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Recent Scenario of Solid Waste Management in India

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ABSTRACT

Industrialization becomes very significant for developing countries like India having large number of population. Rapid increase in urbanization and per capita income lead to high rate of municipal solid waste generation. In recent times, E-waste and plastic waste also contribute considerably to total waste stream due to utilization of electronic and other items. These wastes may cause a potential hazard to human health or environment if any of the aspects of solid waste management is not managed effectively. In India, approach towards Solid waste management is still unscientific. Solid Waste collection efficiency in India is around 70% (Sharholy et al. 2007), while same is almost 100% in the developed countries. Even today, large portion of solid waste is dumped indiscriminately on outskirts of towns or cities without any prior treatment. This leads to groundwater contamination and increase in air pollution due to leachate percolation and release of gases respectively. Various study reveals that out of total solid waste, 80% can be utilized again either by recycling or reusing. Improper waste segregation and other factors lead recycling sector to work on outdated technology. However, plastic and paper recycling have been especially growing due to continuous increasing consumption of both the commodities. This study describes about current status of municipal solid waste management in different regions of India. It further summarizes a collective, systematic effort which improves implementation of legal frameworks, institutional arrangements, financial provisions, technology, operations management, human resource development, and public participation and awareness of Integrated SWM systems.

***Keywords*:** Municipal Solid Waste, Waste generation, Collection, Segtegation, 3R concept, Treatment, Disposal, Landfilling

1. INTRODUCTION

India is having second largest population in the world after China with more than 1.27 billion population contributing 17.6% of world's total population (Official population clock). On the contrary, India is sharing only 5% of world's area accounting 3,185,263 km^2. Out of total population, 68% lives in rural areas, while 32% lives in urban areas (WorldBank, 2014). Urban population is increasing day by day since last few decades. In modern society, industry becomes an essential part. Developing countries like India is in industrialization phase, which also contribute to urbanization. Large number of people are migrating towards city area for better opportunities. In terms of GDP, India is one of the fastest growing economy in the world with 7.30% GDP. It is expected that by 2030 India will be growing with GDP of 10%. Higher GDP will result into improved living standards. Over-population, Rapid industrialization. Uncontrolled urbanization and improved living standards thereby lead to increased rate of per capita waste generation.

Currently, 1,27,486 tons per day of municipal solid waste is being generated due to various household activities and other commercial & institutional activities (CPCB, 2012). Municipal waste and certain industrial waste have comparatively significant impact on environment. A substantial amount of these wastes is extremely dangerous to the living organisms including human beings (Misra et al. 2004). It may downgrade groundwater quality by leachate percolation and also cause air pollution by emission of greenhouse gases through various course of treatment. Nowadays, E-waste and nuclear waste are other waste streams which are requiring attention due to fastest growing electronics & nuclear sector. To overcome this problem, effective solid waste management must be implemented. The objectives of solid waste management are to control, collect, process, utilize and dispose of solid wastes in such an economical way which protects health of human being and natural environment and the objectives of those served by the system. In this regard, in 1989, the U.S. Environmental Protection Agency (U.S. EPA) adopted hierarchy of waste management practices (Henry & Heinke, 2008). The elements of hierarchy are:

- Source reduction
- Recycling of materials
- Combustion
- Landfilling

In India, initially there has not been much awareness about solid waste management and its hierarchy. However, since last few years, the scenario of solid waste management has been changing continuously. Still, there is a long way to implement an effective solid waste management practices. Even today, only few portion of solid waste generated is disposed through proper treatment. Lack of waste segregation is the biggest obstacle in implementing effective solid waste management. Though, Plastic and paper recycling sector is growing due to huge market demand for these commodities. Improper collection, unavailability of transportation in some areas, lack of advancements in treatment technologies, financial shortage in municipalities are other factors for poor solid waste management practices. It is important to recognize the fact that there are varying degrees of hazards associated with different waste streams and there are economic advantage for ranking wastes according to the level of hazards they present (Misra et al. 2004). In this study, comprehensive review of MSW of India has been provided to elaborate current status and to identify problems of municipal solid waste management. It also summarizes future trends to make MSW effective. However, it covers brief discussion of other wastes where it is necessary.

2. WASTE CHARACTERISTICS

In general terms, solid waste can be defined as waste not transported by water; that has been rejected for further use. It includes industrial, mining, municipal and agricultural wastes. It mainly consists of a large organic matter, ash and fine earth, paper and plastic, glass and metals (Sharholy et al. 2007). Composition of solid waste however varies depending on various factors such as weather, living standards etc. Table-1 classifies solid waste on basis of its source.

