Changing Trends and Guidelines for Sustainable Solid Waste Management in Rural India

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Abstract— A major part of India's population about 65% is living in rural areas. Solid waste management and efficient waste disposal is one of the essential services to be effectively planned for development of rural areas. The quantity of waste generated is increasing in rural areas as a result of increased population and commercial activities. It is estimated that 0.3 to 0.4 million metric ton of solid waste is generated each day in rural areas (DDWS-UNICEF, 2008). Waste generated in rural areas has more organic content and is lesser in quantity as compared to urban areas but with the changing times polythene, plastic, thermocol, paper, bottles, glass etc and other non – biodegradable wastes have made their way in rural waste. Most parts of rural India have no waste collection and management mechanism in place. Improper disposal and poor management of solid waste in rural areas leads to illegal dumping on the village outskirts or periodical burning which has direct and adverse impacts on environment and health. Solid waste management has become a common problem but a practical necessity in rural areas. With the introduction of Swachh Bharat Mission implementing a functional and sustainable waste management system for rural India is the need of the time. The paper focuses on documenting modes solid waste generation, classification of solid waste, approaches for solid waste management and treatment, recycling and identifying rural waste to energy potential. The paper seeks to discuss guidelines and actions taken for sustainable solid waste management to ensure that solid waste generated in the rural areas is collected, segregated, treated and disposed in the correct manner with least impact on the environment.

Index Terms— rural area; solid waste; classification of waste, scientific waste management; recycling; waste to energy; environment.

1 Introduction

A major part of India's population about 65% is living in rural areas. In India solid waste generated in rural areas has become a severe problem and its management is one of the major concerns for the environment. Littering of solid waste in open areas and illegal dumping causes unhealthy living conditions in rural areas. Most parts of rural India have no waste collection and management mechanism in place. Improper disposal and poor management of solid waste in rural areas leads to illegal dumping on the village outskirts or periodical burning which has direct and adverse impacts on environment and health. Solid waste management has become a common problem but a practical necessity in rural areas.

Solid waste management and efficient waste disposal is one of the essential services to be effectively planned for development of rural areas. The quantity of waste generated is increasing in rural areas as a result of increased population and nearby commercial activities. Waste generated in rural areas has more organic content and is lesser in quantity as compared to urban areas but with the changing times polythene, plastic, bottles, thermocol, paper, glass etc. and other non – biodegradable wastes have made their way in rural waste. In order to manage waste in an advantageous way, a functional and sustainable waste management system in rural areas should be in place.

2 Generation and Classification of Solid Waste in Rural Areas

About 960 million tons of solid waste is generated annually in India as byproducts during industrial, mining, municipal, agricultural and other processes. Of this, 350 million tons are organic wastes from agricultural sources; 290 million tons are inorganic waste from industrial and mining sectors and 4.5million tons are hazardous in nature. (HANDBOOK ON SOLID AND LIQUID WASTE MANAGEMENT IN RURAL AREAS OF HARYANA)

Waste generated in rural areas is namely; household wastes, community wastes, wastes from agricultural and agro-based

industries, animal wastes etc. In rural areas, sources of solid waste include wastes from kitchens, gardens, cattle sheds, agriculture, and other materials such as metal, paper, plastic, cloth, and so on. The composition of waste in rural areas is witnessing a major shift to use of plastics and paper and other non-biodegradable contents of waste.

Waste generated from household is *food waste* namely kitchen waste and food leftovers, *animal waste* namely; excreta and residual from animal feed, *recyclables* namely; paper glass plastic etc., *non-recyclable*s namely; thermocol, packaging waste, *Biomedical and hazardous waste* namely; expired medicines, bulbs, used batteries, fertilizers/ pesticides wastes etc. Waste generated from community waste is waste generated from small institutions, market places, small industries etc. Waste generated from agricultural and agro based industries is oils seeds, agro industry by products etc.

