links to the secondary materials network are crucial. Traders should be financially capable to add and conserve value of recyclates. Difference between buying and selling should also provide buffer against risk

Source: (Wilson, Velis, & Cheeseman, 2006)⁸

2.5 Review of Selected Research Articles

Based on initial literature keywords search, about 45 journal articles on municipal solid waste management were shortlisted. While many of these helped in building perspective, 6 case studies of various cities which focused on informal sector in waste management were shortlisted and studied in detail.

These studies are of Delhi, Bhopal, Dhaka, Bangalore, Xiamen, and Amritsar cities. No relevant study, in current decade, was found for Mumbai. Thus, data of Mumbai, as presented earlier, is mostly from government sources.

2.5.1 Exploring linkages between sustainable consumption and prevailing green practices in reuse and recycling of household waste: Case of Bhopal city in India (Pandey, Surjan, & Kapshe, 2018)

This study looks at waste generation and lifestyle of households and discusses reuse and recycle of waste. It used a questionnaire survey, administered to economically weaker sections, low-income, middle-income, and high-income groups, to understand the various waste management practices (waste generation/reuse/recycling/disposal practices). While this is a good case study of household level reuse, recycling, and segregation, it doesn't much discuss the role of the informal sector in the same.

2.5.2 Municipal solid waste recycling and associated markets in Delhi, India (Agarwal, Singhmar, Kulshrestha, & Mittal, 2005)

This paper collects information on waste management system in Delhi through field surveys using a questionnaire designed for sanitation staff, workers, patients, government engineers, and recyclists. It captures the waste trade chain and focuses on the recyclists, the informal waste/ rag pickers and records their residential status, lifestyle, and work conditions. It also provides a sketch of the further recyclables waste stream and the market prices at various recycling levels. Through some analysis, it concludes that if waste recycling sector is privatised, more than two-thirds of the informal recyclists will be jobless; instead it suggests that these people should be trained in safe garbage handling and processing organic waste.

2.5.3 Promoting public participation in household waste management: A survey-based method and case study in Xiamen city, China (Xiao, Zhang, Zhu, & Lin, 2017)

This study describes the status of waste source separation program adopted in 2000. The data for people's willingness to participate in WM related to WM and its influencing factors are derived from an onsite questionnaire-based door-to-door survey conducted in 2012. A structural equation model is constructed to explain the factors affecting people's willingness to participate. The paper concludes that knowledge of segregation and social motivation are crucial factors in people's willingness while rewards and laws are not important in the study area. Thus, they recommend that future urban waste management programs should focus on facilities, knowledge, and social behaviour rather than legislations.

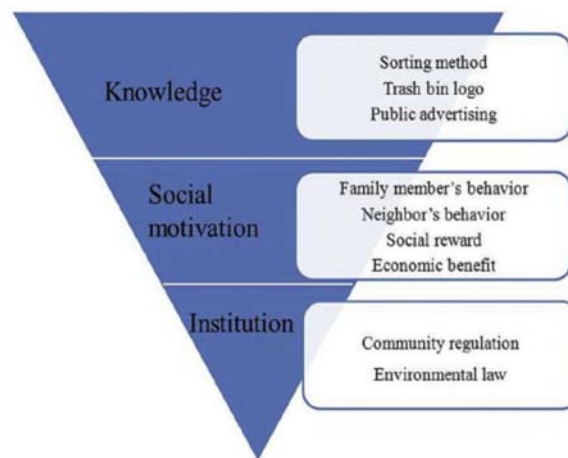


Figure 6: Waste policy hierarchy in China

2.5.4 Improving the informal recycling sector through segregation of waste in the household - The case of Dhaka Bangladesh (Matter, Dietschi, & Zurbrügg, 2013)

This paper focuses on household waste production and explores how its segregation can preserve the value of recyclable materials, enhance their accessibility to informal workers, and reduce the overall waste flows. This study used baseline survey of previous studies which looked at households, collection points, and institutional surveys. The current study added qualitative data through focus group discussions and semi-structured interviews of authorities, waste collector societies, waste collectors, waste pickers, recyclable collectors, and shops keepers. It describes how increased segregation can lead to various benefits and outlines the current challenges to the same. It discusses how plastics and organics economics plays out; what are the interests and incentives to various stakeholders in the process.