2. 1. Type of Solid Waste

Solid waste can be classified in many ways according to its source, composition, phase, treatment required etc. Table - 1 describes type of wastes on basis of its source. It includes residential, municipal, mining, agricultural, industrial etc.

Table 1. Type of Industrial Waste

Source	Typical Waste Generators	Type of Solid Waste
Residential	Household activities	Food waste, paper, cardboard, plastics, wood, glass, metals, electronic items etc.
Industrial	Manufacturing units, power plants, process industries etc.	Housekeeping wastes, hazardous wastes, ashes, special wastes etc.
Commercial & Institutional	Hotels, restaurants, markets, office buildings, schools, hospitals, prisons etc.	Bio-medical waste, Food waste, glass, metals, plastic, paper, special wastes etc.
Construction and Demolition	New construction sites, demolition of existing structures, road repair etc.	Wood, steel, concrete, dust etc.
Municipal services	Street cleaning, landscaping, parks and other recreational areas, water and wastewater treatment plants	Tree trimmings, general wastes, sludge etc.

Agriculture	Crops, orchards, vineyards, dairies, farm etc.	Agricultural wastes, hazardous wastes such as pesticides
Mining	Open-cast mining, underground mining	Mainly inert materials such as ash

Further municipal solid waste can be classified into putrescible solid wastes as garbage and nonputrescible wastes as rubbish. Rubbish may include variety of materials which may be combustible (paper, plastic etc.) or noncombustible (glass, metal etc.). There are special wastes such as construction debris, leaves and street litter, abandoned automobiles, and old appliances that are collected and managed separately. It consists of organic matter (51%), recyclables (17.5%) and others i.e. inert (31%) (Annepu, 2012). It should be noted that actual composition may differ due to informal separation of recycling wastes at source. Table - 2 gives approximate details about MSW composition in different parts of India.

Table 2. Composition of MSW in India and Regional Variation (Annepu, 2012)

Region/City	MSW (TPD)	Compostables (%)	Recyclables (%)	Inerts (%)	Moisture (%)	C.V. (MJ/kg)	C.V. (kcal/kg)
Metros	51,402	50.89	16.28	32.82	46	6.4	1523
Other Cities	2,723	51.91	19.23	28.86	49	8.7	2084
North India	380	50.41	21.44	28.15	46	9.8	2341
East India	6835	52.38	16.78	30.85	49	6.8	1623
South India	2343	53.41	17.02	29.57	51	7.6	1827
West India	380	50.41	21.44	28.15	46	9.8	2341
Overall Urban India	130000	51.3	17.48	31.21	47	7.3	1751

2. 2. Physical Characteristics of MSW

7CPCB reported the physical characteristics of MSW in different cities of India, which is shown in Table - 3 (CPCB, 2000).

Table 3. Physical Characteristics of MSW in Indian Cities (CPCB, 2000)

City	Paper	Textile	Leather	Plastic	Metal	Glass	Ash, Fine earth, others	Compostable matter
Ahmedabad	6.0	1		3			50	40
Banglore	8.0	5		6	3	6	27	45
Bhopal	10.0	5	2	2		1	35	45
Mumbai	10.0	3.6	0.2	2		0.2	44	40
Culcutta	10.0	3	1	8		3	35	40
Coimbatore	5	9		1			50	35
Delhi	6.6	4	0.6	1.5	2.5	1.2	51.5	31.78
Hyderabad	7	1.7		1.3			50	40
Indore	5	2		1			49	43
Jaipur	6	2		1		2	47	42
Kanpur	5	1	5	1.5			52.5	40
Kochi	4.9			1.1			36	58
Lucknow	4	2		4	1		49	40
Ludhiana	3	5		3			30	40
Madras	10	5	5	3			33	44
Madurai	5	1		3			46	45
Nagpur	4.5	7	1.9	1.25	0.35	1.2	53.4	30.40
Patna	4	5	2	6	1	2.0	35	45
Pune	5			5		10	15	55
Surat	4	5		3		3	45	40
Vadodara	4			7			49	40
Varanasi	3	4		10			35	48
Visakhapatnam	3	2		5		5	50	35
Average	**5.7**	**3.5**	**0.8**	**3.9**	**1.9**	**2.1**	**40.3**	**41.8**

2. 3. Chemical Characteristics

MSW contain few chemicals of which care must be taken i.e. nitrogen, phosphorus, potassium etc. In August 1995, NEERI presented a strategy paper of SWM in India in which chemical characteristics of MSW were discussed according to population range.

