Solid Waste Management in India: A review and road ahead

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ABSTRACT

This study involves in depth research in the various aspects of the solid waste management which includes studying waste generation its classification and further focusing mainly on solid waste. The management of the waste has been an issue for the every country as the increase in population has also led to the increase in the waste generation. Managing of this waste has been an issue of concern for all the countries across the globe. Out of the many sorts solid waste is one of the major contributors in the category of wastes and managing it is a task. This study presents a comprehensive review of literature of solid waste management and best practices adopted in various countries for the issue. The paper also discusses at length strategy implemented in various parts of India keeping in mind the diversity and a variety of factors. Additionally the existing legislations and norms were studied according to which the areas of improvements and the future scope are suggested.

Keywords: Solid waste, management, legislations.

INTRODUCTION

Rapid urbanization and economic growth are the main factors of increasing Solid Waste generation(Mian, M. M., et.all.,2017) and it has started gaining attention in the developing economies also.One of the major challenges in big cities is planning and implementation of an optimized, integrated solid waste management system(Erfani, S. M. H., Danesh, S., Karrabi, S. M., & Shad, R., 2017). In India also, Solid waste management (SWM) is now realized as one of the major environmental problems (Sharholy M. 2008) and without aneffective and efficient solid-waste management program, the waste generated from varioushuman activities, both industrial and domestic, is resulting in health hazards and having a negativeimpact on the environment.

In its scope, solid-waste management includes all administrative, financial,legal, planning, and engineering functions providing solutions to all problems of solidwaste. The solutions may involve complex interdisciplinary fields such as political science,city and regional planning, geography, economics, public health, sociology, demography, communications,and conservation, as well engineering and materials science (APO, 2004-05).

The Indian subcontinent displays vast diversity in its geographic area. It stretches fromthe snow-covered Himalayan heights in the north to the Deccan plateau in the south, Indo-Gangetic plains in central and eastern India, and Thar Desert in the west. It shares internationalboundaries with Bangladesh, Myanmar, Bhutan, China, Nepal, and Pakistan. India has a coastlineof about 7,600 km. The total area of India is 3,287,590 sq km. The total land area is2,973,190 sq km, and 314,400 sq km is occupied by water. About 54.3% land is arable,2.66% of the land is permanently covered with crops, and 42.99% of the land is used for otherpurposes. Its climate is tropical and subtropical in south and temperate in north. The commonnatural hazards that occur in India are widespread and destructive—flooding by monsoon rains,drought, flash floods, and severe thunderstorms (al., 2009).

The intensification in the quantity of solid-waste production in India masqueradesa lot ofcoercion to the environmentand to professional health. The inappropriate and labour-intensivemanagement of solid waste causes menace and relocating the waste in open vehicles createsfoul conditions. Discarding waste in low-lyingareas without liners, leach ate collection and treatment creates groundwatercontamination. The dumpingwithout treatment of solid waste into streams and rivers creates water pollution. Airpollution is produced by odour nuisance and the production of greenhouse gases largely fromthe landfill sites.

In short, releasing dump in the open adversely influencesthe environment and human beings. The entire carriers of diseases like flies, mosquitoes, rats, and stray animals like cows, dogs, and pigsstrain at receptacles due tofavourable atmosphere. They then simply reproduce and become thesource of diseases like plague, malaria, typhoid, and cholera.

The present paper provides a critical analysis of present situation in India in terms of solid waste management- the initiatives taken by the government, role of NGO and other stakeholders and challenges present in this area.

The paper is broadly categorized into three areas- literature review, present situation and future strategies for Indian subcontinent.

UNDERSTANDING SOLID WASTE MANAGEMENT

Solid waste is defined as any waste that someone would consider disposing of on the land. Hazardous waste is a waste that has been legally designated as having both a chemical characteristic and a quantity of generation to make it require special attention. Specific categories of solid waste include garbage, municipal solid waste, construction and demolition debris, and special waste such as coal ash, medical wastes, and rejected consumer products.

