JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Assesment of Solid Waste Management in Smart Cities.

Rishabh Chaudhary

PG Student

Babu Banarsi Das University, Lucknow, (U.P.) India

1. Introduction

The municipal wastes budgets in high income countries account for about 4%, 10% for middle income countries and 20% for low income countries. The waste induced/person/day ranges from 0.11-4.54 kilograms or an average of 0.74 kilograms, accounting to total 2.01 billion tonnes annually worldwide in 2016. The statistics is expected to increase by 2050, to 3.40 billion tonnes. The projected increase of daily waste generation in high-income countries is 19%, 40% for middle-income and low-income countries, as per the World Bank's report in 2018. The waste generation and its projection in India as per the world bank report is based on per capita waste generation daily rates published by the CPHEEO, segmented by population groups.is illustrated in the table 1. Population was taken from 2011 census. Calculations as follows: Population>5 million, 0.5kg/person/day; Population between 2-5 million, 0.35 kg/person/day.The quantitative and qualitative characteristics of MSW along with basic information have been evaluated. The geographic information system has also been used to digitize the existing MSW dumping sites. The quantity and composition of MSW generated over last four decades, pattern of primary and secondary collection, transportation, treatment, and disposal and recycling has been discussed in detail. According to the NEERI project sponsored by CPCB for 24 state capitals and 35 metro cities in India, rate of waste generation varied from 0.12-0.60 kg/capita/day. The observed carbon nitrogen (C/N) ratio was 20-40% and the moisture content ranged from 30-60% (NEERI, 2005). Waste to energy realises the waste potential which is sustainable source of energy as well as reduces harmful effects on environment, exclusively for developing countries . If 1 tonne municipal solid waste is incinerated rather than landfilled for same amount of electricity generation as by power plants based on fossil fuel, then avoided equivalent emissions of carbon dioxide amount to 1.3 tonnes . Also, if 1 million tonne waste is processed per pear in a waste to energy plant having average 30 years working life will require land area less than 100,000m2 , whereas, if 30 million tonne waste is landfilled, it will require land of about 300,000m2. This paper lists the established setup, operational plants and the planned setups.

2. Legal Aspects for MSWM in India

For collection, segregation, storage, processing, transportation and disposal of MSW local municipal bodies are responsible according to Rules of MSW, 2000. Besides these rules, the Government of India, State Governments also drafted several acts and rules for MSWM in India. Which are summarized as follows: i. The Water (Prevention and Control of Pollution) Act, 1974 made to consent from the state pollution control board for establishment of a sanitary landfill site and compost plant is essential and, no water pollution should be caused by the leachate that is emitted by the sanitary landfill site. The Water (Prevention and Control of Pollution) Cess Act, 1977 and amendments aspect that for MSWM there should be is provision for levying and collection of 3 Cess on water consumed for the sanitary landfilling, composting and anaerobic digesters. ii. The Environmental (Protection) Act, 1986 aspect in regard to MSWM would be the EIA notification, 1944. For any project to be authorized an EIA report should be submitted first. Hazardous Waste (Management and Handling) Rules, 1989 and Amendment Rules, 2000 and 2003 specifies process and limits waste applicable for import and export. Occupier would be responsible for proper management and handling of waste either themselves or through the operator. iii. The Bio- Medical Waste (Management and Handling) Rules, 1998 and

Amendment Rules, 2003 recommended for treatment and disposal option according to their different 10 category. The treatment technologies would be done according to Standards given in Schedule V. iv. The MoEF, 2000 (government of India) has been defined MSW as a waste generated from residential and commercial area in municipal area which included treated biomedical wastes may be solid or semi-solid form without including any type of hazardous industrial waste. MoEF. Municipal Solid Waste (Management and Handling) Rules, 2000 stated that every municipal authority is responsible for setting up a waste processing and disposal facility, and for preparing an annual report. The State governments will have overall responsibility for enforcement of the provisions of these rules in the metropolitan cities and within territorial limits of their jurisdiction (MSW Rules, 2000). The guidelines given in this law covers all the functional elements of municipal solid waste management. The CPCB, State Boards, NGOs and the other committees are required to monitor the compliance of the standards regarding groundwater, leachate quality, and compost quality including incineration standards, and they are to examine the proposal taking into consideration the views of other agencies. Waste collection by any method (community bin or hometo-home collection, etc.) must be conducted by using bell ringing or a musical vehicle to alert citizens without exceeding permissible noise levels.

