Waste Management, Sanitation and Society

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Edited by

Amrita Dwivedi

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PREFACE

The disposal of waste is now largely the domain of sanitarians and public health engineers, though health professionals need to have a basic knowledge of the subject since improper disposal of waste is a health hazard. On account of increasing populations and the changing consumption patterns of commodities, there has been a substantial increase in the generation of solid waste, both in absolute terms and in terms of per capita generation. Many developing countries currently have insufficient collection efficiency and improper systems for the disposal of waste, both of which have a major impact on such societies.

This book investigates municipal solid waste and its generation, collection, transportation, and disposal. It not only focuses on urban waste, but also looks at various challenges and problems associated with the rural waste management practices adopted in Indian villages with the help of case studies. The book considers waste prevention strategies like recycling, reuse, and recovery which ease the burden on landfills, contribute towards the conservation of natural resources, and save energy. It also discusses the social perception of waste and the inclusiveness of non-formal sectors, emphasising their role in waste management. This book is organised into ten chapters. **Chapter one** discusses the domestic waste generated in the rural households of India, which is increasingly becoming an issue of serious concern. There have been initiatives like the Swachh Bharat Mission which are trying to create universal sanitation. The present chapter tries to understand the various challenges and problems associated with the rural waste management practices currently undertaken in India. The major conclusion which the study derives is the importance of active community engagement. **Chapter two** attempts to highlight the sanitary zone-wise solid waste generation in general and, in particular, the ward-wise waste generation of Kanpur City. The main objective of the study is to categorize the different sanitary zones of Kanpur City on the basis of existing waste management services. The study is based on primary as well as secondary data. The quantity of waste generation has been computed by counting the number of waste vehicle trips/day; this data is used as the primary data. The secondary data has been collected from Kanpur Municipal Corporation (KMC). To determine the level of existing waste services, a Waste Service Index (WSI) has been designed. Three

variables, namely: the number of waste transportation vehicles, sweepers and dustbins in all the Kanpur Municipal Corporation zones have been taken into account for calculation, for the Waste Service Index. Three categories i.e., highly served, moderately served and least served zones have been identified. The study also examines the deficiency in the existing system of waste transportation in Kanpur City. **Chapter three** attempts to build a new line of argument in the reconceptualization of sustainability while centring around the question of waste management. Most waste management models consider the environmental and economic factors, but social factors, particularly localised social factors, should be incorporated as well to achieve regional waste management sustainability. This chapter tries to identify the paradigm shifts of various approaches toward achieving sustainability and their various strategies, practices, and challenges. Departing from the grand narratives of sustainability as a contribution to the existing knowledge, in this chapter we discuss why and how to conceptualise waste management spatially to achieve the goal of sustainability. **Chapter four** discusses the idea that access to water and sanitation are the two fundamental factors for future development. Sustainable Development Goals (SDGs) call for universal access and adequate clean drinking water and sanitation which require the progressive reduction of inequalities. Moreover, it emphasizes the improvement and efficacy of water and its ecosystem. It is necessary to understand how India's policies and programmes align with the SDGs. This would help to ensure the orientation, which is needed to make SDGs more attainable in the field of sanitation and water. Different articles, reports, and policy documents have been reviewed to give a comprehensive analysis. In this chapter, analysis shows that achieving progressive and sustainable development in water and sanitation will require addressing a broad range of challenges. **Chapter five** focuses on sanitation and waste management scenarios in urban village areas during the pre-COVID and COVID periods. The chapter also explores the societal swachhta and vulnerability of Delhi's urban villages, as well as changing perceptions over time. This study relied on primary field data from the pre-COVID and COVID period. In addition, different scenarios were examined, as well as how people's perceptions of cleanliness and waste management in urban communities have changed over time. The Urban Village Cleanliness Index was developed to assess 'swachhta' from an Indian perspective. A ranking of urban villages was created based on comparison scenarios. The key findings indicate that sanitation and waste management practices, beliefs, and perceptions have evolved and changed. **Chapter six** highlights the way people living in different societies behave and live life in different

