R4D PROJECT:

CHALLENGES OF MUNICIPAL WASTE MANAGEMENT: LEARNING FROM POST-CRISIS INITIATIVES IN SOUTH ASIA

PROJECT WORKING PAPER #9

A REVIEW OF INTEGRATED SOLID WASTE MANAGEMENT: APPROACH AND STRATEGY FOR INDIA WITH SPECIAL FOCUS ON KERALA

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Abstract

Municipal Solid Waste Management has become a very important discussion among urban planners and policy decision makers in the last two decades since the urban local bodies in India faces the formidable challenge of solid waste management, which is considered an essential service delivery for sustainable development. Environmentally sound, effective, financially viable and people friendly solid waste management is crucial in ensuring a healthy living environment. The present paper discusses the current policies and legal framework, strategies and approach and resource availability for SWM in India with special focus to Kerala. It presents an overview of waste generation, legal framework, and management strategies. The paper reviews the evolution of decentralized waste management in Kerala as an alternative solution representing a paradigm shift in the area of solid waste management as well as urban management. It highlights the decentralized system involving the segregation and processing of waste at source to the maximum extent possible and then at the community level, making non-biodegradable waste available for recycling, source level and community level composting or biomethanation for the organic fraction of waste. The solid waste management strategies for products recycle are promising practices that positively impact the circular economy, address the livelihood issues of large number of women and sustainability goals. The consequent development of an effective institutional mechanism is highlighted along with the Green Protocol activities in Kerala. This review paper has high relevance in the present scenario in Kerala especially since Kerala is in the process of implementing the World Bank funded Kerala Solid Waste Management Project (KSWMP). This comprehensive review not only provides an insight into the status, challenges, and implementation of waste segregation at source but also into further plans, designs and implementation strategies.

Key Words

Integrated Solid Waste Management, Sustainable Development, Circular Economy Solutions, Decentralized Waste Management, Participatory SWM.

1 Introduction

Solid Waste Management is one the major activities taken up by the urban local bodies in India during the last few years considering the impact of mismanagement of SWM, which leads to many environmental and public health issues. The concept of “Zero Waste” is gaining momentum in recent times though it is really a hard task to achieve. Efficient delivery of public services and infrastructure for SWM has become a top priority. Solid waste management (SWM) is costly and complex for local governments, but it is so essential to the health, environment, and quality of life of the people. They must be safe for workers and safeguard public health by preventing the spread of disease. In addition to these prerequisites, an effective system of solid waste management must be both environmentally and economically sustainable.

Municipal solid waste management (MSWM) involves the application of the principle of Integrated Solid Waste Management (ISWM) in managing municipal waste. ISWM is the application of suitable techniques, technologies and management options dealing with all types of solid wastes from all sources to achieve the twin objectives of (a) waste reduction, and (b) effective management of waste still produced after waste reduction (Cointreau, 2001,)

With rapid population expansion and constant economic development, waste generation both in residential as well as commercial/industrial areas continues to grow rapidly, putting pressure on society's ability to process and dispose of this material. Also, inappropriately managed solid waste streams can pose a significant risk to health and environmental concerns. Improper waste handling in conjunction with uncontrolled waste dumping can cause a broad range of problems, including polluting water, attracting rodents and insects, as well as increasing floods due to blockage in drains.

Furthermore, it may bring about safety hazards from explosions and fires. Improper solid waste management can also increase greenhouse gas (GHG) emissions, thus contributing to climate change.

Having a comprehensive waste management system for efficient waste collection, transportation, and systematic waste disposal—together with activities to reduce waste generation and increase waste recycling—can significantly reduce all these problems. An ISWM approach provides the opportunity to create a suitable combination of existing waste management practices to manage waste most efficiently (Vesilind and Worrel, 2012). For cities to be sustainable and to continue their economic development, they must be clean and healthy. They need to improve their SWM systems by adopting good collection coverage, appropriate transfer methods, and healthy disposal practices (Zhu DA et.al, 2008).

Waste generation is increasing day by day not only in urban areas but also in rural areas due in part to the expansion of urban facilities in rural areas and a large number of people migrating to the fringe areas of urban areas for want of livelihoods, education and other facilities. The solid waste generation in any area is strongly dependent on the local economy, lifestyle, and infrastructure. It has been well established that waste generation of an area is related to the average income of the people of that area: the generation of organic, plastic, and paper waste tends to be high in high income areas.

2 Review of Studies

During the last two decades, the type and characteristics of the waste has considerably changed. Several studies were conducted by Central Pollution Control Board (CPCB) over the last two decades to arrive at waste generation details and composition of MSW generated in the country (CPCB Reports). Findings from several studies can be summarized as below:

2.1 CED Study on Informal Sector participation in Waste Collection, 1994

The Centre for Environment and Development, Thiruvananthapuram carried out a study of the informal sector participation/ragpickers in waste collection, segregation and transportation in 1994.The study was conducted in Thiruvananthapuram City Corporation and municipalities such as Alappuzha, Palakkad and Vadakara of Kerala, India. The study brought out the details of people involved in collection of waste materials from waste bins, commercial places, markets, institutions and to some extent households. It was found that the majority of the waste collectors were children between 15-18 years old. It was also found that women collectors outnumbered men. It was also interesting to see that most of these waste collectors were very much location specific in that they were collecting waste from some prefixed locations. Another interesting observation was that most of the collectors were specialized collecting some specific waste materials only. They were primarily involved in collection of non-degradable wastes, especially the waste which has reuse or recycle value. Another observation was that there were children/others who are individually collecting the waste and sell to big Khabadiwalas.(Scrap dealer)

In the meantime, most of these ragpickers/informal sector waste collectors have been replaced by Self Help Groups of Kudumbasree Mission in Kerala.

2.2 NEERI Study 1996

The National Environmental Engineering Research Institute (NEERI),one of the premier Environmental Engineering Research Institute in India carried out a study in 43 cities of varying sizes across the country. The study revealed that the quantum of waste generation varies between 0.2 and 0.4 kg/capita/day in the urban centres and goes up to 0.5 kg/capita/ day in metropolitan cities (NEERI, 1996). The characterization studies indicated that MSW contains large organic fraction (30%–40%); ash and fine earth (30%–40%); paper (3%–6%); and plastic, glass, and metal (each less than 1%). The calorific value of refuse ranged between 800 and 1,000 kilocalorie per kilogram (kcal/kg) and carbon-to-nitrogen (C/N) ratio ranged between 20 and30.

2.3 CPCB through EPTRI in 1999-2000

The study conducted by CPCB through the Environment Protection Training and Research Institute, Hyderabad (EPTRI) in , 1999–2000 in 210 Class I cities (As per 2001 census, population with more than 1 lakh) and 113 Class II towns (Population with more than 50,000 and less than 1 lakh) indicated that Class I cities generated an average of 48,000 tons per day (TPD) of MSW while Class II towns generated an average of 3,400 TPD of MSW. The study revealed that waste generation rate in Class I cities was approximately 0.34 kg/ capita/day while the waste generation rate in Class II towns was found to be 0.14 kg/capita/day.

2.4 NEERI Study in 2004-2005

The study named “Assessment of Status of Municipal Solid Wastes Management in Metro Cities and State Capitals” conducted by NEERI in 2004–2005 assessed 59 cities (35 metro cities and 24 state capitals).The study revealed that waste generation rate varied from 0.12

to 0.60 kg/capita/day. Analysis of physical composition indicates that total compostable matter in the waste is 40%–60%, while recyclable fraction is 10%–25%. The moisture content in the MSW is 30%–60%, while the C/N ratio is 20–40. It is reported that an average of 39,000 TPD of MSW was generated from these cities/towns during the year2004–2005

2.5 CPCB study in 2020 - 2021

As per the CPCB annual report 2020-2021,total Solid waste generated among 35 states in India including Union Territories is 160039 TPD, total waste collected is 152750 TPD, total waste treated is 79956 TPD and total landfilled is 29427 TPD .Maharashtra is the leading state in terms of waste generation, collection ,treatment and disposal. Refer to Table 1.0 and Fig 1.0.