Table 4. Chemical characteristics of MSW in India (NEERI, 1995)

Population Range	Nitrogen (total nitrogen)	Phosphorus (P_2O_5)	Potassium (K_2O)	C/N Ratio	C.V. kcal/kg
0.1-0.5	0.71	0.63	0.83	30.94	1009.89
0.5-1.0	0.66	0.56	0.69	21.13	900.61
1.0-2.0	0.64	0.82	0.72	23.68	980.05
2.0-5.0	0.56	0.69	0.78	22.45	907.18
5.0 and above	0.56	0.52	0.52	30.11	800.70

3. WASTE GENERATION

As per CPCB report, municipal solid waste generation in year 2010-11 is about 1,27,486 Tons per day. The same was about 1,00,000 TPD (Tons Per day) in year 2000 as per report (May, 2000) of Ministry of Urban Development (MoUD), Government of India. During 2004-05, CPCB conducted survey through NEERI in 59 cities and estimated 39,031 TPD MSW generation. In year 2010-11, survey was again conducted by CIPET at the instance of CPCB and estimated 50.592 MSW generation.

Table 5. MSW generation Details of different states of India (CPCB, 2012)

State	Waste Generated
Maharashtra	19204
West Bengal	12557
Tamil Nadu	12504
Uttar Pradesh	11585
Andhra Pradesh	11500
Kerala	8338
Delhi	7384
Gujarat	7379

Karnataka	6500
Rajasthan	5037

As the data only accounts for proper scientific waste disposal, this amount can be very large in actual. Per capita waste generation varies between 0.2 to 0.6 kg per capita per day depending upon population size, living standards etc. It is estimated to increase at 1.33% annually. Industrial sector generates 100 million tons/year of no-hazardous solid waste consisting coal ash more than 70 million tons/year. About 8 million tons/year of hazardous waste is generated in each year out of 4.8 million tons is recyclable. As a matter of fact, people still throw household waste without following proper waste management channel, few industries dumping their wastes illegally and lack of awareness is still there related to agricultural waste disposal. Rate of waste generation is increasing continuously due to increasing population, industrialization, rapid urbanization and change in living standards. It should be noted that the significant amount of waste generation is contributed by metropolitan cities and other industrial areas. Nowadays, Electronics industry is one of those sectors which is rapidly growing in the world. Extensive use of electronic items and their short life causes the disastrous proportions of E-waste. Apart from these, nuclear waste is of prior importance due to its adverse environment impacts.

4. WASTE COLLECTION AND TRANSPORTATION

Until 1980, there was not much data available about solid waste generation and solid waste management was paid very little attention. But, implementation of Hazardous Waste Management Rules (1989) under Environment Protection Act - 1986 has changed the attitude of government and local authorities.

4. 1. Methods of Collection

According to Municipal Waste Management Rules (2000), it is the responsibility of municipalities to prohibit littering of solid waste in cities, towns and in urban areas notified by governments. To facilitate compliance, municipal authority have to organize house to house collection through any of the methods:

- Community bin collection
- House to house collection
- Collection on regular time interval (which must be pre-informed)
- Scheduling by using bell ringing of musical vehicle (without exceeding the noise levels)

To increase collection efficiency, the integration of these methods is required (Talyan et al. 2007). The transportation of municipal solid waste is generally carried out twice in a week or weekly basis by container carriers. However, in small towns and rural areas, open trucks, dumper trucks are used for waste collection. In recent times, with support of NGO and local communities, waste collection efficiency has increased remarkably in few rural areas. Since collection costs are 50-70% of solid waste budget, it is the most significant area for cost reductions. Interrelated variables such as labor costs, crew size, union restrictions, collection frequency, distance (travel time) to disposal and performance and annual costs of equipment must be considered during planning stage.

4. 2. Scenario of MSW Collection in India

Many local bodies has taken initiative for efficient waste collection alongwith certain NGOs having expertize in this sector of Solid Waste Management. It has been observed that waste collection is much greater in metropolitan cities or other urban areas as compared to that of rural areas. States like Gujarat, Maharashtra, Andhra Pradesh, Delhi, Tripura has taken initiatives to increase collection efficiency, while states like Arunachal Pradesh, Nagaland are still not complying MSW Rules, 2000 and following unscientific methods for waste collection transportation (CPCB, 2011). Table – 6 represents the collection rate of different states of India.