ways due to an array of differences in their social, cultural, political, and economic setup and conditioning. The micro perspective on how and why people develop such ways of living and viewing things can be understood better by studying the society and individuals in their miniature world. In the contemporary period, it is important to understand how people see their environment, the animate and inanimate subjects that constitute it, and particularly 'waste' which is inherent in the environment. This very perception of them, and their thinking towards waste, constitutes a major aspect of understanding the problem of waste. The way people view waste determines that community's entire waste management process. This chapter examines the social perception of waste and attempts to provide a reasonable account of how city dwellers in Bhubaneswar, the capital city of Odisha, view waste which, in turn, has impacted the waste management in the city. **Chapter seven** analyzes the amount of waste generated by India which is so huge that now the focus is on management of waste. There are many approaches and models in place to solve this problem, but still, it's a humongous task to deal with it. The biggest problem that is being faced in waste management is segregation. All the solutions of recycling, waste to wealth and the circular economy come into the picture after segregation. The chapter signifies how the role of rag pickers in segregation becomes very important in the context of India but they get their due, neither in economic terms nor in terms of social recognition and security. Rag pickers are one of the important keys to better waste management.

Chapter eight describes the concept of composting which can play a crucial role in diverting this problem into a beneficial solution that might generate a valuable product as a soil conditioner for poor urban soils. This could then promote cleaner cities and support recent trends like urban farming or terrace farming and support other farmers too. Cities can also establish a supply chain for excess compost to export to exterior farm lands. This chapter explains compost, the composting procedure, the value and quality of compost, and how composting in cities can bridge the gap by minimizing the organic load from the waste stream and add a value product to urban farms by enriching their soil with useful nutrients. **Chapter nine** seeks to understand how waste and its management are significant challenges for most countries globally, which can have serious negative consequences for the environment and human health. The issue of waste management in rural communities has not received much attention from policymakers. This chapter seeks to understand the problem of SWM in rural communities and the perception of people towards its management. The chapter includes an in-depth analysis of certain socio-

cultural variables influencing the perception of rural inhabitants towards waste and its management.

Chapter ten focuses on modernizing the agricultural system to boost productivity and support food production by utilizing waste-to-resources effectively. Smart Agriculture (SA) is becoming increasingly vital in agricultural development. Smart agriculture, which strives to balance agricultural production and environmental exploitation via the use of smart technology gadgets and equipment, is critical for optimal farming management. We have concentrated on the different applications of innovative waste management technology for smart agricultural development, both to promote food supply and to alleviate livelihood crises in the face of increasing population growth. We have used a multiple regression model to determine how waste management technologies and smart agriculture can help increase food output. The findings reveal that smart agriculture technologies make a bigger contribution to food production in India in order to meet the nation's food supply requirements and agriculture sustainability as well.

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—Dr. Amrita Dwivedi

ABBREVIATIONS

AW	Agricultural waste
BMC	Bhubaneswar Municipal Corporation
BtB	Biowaste to Bioenergy
C & D	Construction & Demolition
CDB	Community Development Block
COVID	Corona Virus Disease
CRSP	Central Rural Sanitation Programme
CUA	Comprehensive Utilization of Agricultural
ENVIS	Environmental Information System
DLHS	District Level Household & Facility Survey
DOD	Department of Defense
EPA	Environmental Protection Agency
GHG	Green House Gas
HRD	Human Resource Development
IEC	Information, Education, and Communication
ISWM	integrated solid waste management
KKPKP	Kagad Kach Patra Kashtkari Panch
KMC	Kanpur Municipal Corporation
MDG	Millennium Development Goals
MIS	Management Information System
MoU	Memorandum of Understanding
MPCC	Medical Pollution Control Committee
MSW	Municipal solid waste
MW	Megawatt
NBA	Nirmal Bharat Abhiyan
NFHS	National Family Health Survey
NPK	Nitrogen, Phosphorus, Potassium
NSS	National Sample Survey
ODF	Open Defecation Free
PCMC	Pimpri-Chinchwad Municipal Corporation
R&D	Research and Development
SA	Smart Agriculture
SBM	Swachh Bharat Mission
SDG	Sustainable Development Goals
SWaCH	Solid Waste Collection and Handling
TDP	Tonnes per day

TSC	Total Sanitation Campaign
UVCI	Urban Village Cleanliness Index
USPEO	United States Presidential Executive Order
WSI	Waste Service Index

CHAPTER 1

UNDERSTANDING THE CURRENT WASTE MANAGEMENT SCENARIO IN THE RURAL AREAS OF INDIA AND THE WAY FORWARD

VIDHU BANSAL[1], NAZISH ABID[2], SUNNY BANSAL[3], MOHD. RESAAL ANSARI[4], JOY SEN[5]