The discarded and superfluous waste given off by animals and humans comprises of Solid waste. The major branches contributing to may be industrial, residential or commercial and managing the same requires different approach for different category of waste.

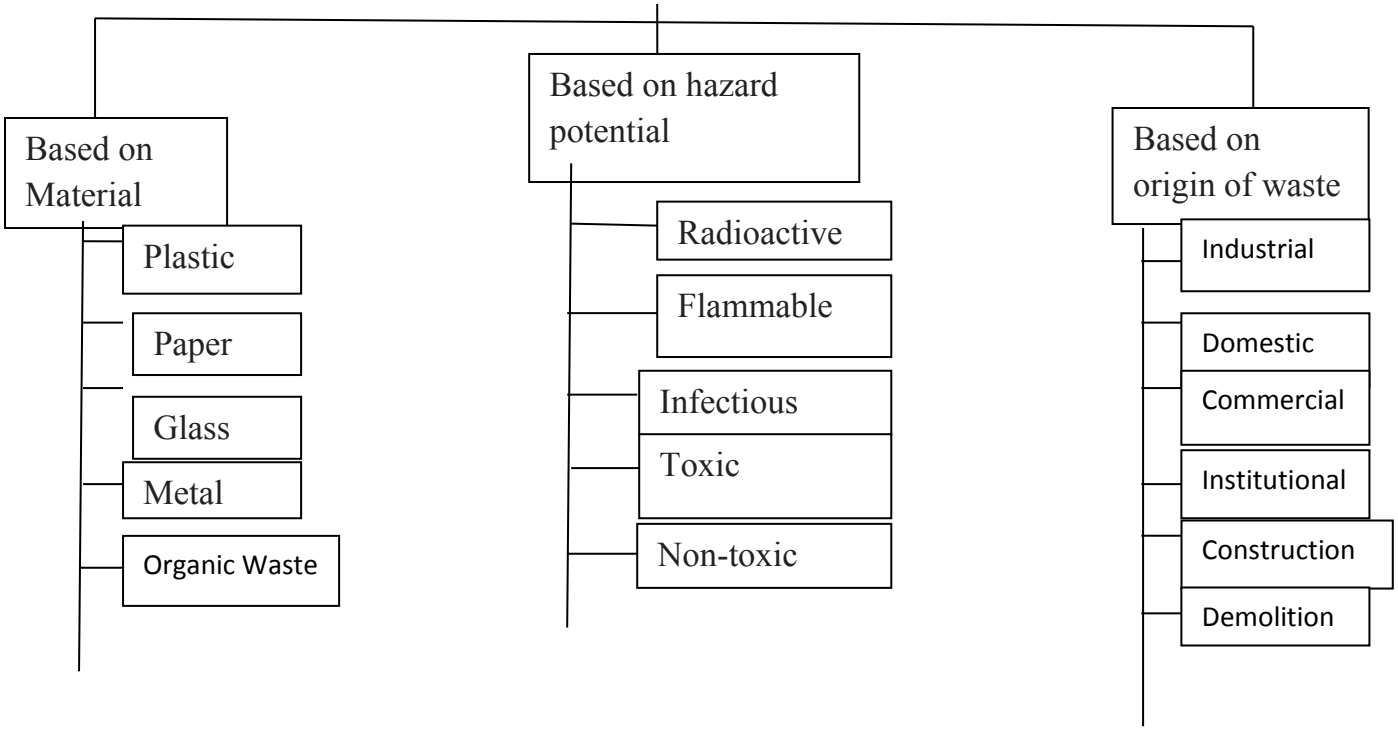
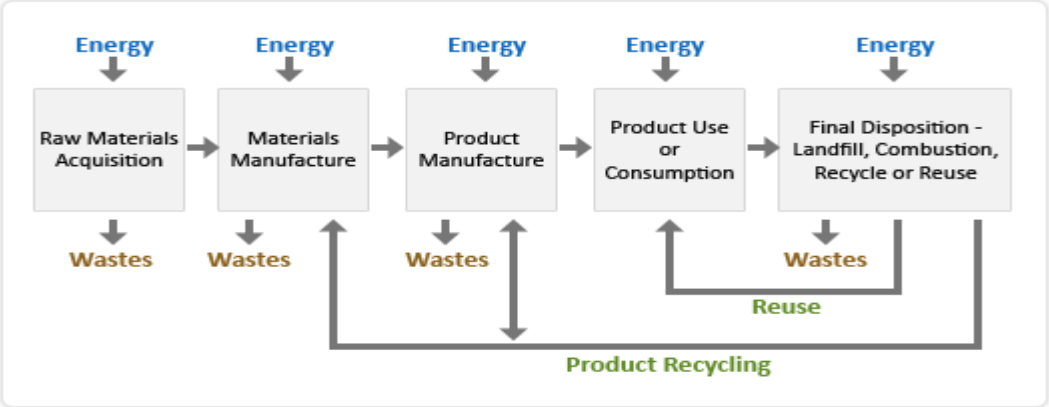