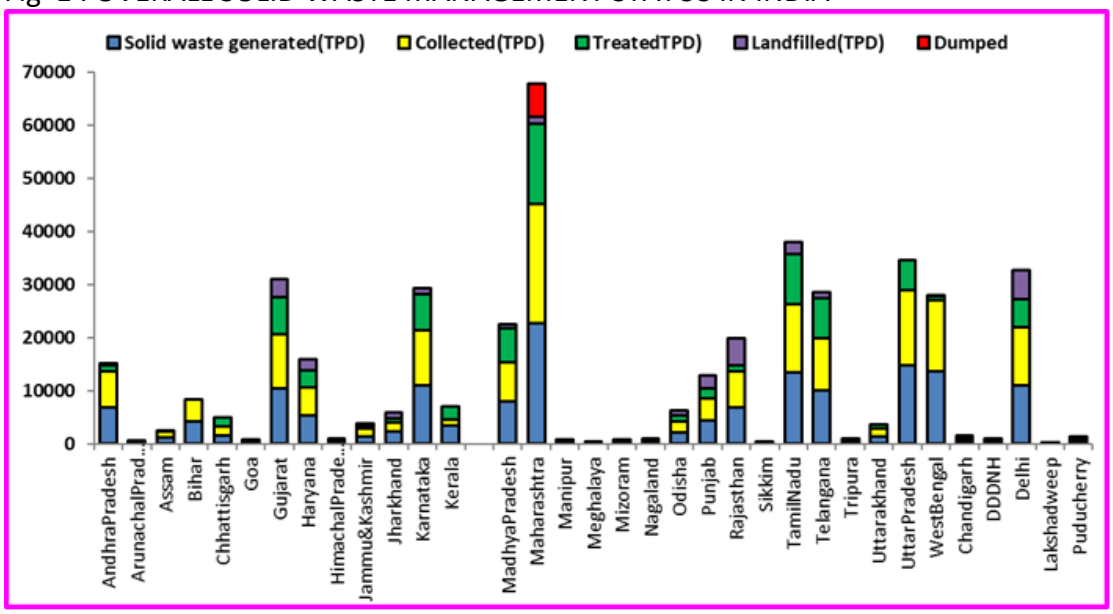
Table 1 : OVERALL SOLID WASTE MANAGEMENT STATUS IN INDIA

Sl. No.	State	Solid waste generated (TPD)	Collected (TPD)	Treated TPD)	Landfilled (TPD)
1	Andhra Pradesh	6898	6829	1133	205
2	Arunachal Pradesh	237	202	Nil	28
3	Assam	1199	1091	41	0
4	Bihar	4281	4014	Not provided	No
5	Chhattisgarh	1650	1650	1650	0
6	Goa	227	219	197	22
7	Gujarat	10374	10332	6946	3386
8	Haryana	5352	5291	3124	2168
9	Himachal Pradesh	346	332	221	111
10	Jammu & Kashmir	1463	1437	548	376
11	Jharkhand	2226	1852	758	1086
12	Karnataka	11085	10198	6817	1250
13	Kerala	3543	965	2550	Not Provided
14	Madhya Pradesh	8023	7236	6472	764
15	Maharashtra	22633	22584	15056	1355

16	Manipur	282	190	109	82
17	Meghalaya	107	93	10	83
18	Mizoram	345	276	270	0
19	Nagaland	330	285	122	8
20	Odisha	2133	2097	1038	1034
21	Punjab	4338	4279	1894	2385
22	Rajasthan	6897	6720	1210	5082
23	Sikkim	72	72	20	52
24	Tamil Nadu	13422	12844	9430	2301
25	Telangana	9965	9965	7530	991
26	Tripura	334	318	214	13
27	Uttarakhand	1458	1379	780	-
28	Uttar Pradesh	14710	14292	5520	0
29	West Bengal	13709	13356	668	202
30	Andaman and Nicobar Islands	89	82	75	7
31	Chandigarh	513	513	69	444
32	DDDNH	267	267	237	15
33	Delhi	10990	10990	5194	5533
34	Lakshadweep	35	17	17	Nil
35	Puducherry	505	482	36	446
	TOTAL	160039	152750	79956	29427

(Source : CPCB, Annual Report 2020-2021)

Fig 1 : OVERALL SOLID WASTE MANAGEMENT STATUS IN INDIA



(Source ; CED 2022- Adapted from CPCB 2021)

2.6 CIPET Study in 2010-2011

The survey conducted by the Central Institute of Plastics Engineering and Technology (CIPET) at the instance of CPCB has reported generation of 50,592 TPD of MSW in 2010–2011 in the same 59 cities. During the year 2011, about 1,27,486 TPD MSW was generated from across the country, out of which only 89,334 TPD (i.e. 70%) was collected and 15,881 TPD (i.e. 12.45%) processed or treated. According to CPCB, 2013, during the last decade, solid waste generation has increased 2.44 times.

2.7 CPCB Study in 2014-2015

As per CPCB, 1,43,449 TPD of MSW was generated for 34 states and union territories during 2013–2014. The average rate of waste generation in India, based on this data, is 0.11 kg/capita/day. Other studies and observations indicate that waste generation rate is between 200 and 300 gm/capita/day in small towns and cities with a population below 2, 00,000. It is usually 300–350 gm/capita/day in cities with a population between 2,00,000 and 5,00,000; 350–400 gm/capita/day in cities with a population between 5,00,000 and 10,00,000; and 400–600 gm/capita/day in cities with a population above 10,00,000. In India, approximately 143,449 MT of MSW is being generated daily, out of which around 111,000 Metric tonnes collected, and about 35,602 Metric tonnes are treated (Kumar et al., 2017).

3 Rules, Acts and Policies

Recently, the Government of India and state governments realized the magnitude and challenges to establish scientific solid waste management in the urban local bodies and rural panchayats and formulated a number of Rules, Programs and Campaigns to establish Integrated Solid Waste Management in the Local Bodies and also to ensure its enforcement through strict rules and acts, legislative and administrative measures.

A detailed review of the various Rules and Legislations enacted in India in the area of waste management and the strategy to be adopted for implementing scientific and integrated SWM and a Framework for implementation is attempted in this Review paper.

Recent Rules on waste management (MoEF&CC,2016)

1. Solid Waste Management Rules, 2016 - Ministry of Environment, Forest and Climate Change, 8th April,2016
2. The Plastic Waste Rules, 2016- Ministry of Environment, Forest and Climate Change, 18th March,2016
3. The Bio-Medical Waste Management Rules, 2016 - Ministry of Environment, Forest and Climate Change, 28th March,2016
4. The E-Waste (Management) Rules, 2016, Ministry of Environment, Forest and Climate Change, 23rd March2016
5. The Hazardous and other Waste (Management and Transboundary Movement) Rules 2016-

3.1 Constitutional Provisions

A public interest litigation was filed in the Supreme Court in 1996 (Special Civil Application No. 888 of 1996) against the Government of India, state governments, and municipal authorities for their failure to perform their duty of managing MSW adequately. The Supreme Court then appointed an expert committee to look into all aspects of SWM and to make recommendations and the committee submitted the report to the Supreme Court in March 1999.

On the basis of the report, in September2000, the Ministry of Environment and Forests, Government of India issued the Municipal Solid Waste (Management and Handling) Rules 2000 under the Environment Protection Act, 1986.

Article 48-A and 51A (g) of the Constitution confer constitutional status to environmental protection. Article 42-A on the Environment provides that the State shall endeavor to protect and improve the environment and to safeguard the forests and wild life of the country.

Article 51-A (g) specially deals with fundamental duty with respect to environment that: “It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wild life and to have compassion for living creatures”.

3.2 Solid Waste Management Rules,2016

Solid Waste Management (SWM) Rules, 2016 were published by the Ministry of Environment, Forest and Climate Change in supersession of the Municipal Solid Waste (Management and Handling) Rules, 2000. These rules are applicable to every urban local body and stipulate that all municipal authorities to scientifically manage the solid waste generated in their respective jurisdictions.

A major change that is visible in the new rule from the MSW Rule 2000 is the focus on the processing of biodegradable portion of waste at source. The rule says that the biodegradable waste shall be processed, treated and disposed of through composting or bio-methanation within the premises as far as possible.

The Rule prescribes the duties of waste generators and various authorities in the state:

Every waste generator shall segregate and store the waste generated by him in three separate streams namely bio-degradable, non- biodegradable and domestic hazardous wastes in suitable bins and handover segregated wastes to authorized waste pickers or waste collectors. In the case of sanitary waste like diapers, sanitary pads etc., wrap the same in the pouches provided by the manufacturers or brand owners of these products or in a suitable wrapping material and hand over the same to the collection crew. Horticulture waste and garden waste need be stored separately in the premises and shall dispose of through local body and same is the case for Construction and Demolition Waste also.

The Rule also prescribes the duties of the Secretary–in-charge, Urban Development in the States to prepare a state policy and solid waste management strategy for the state in a period not later than one year from the date of notification of the rules (8thApril,2016). While preparing State policy and strategy on solid waste management, emphasis needs to be put on waste reduction, reuse, recycling, and recovery. Identification and allocation of suitable land to the local bodies need to be ensured within one year for setting up of processing and disposal facilities for solid wastes and to incorporate them in the master plans (land use plan) of the State. Establishment of common regional sanitary landfill need to be facilitated for a group of cities and towns on a cost sharing basis and ensure professional management of such sanitary landfills. Arrange for capacity building of local bodies in managing solid waste, segregation and transportation or processing of such waste at source need to be arranged.

Clause 15 (a) of SWM Rules 2016 stipulates that the local authorities shall prepare a solid waste management plan as per State Policy and Strategy on Solid Waste Management within six months from the notification of State Policy and Strategy and submit a copy to respective Departments of State Government or Union Territory, Administration or Agency authorized by the State Government or Union Territory Administration.

The following Rules related to various sectors / activities of SWM is also framed by the Ministry of Environment, Forests and Climate Change, Govt of India as a follow up of the planning for Solid Waste Management.

3.3 Plastic Waste Management Rules,2016

These rules shall apply to every waste generator, local body, Grama Panchayat, manufacturer, importer, and producer. Carry bag made of virgin or recycled plastic shall not be less than fifty microns in thickness. The generator will have to pay user fee as prescribed by ULB and in case of violation there is spot fine. Producer/ Brand Owner needs to work out modalities for waste collection system for collecting back the plastic waste within a period of six months in consultation with local authority / State Urban Development Department and implement within two years thereafter. This plan shall be submitted to the SPCB while applying for Consent to Establish or Operate or Renewal. The local body is responsible for plastic waste management system and for performing the associated functions. They can seek financial assistance from producers to set up the Waste Management System. It should promote use of plastic waste for road construction as per Indian Road Congress guidelines or energy recovery or waste to oil etc. The local body should introduce collection of plastic waste management fee through pre-registration of the producers, importers of plastic carry bags / multilayered packaging and vendors selling the same. Plastic waste management fee shall be of minimum Rs.48,000/- @ Rs.4000/- per month. The local body may prescribe higher plastic waste management fee, depending upon the production or sale capacity.