Abstract

Waste management refers to the activities and actions that handle waste materials. It includes the collection, transportation, processing, and disposal of waste. Waste prevention, recycling, reuse, and recovery are important waste management strategies that ease the burden on landfills, conserve natural resources, and save energy. The World Bank estimates that waste generation will increase from 2.01 billion tonnes in 2016 to 3.40 billion tonnes in 2050. At least 33% of this waste is mismanaged globally today through open dumping or burning. India generates 62 million tonnes of waste each year. About 43 million tonnes (70%) are collected, about 12 million tonnes are treated, and 31 million tonnes are dumped at landfill sites. The domestic waste generated in the rural households of India is increasingly becoming an issue of serious concern. There have been initiatives like the Swachh Bharat Mission which are trying to create universal sanitation. The present chapter tries to understand the various

[1] Research Scholar, IIT Kharagpur, India (Corresponding Author)
[2] Lecturer, Department of Architecture and Interior Design, University of Bahrain, Bahrain
[3] Research Scholar, IIT Kharagpur, India
[4] Architect, XXI Architecture, Varanasi
[5] Professor, IIT Kharagpur, India

challenges and problems associated with rural waste management practices in India. The major conclusion that the study derives is the importance of active community engagement. A 'Solid Waste Management' system can only be successful if the community takes ownership and actively participates at the grass-root level.

Keywords: *Solid waste management, community engagement, rural areas, Swachh Bharat Mission*

1.1 Introduction

We are currently in the year 2022. During the 1970s or 80s, this year must have been imagined as extremely technologically advanced compared to that era. But is it? It can be said that there has been a lot of technological advancement since the 70s and 80s. There has been a huge change in communication, agriculture, living, and so on. But with great technological advancement, which makes life easier, comes a unique set of problems to be solved. One such problem is that of ever-growing waste. The minimalist ways of life have long departed for an ever-increasing consumerist approach. It is a problem in urban areas and a concern in rural areas. The pendulum of sustainability has oscillated from 'reduce, reuse, recycle' to 'use and throw' and back again to the 'three Rs'. The gravity of the situation is becoming vividly clear with each passing day, and the grave danger of making our lands unfit for consumption has rapidly materialized. The present chapter focuses on the rural areas of India and tries to understand the current waste management scenario in these hinterlands. The chapter investigates the types of waste and what is predominantly found in these areas. The chapter also looks into how the current ways of waste disposal harmfully affect rural health. The chapter includes waste generation, its different categories, and the approaches to solid waste management generally taken up in these areas. In the later parts, the chapter explores the institutional arrangements which facilitate solid waste management. The chapter concludes with an overall evaluation and a way forward for solid waste management in rural areas of the country.

1.2 Types of waste

Waste is any item beyond use in its current form and discarded as unwanted. It can be solid or liquid with respective management methods. Even though waste (both solid and liquid) produced in rural parts of the country is mostly organic and biodegradable, it has become a major challenge for the overall

sustainability of an ecological balance. Improper solid-liquid waste disposal can lead to various health and hygiene problems. Vector-borne diseases such as diarrhoea, malaria, polio, dengue, cholera, typhoid, and other water-borne infections such as schistosomiasis result from haphazard solid and liquid waste disposal. The lack of clean water, sanitation, and inadequate solid and liquid waste management account for 85 to 88% of the total disease load.

Waste can be classified into the following categories based on its physical characteristics:

1) **Solid waste:** Solid waste is any waste that is not human excreta, urine, or wastewater. House sweepings, kitchen rubbish, garden waste, bovine dung and waste from animal sheds, broken glass, agricultural waste, plastic, metal, wastepaper, textiles, rubber, and waste from markets and shopping areas, and hotels, etc. are all examples of solid waste in rural areas. Solid waste is organic and inorganic waste produced by households, businesses, and industries with no economic value to the owner. Based on the nature of waste, the above-mentioned waste can be categorized as below:

    i) **Inert waste:** broken pieces of glassware, earthen pottery grit, ash, tin, cans, plastics, polythene bags, etc.
    ii) **Combustible waste:** paper, leaves, bark, stalks, etc.
    iii) **Compostable waste**: animal dung, crop residue, fodder residue, and vegetable waste from the kitchen.

    Solid waste can be categorized into the following categories based on biodegradability:

    1. **Biodegradable:** biodegradable waste is completely decomposed by biological processes in the presence or absence of air. For example, kitchen trash, animal excrement, agricultural waste, and so on (ENVIS Centre on Hygiene, Sanitation, Sewage Treatment Systems and Technology, 2022).
    2. **Non-biodegradable:** non-biodegradable waste is waste that biological processes cannot decompose. There are two types of these:
        i. **Recyclable:** plastic, paper, old clothes, and other garbage with economic worth but headed for disposal could be recovered and reused, along with their energy.

ii. **Non-recyclable:** waste that does not have an economic value of recovery, e.g., Tetra packs, carbon papers, Thermocol, etc.