In India, rate of waste generation changes in response to changing regions, places, living habits, traditions, seasons and cropping patterns. Average rate of waste generation in rural areas is 0.15 kgs/capita/day. Waste generated per household in grams/capita/day can be approximated as food waste – 150 - 135 gms/capita/day, dry waste like paper plastic etc. – 125-350 gms/capita/day. Animal generated waste can be approximated as– cow / buffalo - 5 to 7 kg/day , goat/ sheep droppings: 0.2 kgs per day and sweepings (dust , dry organic matter) : 250 -750 gms/day. (WORLD BANK GROUP)

2.1 Classification of solid waste in rural areas

Although rural citizens in India produce half the quantum of waste compared to their urban counterparts, the quality and characteristics of waste in rural areas is changing and is a cause for concern. Rural Waste can be classified in different ways; Based on its physical properties or contents of waste, based on pattern of use and based on source. Key waste streams in rural areas can be broadly classified as food waste, animal fecal matter, sweepings, dry waste and agricultural waste.

Solid waste can be classified into two types: biodegradable and non-biodegradable. Biodegradable waste is that which can be decomposed by biological processes, for example, vegetable peel, food, farm waste, and so on. Organic waste is biodegradable and can be recycled; and Non-biodegradable waste cannot be broken down by biological processes, for example, paper, glass, metal, and so on. Non- biodegradable waste can be further classified into two types: recyclable and non-recyclable – Recyclable waste is that waste which has economic value that can be recovered, for example, metal, paper, glass, plastic bottle, and so on – Non recyclable waste is that waste which does not have economic value of recovery, for example, tetra packs, thermocol, and so on.

Solid Waste	Biodegradable		Examples: vegetable peel, food, farm waste, animal waste
	Non-Biodegradable	Recyclable Waste	Examples: metal, paper, glass, plastic bottles
		Non-Recyclable Waste	Examples thermocol, wrappers etc.

Based on the source i.e. place of generation rural waste be classified into four main categories as WET waste, DRY waste, SPECIAL waste and AGRI waste. WET waste namely; organic waste, DRY waste namely; recyclable and SPECIAL waste namely;

WET waste	**DRY waste**	**SPECIAL waste**	**AGRI waste**
Leftover or spoilt food, Vegetable and fruit, peels ,Leftover cooking, oil/grease , Fruit seeds, including, fruit kernels Coconut shells, , coconut fiber Used flowers/dry flowers , Used organic plates/eating utensils, Fish and	Metal, Paper, & Paper Pieces, Newspaper & Magazines Cardboard Hard Plastic Glass Bottles & Jars Broken Glass, Plastic Bottles & Containers Milk Packets Rubber, Cloth etc.	Sanitary waste, rejected waste, medical waste, etc.	Crop residue, weeds and reeds, leftover crop or vegetable produce. manure, oil, silage plastics, fertilizer, pesticides and herbicides; wastes from farms, poultry houses and slaughterhouses; veterinary medicines, or horticultural plastics

Meat Bones Food stained paper, Hair clumps, Nail clippings, Floor sweepings and, dust etc.			

Most household waste in rural areas is organic, with little inorganic material, and is non-toxic. Based on its physical properties or contents of waste can be classified as:

Biodegradable	55 – 75%
Recyclables	20 – 30%
Inert Material	5 – 10%

3 Current disposal practices of solid waste in rural areas

Uncollected wastes across rural areas is prone to uncontrolled disposal via open dumping or open burning practices, with direct environmental impacts and public health. Open dumping of waste generated and littering uncollected in community areas, rural outskirts and agricultural fields is the most common option in waste disposal in rural areas.

Current disposal practice: Animal Waste: Heaps of animal waste are haphazardly stacked on the roadside – unsightly. Animal waste washed by the rains and flows to drains. Animal waste is transferred once or twice only a year to the farmland as semi composted manure.

Current disposal practices: Plastic and Paper Waste: Plastic and paper waste is often littering and is growing as a dump. It is dumped in the open or surface drains which may often block surface drains.