Table 6. State wise Waste Collection Data (CPCB, 2012)

State	Quantity Generated (TPD)	Collected (TPD)
Andaman & Nicobar	50	43
Andhra Pradesh	11500	10655
Arunachal Pradesh	94	NA
Assam	1146	807
Bihar	1670	1670
Chandigarh	380	370
Chhattisgarh	1167	1069
Daman Diu & Dadra	28+13=41	NA
Delhi	7384	6796
Goa	193	NA
Gujarat	7379	6744
Haryana	537	NA
Himachal Pradesh	304	275
Jammu & Kashmir	1792	1322
Jharkhand	1710	869

Karnataka	6500	2100
Kerala	8338	1739
Lakshadweep	21	21
Madhya Pradesh	4500	2700
Maharashtra	19204	19204
Manipur	113	93
Meghalaya	285	238
Mizoram	4742	3122
Nagaland	188	140
Orissa	2239	1837
Puducherry	380	NA
Punjab	2794	NA
Rajasthan	5037	NA
Sikkim	40 (capital)	32
Tamil Nadu	12504	11626
Tripura	360	246
Uttar Pradesh	11585	10563
Uttrakhand	752	NA
West Bengal	12557	5054
34 States	**127486**	**89334**

Table 7. Collection Efficiency of Indian Cities
(Gupta et al., 1998; Maudgal, 1995; Khan, 1994)

Name of the City	Collection Efficiency (%)	Name of the City	Collection Efficiency (%)
Bombay	96.6	Madurai	51.6
Madras	90	Pune	70

Banglore	68.1	Baroda	60
Coimbatore	64.6	Bhopal	93.5
Ahmedabad	90	Salem	19.2
Kanpur	70	Lucknow	83
Indore	83.3		

5. WASTE SEGREGATION 3R CONCEPT

5. 1. Waste Segregation

Waste segregation is the biggest obstacle for effective solid waste management. It is common in developed countries like U.S., Europe and Japan; but countries like India most often collect MSW in a mixed form. It is mainly because of lack of public awareness and advancements in source separation techniques. However, paper and certain type of plastics are separately collected at source level by waste pickers or waste buyers. Source separation increases recycling efficiency. It also improves performance of waste treatment units due to good quality of feed and lesser amount of impurities.

5.2. 3R Concept

Reduce: The term 'Reduce' can be defined as a reduction in the amount and/or toxicity of waste entering the waste stream. Use of green elements as raw materials, extension of product life cycle, optimum process design, reducing energy and heat losses, replacing raw materials by lighter material can help to reduce the amount of waste generation. 'Reduce' is the top ranking component of solid waste management hierarchy because it represents most effective means of reducing economical costs and environmental impacts associated with handling waste (Henry & Heinke). Life cycle assessment is very important for effective source reduction of waste. (Masters and Ela, 2015).

Reuse: The term 'Reuse' means usage (or utilization) of a product in the same application for which it was originally used. For example, a plastic bag can carry groceries home from the market over and over again, a tin can be used as a multi-purpose container. A product can also be reused for some other purpose, such as occurs when glass jars are reused in a workshop to hold small objects such as screws or nails. Remanufacturing is often used in this regard which means restoring a product to like new condition. It involves disassembling the product, cleaning and refurbishing the useful parts and stocking those parts in inventory. (Masters and Ela, 2013). While repair means only those parts that have failed are replaced.

Recycling: The recovery of materials for recycling is given second highest priority in the solid waste management hierarchy after source reduction. 'Recycling' simply means use of waste as raw materials for other products. It includes collection and separation of recyclables and processing them to useful raw materials for other products. It can be classified as preconsumer and postconsumer recyclable materials. Preconsumer materials consist of scrap that is recycled back into manufacturing process without having been turned into a useful product. Postconsumer recyclables are products that have been used by consumers, such as newspaper or plastic bottles. Glass, aluminium, heavy metals, construction and demolition debris are another example of recyclables. An example of resource recovery system for mixed solid waste is shown in Figure 1.