Depending on the source, solid waste can be classified into different types:

a) **household waste** is generally classified as municipal waste
b) **industrial waste** as hazardous waste
c) **biomedical waste** or hospital waste as infectious waste.

2) **Liquid waste:** When water is used once and is no longer fit for human consumption or any other use, it is considered to be liquid waste. Wastewater can be sub-categorized as industrial and domestic.

a) **Blackwater:** wastewater generated in the toilet is called blackwater. It contains harmful pathogens.
b) **Greywater:** wastewater generated in the kitchen, bathroom, and laundry is called greywater. It may also contain pathogens. In the case of water supply to the community, part of it comes out as household waste. Such waterfalls are in the category of liquid waste generated by the community. It is different from rainwater.

In addition to the wastes listed above, a type known as "Domestic Hazardous Waste" may be generated at the household level. Some examples are: used aerosol cans, batteries, household kitchen and drain cleaning agents, car batteries and car care products, cosmetic items, and chemical-based insecticides/pesticides. Even light bulbs, tube lights, compact fluorescent lamps (CFL), paint, oil, lubricant, and empty containers are examples of such domestic hazardous wastes. According to the Environmental Protection Agency (EPA), hazardous waste must first satisfy the legal definition of solid waste. The EPA categorizes hazardous waste into three types. The first group includes source-specific wastes, the second group includes non-specific wastes, and the third group includes commercial chemical products (USEPA, 2020).

Similarly, there is ‘Non-Hazardous Waste’. Waste is “the excessive, careless, or wasteful use of DOD funds or consumption of DOD property that resulted from inadequate practices, systems, controls, and decisions” by the Department of Defense and the EPA Furthermore, "abuse" is defined as "how resources or programs are managed in such a way that waste is created or perpetuated, and it includes incorrect actions that are not prosecutable fraud" (USEPA, 2020). Solid non-hazardous waste is defined by the EPA

as "any garbage or refuse sludge from a wastewater treatment plant, water supply treatment plant, or air pollution control facility, and other discarded material, including solid, liquid, semi-solid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations, and community activities" (USEPA, 2020). Financial waste is also included in the definition of non-hazardous waste. Due to the public's zero-tolerance policies for fraud, waste, and abuse, the United States Presidential Executive Order (USPEO) Minimizing Inappropriate Payments and Eradicating Waste in Federal Programs was issued in 2009 to minimize payment blunders, waste, fraud, and misuse in major Federal government programs. This Executive Order is based on a transparent, collaborative, and participatory framework for the government and the public.

1.3 Impact on rural health

Modernization and progression have several disadvantages, one being the pollution it causes around the globe – on earth, in the air, and in the water. With the increasing world population, the need for food and other requirements has grown, and so has the quantity of waste produced by each household daily. This waste is finally dumped in solid waste collection facilities, from where local governments process it before it is dumped in landfills. However, due to a shortage of resources or insufficient facilities, not all of the garbage is collected and carried to the final dumpsites. If solid waste is handled poorly at this point, it can have serious health repercussions and environmental concerns (International Institute of Health and Hygiene, 2021). Because of their widespread dissemination, a wide versatility, spanning technology, agriculture, industrial, domestic, and medicinal, concerns have been raised about the environment and human health (Senekane, et al., 2021).

Solid waste forms a major part of the environmental pollution in the world and, thus, is a major cause of the spread of several harmful and infectious diseases (Puri, et al., 2008). Even though most of the trash generated in rural regions is organic and biodegradable, it has severely threatened the overall sustainability of an ecological balance (Moharana, 2012). The negative effects of indigenous waste management systems include diseases spread by numerous vectors, such as rats and mosquitoes. In addition,, disagreeable odours from inadequately managed trash heaps impact humans. There has been evidence of an association between indigenous SWM methods and practices and rural communities' health and environment. This study implies that biomass fumes and heavy metal-contaminated water are associated with

poor environmental health. The influence of SWM on community health in rural regions has garnered much attention in academic studies because it isn't well understood and is often misunderstood as an aesthetic rather than a public health issue. Potential health problems may arise from exposure to environmental risks found in waste, which are linked to every stage of waste management, from generation to ultimate disposition (Senekane, et al., 2021).