Current disposal practices: Agricultural waste: India, the second largest agro-based economy with year-round crop cultivation, generates a large amount of agricultural waste, including crop residues. Crop residue and other agricultural by-products are burned intermittently in rural areas which is causing a major environmental problem giving rise to health issues as well as contributing to global warming.

4 Issues and objectives of solid waste management in rural areas

Lack of awareness, growing population, ignorance towards sanitation and unplanned development has led to waste becoming a serious challenge in rural India.

The uncollected waste pollutes the air, water and soil. Waste dumped in open areas leads to rotting and incomplete decomposition producing foul odor, unpleasant surroundings and causes many harmful diseases. Incomplete decomposition of waste also pollutes the open water sources in or around the rural areas as it reaches there by surface run off with rain water.

The burning of agricultural waste like crop residues causes many environmental impacts which includes the emission of greenhouse gases (GHGs) that contributes to global warming, increased levels of particulate matter (PM) and smog that cause health hazards, loss of biodiversity of agricultural lands, and the deterioration of soil fertility.

The primary objective of solid waste management in rural areas should be focused on to device an efficient and workable waste collection and management system in rural areas to reduce pollution and minimize environmental impacts. The other objectives should focus on promoting in situ recycling and reuse of solid waste, conversion of waste to energy for both house hold and agricultural waste resulting in energy security at rural level, generating employment in rural areas by offering opportunities in waste management by adopting cost effective and economically viable waste management technologies. The secondary objectives should be protecting health and improve quality of life of the people living in rural areas and make rural areas clean.

5 Technology options for treatment of Rural waste

Inadequate and inefficient solid waste management (SWM) directly have adverse effects on rural households, open or covered community areas in villages and agricultural fields which in turn affects rural health and surrounding environment. Effective treatment and disposal technology plays a significant role in improving this situation, by providing sustainable, economical and easy-to-implement solutions for the rural waste.

Techniques and processes can be applied from the collection point to the disposal point of rural waste can be summarized as:

Factors to be considered while selecting a treatment technology includes:

- Characteristics of the waste being generated;
- Quantity and frequency of waste generation;
- Availability and affordability of technology options;
- Applicability of the technology option in the area; and
- Availability of skilled personnel, energy, O&M needs, land requirements etc.

Household Waste: Examples : Food wastes can be converted to animal feed, compost or biogas and

Animal waste can be converted compost

Criteria for technology selection: Low capital cost, Low maintenance cost, Low space requirement, Householder responsible for maintenance

The household waste should be segregated in different coloured bins as biodegradable & non-biodegradable.

Community waste: Food & animal waste should be collected and processed (compost / biogas)

Community managed systems- Recyclable waste – storage & sale or processing and Biodegradable waste processing systems

Criteria for technology selection: Capital cost, operation and maintenance cost and space requirement.

Efforts should be made to manage the solid waste at household level for minimum community waste to be generated.

Agricultural waste: Agricultural waste is composed of organic waste which includes plant waste, animal waste and agro industrial waste.

Criteria of technology selection: health and safety regulations, space requirements for storage and disposal, method of reuse, recycling and recovery

	Household wastes	Community wastes	Agricultural waste
Treatment methods	Compositing – pit method Vermi Composting NADEP method Bio-Gas Plants	Reuse and Recycling of non biodegradable waste Bio-degradable wastes - Heap Method Pit Method Lagoon Method Chamber Method Berkeley's Method Nadep Method Recycling of paper Recycling of plastic	Thermal Processing – Pelletization and Briquetting Composting and Anaerobic digestion Landfarming Biodrying Controlled incineration