The shopkeepers and street vendors willing to provide plastic carry bags for dispensing any commodity shall register with local body on payment of plastic waste management fee as mentioned

above. Only the registered shopkeepers or street vendors shall be eligible to provide plastic carry bags for dispensing the commodities. The registered shop keepers shall display at prominent place that plastic carry bags are given on payment. They should not sell or provide commodities to consumer in carry bags or plastic sheet or multilayered packaging, which are not manufactured and labelled or marked, as prescribed under these rules. Defaulters are liable to pay such fines as specified under the byelaws of the local bodies.

3.4 Bio-Medical Waste Management Rules, 2016

Segregation of biomedical waste at the source of generation is the first and essential step in biomedical waste management and it continues to be the key message and central theme of the Bio Medical Waste Management Rules, 2016. The 10 categories of biomedical waste are now simplified and categorized in 4 different color categories only. All types of wastes have been compiled in four categories for ease of segregation at a healthcare facility. Technically however, the categories of biomedical waste addressed through the Rule are now increased as some categories are further split into sub categories (e.g. sharps including metals & glassware are now considered as separate category and color code). Additional establishments are added e.g., AYUSH Hospitals,

The new Rule specifically enlists 20 points for the duty of the occupier and 17 points for the duty of the Common Biomedical Waste Treatment Facility (CBWTF) operator. Adding further to the clarity, the list of prescribed authorities and their corresponding duties are also clearly mentioned in the new Rule. Considering the environmental hazard due to the emission of toxic gases like dioxin and furan due to inadvertent burning of chlorinated plastics, the new Rule has made the provision to phase out use of chlorinated plastic bags, gloves and blood bags within 2 years. As per the new Rule, the CBWTF operator has to collect the biomedical waste even on holidays and in no case the time limit should cross the prescribed limit. The untreated biomedical waste shall not be stored beyond a period of 48hours.

3.5 Construction and Demolition Waste Management Rules, 2016

The Rules shall apply to every waste, resulting from construction, re-modeling, repair and demolition of any civil structure of individual or organization or authority that generates construction and demolition waste such as building materials, debris, rubble. As per Construction and Demolition (C&D) Waste Management Rules, there should not be any littering or deposition of construction and demolition waste so as to prevent obstruction to the traffic or the public or drains. Duties of Local Authority include:

Procurement of materials made from construction and demolition waste shall be made mandatory to a certain percentage (say 10-20%) in municipal and Government contracts subject to strict quality control. It shall make provision for giving incentives for use of material made out of construction and demolition waste in the construction activity including in non-structural concrete, paving blocks, lower layers of road pavements, colony and rural roads. The numerical targets for waste processing facilities utilizing C&D waste in cities are based on population. The large generators (who generate more than 20 tons or more in one day or 300 tons per project in a month) shall submit waste management plan and get appropriate approvals from the local authority before starting construction or demolition or remodeling work. They shall have environment management plan to address the likely environmental issues from construction, demolition, storage, transportation process and disposal/reuse of C&D Waste. Large generators shall segregate the waste into four streams such as concrete, soil, steel, wood and plastic, bricks and mortar

3.6 E-Waste (Management) Rules,2016

The applicability of the previous Rule was only to producer, consumer or bulk consumer, collection centre, dismantler and recycler and is now expanded to manufacturer, dealer, refurbisher and Producer Responsibility Organization (PRO). The applicability of the Rule has been extended to components, consumables, spares and parts of Electrical and Electronic Equipment (EEE). Compact Fluorescent Lamps (CFL) and other mercury containing lamps are brought under the purview of these rules. Collection is now exclusively Producer's responsibility, which can set up collection centres or point or even can arrange buy back mechanism for such collection. No separate authorization for such collection will be required, which will be indicated in the Extended Producer Responsibility (EPR) Plan of Producers. Single EPR Authorization for Producers is now being made Central Pollution Control Board's(CPCB) responsibility to ensure pan India implementation. Procedure for seeking the authorization and for effective implementation has now been elaborated with various kinds of provisions. Option has been given for setting up of PRO, e-waste exchange, e-retailer, Deposit Refund Scheme as additional channel for implementation of EPR by Producers to ensure efficient channelization of e-waste. Collection and channelization of e-waste in Extended Producer Responsibility-Authorization shall be in line with the targets prescribed in Schedule III of the Rules.

Deposit Refund Scheme has been introduced as an additional economic instrument wherein the producer charges an additional amount as a deposit at the time of sale of the electrical and electronic equipment and returns it to the consumer along with interest when the end-of-life electrical and electronic equipment is returned.

3.7 Hazardous and Other Wastes (Management and Trans-boundary Movement) Rules, 2016

In exercise of the powers conferred by sections 6, 8 and 25 of the Environment (Protection) Act, 1986 (29 of 1986), and in supersession of the Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008, Ministry of Environment, Forest and Climate Change, Government of India, issued the Hazardous and Other Wastes (Management and Transboundary Movement) Rules,2016.The rules apply to the management of hazardous and other wastes as specified in the Schedules to the rules.

3.8 CPHEEO Manual on Municipal Solid Waste Management, 2016

The Manual on Municipal Solid Waste Management prepared by CPHEEO as part of SBM(Urban) is published by the Ministry of Housing & Urban Affairs (formerly MoUD) Government of India. This is a thorough revision of the earlier version of MSW Manual 2006. The Manual has three parts, Part I is an overview of SWM. Part II is actually the Manual and Part III contains a Compendium of national and international good practices and the relevant rules related to SWM (CPHEEO,2016)

The Manual on Municipal Solid Waste Management provides guidance to urban local bodies on the planning, design, implementation and monitoring of municipal solid waste management systems. The Manual clearly defines the planning process to be adopted by urban local bodies for preparing, revising and implementing Municipal Solid Waste Management Plans (MSWM Plans). The Planning process suggests the adoption of the integrated solid waste management hierarchy for deciding on processing or technology solutions for municipal solid waste. Guidance on the ULBs' responsibilities

for managing specific special waste streams namely, plastic waste, bio-medical waste, slaughter house waste, E-waste, waste tyres and lead battery waste are included in this Manual.

3.9 SWM Bye-Laws

A few Urban Local Bodies in Kerala have formulated SWM Bye- Laws based on the SWM Rules,2016 to customize and strengthen the Rules to implement the Rules and to take stringent measures in case of violation. The Centre for Environment and Development has developed Bye-Laws for Thiruvananthapuram and Kochi City Corporations in Kerala and also a Model Bye-Law for Ministry of Housing & Urban Affairs, Government of India as part of the Centre of Excellence Program of MoHUA at CED. The Byelaws are very useful to fill the gap and deficiency in implementing the SWM Rule and to make it more locally-specific and customized

4 New Initiatives in Waste Management-Swachh Bharath Mission (Rural and Urban)

Solid and Liquid Waste Management is one of the key components of SBM (Rural). (www.wateraid.org)

The total assistance for SLWM projects is Rs. 20 lakhs for GPs having more than 500 households. Funding of SLWM project under SBM (Rural) is provided by central and state government in the ratio 75:25.

Urban Local Governments are required to prepare Detailed Project Report (DPR) for Solid Waste Management in consultation with State Government for the respective areas. 100% cost reimbursement for preparing the DPR shall be done by Government of India as per unit cost and norms set up by Government of India

In addition to these, a few externally funded SWM projects are being conceived and started implementation in few states of India. The state of Kerala has been in the process of implementing the Kerala Solid Waste Management Project (KSWMP), with support from World Bank. One of the positive aspect of these project is that it plans a totally integrated SWM plan, bringing together the decentralized approach with the centralized approach wherever necessary and also providing space for ULB and community participation in planning and implementation. The process includes the creation of a database, the preparation of an environmental status plan, a detailed SWM Plan for each ULB, the consultation with all stakeholders, the integration with various components including environmental and social safeguards, livelihoods

5 Status of SWM in Kerala

In Kerala, there are 93 Municipal Authorities (6 corporations and 87 Municipalities) responsible for MSW management. Nearly 3543 TPD of MSW generated in the State, out of which 964.76 TPD waste is collected and 2550 TPD waste is treated. There are 2 large and 12 small, centralized windrow composting plants and 7 vermi composting plants setup in the State. 1 landfill site has been identified in the State and total 41 dumpsites have been reported.

Extract of World Bank Study (2020)

A brief study was undertaken through Socio Economic Unit Foundation, Kerala on behalf of World Bank. The study has revealed current waste generation rates and waste characterization as shown in tables below:

Total solid waste generation in the State is around 8000 to 10000 TPD. The total waste generation in the year 2020 for the 93 ULBs (Municipalities plus Corporations) in the State is estimated at 3755 TPD.