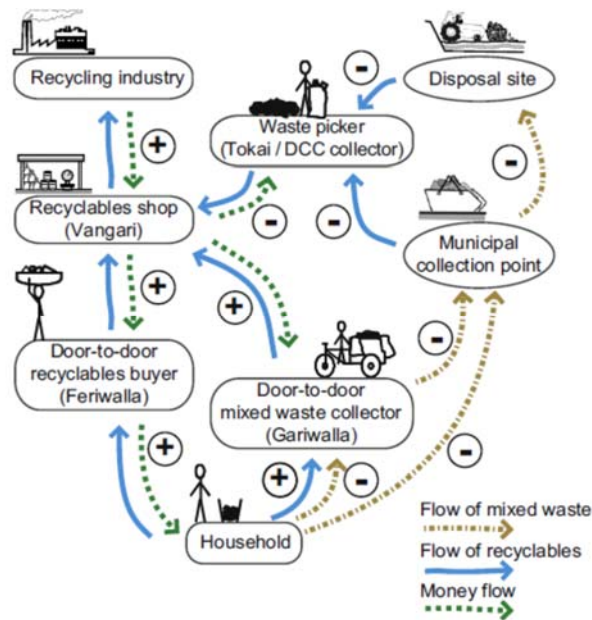


Figure 7: Reinforcing loops from increased HH waste segregation

2.5.5 Between hype and veracity; privatization of municipal solid waste management and its impacts on the informal waste sector (Sandhu, Burton, & Dedekorkut-Howes, 2017)

Study based on evaluation of privatisation of waste collection in Amritsar. This paper uses qualitative approach, first literature is studied for selection of criteria and indicators for analysis, followed by 32 semi-structured interviews and direct observation methods. Data reduction and verification was enabled using the principles of constant comparison, theoretical

saturation, and triangulation. A descriptive and exploratory narrative is adopted towards constructing interpretations emerging from the research. It looks at privatisation and its impact on informal stakeholders' access to waste, impact on income, impact on relationships with other stakeholders and then proposes possibilities to integration.

2.5.6 Sample Study of Informal Waste Pickers in Bangalore (CHF International; MSSS, 2010)

In this report, 264 waste collectors (Migrant waste pickers, living in city for below 10 years, Local waste pickers living in city for more than 10 years, Waste pickers who work only in landfills and Contract municipal workers) are surveyed and the results of their demographics, economic status, work conditions, access to services, etc. are presented. Through focus group discussions and case studies, the report brings out the challenges faced by these communities and recommend certain actions.

Sample Study of Informal Scrap Dealers and Recyclers in Bangalore (CHF international; MSSS, 2011) 13

In this report, results of surveys of recyclers are presented. It presents statistics on types of shops, length of time in business, ownership, number of employees, sources of recyclables, frequency of sale, average incomes, links with dealers, transportation and challenges faced. It also presents some case studies and proposes recommendations for source segregation and collection to maximise recovery, connecting to bulk generators, enumeration to provide formal identity and prevention of child labour.

Chapter 3 Methodology

Using the research process mentioned in Chapter 1, the focus of this research was narrowed down to understanding why households do not segregate waste. It was hypothesised that the level of knowledge related to waste segregation is poor and/or access to facilities necessary to segregate (like multiple bins, local scrap dealers, institutional mechanism, etc.) is low and thus segregation doesn't take place. Thus, the flow of research was planned accordingly and final questionnaire-based data collection tried to understand current segregation practices, knowledge of segregation, attitude towards institutional mechanisms, and willingness to segregate.