Pollution of groundwater and soil and poor air quality from improper waste burning poses a substantial danger. Many waste-related activities emit greenhouse gases, such as methane from landfills and carbon dioxide and nitrous oxide from garbage trucks. Surface and ground waterways are contaminated by leachate from unlined and exposed dumpsites. Incineration of hazardous and non-hazardous wastes may release compounds that pollute the air, water, and soil and have negative health consequences (Shah, et al., 2012).

Most rural residents cannot access adequate sanitary facilities and must defaecate in the open. The habit of open defecation produces vast numbers of flies, which act as carriers of infectious diseases and transfer them to humans. Defaecating and urinating in public locations can lead to infections of the kidneys and bladder, as well as hookworm infection. Diarrhoea, cholera, dysentery, anaemia, typhoid, urinary tract infection, and other ailments affect most people. Dysentery is the most common among locals (Dey, 2018).

Crop residue burning is one of several sources of pollution in the air. On a local and regional scale, the burning of agricultural waste pollutes the soil and water. It harms the soil's nutrient budget. These gaseous emissions can aggravate asthma and chronic bronchitis and reduce lung function, putting people's health at risk (Kumar & Joshi, 2013). Particulate matter and toxic gases such as nitrogen dioxide (NO_2), nitrogen oxide (N_2O), sulphur dioxide (SO_2), carbon monoxide (CO), carbon dioxide (CO_2), and methane (CH_4) are all present in the emissions, all of which are hazardous to human health (Abdurrahman, et al., 2020).

Heavy metals found in rubber, paper, and cement, are a dangerous component of general garbage. Even at low concentrations, many metals are poisonous, and some, such as chromium (Cr), can cause skin irritation and ulceration. Because of their role in causing various organ damage,, heavy metals are considered to be systemic toxicants even at low concentrations (Senekane, et al., 2021). Hazardous waste exposure can harm human health,

with children exposed to these contaminants (International Institute of Health and Hygiene, 2021).

As per the global statistics of the WHO, every year 1.8 million people die from diarrheal diseases (including cholera); 90% are children under five, predominantly in underdeveloped nations. Malaria kills 1.3 million people yearly; 90% are children under five. Schistosomiasis affects an estimated 160 million individuals worldwide. It has much to do with unclean faeces disposal and the lack of reliable water sources. Intestinal helminth infection can affect about 133 million people globally, resulting in catastrophic consequences such as cognitive problems, severe diarrhoea, and anaemia. Ascariasis morbidity can be reduced by about 29%, and hookworm morbidity by about 4%, with access to clean water, sanitation and better hygiene practices (Gupta, 2013).

1.4 Generation of solid waste in rural India

Solid waste management and disposal is a worldwide issue, especially in developing countries, due to population growth, changes in living standards as well as lifestyle, and increasing waste generation rates, all of which result in increased land requirements for waste disposal and dumping. India has a population of 1.36 billion, accounting for 17.6% of the global population (as of 2019). Rapid population growth in a developing country like India has created complex and colossal waste management challenges (Department of Economic and Social Affairs, UN Secretariat, 2019). According to the census of 2011, there are 638,365 villages, 748 districts, and 7,935 towns in India. Despite rapid global urbanization in recent decades, according to a World Bank report, approximately 47% (3.31 billion) of the world's population and 68.84% (0.83308 billion) of India's population still reside in rural areas. Rural communities make up a significant portion of the country's population. According to the Centre for Rural Infrastructure National Institute of Rural Development and Panchayati Raj, Union Ministry of Rural Development, Government of India, the total waste generated in rural areas is estimated to be between 0.3 and 0.4 million metric tonnes per day (CRI, 2016).

Population growth, combined with improved lifestyles, increases solid waste generation in urban and rural areas. There is a clear divide between urban and rural solid waste in India, as in all other sectors. However, the gap between the two is closing with increasing urbanization, rapid adoption of the "use and throw concept", and equally rapid communication between urban and rural areas. Solid waste in rural areas is biodegradable, whereas

solid waste in urban areas comprises more non-biodegradable elements such as plastics and packaging. However, both sectors share an intolerable attitude towards solid waste and its management. The universally accepted practice is to 'keep garbage out of sight' (Raveesh Agarwal, 2015). Currently, waste management in India mainly comprises collecting waste from industrial and residential zones and dumping it at landfill sites (Agarwal, et al., 2015).