6 SUSTAINABLE PRINCIPALS OF SOLID WASTE MANAGEMENT IN RURAL AREAS

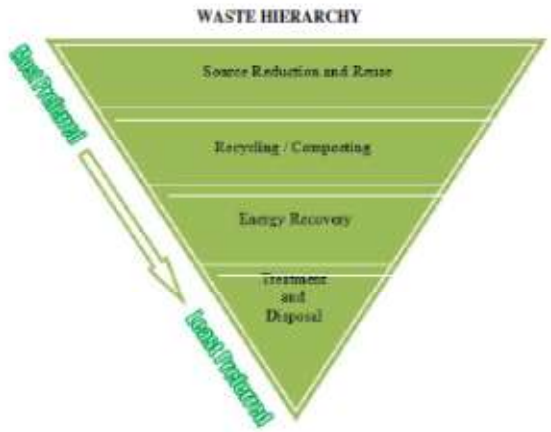
A sustainable solid waste management system is where you have affordable, long-term and cost- effective, efficient solutions for all the solid waste that is generated in the rural area.

Creating awareness and initiating community for active participation & involvement of the people living in rural areas to discontinue the current system of solid waste management i.e. burning and dumping in land, water or surrounding environment that is posing a major threat to health and wellbeing of the people. It must be important that a sustainable solid waste management system is set-up and implemented for all the households in rural areas.

The aim of setting up a sustainable solid waste management system is to ensure that all solid waste generated within the rural area is collected, segregated at primary source and processed/ disposed of in the correct manner with minimum impact on the environment. The system should aim to reduce the amount of waste being generated at the source, through awareness and education as well as maximizing on recycling, processing & up cycling of rural waste.

Approach of Solid waste management in rural areas:

The overall goal of waste management in rural areas should be to promote the outcome of a clean and healthy community where all waste is treated and disposed safely. The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste.



Source: HANDBOOK ON SOLID AND LIQUID WASTE MANAGEMENT IN RURAL AREAS OF HARYANA

Basic principles of solid waste management for effective management of the solid waste in rural; the focus should be on management at house hold level. If the management is not possible at house hold level the management should done at community level.

For the scientific management of solid waste following approach should have to be followed:

- Segregation of solid waste at the household level (biodegradable and non-biodegradable).
- Treatment of waste at household and community systems to be promoted only if space is a constraint.
- Technology choices considered must be simple, easy to maintain and not very capital and operation intensive.
- Reuse of non-biodegradable waste at the household level to the possible extent. Reuse of recyclable and processed (compost / biogas) end products
- Household treatment of biodegradable waste.
- Collection and transportation of segregated waste at the household level to identifies place at community level (cases where household treatment in not possible.)
- Non-biodegradable waste to be further segregated and recycled. Recycling of community waste to the maximum possible extent.
- Biodegradable waste should be composted at community level.
- Pubic support has to be increase by educating them which will increase the source separation at generation point as biodegradable, inert and recyclable material.
- Identifying the areas in and around the rural areas which are prone to waste disposal. Grampanchayats has to educate the house dwellers not to throw waste in empty spaces thereby reducing open dumping.
- Grampanchayats to start focusing on community active participation & involvement of the people.
- Sanitary land filling sites needs to be developed instead of open dumping.
- Scientific treatment and up cycling of agricultural waste.
- Promoting local alternatives to minimizes use of plastic and non-biodegradable items.

6 Rural waste management initiatives in India

The government of India has assigned the responsibilities to various authorities and also initiated some activities in India. Prime Minister Narendra Modi said all stakeholders should stick to the "golden rule" of the 3Rs— reduction, reuse and recycling— which will contribute significantly to waste management and sustainable development.

Sr. No.	Name of the initiative	Description
1	Swachh Bharat Abhiyan (SBA) or Swachh Bharat Mission (SBM)	on behalf of the government of India, the "Swachh Bharat Mission" was initiated on 2 October 2014 with the aim of making our country clean and free from defecation on its 150th birthday by 2 October 2019 as a tribute to Mahatma Gandhi, by building 100 million toilets at a projected cost of 1.96 lakh crore (US$ 28 billion) in rural India. Gramin Swachh Bharat Mission and Bal Swachhata Abhiyan. These looked at implementing the same effort in rural India and instilling the same values among children, respectively.
2	Mahatma Gandhi	The Government of Gujarat has launched Mahatma Gandhi