Table 2 Source wise waste quantity generated per unit in ULBs

ULBs and Parameters	Household waste/ Capita	Shop waste /unit	Hotel waste/unit	Institution& Office waste/ unit	Market waste/ unit	Hospital waste/ Bed	Function halls waste/unit
Per Unit (kg)	0.28	1.16	23.94	1.65	977	0.68	62.74

Source: Field Survey& Analysis for WB

Average per capita waste generation
Municipal towns – 419 grams/capita/day
Municipal Corporations – 545 grams/capita/day

Table 3 MSW generation in lowland, midland & highland areas

Geographical Area	No. of cities/towns	Population 2020	Waste generation rate/capita (g/capita/day)	Projected waste generation in the area (TPD)	Percentage of total waste (%)
Lowland (Coastal area)	22	4162180	419-545	2115	56.4
Midland	55	2941234	419-545	1275	34
Highland	16	872437	419	365	9.6
Total	93	7975851		3755	

Source: Field Survey& Analysis for WB

6 Approach and Strategy for SWM

Waste Stream Assessment

Waste Stream Assessment (WSA) is essential to plan and formulate a scientific and integrated solid waste management plan for any city. It is meant to determine the basic aspect of quantity (the amount of waste generated in the community, both in terms of weight and volume), composition (ie, the different components of waste stream-both physical and chemical characteristics) and source of wastes. The waste composition has a significant impact on waste management practices. (Sridevi et al., 2012)

For successful solid waste management program, knowledge of the local waste stream is essential. With this knowledge, local governments can design an efficient waste reduction strategy that targets the most promising and most problematic waste materials first. A waste stream assessment is the process of understanding the mix of material in the local waste stream. (https://p2infohouse.org/ref/01/00140.htm)

The assessment will help in the following way:

1. It provides the basic data for planning, design and operation of the management system.
2. The analysis of the data helps detect changes in composition, characteristics and quantities of wastes, helps in deciding appropriate technologies and equipment
3. It quantifies the amount and type of materials suitable for processing, recovery and recycling.
4. Field investigations will have to be carried out in the absence of a reliable basic data through carrying out surveys using structured questionnaires and to generate data on the quantity, quality and characteristics of wastes generated in a location.

The management and disposal of solid waste could be premised on three approaches, viz., source level management, community level (decentralized) management and centralized management.

6.1 Source Level Management

The organic fraction of solid waste can be managed at source itself where adequate space is available, by composting or bio-methanation technology. Both options return economic benefit to the person by way of compost, and manure slurry and bio gas. Government/ULB level support and strong IEC could motivate people to resort to source level management of waste. Reduce and reuse strategy of waste management could be applied to non-biodegradable fraction by individuals. A little motivation and some incentives will create good results which includes distribution of bio-bins, inoculum ,growbags and seedlings and also procuring compost back from households which do not have space for kitchen garden.

6.2 Community Level Management

A cluster of houses or a housing colony/apartments, residents' association, local market, group of business establishments, etc., could join together and set up community facility like biogas plant, vermin-compost/compost unit etc. The technology suitable for source level management, in general, could be adopted for community level management also. For this purpose, they should identify suitable land in that locality. To manage the inorganic components, they can establish tie up arrangement with waste dealers/ recycling units. A Material Recovery Facility(MRF) can be established for storing the non-degradable waste collected from the members of the community.

6.3 Centralized Management

Despite existence of source level and community level management, there will still be solid waste left unattended like market waste, street sweepings, waste that are beyond the scope of source level and community level management and waste from bulk generators who presently do not possess facility to manage it. The solution for these items is establishment of a centralized facility. Since 50-70 % of the organic waste is likely to undergo source level and community level management, the volume to be handled by the central facility will be substantially less. There can be multiple number of such central facilities in different locations, so that the volume can further be reduced at one location. This helps to reduce the transportation cost also. The central facility can be a windrow compost plant or a combination of windrow compost unit, vermi compost unit and bio gas plant plus any other appropriate technology.

6.4 Major activities for an Integrated Waste Management are:

Segregation of Wastes at Source is the utmost important activity for any waste management program. The generators will be appraised of the importance of source segregation and also to collect it separately in differently coloured containers as per the instruction from the Local Body. There should be a proper plan as to choosing the right management approach from among the above three options, ensuring public cooperation and support in following the 4R strategy (Reduce, Reuse, Replace, Recycle)

Quantifying waste generation according to season is an important precondition for infrastructure planning. Knowledge of physical and chemical composition helps authorities to determine the scope of retrieval of recyclable material and construction debris and to define appropriate technology for treating waste.The strategy should be in conformity with the Solid Waste Management Rules and other related legislations.

6.5 Waste Segregation and Storage at Source

The strategy to be adopted for efficient waste management and as per the SWM Rules is to separate the biodegradable wastes, (organic waste such as leftover food, vegetables and fruit peels, soiled paper, textile etc) and non-biodegradable wastes(recyclable materials such as plastic, paper, glass, cans, metals, etc) at the source itself by the generator and store the waste in different coloured bins. As per the revised rules domestic hazardous waste is to be stored in a separate container. In the case of sanitary waste the rules stipulate to wrap securely the used sanitary waste like diapers, sanitary pads etc., in the pouches provided by the manufacturers or brand owners of these products or in a suitable wrapping material as instructed by the local authorities and shall place the same in the bin meant for dry waste or non-biodegradable waste. Garden waste and construction waste has to be stored in the premises of the generator till removed as per the schedule.

6.6 Collection and Transportation

Door-to-door collection of segregated waste is mandatory as per SWM Rules, 2016. Collection of segregated waste (wet waste, dry recyclables, inert, domestic hazardous waste, sanitary, horticulture, construction and demolition wastes) from residential, commercial, and institutional areas is to be planned by the Local Body. Separate containers are required for collection of different fractions (wet, dry and domestic hazardous). For bulk waste generators such as hotels, restaurant, and large complexes, waste collection service can be given on demand basis.

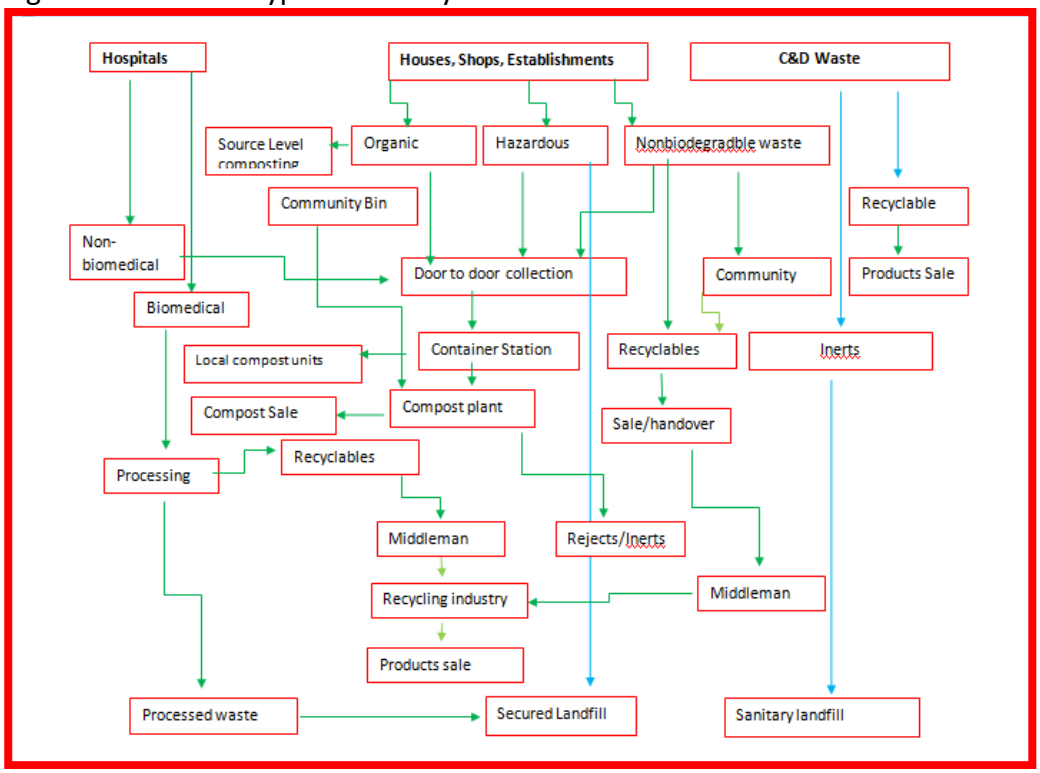
Efficient routing of solid waste collection vehicles is essential for SW management system. A detailed network planning taking in to consideration of the collection area, geographic boundaries, amount of waste to be collected, condition of the road, traffic situation and time of collection, etc., has to be done using maps and GIS.

6.7 Waste Processing and Treatment of Waste

The policy for processing the biodegrade waste is based on the proximity principle that waste shall be processed and treated as close as possible to the place of their origin. The strategy for processing of biodegradable waste consists of source level treatment at households, apartment complexes, hotels, restaurants, auditoriums (bulk generators) as far as possible. The other option is decentralized treatment at community/ward level. Those households or bulk generators having no sufficient land to offer processing at their respective premises shall be brought under the decentralized/centralized systems. In the case of small hotels also this method is required. A centralized treatment facility with a landfill to be established at each local body or for a group of Local Bodies to cater to waste streams from streets, from markets, public places and in exigencies. Composting would be the preferred method of treatment for biodegradable waste.

Currently, there are several technologies for the processing and treatment of organic fraction of MSW, such as microbial composting and vermin composting, anaerobic digestion etc. Waste to energy process like gasification and other technologies like pyrolysis, which are still not in wide use in India.