TABLE-1: TYPES OF SOLID WASTE BASED OF SOURCE OF ORIGIN

Source of Waste	Type of Waste
Residential areas	Food waste, paper, cardboard, plastic, textiles, glass, metal and nonhazardous waste, batteries, construction debris, and demolition waste

Commercial area	general store, Paper, cardboard, plastic waste, glass, metal, and restaurant/hotel waste
Institutional area	school, hospital, Paper, cardboard, plastic waste, glass, metal governmentoffices waste, hazardous waste, processing waste, ashes, infectious and toxic waste
Industrial areas	light, medium, Paper, cardboard, plastic, metal, e-waste, hazardous and major plants waste, and nonhazardous waste
Municipal services	street Green trash, silt/ashes, construction and demolitioncleaning, parks, water, and waste, sludgewastewater treatments

Regardless of the origin, content or hazard potential, solid waste needs be managed systematically to ensure environmental best practices.



LITERATURE REVIEW

Waste is rather considered as a resource in the present time. The revival of this source is the main purpose of the system to function. There can be various ways and methods that seem to be gaining popularity as the developed countries are researching more and more on the same. Further their process is tried and tested in the developing countries. The traditional method was incinerating and land filling which due to the constraint of space and land and pollution isn't possible. Therefore the need for new and innovation is important (Dijkgraaf&Gradus,

2004; Ferrara &Missios, 2005). (Troschinetz&Mihelcic, 2009) (Idris, Inane, & Hassan, 2004).

The choices for solid waste management are becoming very important factors in competitive development (Beranek, W.,Jr., 1992; Sefouhi, L., Kalla, M., &Bahmed, L. 2014). Specific categories of solid waste include garbage, municipal solid waste, construction and demolition debris, and special waste such as coal ash, medical wastes, and rejected consumer products. There are several solid waste management options: 1. reduce waste generated, 2. reuse materials, 3. recycle waste products, 4. compost organic material, 5. combustion, and 6. landfill. Because solid waste management is important to business, economic developers should have answers ready for any questions a business may ask and should work to improve the local climate for solid waste management options (Beranek, W.,Jr., 1992; Craggs, R, 1995).With some of the above management options a series of serious repercussions follow leading to various other problems such as space occupancy, pollutions etc (Thanh, N. P., Matsui, Y., & Fujiwara, T., 2011). The involvement of political parties in deciding the policies has lead to a chaotic situation. As the role of every party is restricted to a duration of time. In some locations, the conversion of old quarries into well-engineered and controlled landfills appears as a promising solution to a continuously increasing problem, at least for many decades to come (El-fadel, M., Sadek, S., &Chahine, W., 2001).