3.1 Research Flow Diagram

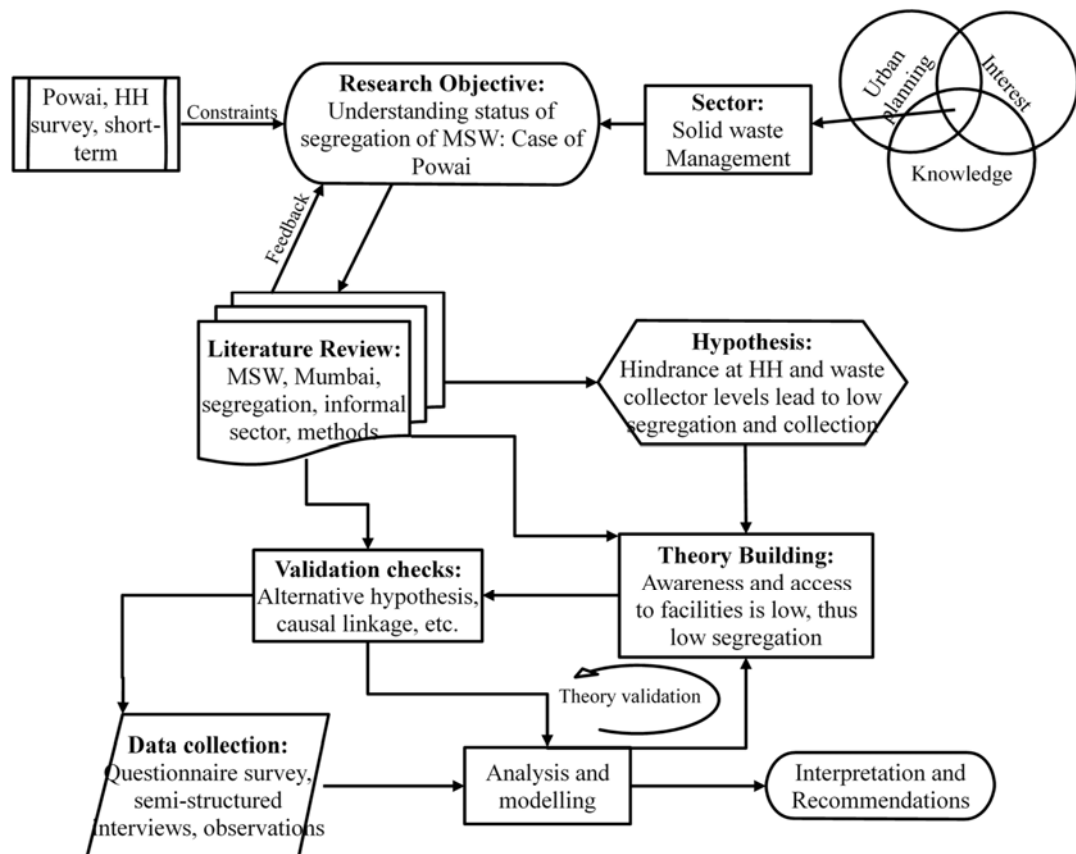


Figure 8: Research Flow Diagram

3.2 Data Required

As the focus was on hindrances (theorised to be due to lack of awareness), following data about current level of awareness and perceptions about hindrances of the HH and waste pickers/collectors seemed to be useful.

Some secondary information about situation in the area and practices prevalent can be obtained through interaction with Municipal officials. Population and other figures can be obtained from online sources or from officials.

3.2.1 Primary data

1. Demographic profile of HH/ respondent
2. Information on waste segregation and disposal practices at HH level
3. Awareness about segregation (existing knowledge) of respondent
4. Willingness and importance of enablers for better segregation (knowledge, institutions, and social motivation)
5. Demographic profile of waste picker/collector,
6. Work details
7. Opinions on segregation, level of existing knowledge about waste flows, markets, etc.