3. Waste to Energy Options

Waste composition and its characteristics are necessary parameters to determine the energy production rate. Particle size, content of moisture, density and its calorific value influences the selection of waste to energy strategy (CPCB, 2016). For faster rate decomposition organic waste size of particle should be less, high density instead of low density (such as plastics, paper, cardboard). In case of anaerobic digestion suitability increases with high moisture content (Beyene et al, 2018). In India, organic material in waste is high upto 40-60%, inert content is also high (30-50%) along with high moisture content (40-60%) and low calorific value of about 800-1100 kcal/kg. Table 2 shows cumulative deployment of various renewable energy systems and devices as on 31st December, 2016 in the annually issued MNRE report 2016-17 where progress of biopower has been revised to installed capacity from exportable power capacity (MNRE, 2017). The cumulative power generating projects using biomass of capacity 7907.34 MW have been commissioned successfully. Power capacity from off-grid biomass gasifiers in industries including 8 rice mills, some flour mills, bakeries for fulfilling captive demand of thermal and electricity applications were installed during 2016-17 in several states (MNRE, 2017).

Table 2. Cumulative deployment of various renewable energy systems and devices as on 31st December, 2016 (MNRE, 2017)

Sector	Achievement during 2016-17	Cumulative achievements
I. Grid-Interactive Power (Capacities in MW)		
Bio Power (Biomass & Gasification and Bagasse Cogeneration)	151.40	7907.34
Waste to Power	7.50	114.08
II. Off-Grid/ Captive Power (Capacities in MWEQ)		
Waste to energy	4.47	163.35
Biomass(non-bagasse) Cogeneration	0.00	651.91
Biomass Gasifiers	Rural-0.00	Rural-18.34
	Industrial-4.30	Industrial-4.30
III. Other renewable energy systems		
Family Biogas Plants (in Lakhs)	0.35	49.40

3.1 Thermal conversion: Dry waste with less moisture content and more percentage of organic matter of non-biodegradable kind is used for thermal conversion to produce fuel oil, heat energy or gas. The treatment rate of the total collected waste is only 19%, and the available WTE treatment facilities in India are: 8 WTE plants, 29 RDF facilities, 172 bio-methanation facilities, 138 vermicomposting and 279 conventional composting facilities (Mohapatra, 2015).

3.2 Incineration: According to the IEA, the minimum calorific value for operating incineration to be feasible should be 1900 kcal/kg. municipal solid waste in India mainly consists of 40-60% organic matter and 30-50% inert content with calorific value as low as 800-1100 kcal/kg and moisture content as high as 40-60% (Kaushal et al, 2012). Also, the costs for setting up as well as running the incineration plants are very high. In 1987, at Timarpur, New Delhi first municipal solid waste incineration large scale plant with 300 tonnes/day capacity 250 million Indian rupees was constructed but it went un-operational after six months due to its unsatisfactory performance. However, small incinerators for burning hospital wastes were still used (CPCB, 2016). Table 3 shows massive power output incineration plants initiatives in India (Mohapatra, 2015 and CPHEEO, 2014).

Table 3. Massive power output incineration plants initiatives in India (Mohapatra, 2015 and CPHEEO, 2014)

Plant name, City	Initiative	Utilisation Waste Capacity (tonnes/ day)	Estimated/ Running Power Output (MW)	Starting year	Closing year	Refuse derived fuel production (tonnes/day)
Timarpur, Delhi	-	350	3.75	1986	1991	-
Gol, Mumbai	DST	250	-	1994	Abandoned	-
Gandamguda, Hyderabad	Selco International Ltd	600	6.6	1999	2009	-

Table 3 (cont'd). Massive power output incineration plants initiatives in India (Mohapatra, 2015 and CPHEEO, 2014)

Plant name, City	Initiative	Utilisation Waste Capacity (tonnes/ day)	Estimated/ Running Power Output (MW)	Starting year	Closing year	Refuse derived fuel production (tonnes/day)
Vijaywada	Shriram Energy	650	6	2003	20069	
Lucknow	Asia Bio-energy India Ltd and Enkem Engrs Pvt Ltd	600	5	2003	2003	
TimarpurOkhla, Delhi	Jindal ITF Ecopolis	2000	16	Operational since 2011		450
Ghazipur, Delhi	ILFS	1300	10	Operational since 2016		433
Bangalore	Srinivasa Gayithri Resources Recovery Ltd and Bruhat Bangalore Mahanagar Palike (BBMP)	-	8	Abandoned		-
Pune	Rochem Green Energy Pvt Ltd	650	10	Operational since 2012		-
Nalagonda, Hyderabad	-	800	11	Yet to commission		-
Kanpur	A2Z	700	12	Yet to commission		-
Narela, Delhi	Ramky	1400	24	Yet to commission		-

In Vijaywada plant the proposal was to convert solid waste into RDF pellets for loading onto the boiler to be burnt along with other fuels and generate power capacity of 6 MW per day. Due to no sustainability and high operational costs the plant was shut down after 2009 (Mohapatra, 2015). The important features of waste to energy plant in Ghazipur are that pre-processing is done, dryers and shredders of high quality are present, it is not dependent on biomass or some other supplementary fuel. One of its salient features is that its design conforms to EURO norms by inhibiting high standard measures to control pollution like treatment of flue gas, dust, odour and noise control (Mohapatra, 2015).