Research shows that the generation of municipal solid waste in is highly correlated to the total GDP, per capita income, and the population (Xiao, Y., at.all, 2007; Yousuf, T. B., &Rahman, M., 2007).Some studies found that the waste generation of the households was significantly affected by environmental consciousness, income groups, particularly the middle-income earners, and willingness to separate (Afroz, R., et. all, 2011)

Nnaji, C. C. (2015) in a study concluded that the rate of generation of plastics, water proof materials and diapers has assumed an upward trend. Due to the dysfunctional state of many municipal waste management authorities, many cities have been overrun by open dumps. Indiscriminate disposal of waste has also resulted in the preponderance of toxic heavy metals in agricultural soils and consequent bioaccumulation in plants as well as groundwater contamination. Disposal of solid waste poses great challenges to city managements. Changes in solid waste composition and disposal methods, along with urbanisation, can certainly affect greenhouse gas emissions from municipal solid wasteLandfill gas flaring, landfill gas utilisation and energy recovery in incineration are three techniques of the after-emission

treatments in municipal solid waste management. The estimation in the reduction of the greenhouse effect 22.7%, 4.5% and 9.8%, respectively (Yu, Y., & Zhang, W. 2016).. Past research has identified the stakeholders or people or organizations that may have an interest in adequate waste management. In a recent study, the life cycle assessment tool was used to assess, from an environmental point of view, the different possible municipal solid waste (MSW) management scenarios. the results obtained indicates that landfilling has the greatest impact in all the analyzed impact categories except ozone layer depletion and human toxicity, while incineration has the least impact on almost all the analyzed damage categories except in global warming potential and human toxicity(Rajcoomar, A., &Ramjeawon, T., 2017).

In another study, the inefficiency of state to address solid waste problems was highlighted. The emphasis was laid on creation of local resources, execution of local codes, and commitment from central government to allow free exercise of existing policies(Dangi, M. B., Schoenberger, E., & Boland, J. J., 2017).

From a study of China, it is revealed that the source separation MSW collection, high energy recovery from incineration plants, appropriate leachate treatment, effective landfill location and management, increase waste recycling and proper taxation system for MSW disposal are essential to improve MSWM in China(, M. M., Zeng, X., Nasry, A. A., Naim, Bin, & Al-hamadani, S., 2017).

Erfani, S. M. H., Danesh, S., Karrabi, S. M., & Shad, R., (2017) proposed an integrated model to optimize two functional elements of municipal solid waste management (storage and collection systems). The integrated model was performed by modelling and solving the location allocation problem and capacitated vehicle routing problem (CVRP) through Geographic Information Systems (GIS).

Ranieri, E., et all (2017) presented the classification of solid recovered fuel from the municipal solid waste treatment plant in Southern Italy in compliancy with the EN 15359 standard. The solid recovered fuel produced meets the European Union standard requirements and can be classified with the class code: Net heating value (3); chlorine (1); mercury (1).

Li, J., He, L., Fan, X., Chen, Y., & Lu, H. (2017). In their study presented a synergic optimization of control for greenhouse gas (GHG) emissions and system cost in integrated municipal solid waste (MSW) management on a basis of bi-level programming. The bi-level

programming is formulated by integrating minimizations of GHG emissions at the leader level and system cost at the follower level into a general MSW framework.

Above mentioned studies from various countries show an increasing interest of researchers and scientists in the field of solid waste management however studies pertaining to role of stakeholders i.e national and local government municipal authorities, city corporations, non-governmental organizations (NGO's), household's private contractors, Ministries of Health,Environment, Economy and Finance and recycling companiesare not yet examined particularly in India. This study therefore tries to fill the gap by comprehensively examining the role of each stakeholder in Indian economy in generation and management of solid waste.

Solid Waste Management in India

Increasing population levels, booming economy, rapid urbanization and the rise in community living standards have greatly accelerated the solid waste generation rate in India. Municipalities, usually responsible for waste management in the cities, have the challenge to provide an effective and efficient system to the inhabitants. However, they often face problems beyond the ability of the municipal authority to tackle mainly due to lack of organization, financial resources, complexity and system multi dimensionality. A study conducted by Sharholy M., et all (2008) concluded that the lack of resources such as financing, infrastructure, suitable planning and data, and leadership, are the main barriers in SWM in India. The increase of service demands combined with the lack of resources for municipalities are putting a huge strain on the existing SWM systems.The existing practices in solid-waste management in India can be classified at three levels, depending upon the quantity of solid waste and the physical area covered-

Rural Level: Rural people generally do not use plastic or metal containers to keep waste segregated as to biodegradable and non biodegradable. Instead, they throw it in the open fields. Sometimes it is naturally composted at the local level.