Fig 2 Flow chart of Typical SWM System



(Source KSUDP 2007 – Modified by CED – 2022)

7 Strategy for Non-biodegradable Wastes

In the case of non- biodegradable waste and hazardous waste the local body can arrange for collection on pre-informed dates from households and other establishments based on collection of user charges

The Local Body has to establish Material Recovery Facility(MRF) at suitable locations for storing non compostable waste / dry waste. Segregation at source, a prerequisite for effective waste management and shall be stored in separate containers at the source by the generators. The waste reaching the MRF need be further sorted into recyclable and non- recyclable. It shall be sorted into various fractions so that it can be transferred to the recycler as per demand. Materials Recovery Facility (MRF)means a facility where non-compostable solid waste can be temporarily stored to keep the sorted waste before the waste is delivered or taken up for its processing or disposal.

TREATMENT OF BIODEGRADABLE FRACTION

- Centralized Windrow Compost Plant of capacity not more than 50 tons.(for ULBs
- Centralized Windrow Compost Plant of capacity not more than 10 tons.(for GPs)
- Decentralized vermi

7.1 Material Recovery Facility (MRF)

As per SWM Rules, 2016 local authorities should setup Material Recovery Facilities. This facility can be a place where non bio degradable waste could be sorted and kept for next level disposal. The disposal could be (i) the MRF will act as a local market from which anyone can take useful things (ii) the left over items will be sent for recycling. The MRF will be designed in such a way to have compartments to collect various types of wastes.

Need for a circular plastics economy

The transition to a stronger circular economy scenario needs hybrid models combining several aspects starting from resource management to create sustainable solutions for products, processes, and businesses which debottleneck the current social and environmental issues such as pollution, scarcity, and low recycling and/or recovery of resources.

A relevant current example in this regard would be the plastic packaging value chain in the plastics economy, which represents the largest portion (i.e., 26% of the total volume).(The new plastics economy,2016)This is an iconic example of a linear economy which utilizes 98% finite feedstock while recycling only a meagre 5% plastic packaging material value. This economy is reliant on non-renewable resources of petroleum, consuming around 6% of world's oil production as material feedstock and in manufacturing process.(J Hopewell et al 2009) The development of new circular plastics economy offers opportunities to tackle some of these problems and envisages global material flow with high resource efficiency to create an effective after-use plastics economy.

In India, about 5.5 million metric tons of PW are reprocessed/ recycled each year, out of which 70% is recycled in certified industries (formal) facilities and 20% by the informal sector. While 10% is recycled at the domestic level (CSE, 2020).

Various recycling technologies for plastic waste have been discovered in order to generate economic and environmentally acceptable value-added products that suit the needs of sustainable development and green environmental protection.

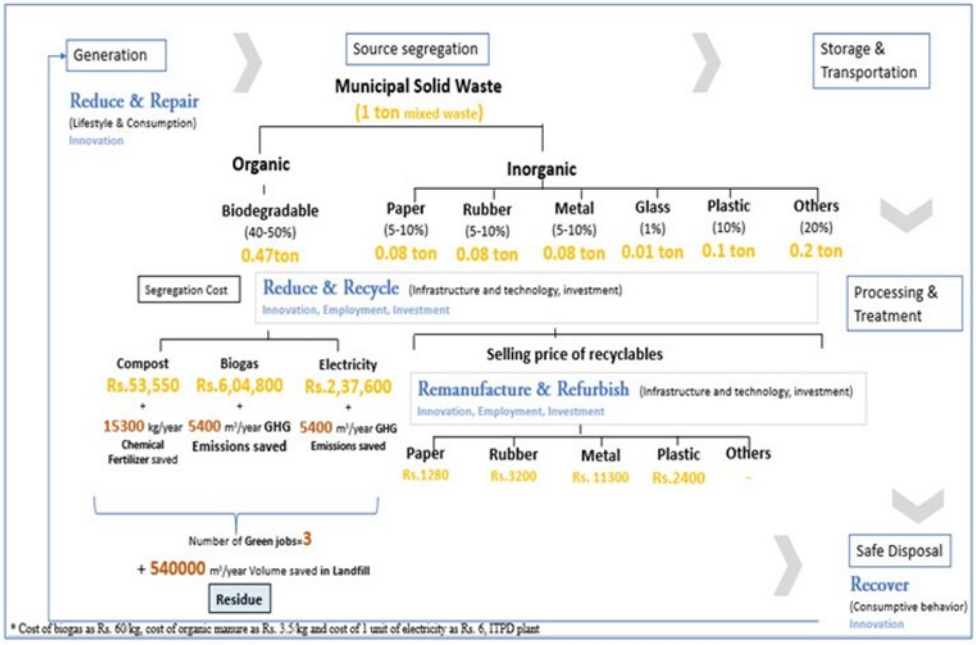
Fig. 3 Plastics Resin Identification code with few plastic products

(Source : Plastics for change ,2021)

There are seven different types of plastic being used around the world - they differ in size, color, usage and disposal.

The second life of Plastic Waste is Recycling.

Fig 4 Value Chain for Solid Waste (1$= 65, 2018 exchange rates)



Source: Waste Life Cycle Assessment (2018)

7.2 Establishing Recycling Units

Formal recycler with pollution control equipment and systems shall be set up through private entrepreneurs or by the state governments as a long term strategy and the state governments shall take active involvement in creating such facility. State Governments shall adopt the policy to become a recycling society.

Table 4 Important Recycling Materials – Advantages and Drawbacks

Material	Advantage	Drawbacks
Aluminum Aluminium	• Aluminum has a high market value. • It can be easily recycled by shredding and melting. • It can be recycled indefinitely because it does not deteriorate from reprocessing. • Aluminum recycling requires significantly less energy than producing aluminum from ore.	• Separate collection is important. • Recycling is suitable only if a processing plant is available.
Batteries	• Recycling recovers valuable metals. • Recycling protects the environment from heavy metals such as lead, cadmium and mercury.	• Large variation in type and size of batteries requires specific recycling processes. • Older batteries have high heavy metal content
Concrete and demolition waste	• Demolition waste can be crushed to gravel and reused in road construction and landscaping.	• Machinery required for crushing is maintenance intensive. • Recycled waste is valuable only if there is a lack of other construction material.
Glass	• Glass has a moderate market value • It can be sorted into colours and melted. • Use of recycled glass saves energy compared with processing raw material. • Glass can be recycled indefinitely because it does not deteriorate from reprocessing.	• Broken glass can contaminate and eliminate opportunities for recycling.
Other metal	• Scrap metal has a high market value (especially steel, copper, silver and platinum) • It can be recycled indefinitely because it does not deteriorate from reprocessing.	• High-value metals (such as copper and silver) are incorporated in electronic devices, but extraction can cause severe environmental impacts.

Paper	• Paper can be easily recycled; however, quality deteriorates with each cycle. • Paper or cardboard from recycled paper requires less energy to produce and protects forests.	• Appropriate technologies with circular processes are required to protect the environment.
Polyethylene terephthalate (PET)	• PET can be recycled if segregated from other waste. • Reprocessing into granulate is very easy. • PET has a high market value if processing plants are available.	• More 'downcyling' than recycling occurs because quality decreases with every processing cycle.
Other plastics	• Other plastics, such as polyethylene or polyvinyl chloride, can be recycled but has less value on the market than PET; the value depends on recycling and manufacturing options in the vicinity.	• Recycling requires specific machinery
Electronic waste	• Electronic waste (such as computers or mobile phones) contains high value metals. • Electronic items can be dismantled, reused or recycled.	• Metals are often covered with polyvinyl chloride or resins, which are often smelted or burned, causing toxic emissions.

Table 5: Common Types of Plastics that may be recycled

Sl.No	Chemical Name	Abbreviation	Typical uses
1	Polyethylene terephthalate	PETE	Soft drink bottles
2	High-density polyethylene	HDPE	Milk cartons
3	Polyvinyl Chloride	PVC	Food packaging, wire insulation and pipe
4	Low-density polyethylene	LDPE	Plastic film used for food wrapping, trash bags, grocery bags, and baby diapers
5	Polypropylene	PP	Automobile battery casings and bottle caps
6	Polystyrene	PS	Food packaging, foam cups and plates, and eating utensils
7	Mixed plastic		Fence posts, benches and pallets

7.3 Final Disposal by Constructing Sanitary Engineered Landfills

The SWM Rules mandate treatment of the organic fraction of solid wastes before final disposal of rejects and inerts in scientifically engineered landfills. Landfill is a vital component of any well designed SWM system. Environmentally safe landfill shall be part of long-term disposal strategy but the landfill should be restricted to waste that cannot be recycled, treated or recovered. This mechanism will cater to the remediation of already accumulated waste and confinement of subsequent rejects. The landfill can be operated directly by the Local Body or through competent agencies in the public or private sector, adopting the procedures and specifications defined in the 2016 SWM Rules as well as SPCB / CPCB norms.(CPCB Annual Report 2020-2021)

With acute shortage of land, resources and other aspects, construction of landfills in each local body is not at all advisable and so a possible option is for going for regional landfills for a group of local bodies. State governments shall facilitate the construction of a few regional landfills for a group of local bodies.