3.2.2 Secondary data

1. Population, no. of societies, and their waste management employees,
2. Number of informal waste pickers in the area
3. SMPA, NGO and MCGM workers, Number of spots for waste pickup in the area
4. Existing waste flow chain - issues
5. Segregated waste/ recyclables flow chain – issues
6. Areas covered by segregated collection, societies expected to segregate/ dispose own waste
7. Systemic efforts to create awareness/ knowledge, institutionalise segregation

Interview was done with S-ward official and a wet waste composting machinery provider in the area. Based on these two interviews, it was realised that very limited secondary data would be available and vested interests of various people in the waste collection chain

limits the enforcement of waste segregation at source. In S-Ward, MCGM doesn't practise segregated collection.

3.3 Questionnaire

The following questions were added to common questionnaire for the survey:

36. How many dustbins do you have: 1. One, 2. More than one

37. If more, what are they used for: 1. Kept in different rooms, 2. For different types of waste

38. How do you dispose your kitchen and food waste: 1. Given out mixed with garbage, 2. Separated, but given out with garbage, 3. Feed to animals, 4. Compost at home/ society

39. How do you dispose plastic, paper, and other dry waste in house: 1. Given out mixed with garbage, 2. Separated, but given out with garbage, 3. Sold

40. If waste is separated in the house, who does it in relation to respondent: _____

41. Do you sell any waste to scrap dealer/ raddiwala/ kabadiwala? : 1. Yes, 2. No.

If Yes, what is sold and at what rate: _____

(Surveyor: please get price of any 1-2 items s.a. paper, plastic)

42. Please classify these items into wet waste or dry waste (tick one in each)

Item	Vegetable peels	Packaging box	Used Diapers	Plastic bags	Disposable paper plates
Wet					
Dry					

43. How do you feel about following statements?

	agree/ disagree	neutral/
Not segregating causes illnesses		
Even if I mix the waste, it is easy to segregate it later		
It is difficult for us to adopt segregation		
If waste is segregated and thrown, it will not smell		
Our colony should enforce segregation & be responsible for disposal		
Municipality should first ensure separate collection		

Municipality should do segregation post collection	
Waste collectors should deny collecting unsegregated waste	
If some conditions are met, we will segregate waste at home	

(question numbers as in the final version of questionnaire)

Chapter 4 Results

After the freezing of the questionnaire, over a period of two weeks, each group carried out household surveys. A total of 42 forms were entered in the online google form, of which two lacked the necessary data for many questions of interest. Thus, ignoring these two submissions, rest 40 were analysed. Some forms filled after the analysis was started were ignored.

4.1 Sample Descriptive Statistics

As the household, education, income related data from the filled forms is missing, no descriptive statistics of the respondents is possible. But it can be seen that most of the families are somehow connected to IITB, some have a member working in IITB and some stay on campus. Also, most houses are 1,2 BHK houses in apartments and half the families own car. Thus the survey doesn't give a complete picture of Powai, but gives the picture of middle income groups, and the poor living in slums who make up 76% of Powai population are not represented.

4.2 Analysis

4.2.1 Primary Analysis

From the data related to segregation and solid waste related practices, following primary inference can be drawn.

While 31 respondents report having more than 1 dustbin (modal value for the entire sample is 2 dustbins, the number ranging from 1 to 6), only 13 families reported using them for throwing separate types of waste, or for segregation. From here onwards, the discrepancies in the data start to become important. Many people who say that they have only one dustbin, or use the separate dustbins for keeping in separate rooms rather than for separate types of waste

respond that they compost their wet waste or store and sell for recycling their dry waste like paper and plastic. Also, while only 13 hinted at segregation, 15 respondents mention someone in the house segregates the waste.

Often, the answer to who segregates the waste in the house is given as some female member of the household and/or maid, while only 4 respondents mentioned that everyone in the house segregates waste by throwing in respective bins.