Town Level: In most towns in India, the practices for the collection and transportation of waste are not defined. No specific mode of collection, transportation, and disposal exists. The garbage is generally dumped in low-lying areas and burned openly.

Big-City Level: A more defined system of collection, transportation, and disposal/composting exists. People send their waste through locally hired waste collectors and organizations to the

community bin. From the community bin, it is transported by various methods to sanitary landfill sites. Rag pickers can be seen at waste collection and disposal points.

The types of waste generated in the country is as follows-

Hazardous waste is the waste that might have an adverse effect on the environment or on any form of living beings. Its management is crucial as the management needs proper functioning and administration and it can be in any form.

The effect on environment and human health, Govt of India notified, the Hazardous Wastes (Management and Handling) Rules, in the year 1989 under the Environment (Protection) Act, 1986 and these rules are amended from time to time and have recently been revamped with notification of Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016.

The present status of generation and management of hazardous waste (HW) in the country is as below:

No of HW generating industries	43938
Total generation of HW	7.467 Million Tons Per Annum
Land fillable waste	3.416 Million Tons Per Annum
Incinerable waste	0.695 Million Tons Per Annum
Recyclable waste	3.356 Million Tons Per Annum

Source: CPCB Report, 2016

The Bio-medical Waste: According to **Biomedical Waste**(Management and Handling) Rules, 1998 of India "Any **waste** which is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining thereto or in the production or testing of biological is considered as bio-medical waste. According to CPCB report (2013),there are total 168869 health care facilities in India and the total Bio-medical waste generated in the country is 484 Tonnes per Day out of which 447 TPD is treated and disposed of by these facilities.

E-waste :Electronic waste, or e-waste, is a term for electronic products that have become unwanted, non-working or obsolete, and have essentially reached the end of their useful life. Because technology advances at such a high rate, many electronic devices become "trash" after a few short years of use. The Ministry of Environment, Forest and Climate Change, India has revamped the E-Waste Management Rules, 2016 in supersession of the e-waste (Management 19 & Handling) Rules, 2011. The generation of e-waste in the year 2015 was

1.7 million Tonnes (CPCB, 2016). At present in the country, there are 149 registered dismantler/recycler, having dismantling and recycling capacity of 462896 Tonne per annum.

Municipal Solid Waste: Municipal solid waste (also called trash or garbage) is defined at the national level as wastes consisting of everyday items such as product packaging, grass clippings, furniture, clothing, bottles and cans, food scraps, newspapers, appliances, consumer electronics, and batteries. These wastes come from homes; institutions such as schools and hospitals; and commercial sources such as restaurants and small businesses.

The overall status of municipal waste management based on the available data for 2013-2014 in the country is given below:

Waste Generation	141064TPD
Waste Collected	127531TPD(90%)
Waste processed	34752TPD (27%)

Source: CPCB Report 2016

Plastic Waste: Indiscriminate littering and non-biodegradability of plastic waste raises several environmental issues; such as choking of drains, making land infertile & on ingestion by cattle lead to death;Burning of plastic generates toxic emissions. No organized/systematic system has been developed by concerned municipal authorities for collection, segregation, transportation and disposal of plastics waste. As per estimation the plastic waste generation is 15342 tons/day in the country. Plastic waste generated in 60 major cities is 3501 T/day.

STEP TAKEN BY GOI FOR SWM:

A new categorization of industries is proposed by government of India, based onthe relative pollution potential of the industrial sectors. The thinking behind this is that the industries start to think and implement.

The categorization of industries is based on relative Pollution Index scores and categorized as follows:

Classification	Pollution Index
Red category	≥60
Orange category	41-59
Green category	21-40
White category	<20

The newly introduced ‘White category’ contains 36 non-polluting industrial sectors which do not need “Consent to Operate’’.