8 Successful Models of Decentralized SWM Approach in other States: Odisha

A few successes stories are available in India, the latest being that of Odisha, which speaks of a major turn around from SWM being primarily a revenue spending activity to wealth creating endeavour while making the cities clean and protecting the environment..In the year 2019, the Housing and Urban Development Department, Govt. of Odisha after adequate brainstorming, consultations and studies, decided to opt for decentralized solid waste management system for all urban local bodies of the state. All ULBs were instructed to set up Micro Composting Centres(MCCs) and Materials Recovery Facilities (MRFs). The wet waste is treated at the MCCs that is scientifically composted to make organic manure branded as “Mo Khat”; and the MRFs are segregating the dry waste, which is recycled for revenue. These facilities are officially called as “Wealth Centres” and are kept clean and fully sanitized. More than 2,000 Mission Shakti Women SHGs, Transgenders’ groups and Ragpickers’ groups have been converting these MCCs and MRFs from ‘Waste’ into ‘Wealth Centres’. they have been playing a critical role in collection, segregation, transportation, treatment, and reuse of wet and dry waste across 114 ULBs in the state. About 600 metric tonnes of wet waste is being processed every day in the State of which about 15 per cent turns into compost. The H&UD Dept. roped in ITIs for strengthening these Wealth Centres. As many as 33 ITIs are partnered for repair and maintenance of equipment of the Wealth Centres and sanitation vehicle. Till date, 101 Wealth Centres in 62 ULBs have received ISO certification for quality management. As part of implementation of E-Waste (Management) Rules, 2016, E-waste is being collected by the ULBs on each Saturday of the week and is transported to MRFs to kept at the E-corner over there. The collected E-waste is channelised to the registered recyclers designated by the SPCB, Odisha. Women Ragpickers Groups are formed and integrated with the SWM programme who are paid under Urban Wage Employment Initiative programme named as ‘MUKTA’. This has helped Urban Local Bodies to generate wealth from waste,minimize dependence on government schemes and avoid big dumping yards that are far away from the cities and major pollutants of the adjoining villages. The end-to-end model covers all aspects by involving the community in a institutionalized manner, with no contractors involved. The resources generated from the sale of the compost as well as the recyclables and nonrecyclables are being deposited in the corpus fund of the MCCs. The resource generated is being utilised to meet the operation and maintenance cost of the Wealth Centres and the respective ULBs are spending no money in the entire waste management exercise. The decentralised solid waste management model adopted by Odisha eliminates the tipping fee model (at landfills) and the associated profit motive of contractors, thus reducing the capital and operating expenditure. This sustainable waste management model also reduces the burden of dumping on open land and minimise the carbon footprint in the urban space.

Best Practices in Solid Waste Management

The best practices as reported by the SPCBs/PCCs in their Annual Report is summarized in table below:

Table 6 Best practices as reported by the SPCBs/PCCs

Sl. No	State	Best Practice
1	Andhra Pradesh	• CCTVs installed at dumpsites in 70 ULBs and is in progress in remaining 54 ULBs • 99% Households covered under door-to-door collection
2	Andaman & Nicobar Island	• 100% waste collected in segregated form • Spot fine imposed on littering • Implementation of levy of user fee as door-to-door monthly charge • Water ATMs installed
3	Chandigarh	• Waste collected from vegetable, fruit, flower, meat, poultry and fish market is treated in bio- methanation plant. • All the bulk waste generators are practicing onsite composting of their wet waste.
4	Chhattisgarh	• Percentage of waste processed: 100% • Timely monitoring for implementation of SWM policy is being done through MIS database. • Project implementation units (PIUs) & S state level project management units (PMUs) are developed for management of solid waste. • Solid Liquid Resource Management centers established in 164/ 166 ULBs. Integrated waste management centres set up in remaining two Local bodies. • Registration of waste pickers done, and survey conducted to identify new waste pickers • PPEs have been provided to sanitation workers to ensure the safety and hygiene
5	Delhi	• 100 % door to door collection of MSW has been achieved.
6	Goa	• Waste processing is 87%. • Decentralized composting in housing societies, municipal markets and public gardens to treat biodegradable waste.
7	Gujarat	• 100 % door to door collection of MSW has been achieved.
8	Haryana	• Govt. of Haryana has adopted cluster based integrated approach for solid waste management. State has been

		divided in 14 clusters out of which 4 will be based on waste • to energy and 10 will be based on compost/RDF.
9	Himachal Pradesh	• Pit composting facility is operational in all ULBs.
10	J&K	• Composting practiced through Auto-Composters and Disintegrators.
11	Kerala	• Different types of composting including aero bins, bio bins, pipe compost and ring compost are practices adopted in the state.
12	Karnataka	• 100 % door to door collection of MSW has been achieved.
13	Lakshadweep	• Provided blue and green bins to each household to get segregated bio degradable and non- biodegradable. • 455 swachh workers are engaged to carry out various SWM activities.
14	Madhya Pradesh	• 100 % door to door collection of MSW has been achieved. • Composting setup in 130 towns, RDF palletization in 47 towns, biogas in 3 towns and vermi-composting in 33 towns. • 50 out of 328 dumpsites reclaimed. • State actively promoting home composting to reduce waste at source.
15	Maharashtra	• Maharashtra has registered its own brand “Harita Maha City Compost” for sale of city compost which is as per FCO standards. • Board has developed web portal for ULBs for monitoring daily and monthly data for solid waste management. Board has initiated concept of providing financial and technical assistance to Municipal Councils and Nagar Panchayats for setting up solid waste management facilities. • Board has prepared model tender document on SWM for ULBs • ULBs have integrated rag pickers into formal system and involved them for recycling and recovery of waste
16	Manipur	Trial run for Waste to Energy plant based on pyrolysis technology is under process at Langdeng site.

17	Mizoram	• Training was conducted for waste pickers collectors & workers throughout the year. To minimize nuisance of order, flies eco micro solution is used.
18	Nagaland	• Bailing machines have been provided in 11 district headquarters. • Dimapur Municipal Corporation has begun developing existing dumpsite to develop solid waste processing.
19	Pondicherry	• 18 out of 18 application received have been granted authorization for solid waste processing • All local bodies have identified suitable land for SLF and MRF & authorization has been used to the Local bodies. • Local bodies have taken initiatives for processing of solid waste as per Nisarguna technology of BARC with financial assistance of PPCC. • Pipe composting is practiced in one of the local body.
20	Sikkim	• Transportation of waste is being done by vehicles with GPS facility.
21	Tamil Nadu	• Onsite compositing Barrel method is being practiced in 25 wards. • ULBs are adopting Micro Compost Centre (MCC) methodology for composting, in which • the leachate generated is recycled.
22	Telangana	• 100% door to door collection of MSW has been achieved. • Feacal Sludge Treatment plants (FSTP) are established in 2 ULBs. • 67 ULBs are grouped into 5 clusters for allotting the Bio-mining work on PPP basis.
23	Uttarakhand	• GPS enabled vehicle used for collection & transportation of waste • Onsite composting is practiced in all ULBs.

8.1 Experience of decentralised and participatory SWM in Kerala

The State of Kerala has been engaged in an innovative experiment to implement Decentralised and Participatory Solid Waste Management in Urban Local Bodies and Grama Panchayats in the state since 2012.This was initiated to absorb the crisis emerged due to the social protest against the centralized system of waste management implemented in a few cities especially the Thiruvananthapuram City Corporation. Even before that, a system was evolved for segregated

collection of wastes-degradable and non-degradable by segregating it by the households and other generators at the source itself and handing over to the SHG members(Kudumbasree workers), finally to transport it to the processing plants (LSGD,2021)

One major issue was related to the huge quantity of plastic carry bags and other plastic objects generated. It is in this context that the Government initiated a massive **Campaign on 4-R concept- Reduce, Reuse, Recycle and Replace,** through which the government plans to reduce the generation of this kind of wastes, Reuse materials as much as possible, collect and Recycle all the recyclable materials and Replace the plastic materials with other materials which can be recycled or degradable like paper, cloth, etc.

The Suchitwa Mission, which is the Nodal Agency for Sanitation in Kerala also brought out a GREEN PROTOCOL, which framed the Do..s and Don'ts in Sanitation and Waste management and the Protocols to be followed to achieve the 4-R Principle.

8.2 Implementation of 4-R Principle and Green Protocol

The first step taken by the Government was ban of all kinds of plastic carry bags below 50 microns and this was implemented throughout the state -both urban and rural areas..The Government had also brought out the Green Protocol, which stipulates the regulations and conditions to be observed when organizing various kinds of events, functions, meeting, marriages, even the conditions to be observed in office functioning, household activities, individual activities, etc. These protocols are being strictly followed. The basic intention of the protocol is to reduce/eliminate the use of plastic and other non-degradable waste materials which are causing problems of management and use materials which can be reused and not creating any major management issues.