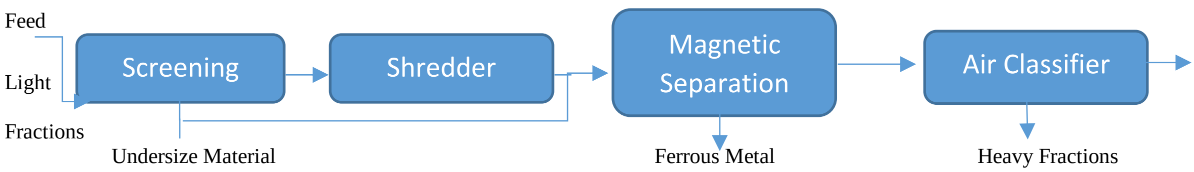

Figure 1. Resource Recovery System for Mixed Solid Waste (Masters and Ela, 2015)

6. ENERGY CONTENT OF MSW

The energy content of MSW depends on its composition and moisture content. It is reported that MSW can yield an average of 95 m^3 CH_4/tonne, having 19.43 MJ/m^3 calorific value. If we consider conversion efficiency 25% and overall generator efficiency 80%, energy cab be produced at a rate of $12.98 \cdot 10^5$ KWh/year (Kumar et al., 2002). Bomb calorimeter is used to determine the energy content of waste. It involves complete burning of a sample and then measuring the rise in temperature of a surrounding water bath (Masters and Ela,2013). This value is known as higher heating value (HHV). The heating value of MSW in industrialized area is higher than other areas due to higher percentage of manufactured materials such as paper, metals, plastics etc. (Khan and Gharrarah et al., 1991) have developed an equation that predict heating values based on paper and food fractions, plus a term that accounts for plastic, leather and rubber. However, this equation must be verified for solid waste of India.

$$\text{HHV (kJ/kg)} = 53.5\,(F + 3.6\,CP) + 372\,PLR$$

where, F is food, CP is cardboard and paper, and PLR is plastic, leather and rubber, all expressed as mass percentages (Masters and Ela, 2013). However, certain energy of HHV is lost to vaporize moisture, therefore lower heating value (LLV) should be considered which is also known as net energy.

7. SOLID WASTE TREATMENT

The remaining final solid waste is disposed in landfills after necessary treatment to lessen the adverse environmental impacts. The objective of treatment is to improve physical and/or chemical characteristics of waste, reduce toxicity and reduce its final volume (Misra et al., 2005). In India, different treatment methods are practiced depending on the type of waste. They are characterized by their capacity to treat specific type of waste, residues generation, cost, risk associated, safety and other environmental aspects (Blackman, 1996). The various treatment methods practiced for MSW and other similar type of waste are : Composting, landfills, Thermal processes (incineration, pyrolysis) etc. However, the same is not effective for hazardous industrial waste. There must be separate consideration to handle hazardous waste. Common methods which are adopted for hazardous waste are chemical fixation, volume reduction, detoxification, degradation, encapsulation etc. (Dawson and Mercer, 1986).

7. 1. Composting

Composting is a biological process of decomposition and stabilization of organic matter of solid waste by microbes either in presence or absence of oxygen. Depending on availability of oxygen, it is further classified as aerobic composting and anaerobic composting also known as biomethanation. It can also be classified as open or window, mechanical or closed etc. depending upon operating condition and design of plant. In India, large amount of waste is treated by this method for which efficiency largely depends on temperature (Rajvaidya and Markandey, 2008).

7. 2. Aerobic Digestion

As name suggest, aerobic composting means bacterial conversion of organics in presence of air. It yields compost as final product which is extensively used as fertilizer. Final product is free from odour and pathogens (Ahsan, 1999; Khan, 1994). It can reduce waste volume to 50-85%. Mechanical controlled plants are being installed in metropolitan cities, while manually control plants are set in relatively smaller urban township (Bhide and Shekdar, 1998; Chakrabarty et al., 1995). During 1975- 1980, large scale composting plants were installed in cities like Bangalore, Baroda, Mumbai, Calcutta, Delhi, Jaipur, Kanpur and Indore having capacity of 150 to 300 tonne/day. But due to poor performance and no usefulness in soil enrichment, plants were shut down. After that the first large scale plant was set up in Mumbai in 1992 with 500 t/day capacity of MSW followed by Vijaywada, Delhi, Bangalore, Ahmedabad, Hyderabad, Bhopal, Luknow and Gwalior. (Sharholy et al., 2008; Rao and Shantaram, 1993; Dayal, 1994; Kansal et al. 1998; Reddy and Galab, 1998; Gupta et al., 1998; Malviya et al., 2002; Kansal, 2002; Srivastava et al., 2005; Sharholy et al., 2006; Gupta et al., 2007)

7. 3. Biomethanation

It is the process of conversion of organic matter into stable, inert residue by microorganisms in the oxygen-free environment. It yields methane-rich biogas which can be used for electricity, cooking and inert residue which can be used as manure. Microorganisms used in this process are known as methanogens. The biggest advantage of biomethanation is that it can reduce the release amount of methane – a powerful greenhouse gas and simultaneously generates electricity. Another important aspect of this technology is its relevant use in rural areas for cooking.