Development of Emission Standards: CPCB has revised/developed emission/effluent discharge standards for 20 industries.
Plastic Waste Management: 14 states/UTs have banned plastics carry-bags. These include- Andaman & Nicobar Islands, Chandigarh, Chhattisgarh, Delhi, Haryana, Himachal Pradesh, Jammu &Kashmir, Karnataka, Lakshadweep, Nagaland, Rajasthan, Sikkim, Tripura, Uttar Pradesh.

ROAD AHEAD:

Reusability is not only an option but is also one of the most feasible solutions (Kasseva&Mbuligwe, 2000; Sudhir, Muraleedharan, &Srinivasan, 1996 Kaseva& Gupta, 1996; Misra&Pandey, 2005; SchootUiterkamp, Azadi, & Ho, 2011) and even with reusability sorting of the waste is the major concern (Buenrostro&Bocco, 2003; CPCB, 2000a; Position paper on the solid waste management sector in India, 2009).

According to Beranek, W.,Jr. (1992) There are several solid waste management options: 1. reduce waste generated, 2. reuse materials, 3. recycle waste products, 4. compost organic material, 5. combustion, and 6. landfill. Because solid waste management is important to business, economic developers should have answers ready for any questions a business may ask and should work to improve the local climate for solid waste management options.

Some scholars have identified factors influencing the elements of the waste management systems. The generation of waste is influenced by family size, their education level and the monthly income. Households attitudes related to separation of waste are affected by the active support and investment of a real estate company, community residential committees’ involvement for public participation and fee for collection service based on the waste volume or weight Gender, peer influence, land size, location of household and membership of environmental organization explain household waste utilization and separation behaviour .

It has been reported that collection, transfer and transport practices are affected by improper bin collection systems, poor route planning, lack of information about collection schedule insufficient infrastructure poor roads and number of vehicles for waste collection Organizing the informal sector and promoting micro-enterprises as effective ways of extending affordable waste collection services.

Lack of knowledge of treatment systems by authorities is reported as one factor affecting the treatment of waste analyzed the factors that influence household waste disposal decision making. Results showed that the supply of waste facilities significantly affects waste disposal choice. Inadequate supply of waste containers and longer distance to these containers increase the probability of waste dumping in open areas and roadsides relative to the use of communal containers. Insufficient financial resources limiting the safe disposal of waste in well equipped and engineered landfills and absence of legislation

Discussions

The amount of population in India and with the diversity of the system that is at three levels rural, town and city eradicating any problem becomes a challenge. This challenge of implementing new systems and policies at every level and its success in the system is the cause of concern. There are numerous suggestions deduced from understanding the above system and it's functioning in the country. The first and the foremost beginning from the reduction of the waste generation at the root level creating awareness amongst

Rubbish and its collections form the foremost objective of the structure of waste management system. Sorting it and defining the processing to be implemented on the same in accordance to its capacity is also available today with the technology. There is no single method that can be implemented.

Comprehending the waste generated also a crucial step of all. The classification of waste is not on solid, municipal etc but is also on the basis of composition of waste and also its percentages, Source and point of collection. Focussing on the composition of waste and its percentage, the components can be further classified into plastics, organic, recyclable, glass, papers, metals, and hazardous components. Additionally the percentage of the composition may vary from area to area as in the sources like household, industry, markets etc. under the point of collection an immediate collection and a communal collection are the two ways which in a country like India is quite varied. The immediate collection is achieved for higher to middle income section of people wherein door o door collection of waste is provided. The sufferers are the lower income people, who without this service and lack of knowledge allow the waste to decompose or directly send it to the dump without being processed or sorted. At this stage many solutions need to be provided. Beginning from services to all initiatives need to be taken from the government the housing societies on educating the people of the higher

and middle income population on reduction of waste generation first and also on dividing the waste into fractions of reusability, recyclibity, organic waste and wet waste. Frequent collection of waste from the lower income areas and proper collection is imperative. This would not only reduce the diseases from spreading but will also ensure proper disposal of wastes through appropriate processing and channels. The involvement of NGOs at this stage becomes decisive. Knowledge of waste disposal and how it is affecting the health and welfare of the beings in the vicinity would ensure an extended stream of support.

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