Of the 40 respondents, 27 responded positively to selling certain waste items to scrap dealer. Any bulk dry waste is generally sold out, as is the standard practise across the country. Though, when the same question is asked about sale of plastic or regular dry waste, only 8 respondents mention selling these items to scrap dealers.

When asked about waste categories to judge the knowledge levels regarding types of waste, grouping all waste into wet or dry categories, almost all respondents were able to answer correctly. Most people also showed a high awareness about environmental, health and other issues related to garbage.

36 respondents positively told that if asked by the waste collection service provider, i.e., either their society or by MCGM, they would start segregation. Most people also agreed with statements such as their society should start segregation and Municipality should ensure segregated collection. A good number (23) also agreed that waste collectors should deny collecting unsegregated waste, if segregation is enforced. Most respondents were ready to pay for better and efficient waste collection services which would ensure segregation.

4.3 Model

To check the hypothesis that level of awareness, measured through knowledge level and environmental awareness affects the segregation status, following model was constructed.

For construction of model, responses to all questions were coded into binary (0,1) for negative-positive/ no-yes/ undesired response-desired response answers. For some questions such as opinion based and where there were three responses possible, the coding was done as 1,0,-1 for most desired, neutral and most undesired answers. For opinion based answers, initial coding done was 1 for agree, 0 for neutral and -1 for disagree. During linear combinations for

making up composite scores, based on desirability of either agree or disagree, positive or negative sign was attached to the specific answer.

4.3.1 Composite scores

Level of Knowledge

A composite score for level of knowledge was generated by averaging out the responses to 12 questions about classifying waste as wet or dry. As Diapers and Sanitary napkins classification under wet-dry was debatable, the responses for them were ignored and thus 10 questions were left. Thus, the score for each (0/1) were added and divided by 10 to get a final composite knowledge score between 0 & 1.

Level of Awareness

Similarly, using three opinion based questions (segregation-illness, segregation of mixed waste, and smell of segregated waste) scored as -1,0 or 1, a linear combination was made to get final composite level of awareness score between -1 and 1.

Response to Institutional enforcement

Based on responses to opinion-based questions about colony enforces segregation, Municipal segregated collection, waste collector denial of service for unsegregated waste and post collection segregation, a linear construct was made to have scores between -1 and 1.

Willingness to segregate

Willingness of segregation was calculated from response to questions such as readiness to segregate if some conditions are met, perceived difficulty to segregate and willingness to segregate if asked to by the municipality.

Current level of Segregation

This score was calculated by current averaging scores for current practices, such as, method of disposing wet and dry waste, family members involved in segregation,

Descriptive statistics

Here is the descriptive statistics for the above composite scores

Table 8: Descriptive statistics for composite scores

Statistics	Willingness to Segregate	Current level of segregation	Level of Knowledge	Level of Awareness	Response to institutional enforcement
Mean	0.633	0.179	0.888	0.383	0.556
Std. Error	0.062	0.053	0.021	0.069	0.070
Median	0.667	0.167	0.900	0.333	0.625
Mode	1.000	0.167	0.900	0.333	1.000
Std. Dev.	0.391	0.334	0.130	0.437	0.440
Variance	0.153	0.112	0.017	0.191	0.194
Range	1.667	1.333	0.700	1.333	1.500
Minimum	-0.667	-0.333	0.300	-0.333	-0.500
Maximum	1.000	1.000	1.000	1.000	1.000

4.3.2 Regression Analysis

Estimating Current level of segregation against knowledge, awareness, and response to institutional enforcement, in MS Excel data analysis plugin gives following results

Table 9: Level of Segregation

SUMMARY OUTPUT

<i>Regression Statistics</i>					
Multiple R		0.391			
R Square		0.153			
Adjusted R Square		0.082			
Standard Error		0.320			
Observations		40			