7. 4. Incineration

Incineration is a combustion process which simply means drying and burning of waste. The final product of the process is CO_2, H_2O in vapor form and ash with a large amount of heat. It requires high temperature ranging between 980 to 2000 °C (Sharholy et al., 2008). Incineration reduces the final waste upto 75% approximately (Rajvaidya and Markandey, 2008). This process releases large amount of heat which if recovered properly can turn out to be a potential source of energy generation (Tan et al., 2015). Bio-medical waste and certain toxic industrial waste are also treated by this method having small capacity incinerators

(Sharholy et al., 2005; Lal, 1996). In most of the Indian cities, incineration is less common due to solid waste composition i.e. high organic matter (40% to 60%), high moisture content (40% to 60%) and presence of inert material (30% to 50%) and low calorific value (800 to 1100 kcal/kg). Calorific value must fall between 1200-1400 kcal/kg for energy generation. (Talyan et al., 2007, Kansal, 2002; Joardar, 2000; Bhide and Shekdar, 1998; Sudhire et al., 1996; Jalan and Srivastava, 1995; Chakrabarty et al., 1995). However, modification in design of incinerator and scientific waste management leads to avail large scope of this technology in recent times. Delhi was the first city to have MSW incineration plant. In 1987, the plant was constructed at Timarpur, New Delhi with a capacity of 300 t/day costing Rs. 250 million by Miljotecknik volunteer, Denmark. But, its poor performance led to shut down of plant after 6 month of operation. The disadvantage with this process is that it releases compounds containing sulphur, nitrogen and halogens deteriorating air quality. To overcome the problem, scrubbing, filtering are used to dilute concentrations to acceptable level prior to release into atmosphere. It also forms poisonous soluble metal oxides which must be controlled by recovery/detoxification/disposal (Misra and Pandey, 2005).

7. 5. Pyrolysis

Pyrolysis is an effective waste-to-energy concept refers to destructive distillation of the solid waste to recover its constituents and energy. In other words, pyrolysis is a thermal degradation process in absence of air which yields recyclable products such as char, oil/wax and combustible gases (Chen et al., 2014). It is generally preferred for treatment of waste having less moisture content like paper, cloth, plastic, yard wastes etc. as waste containing high moisture content require more heat supply. In this process, the solid waste is heated in a pyrolysis reactor at 600-1000 °C which yields oil phase i.e. methanol, acetone, acetic acid etc; gaseous phase i.e. H_2, CH_4, CO, CO_2 etc. and solid phase i.e. carbon char and inert materials (Dara 2004). Various reactors employed for pyrolysis are fixed bed reactor, rotary kiln, fluidized bed reactor and other innovative reactors (Chen et al., 2014, Peng et al., 2006, Arena and Mastellone, 2006, Hrabowsky et al., 2006). The total heat can be further divided into three types based on its consumption. Q1 is amount of heat which is required for moisture vaporization, Q2 refers to calorific requirement of pyrolysis, while Q3 is the radiation loss during the process (Weng et al., 2012, Boukis et al., 2007). It depends on various factors such as temperature, heating rate, residence time in reactor zone, material size etc. (Chen et. al, 2014) The biggest advantage of pyrolysis over incineration is very little effect to environment in terms of air pollution. Though, high initial cost and operation cost make this process difficult to emerge as commercially sound practice.