Every year, India generates approximately 960 million tonnes (MT) of solid waste, which are environmentally unfriendly by-products that are detrimental to ecology and the environment if not managed sustainably (Pappu, et al., 2007). Even though garbage generation in India's rural sector is substantially lower (0.3-0.4 MT per day) than in urban areas, waste management in rural areas has been a public concern (Balu, et al., 2020). Southern Indian villages with a population of about 500 generate 2,364 tonnes of solid waste annually (Gowda, et al., 1995). In the Urban Indian context, solid waste has two major components; domestic waste accounts for 67.8% of urban solid waste, and commercial garbage accounts for 23.5%, whereas rural solid waste has only one primary component: domestic waste accounts for 92.4%. The rural community produces 63.5% bio-degradable and 36% non-bio-degradable waste, while the urban community produces 50% bio-degradable and 50% non-bio-degradable waste. In rural locations, open dumping is a serious concern; around 78% of the rural population uses open dumping to store and collect solid waste (Patwaa, et al., 2020). Since the solid waste generated in rural areas is organic, composting is an excellent technology for converting waste into manure. Recyclable materials were brought to a government-approved recycler, and toxic waste was delivered to a nearby municipal corporation (Agarwal, et al., 2015). The difference in waste generation rates between rural and urban areas is commonly due to differences in standards of living, income, and the availability of resources. Low-income groups or families produce less waste compared to high-income groups or families (Taghipour, et al., 2016)

***Table 1**: Solid waste composition data of rural areas in India*

Sr. No.	Village/dist.	Population	Composition % by mass					
			Organic	Plastic	Paper	Metal	Glass	Other
1	Mahalung/solapur	20833	69	10	15			6
2	Fijian/Rewa Province	–	69.9	7.5	6.4	4.1	1	10
3	Indo Fijian/ Rewa Province	–	52.8	9.4	16.9	5.6	9.4	5
4	Shyampur/Haridwar	2812	78.46	1.21	3.57	0.52	0.92	15
5	Sajanpur/Haridwar	2345	80.16	1.21	2.73	0.18	0.73	15
6	Kongri/Haridwar	2205	65.61	0.74	14.4	1.21	1.55	16
7	Bhogpur /Haridwar	9293	76.52	0.59	1.54	00	6.07	16
8	Dummanpur/Haridwar	3231	71.88	0.73	11.16	0.15	5.36	12

Source: (Patwaa, et al., 2020)

***Table 2**: Solid waste composition data of rural areas in other countries*

Sr.No.	Country	Population	Composition % by mass						
			Putrescible	Plastic	Metal	Glass	Textile	Paper	Other
1	Iran (Bakhtiari)	1312	41.0	10.1	8.0	8.2	4.5	7.2	21.1
2	Iran (yazd)	3438	39.3	9.5	12.1	10.1	3.5	6.3	20.2
3	Perian Gluf	1942	42.49	8.24	6.08	5.77	4.84	8.77	23.5
4	Iran (Khosrowshah)		45	13	0.45	1.9	1.5	6.0	32
5	Ghana	400	63.7	36.3					
6	South China (Yunnan–Guizhou Plateau)	–	52	11.5	0.7	2.3	2.6	1	30
8	Europe (Czech Republic)	–	11.7	9.7	2.6	4.9	2.3	9.7	44
9	China	–	43.54	8.78	1.28	2.54	2.75	7.7	32

Source: (Patwaa, et al., 2020)

The organic proportion of solid waste in the rural part of India is substantially higher than in other nations' rural areas, as shown in Tables 1 and 2.

1.5 Approaches for solid waste management

Solid waste management is the discipline that deals with the control of solid waste generation, storage, collection, transfer, processing, and disposal (Mishra, et al., 2014). The focus should be at the household level for waste management in rural areas for successful solid waste management. Anything that cannot be handled at the household level should be handled at the community level. In general, the following approach for solid waste management should be followed:

1. At the household level, solid waste is separated (biodegradable and non-biodegradable).
2. To the degree practicable, domestic non-biodegradable garbage should be reused.

3. Treatment of biodegradable waste at the household level.
4. Collection and delivery of segregated garbage from households to a community-identified location (in cases where household-level treatment is impossible).
5. Waste treatment or recycling/reuse at the community level.
6. At the communal level, all biodegradable trash should be composted.
7. Non-biodegradable garbage can be separated further and sold or recycled.
8. Wastes that cannot be composted, recycled, or repurposed may be disposed of at landfill sites following local regulations (such waste may usually be construction waste, debris, etc.) (Moharana, 2012).