	Swachhata Mission:	Swachhata Mission to achieve the mission, goals and objectives which is same as the Swachha Bharat Abhiyan launched by the Government of India. The dream of the Mahatma Gandhi was all the cities, towns and villages should be clean, to have completely worked sewerage system important for improved health.
3	Swachh Survekshan	Ministry of Housing and Urban Affairs (former Ministry of Urban Development) since 2016 has introduced new scheme known as Swachh Survekshan. Surveyshan's goals are to encourage large-scale citizen participation, to raise awareness among all segments of society, to work together to make cities and towns a better place to live. It also helps the towns and cities to improve their service to society in order to build a city clean by healthy competition.
4	Indian Corporates Initiatives	This provides a comprehensive solution for municipal / hazardous waste collection, transportation and disposal, separation and reuse of municipal waste, development and maintenance of sanitary landfills, construction and operation of compost and waste plants.
5	IT Initiatives - Swachhata Helpline	Four-digit Swachhata Helpline "1969" was also introduced by the government to involve more people in reducing solid waste management and swachhata in one call. Here the citizen can call and file the complaint, including the current status of their complaint and their toilet building applications.
6	Swachhata App:	The Swachhata App is a mobile and web software of the fourth generation, launched by the Ministry of Housing and Urban Affairs. Anyone can download the app and file complaints on the app if they find discarded waste or overflowing dustbins or other cleanliness about problems.
7	The Municipal Solid Wastes (Management and Handling) Rules, 2000	This shall apply to every municipal authority responsible for collection, segregation, storage, transportation, processing and disposal of municipal solid wastes.

7 GUIDELINES FOR SUSTAINABLE SOLID WASTE MANAGEMENT IN RURAL AREAS

A framework is a must as a guide to assist rural areas in developing guidelines for sustainable management of solid waste in rural areas.

Analyze the existing waste management situation
Data Collection and Analysis for accurate quantification and characterization of waste
Design waste management hierarchy, planning and design of systems, technology selection.
Preparation of plan for collection and segregation of solid waste.
Preparation of plan for disposal i.e. environmentally safe and sustainable disposal.
Implement the action plan and monitor the results.

Step by step guidelines for Sustainable Solid Waste Management in Rural Areas

STEP I	Preparation and awareness	Community Education Identify infamous spots Community Preparation	Garner local Support, involve grampanchayats , render support from NGOS and government initiatives, Information, Education and Communication (IEC)
Step II	Planning	Area Survey Material Planning Manpower Planning Technical Planning Financial Planning	Create a map, identify best possible options, identify local scrap dealers for sale of recyclable waste, list of resources required for implementation.

Step III	Organization	Technology Funds Coordination	Prepare budgets, Recruit manpower, equipment and facilities for transport and storage, install machines or advanced technologies for implementing the solid waste management systems, Coordinate funds for manpower, equipment, storage, and transport.
Step IV	Implementation	Segregation at Source Collection Secondary Segregation Tertiary segregation Facility for Treatment & Treatment of Waste	Waste collection, seggregation, Recycling, upcycling, composting of food waste, disposal of non recyclable waste.
Step V	Monitoring	Household adherence: Feedback from Households, waste collectors Corrective Measures	Systems monitored continuously and corrective measures, Conduct monthly meetings with the implementation, Encourage community involvement, conduct an impact assessment study

8 CONCLUSIONS

In many rural areas of India, appropriate methods for collection, segregation and transportation of solid waste is still not in place. As the majority of the people are still living in rural areas, Government of India must take severe steps to address problem of solid waste management. Sustainable solid waste management can be implemented by adopting a scientific way of management. Educating people about the importance of solid waste management, achieving source separation of solid waste, introduction of the effective methods for collection and transportation of solid waste is a necessary requirement for effective solid waste management.

ACKNOWLEDGMENT

I extend my sincere gratitude to my co-author. I would also like to thank the organizing team for giving an opportunity to present this research paper in this conference. I appreciate the help and support of my co faculty throughout this paper writing process.

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