7. 6. Landfills

In India like many developing countries, waste is disposed in an open area without any precautions. In most of the indian cities, waste is thrown outskirts of the city area without any prior treatment which leads to environmental deterioration. Open dumping of solid waste leads percolation of leachate to underground water and gas emissions resulting into excessive air pollution. It also disturbs aesthetic surrounding by its odorus environment. Various study reported that groundwater of residential areas near landfills is significantly contaminated by leachate percolation. NEERI (1996) reported that only 25-30% gas can be recovered in the absence of base liner and top covering. Compaction, leveling of waste and final covering by earth materials are rarely observed practice in these waste handling sites. (Talyan et al., 2008; Shaeholy et al., 2007; Mor et al., 2006; Bhide and Shekdar, 1998). To overcome this problem, secure and sanitary landfill must be included in landfilling practices. The term ‘Secure landfill’ refers sites allocated for managing hazardous wastes and term ‘Sanitary Landfill’ refers to sites allocated for managing municipal solid wastes (Masters and Ela, 2008; Dara, 2004). There are many landfill sites operating in India, but their efficiency towards pollution reduction is still a matter of concern. Considering rapidly increasing waste generation, the land requirement will increase in coming years in urban areas. Contrary, due to rapid industrialization and urbanization, the land availability is decreasing day by day. Therefore, before ultimate disposal through landfilling volume and toxicity of solid waste must be reduced by other treatment options (More at al., 2006). As secure landfilling is expected to be the ultimate disposal option which receives residues remained after other treatments, further improvements in its design and planning are necessary (Shaeholy et al., 2007; Kansal, 2002). Landfill should be provided composite liners to restrict leachate percolation to underground water level. It must be equipped with proper collecting and ventilating system in order to recover gas produced. Under the MSW rules, Government of India has made it mandatory to install Land Fill Gas (LFG) control system. LFG should be used either for energy generation or direct recovery of heat or should be flared to avoid air quality degradation (Talyan et al., 2008). Moisture is an important factor which needs to be considered while designing a landfill (Masters and Ela, 2008).

8. GOVERNMENT POLICY AND INITIATIVES

The Ministry of Environment and Forests (MoEF) is taking care of the issues related to solid waste management together with Central and State Pollution Control Boards. There are various rules framed under Environment Protection Act - 1986 for improving management of solid waste. SWM falls under state list as it is considered as public health and sanitation as per Indian Constitution. Due to its local nature, SWM is the responsibility of Urban Local Bodies (ULBs) (European Business and Technology Centre).

8. 1. Legislation

- Environment Protection Act – 1986
- Hazardous Waste Management and Handling Rules – 1989
- Manufacturing, Storage and Transportation of Hazardous Waste Rules – 1989
- Bio-Medical Waste Management and Handling Rules – 1998
- Municipal Solid Waste Management and Handling Rules – 2000
- Plastic Waste (Management and Handling) Rules – 2011
- E-Waste (Management and Handling) Rules – 2011

8. 2. Municipal Solid Waste Management and Handling Rules – 2000

A PIL was filed by Almitra H. Patel in Supreme Court based on allegations of failure of MSW management by GOI, State Governments and Local Authorities. The Supreme Court then appointed an Expert committee which submitted its report to Supreme Court on March, 1999. Local authorities were asked to implement the recommendations given by Expert committee. The major recommendations have been included in the Municipal Solid Waste (Management and Handling Rules – 2000) notified by Ministry of Environment and Forest, September 2000. These rules apply to every municipal authority responsible for collection, segregation, storage, transportation, treatment and disposal of municipal solid waste.

8. 2. 1 Responsibility of Municipal Authority

- Every municipal authority shall, within the territorial area of the municipality, be responsible for the implementation of the provisions of these rules, and for any infrastructure development for collection, storage, segregation, transportation, processing and disposal of municipal solid wastes.
- The municipal authority or an operator of a facility shall make an application in Form-I, for grant of authorization for setting up waste processing and disposal facility including landfills from the State Board or the Committee in order to comply with the implementation programme laid down in Schedule I.
- The municipal authority shall comply with these rules as per the implementation schedule laid down in Schedule I.
- The municipal authority shall furnish its annual report in Form-II, -
    a. to the Secretary-incharge of the Department of Urban Development of the concerned State or as the case may be of the Union territory, in case of a metropolitan city; or
    b. to the District Magistrate or the Deputy Commissioner concerned in case of all other towns and cities, with a copy to the State Board or the Committee on or before the 30th day of June every year.

8. 2. 2. Responsibilty of State Government and The Union Territory

- The Secretary-incharge of the Department of Urban Development of the concerned State or the Union territory, as the case may be, shall have the overall responsibility for the enforcement of the provisions of these rules in the metropolitan cities.
- The District Magistrate or the Deputy Commissioner of the concerned district shall have the overall responsibility for the enforcement of the provisions of these rules within the territorial limits of their jurisdiction.