1.5.1 Composting of biodegradable waste

Composting is one method of utilizing organic and biodegradable trash. Composting is a controlled process in which biological and organic waste is turned into tidy humus. The humus has no disagreeable odour and can be used as a fertilizer by the action of microorganisms living in the soil (bacteria, fungi, and so on) (Kristic, et al., 2018). Farmers benefit from composted manure since it increases output and is environmentally beneficial (Moharana, 2012). Some of the methods of composting in rural areas are mentioned below:

1. ***Indore Method***: this approach has been the only systematic approach to mature compost in the initial days of organic gardening/farming. Animal manure is employed as a catalyst support in this process, along with various forms of organic waste on the farm (Niladri, et al., 2019).
2. ***Bangalore Method***: this approach is recommended where the compost is made from night soil and garbage. Many of the inadequacies of the Indore method are addressed, including the problem of heap protection from bad weather, nutrient losses from heavy rains and intense sun, frequent turning requirements, and fly nuisance. The approach is appropriate for locations where rainfall is scarce. Composting occurs in trenches (Niladri, et al., 2019).
3. ***Windrow Composting:*** windrow composting involves putting raw materials in long, narrow stacks called windrows that are turned regularly. The components are mixed, allowing for aeration of the setup. For solid materials like manure, a typical windrow composting setup should start at 3 feet and end at 12 feet for fluffy materials like leaves (Ayilara, et al., 2020)

4. ***Vermicomposting:*** vermicomposting utilizes earthworms to convert organic waste into finely degraded peat-like material. Vermicomposting can be done using any composting process, but earthworms are used after the partial decomposition of the waste materials. Vermicompost is a biofertilizer that contains all the important plant nutrients, such as N, P, and K, and all the helpful soil bacteria (Pilli & Sridhar, 2019).

1.5.2 Reuse and recycle of non-biodegradable solid waste

Non-biodegradable solid waste should be categorized into two at the individual and community levels: recyclable and non-recyclable. Women's self-help organizations can sort or segregate paper, plastic, cloth, metal, glass, and other materials at the community level (Moharana, 2012). Recycling as often as possible, reducing packaging waste, using reusable things rather than disposable items, and reusing disposable items are all great strategies to drastically reduce non-biodegradable waste in one's home (Wise, 2017).

1. ***Recycling of Paper:*** it is feasible to recycle waste paper and turn it into a valuable product. Making pulp from scrap paper is a time-honoured tradition. The procedure has now been fine-tuned. The pulp can be used to make various items, including showpieces. The pieces are so strong that they can sometimes be used as a substitute for wood. As a result, it is also known as pep wood.
2. ***Recycling of Plastics:*** plastics have become a major cause of concern in rural areas for all types of solid waste. Each homeowner should segregate this waste at the domestic level. Segregated plastic garbage must be packed and stored securely before being sold to local recyclers (Moharana, 2012).

1.5.3 Landfilling

Although landfilling is a widely approved and employed method for final waste disposal, the current scientific information on the waste-related environmental and health effects is inconclusive (Vaverkova, 2019). Modern dumpsites are well-engineered facilities strategically placed, organized, run, and regularly monitored in compliance with federal regulations. Solid waste landfills must be constructed to protect the environment from contaminants in the effluents. Environmental monitoring equipment on-site keeps a close eye out for indicators of groundwater

quality and biogas, among other things, as part of the landfill siting strategy. Furthermore, a growing number of new landfills are gathering potential hazardous landfill emissions and turning them into energy (Meegoda, et al., 2016).

1.6 Institutional structure

The first policy ever introduced in India that dealt with waste and its impact on the environment was the National Environment Protection Act in 1986 (Swaminathan, 2018). After that, Municipal Solid Waste (Management and Handling) rules came in in 2000 (Sambyal, 2016). These were active for 16 years, with a few inclusions in 2011. In 2016, Solid Waste Management rules (SWM) came into the picture. These rules had mandates which included waste processing and treatment, promoting the use of compost, promoting waste to energy, managing waste in hilly regions, formulating the central monitoring committee, and revising the parameters and existing standards (Sambyal, 2016). In 2014, the Swachh Bharat Mission was launched, which aims to provide all sanitation facilities that include scientific municipal solid and liquid waste management. The mission has been active till now and shows considerable progress in rural and urban sanitation.

The Swachh Bharat Mission (SBM) has Solid and Liquid Waste Management (SLWM) as one of the key components. Correlating to the SDG goals, it is directly related to Water, Sanitation, and Hygiene (WASH) indicators. These indicators have a direct impact on the health and well-being of humans. India is counted among the fastest growing economies, but looking at the WASH indicators, it can be said that it is still far behind in the race (Ministry of Jalshakti, GoI, 2016). The conditions in rural areas are not in a good state. Thus, it becomes the need of the hour to look at the prerequisites required to improve the current conditions.