ANOVA					
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	3	0.665	0.222	2.162	0.110
Residual	36	3.690	0.103		
Total	39	4.355			

	<i>Coefficients</i>	<i>Std Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
Intercept	-0.141	0.357	-0.395	0.695	-0.866	0.584
level of knowledge	0.162	0.405	0.400	0.692	-0.660	0.984
level of awareness	0.129	0.120	1.072	0.291	-0.115	0.372
Institutional enforcement	0.229	0.123	1.862	0.071	-0.020	0.477

It can be seen that the current status of segregation is not strongly correlated with either knowledge, awareness, or response to enforcement.

Estimating willingness to segregate against the same three variables gives following results

Table 10: Willingness to Segregate
SUMMARY OUTPUT

<i>Regression Statistics</i>						
Multiple R						0.524
R Square						0.275
Adjusted R Square						0.214
Standard Error						0.346
Observations						40

<i>ANOVA</i>						
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>	
Regression	3	1.636	0.545	4.544	0.008	
Residual	36	4.320	0.120			
Total	39	5.956				

	<i>Coefficients</i>	<i>Std Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
Intercept	-0.238	0.387	-0.616	0.542	-1.023	0.546
Level of Knowledge	0.792	0.439	1.805	0.079	-0.098	1.681
Level of Awareness	-0.076	0.130	-0.583	0.564	-0.339	0.188
Institutional enforcement	0.356	0.133	2.680	0.011	0.087	0.625

Looking at both the results, it is clear that only significant variable is response to institutional enforcement with a high value of 0.229 and 0.356 respectively. Willingness to segregate is also correlated to Knowledge at 10% significance, with a high value (0.792).

Thus, in Indian scenario, especially in Mumbai, where the Municipal Corporation of Greater Mumbai has not yet enforced segregated collection and disposal of wet waste at generation level, segregation is most affected by perceived response to institutional enforcement. Though knowledge level and awareness level scores are generally high in the sample, these don't translate into action as people can get away with not segregating.

Chapter 5 Conclusion

This study taught the basic research design and flow, which was the real purpose of this course project.

As most literature from China and some cities in India focused on the knowledge and other factors acting at the individual level as being crucial to adoption of segregation at the household level, same hypothesis was tested in Powai, Mumbai. The main difference between these case studies and Mumbai is the waste collection service provider in Mumbai, i.e., MCGM doesn't collect segregated waste or enforce segregation yet. In absence of this pressure people with good level of knowledge and awareness, as were surveyed in this study from middle income and white-collar job groups, do not practise segregation as they can get away with it. The awareness that their individual efforts will not work in absence of institutional processes might also be deterring certain individuals from segregating, though this is questionable as a significant fraction of the respondents (22%) seem to practise composting wet waste at either individual or society level and also send their dry waste into the recycling chain through scrap dealers.

It is seen that in most houses where segregation is practised, either due to self-awareness or because their society enforces it, it is the women who are responsible for it. While some houses did respond that everyone in the house segregates, as in most typical Indian households it is the women who clean the house, segregation is seen as their responsibility. It might seem as an additional burden if others in the house do not practise it, but at the same time this identifies the primary target of any waste segregation adoption drive. Working with women first will help introduce the practise in the households and then other members can be made to follow suite. While this is true in middle class, educated, working families, where women might be able to force others to adopt, the situation in homes where women do not enjoy equal status, such as lower income and high-income group families where women are supposed to sit at home, might be different.

The model constructed and analysis carried out was very simplistic. Other constructs of composite scores, with some weights or a multinomial probit model (as important variables were captured in binary or tertiary forms) could have been more suited. Also using a statistical

package for the analysis might have made playing around with the data a bit easier, though my unfamiliarity with the tools limited this.

The most important takeaway of this study is the need to learn R statistical package, establish better connection between aim, hypothesis and collected data to draw relevant conclusions and chose the right methods of data collection based on the nature of the study.

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