Table 7 Framework for Green Protocol

1	Green protocol during festivals	• Avoid use of plastic and disposable items • Use utensils that can be washed and reused
2	Green Protocol for function	• Avoid paper and plastic cups, plastic bottles and plates in public functions • Use utensils that can be washed and reused • Use energy efficient lighting • and appliances • Grey water treatment in the premises and practice recycling • Of treated effluent
3	Green protocol during sports and other events	• Avoid paper and plastic cups, PET bottles and plates • Use utensils that can be washed and reused
4	Green protocol for individuals	• Reduce waste generation. Avoid use and throw items. Develop habit of reuse

		• Use energy efficient lighting and appliances • Home composting and organic Cultivation • Plastic should be cleaned and segregated to be handed over to scrap dealers • Use of public transport
5	Green protocol in institution	• Reduce waste generation. • Avoid use and throw away items. • Use energy efficient lighting and appliances • Plastic free campus

8.3 Recycle Options

The collection of Recyclable materials in frequent intervals have also been planned and implemented. This has been done through frequent collection from the source by the Kudumbasree workers(SHGs) or the people themselves putting it in common Material Recovery Facilities(MRF) established by the Local Bodies based on the requirement. The various types of recyclable materials are collected here separately after source segregation in separate assigned compartments of MRF and from there it is taken by the Clean Kerala Company, which is a government promoted company for managing the recyclable wastes, and from there to the different recycling units as per the agreement with them.

Through implementing the 4-R principle and Green Protocol, the Government and Local Bodies in Kerala could bring a perceptible change in the management of Non-degradable waste materials

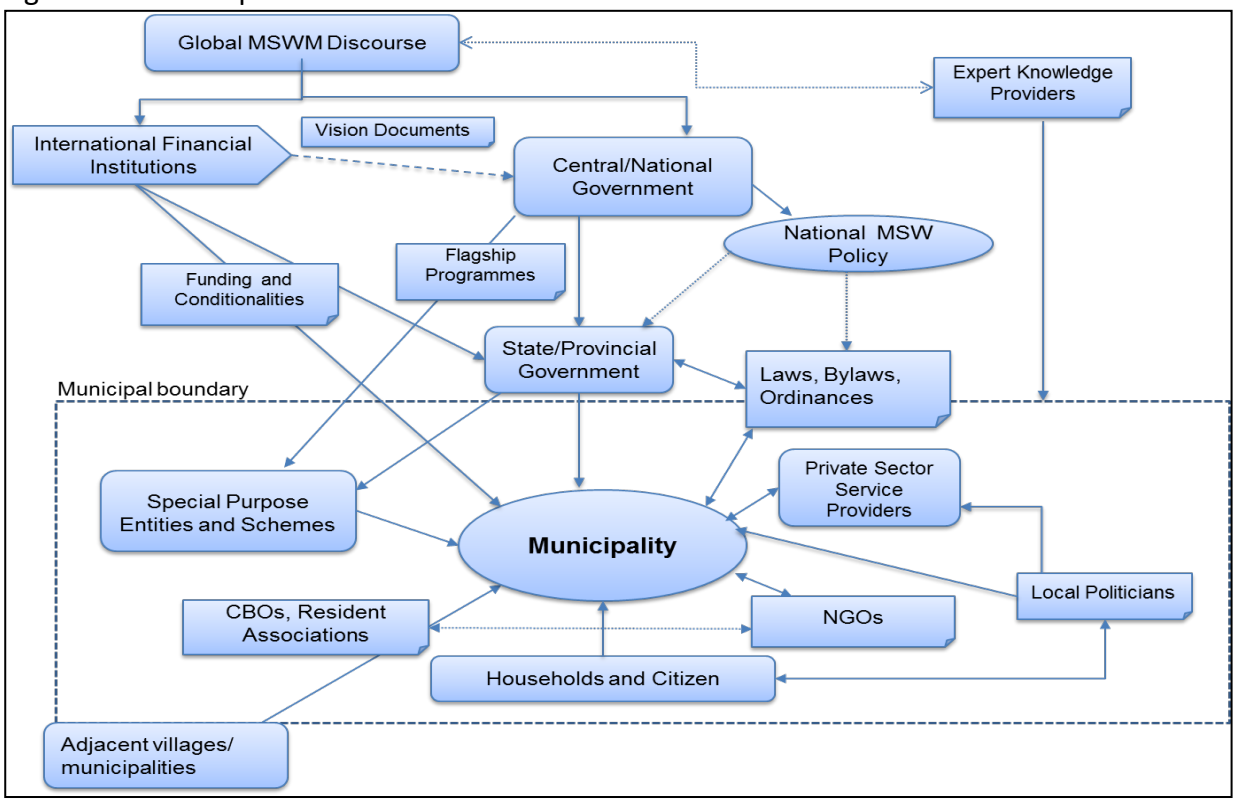
8.4 Institutional Architecture on SWM

The figure below represents a largely hierarchical institutional architecture of flows of ideas, funds and commands. In the center stands the municipality, the institution responsible for MSWM, whose practices however are determined by higher-level governments and global (expert) discourses, as well as influenced by interactions with local-level actors (e.g., resident associations, NGOs, private providers). (Narayanan,et al,2019)

Coupled with the institutional topography are the material flows of the waste chain, the waste practices and the labor applied to segregate, transport, recycle and dispose rubbish. The waste chain is conceptualized through the lens of urban metabolism –an understanding of the city as an organism that transforms resources (e.g., minerals, water, biomass, energy) into goods (e.g., buildings, piped water, food) but also into emissions and pollution .This concept not only focuses on the material and energy flow within and through the city, but also sheds light on the reproduction of social inequality through theses flows and altered social relationships . UPE studies link the concept of urban metabolism with the circulation of power [Hence, social and power relations are located at each point of the waste chain implying that the urban metabolism leads to an unequal accumulation

of goods and services, as well as wastes and pollutions, in different parts of the city, often reinforcing spatial inequalities(Narayanan,et al,2019).

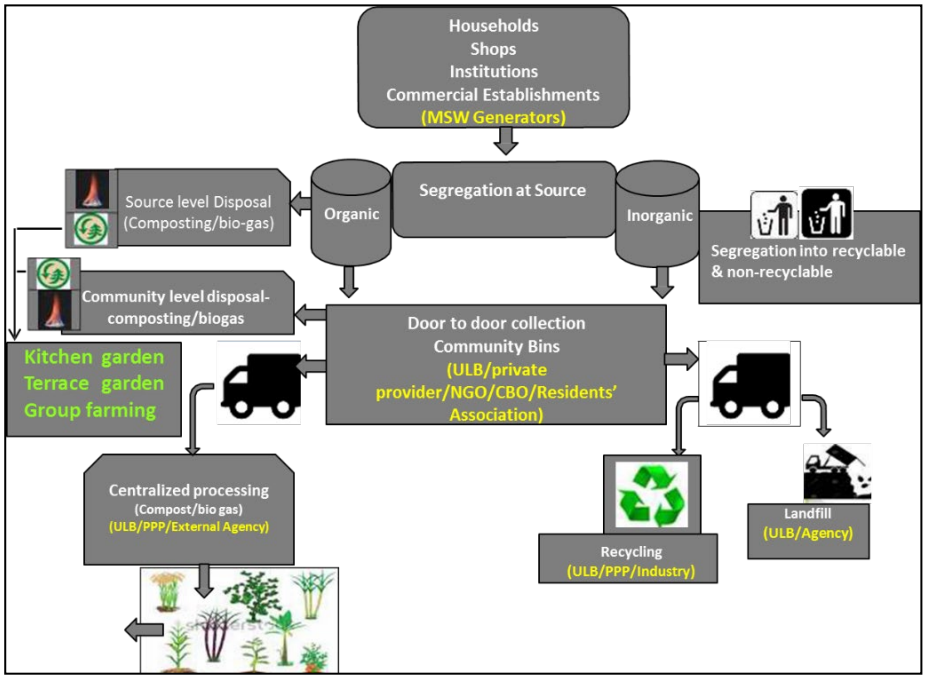
Fig.5 Schematic representation of the institutional MSWM architecture in South Asia



(Source: Veron R et al.,2018)

“The figure below represents a case where segregation at source and decentralized waste recovery and recycling are taking place. More generally, waste chains begin at the site of the waste generator (household, markets, shops, schools, offices, etc.) where it is stored and perhaps segregated. Segregated or non-segregated waste is then either collected from door-to-door, or brought to community bins or dumped in open (public) spaces in the neighborhood or elsewhere. Informal waste workers often pick up valuable recyclables from the source or from bins and dumpsites; glass, paper, cardboard, plastics, etc. enter separate streams. Wastes are transported between primary collection points, secondary transition points and the disposal/treatment facility (open dumps, landfills, composting and recycling plants, incinerators, etc.).”

Fig 6 Schematic representation of partly decentralized waste chains in Kerala



(Source: Veron R et al.,2018)

9 Conclusion

The Government of Kerala has adopted a policy for solid waste management with two strategies: in consideration of the constitutional and legal framework governing waste management in India, and the contextual realities of the state as well. The two-pronged strategies are

1. Decentralised waste management comprising of source level and community level

2. Centralised waste management where ever nnecessary

The decentralized system has been credited for not only being sustainable and financially viable but also for helping to improve the quality of life and working conditions of the waste collectors.

It is to be pointed out, that the DSWM system for biodegradable waste with a successful institutional framework has been evolved through concerted efforts from the LSGIs and state government to change the behaviour of the community to waste management, through IEC campaigns to segregate and treat the waste at source. Mass protest against centralised dumpsites also contributed to the development of the model. Considering the nature of the waste generated in the state which is largely biodegradable, treatment at source also makes administrative and financial sense.

Now this paradigm shift towards decentralised and source level systems has the focus on the circular economy and has significant change in the approach of the administration and people as looking at ‘waste’ as a ‘resource’. Slowly, but steadily, waste has come to be viewed as part of a larger ecosystem, the management of which is considered to play a critical role in the idea of sustainability and livelihood generation.