8. 2. 3. Responsibility of Pollution Control Boards and Committees

- The State Board or the Committee shall monitor the compliance of the standards regarding ground water, ambient air, leachate quality and the compost quality including incineration standards as specified under Schedules II, III and IV.
- The State Board or the Committee, after the receipt of application from the municipal authority or the operator of a facility in Form I, for grant of authorization for setting up waste processing and disposal facility including landfills, shall examine the proposal taking into consideration the views of other agencies like the State Urban Development Department, the Town and Country Planning Department, Air Port or Air Base Authority, the Ground Water Board or any such other agency prior to issuing the authorization.

- The State Board or the Committee shall issue the authorization in Form-III to the municipal authority or an operator of a facility within forty-five days stipulating compliance criteria and standards as specified in Schedules II, III and IV including such other conditions, as may be necessary.
- The authorization shall be valid for a given period and after the validity is over, a fresh authorization shall be required.
- The Central Pollution Control Board shall co-ordinate with the State Boards and the Committees with particular reference to implementation and review of standards and guidelines and compilation of monitoring data.

8. 3. Initiatives

In 2000, CPHEEO developed a manual consisting of guidelines and procedures to implement MSW Rules. In 2004, the MOEF had constituted an expert body to frame guidelines in religious cities in the country. In 2005, a Technology Advisory Group which was constituted under the directions of High Court; submitted its report considering the scope of improvement and implementation of new technologies for effective SWM. Under Electricity Act - 2003, provisions has been made for tariff by state regulators. In addition, incentives are also provided in the form of relief in tax and other duties (i.e. exemption in Income Tax, Custom & Excise Duties) Government of India, Ministry of Urban Development has set up benchmark/targets for SWM such as:

Table 8. Benchmark set by Ministry of Urban Development, Government of India (Ministry of Finance, Government of India, 2009)

Activity	Percentage
Collection Efficiency	100%
Segregation	100%
Recovery/Recycling Efficiency	80%
Cost Recovery	100%
Redressal of Customer Complaints	80%
Collection of User Charge	90%
Processing and Treatment of MSW	100%

9. RESULT AND DISCUSSION

Being one of the most populous country and fastest growing economy, India can not afford to ineffective solid waste management. It seems that policy framework is available only on paper, but ground reality is alarming one.

There is an urgent need to implement the provisions of Municipal Solid Waste Rules-2000 adequately. Poor waste management practice must be shifted to scientific approach. Waste Collection and Waste Segregation are two components of SWM which require prior attention and can open up market for waste management sector. However, for source reduction, public awareness is equally important.

The amount of waste remaining after treatment should be disposed of in closed landfills. Not only in Urban cities, Effective Solid Waste Management should be implemented to rural areas as well. Government has taken various initiatives to improve waste management services, but there is still a long journey to travel to achieve the objectives of effective municipal solid waste management.

However in recent years, government with support of local authorities has accelerated the implementation of better waste management practices. Various NGOs play a vital role in spreading awareness among public and involve citizens for better waste management practices. The most recent initiative is 'Swachchh Bharat Abhiyan', also known as 'Clean India Mission'. One of the objective of this initiative is to aware citizens about the importance of proper waste management approach.

It aims to involve citizens in the campaign of Clean India & to clean urban cities and also rural areas with public support. However, there is a need to ensure that all citizens are taken into confidence and involved morally to this Clean India Mission. Government has also changed its policies to make waste management sector open for private companies, Public Private Partenership (PPP) model has been practiced for various services such as collection, transportation, treatment, development of landfill sites, operation and maintenance of units etc. PPP model can help to generate and increase revenues and eventually competency level which are essential for effective solid waste management.

However, lack of finance, institutional deficiency and lack of public support are main barriers to effective solid waste management. 80-90% of total budget is being spent on collection and transportation only, there is a need to allot more money to disposal and treatment of solid waste. Viability of existing business model is still a matter of concern for this sector.

The local bodies should be provided support in terms of finance & involvement in decision making so that they can effectively decentralize their responsibilities and develop business atmosphere among private sector.

10. CONCLUSION

Despite the fact that Solid waste management practices has been improving in recent years, the pace of improvement needs to be accelerated. Measures mentioned in MSW rules must be implemented.

Time has come to encourage technology based entreprenureship to achieve effective solid waste management. NGOs should be involved in various components of waste management including public awareness. Public involvement in management of solid waste is of significant importance. Authorities must protect fundamental right of citizens by implementing best practices and citizens must perform fundamental duties by their contribution to those practices.

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