First and foremost, the institutional mechanism needs to be examined. When focusing on the institutional arrangement of the SLWM in rural areas, then Gram Panchayats (GPs) are the institutional bodies of importance. The GP authorities would be responsible for the design, implementation, operation, and maintenance of SLWM systems. They would be supported by their respective state governments (Ministry of Jalshakti, GoI, 2016). The institutional arrangement follows the following steps:

1. Step 1: formulation of a state-level SLWM resource team to brainstorm and decide on suitable technologies for their respective areas.
2. Step 2: formulation of the district-level SLWM resource team.
3. Step 3: identification of competent people at the Gram Panchayat level for the operation and management of SLWM schemes.
4. Step 4: involving individuals, communities, and private organizations who can act as facilitators of SLWM schemes.
5. Step 5: initiating the monitoring of indicators as suggested by SBM at the Gram Panchayat level.

Table 3: Actors in rural SLWMs

S. No.	Level	Organization
1	State	Public Health Engineering Department
		Water Supply and Sanitation Department
		Communication and Capacity Development Unit
		Panchayati Raj and Rural Development Department
		Tribal Development Department
		State Pollution Control Board
2	District	Zila Panchayat
		SBM (G) Cell
		NGOs
		Private Sector
3	Block	Block Development Officer
		Panchayat Raj Public Works
		Block Resource Centre
		NGOs
		Private Sector
4	GP	Gram Sevak/Sachiv
		Panchayat Development Office
		Community-based Organizations
		SHGs
		Private Sector/Entrepreneurs
		Households

Source: (WaterAid, 2016)

1.7 Community involvement

SBM is India's prime mission, spearheading sanitation programmes to a new level. The SBM-Gramin is the branch that closely monitors the situation in the rural parts of the country. Here, the main point of concern is how much a government-led scheme can go forward in changing the old ways of living and sanitation. Other stakeholders and actors must start playing an active role. The change, in its true sense, can only come when people at the grass-roots level start taking ownership of the change. The rural area community must unite to put in sustainable systems for the long term. There are few GPs in our country who have managed to achieve incredible results by putting in place an SWM system that worked for their community. A simple solid waste management model on similar lines can be put to practice in rural areas.

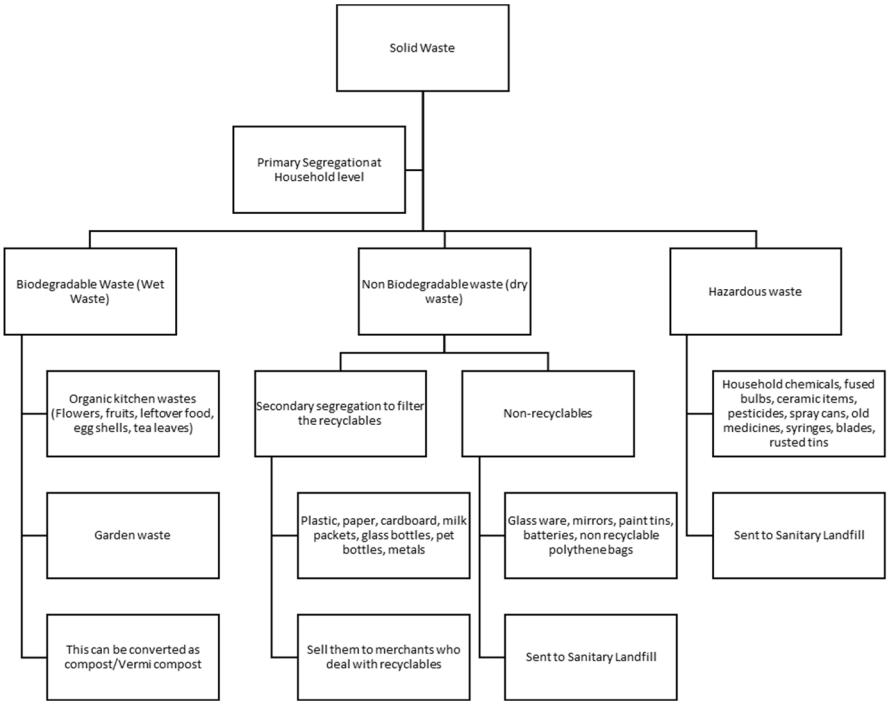

Figure 1.1: A simple solid waste management model.

Source: (NIRDPR, 2018)