In a nutshell, waste management in Kerala now has multiple stakeholders working in close coordination with each other, exchanging knowledge and resources to bring decentralized waste management and the circular economy solutions. The multiple stake holders involving the local governments, who are the most significant stakeholders, the Kudumbashree Mission that empowers the Haritha Karma Sena, for sustainable livelihoods in waste management, the Clean Kerala Company which has been tasked with removing non-biodegradable waste and with converting it into resource wherever possible and technical support agencies such as Haritha Keralam Mission and Suchitwa Mission who are responsible for providing support, hand holding and IEC for behavioural changes. In addition to the monitoring, financial support and coordination are provided by the Directorate of Panchayats and the Directorate of Urban Affairs which further ensures the sustainability.

9.1 Issues

Under ODF+ programme of SBM 1.0 and SBM 2.0 sustainability of SWM systems is the focus. However, institutional strengthening, professionalizing and generating own resources are a few areas, which need attention to make SWM systems sustainable. Swachh Bharat Mission has brought the agenda of waste management in India to the mainstream and there have been significant strides made in both urban as well rural areas. On operational side, huge demand and supply side constraints continue to exist to build and sustain a robust SWM system in the country with community engagement. The rural and urban households need to be sensitized on the benefits of full-cycle SWM and their responsibilities.An essential requisite is the urban and rural local bodies should put in place an arrangement for garbage collection and disposal in a manner that is financially viable,technically feasible and socially acceptable.

9.2 Challenges

Though addressed to a great extent by the flagship mission SBM, resource mobilization for SWM remains another crippling issue, which needs to be settled by the local bodies. The tendency of being over-dependent on government sponsored schemes and programmes makes question marks on making it sustainable over time and space. Making adequate funds available from various sources for operating and maintaining SWM systems remains the major challenge that needs to be addressed to make it sustainable. The next major challenge is to put robust SWM systems in place that can address the complex O&M issues in a decentralized but professional manner. While local bodies need to have more professional approach and expertise in their hand, the same has to be percolated to the ground level operations with the help of the community institutions.

Seggregation at source is a major challenge .Accumulation of plastic waste and nondegradables is a major threat. Technical know how and technology options suitable for each locations,trained manpower to manage Large Scale Processing systems and also lack of previous successful model to showcase are the major challenges.

Other challanges includes getting suitable land for processing,social unrest, NIMBY syndrome,implementation of rules and regulations,participation of community,proper institutional mechanism and lack of will power of decision makers.

9.3 Opportunities

On the operational side, community engagement is the key to successful solid waste management in both urban and rural areas. Women Self Help Groups (WSHGs) and other Community Based Organizations (CBOs) play a catalytic role in making SWM systems functional and sustaining the same for a longer period. On the financial side, since launching of Swachh Bharat Mission (SBM), massive funds have been pumped in to the SWM in both rural and urban areas of the country. The Corporate Social Resposibity (CSR) funds are also available for SWM. The challenges of improving solid waste management services in India are caused by lack of financial resources, lack of appropriate skills and technological competencies with the public sector. Governments have started to explore PPPs as an alternative. However, an emerging area is to generate resource from the waste itself that could meet major portion of expenses on SWM. In many cases, with robust management system in place, wealth generated from the waste has the potential to incur the entire expenses on SWM in a city or village Panchayat. The state has initiated massive capacity building and IEC programs;adopted the 4-R principle and green protocol;ban of plastic carry bags below 50 microns.

As per 2011 Census, there are 7935 towns in India out of which 4,041 are statutory towns and 3,894 are census towns (areas classified as towns by census organization) . The number of Class 1 cities with population above 100,000 is 495 and the number of million plus cities is 53. It is estimated that the current urban population (2017) of India is 44 crores, which is 32% of India’s population.

The Central Public Health and Environmental Engineering Organization (CPHEEO) estimated a per capita waste generation in Indian cities and towns in the range of 0.2 to 0.6 kilograms per day. According to Central Pollution Control Board (CPCB), average collection coverage ranges from 50 to 90 percent. Of the collected waste, 94 percent is disposed of without any scientific management practices. Hence, there is severe pollution of groundwater and surface water through leachate and pollution of air through uncontrolled burning of waste.Paradigm shift from Centralized system to Decentralized system with community participation after Decentralized planning.Decentralized SWM in Kerala is a unique opportunity model.

References

Aarne vesilind P and William Worrel, 2012. Solid Waste Engineering 2nd Edition. (https://bawar.net/data0/books/5a61ab6f194b2/pdf/[William_A._Worrell,_P._Aarne_Vesilind]_Solid_Wast.pdf

Cointreau, Sandra, 2001. Declaration of Principles for Sustainable and Integrated Solid Waste Management SISWM. http//siteresources.worldbank.org /INTUSWM/ Resources/siswm.pdf.

CPCB (Central Pollution Control Board), 2000. Status of Municipal Solid Waste Generation,

Collection, Treatment and Disposal in class I cities.

CPCB (Central Pollution Control Board), 2000. Status of Municipal Solid Waste Generation,, Annual Report 2020-2021 https://cpcb.nic.in/openpdffile.php?id=UmVwb3J0RmlsZXMvMTQwM18xNjU1MzU0NzkxX21lZGlhcGhvdG8xNjQ3MS5wZGY=

CUPS/48/1999-2000- CPCB, Ministry of Environment and Forest, New Delhi

CPHEEO, 2000. Manual on Municipal Solid Waste Management 1st Ed. Central Public Health and Environmental Engineering Organisation, Ministry of Urban Development, Government of India, New Delhi.

Creating Circular Economic Potential as a way for Achieving Smart and Sustainable Cities , Eighth Regional 3R forum in Asia and the Pacific, 9-12 April 2018, Indore, Madhya Pradesh, India

Da Zhu, Asnani P.U, Chris Zurbrugg, Sebastian Anapolsky and Shyamala Mani, 2008. Improving Municipal Solid Waste Management in India, World Bank, Washington, D.C.

Integrated Solid Waste Management for Local Governments: A Practical Guide. Published in June 2017 by the Asian Development Bank,

J. Hopewell, R. Dvorak, E. Kosior, Plastics recycling: challenges and opportunities, Philos. Trans. R. Soc. B 364 (2009) 2115–2126.

Kumar S, S.R. Smith, G. Fowler, C. Velis, S.J. Kumar, S. Arya, Kumar Rena, R., & Cheeseman, C. (2017) Challenges and opportunities associated with waste management in India. R. Soc. Open Sci., 4 (3) (2017), 10.1098/rsos.160764

Kerala Sustainable Urban Development Project, Trissur Municipal Corporation,2007

LSGD 2021 State of Decentralised Solid Waste Management in Kerala , LSGD, Government of Kerala, Report 2021

Manual on Municipal Solid Waste Management – 2016

Ministry of Housing and Urban Affairs, GoI, http://cpheeo.gov.in/cms/manual-on-municipal-solid-waste-management-2016.php

MoEF, 2000. Municipal Solid Waste (Management and Handling) Rules 2000. Ministry of Environment and Forests, NewDelhi.

NEERI, 1996. Municipal Solid Waste Management in Indian Urban Centres. Rep. National Environmental Engineering Research Institute. Nagpur.

NITI Aayog Waste Segregation at Source offer far-reaching benefits- optimal utilization of municipal machinery and workforce, efficient infrastructure operations, and enhanced environmental outcomes

Promoting behaviour change for Strengthening Waste Segregation at Source, Policy Guidelines

National Institute for Transforming India, NITI Aayog New Delhi November 2021

Recent Trends in Green and Sustainable Chemistry & Waste Valorisation: Rethinking Plastics in a

Circular Economy Guneet Kaur, Kristiadi Uisan, Khai Lun Ong, Carol Sze Ki Lin November 2017

Sini Mamminiyan 2022 Implementation of Green Protocol as policy initiative for environmental Sustainability: A Kerala Experience. 5th International Conference on Economic Growth and Sustainable Development: Emerging Trends, November 15-16, 2019, Mysuru, India

Suchitwa Mission, June 2020. Volume1 ,introduction and strategic enviromental assessment of waste management sector in Kerala,Kerala solid waste management project (KSWMP)

The New Plastics Economy - Rethinking the future of plastics, World Economic Forum, Ellen MacArthur Foundation and McKinsey & Company. http://www.ellenmacarthurfoundation.org/publications, 2016 (accessed 21.06.2017).

Tchobanoglous G. 2003. Solid Waste Management in Environmental Engineering (Ed. Salvato J.A., Nemerow N.L. and Agardy F.J). 5th Ed. John Wiley and Sons Inc. New Jersey

Waste reduction fact sheet. North Carolina Division of Pollution Prevention and Environmental Assistance, NC department of Environment, health and natural resources

https://p2infohouse.org/ref/01/00140.htm

UNDP: Developing Integrated Solid Waste Management Plan Training Manual. Volume 4. UNDP Division of Technology, Industry and Economics International Environmental Technology Centre, Osaka/Shiga, Japan

Véron R, Fernando N, Narayanan N, Upreti B, Ambat B, Pallawala R, Rajbhandari S, Rao Dhananka S, Zurbrügg C (2018) Social processes in post-crisis municipal solid waste management innovations: A proposal for research and knowledge exchange in South Asia. Research Ideas and Outcomes 4: e31430. https://doi.org/10.3897/rio.4.e31430

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