Table 4. Statistics related to bio-energy potential, solid waste generation and bio gas facilities (CPCB, 2016 and MNRE, 2017)

State	Bio mass power	Bagasse cognition	Waste 2 energy	Generated	Collected	Treated	Land filled	Set Up	Operational	Installed
Andhra Pradesh	578	300	123	6470	6396	1623.5	233	7	7	1
Arunachal Pradesh	8	-	-	16.2	11.76	-	-	-	-	-
Assam	212	-	8	8110	7200	200	-	-	-	-
Bihar	619	300	73	-	-	-	-	-	-	-
Chhattisgarh	236	-	24	6000	4200	20	-	-	-	-
Goa	26	-	-	226.8	218.8	-	26.05	-	-	-
Gujarat	1221	350	112	-	10527	757	9770	1	1	-
Haryana	1333	350	24	4514	3159.8	188	2371.8	-	-	-
Himachal Pradesh	142	-	2	342.35	-	-	-	-	-	-
Jammu & Kashmir	43	-	-	-	-	-	-	-	-	-
Jharkhand	90	-	10	-	-	-	-	-	-	-
Karnataka	1131	450		11186	9706	3475	5170	13	13	3
Kerala	1044	-	36	-	-	-	-	-	-	-
Madhya Pradesh	1364	-	78	6773	5480	1141	4339	1	1	-
Maharashtra	1887	1250	287	23449.66	23079.57	7543.1	15536.47	38	34	6
Manipur	13	-	2	-	-	-	-	-	-	-
Meghalaya	11	-	2	187	156	36	120	-	-	-
Mizoram	1	-	2	159.88	159.88	-	-	-	-	-
Nagaland	10	-	-	337	255	28	7	-	-	-
Orissa	246	-	22	18.55	14.28	30	-	-	-	-
Punjab	3172	300	45	4544.35	4520.35	39.175	3278.06	-	-	-
Rajasthan	1039	-	62	-	-	-	-	-	-	-
Sikkim	2	-	-	76.04	62.1	11.05	-	-	-	-
Tamil Nadu	1070	450	151	14658.5	14416.63	4776.218	7336.951	39	39	5
Tripura	3	-	2	428.09	379.2	134.4	244.8	-	-	-
Uttar Pradesh	1617	1250	176	15500	12000	3115	-	-	-	-
Uttarakhand	24	-	5	1180	1180	-	-	-	-	-
West Bengal	396	-	148	12600	12600	830	515	-	-	-
Andaman & Nicobar	-	-	-	115	115	26.45	88.55	-	-	-
Chandigarh	-	-	6	450	450	61.157	410.8			
Delhi	-	-	131	-	-	-	-	-	-	-
Puducherry	-	-	3	398.5	398.5	10	388.5	2	2	1
Others	-	-	1022	-	-	-	-	-	-	

Table 4 shows the solid waste generation rate in tonnes/day, set-up bio-gas facilities that are operational and planned, and the table provides data regarding the total bio-energy potential in MW for the various Indian states and union territories as per the data given in reports of CPCB and MNRE.

3.3 Refuse Derived Fuel (RDF): The non-recyclable processed MSW having high calorific value can be used as RDF in boiler/ furnaces as alternate fuel or as a fuel for electricity generation. RDF is a mixture of composition having combustible materials with high concentrations than in the original mixed MSW. RDF projects in India fall under the Electricity Act of 2003 and are monitored by Environment Protection Act adhering to emission standards along with National Ambient Air Quality Standards 2009. RDF is generally used in coal fired power plants for co-combustion and in cement kilns for co-processing (CPCB, 2016).

3.4 Gasification: Two types of gasifier designs can be found in India namely: firstly the NERIFIER unit at Hanugarh, Rajasthan established by NEERI for agro-wastes, forest wastes, sawmill dust burning, and, secondly the one at Gaul Pahari campus, New Delhi is the TERI unit (Kaushal et al, 2012). Feeding rate of waste is 50-150 kg/h with 70-80% efficiency and fuel gas produced of about 25% is recycled back and rest is used for generating power (NEERI, 2005).

3.5 Pyrolysis: It is a destructive distillation process where indirect heat when applied, volatiles get captured. Carbohydrate polymers like hemicellulose and cellulose are first degraded and then converted. It produces bio-oil which fulfils energy recovery and secondly it recovers solids left at the end of the process which fulfils the material recovery.

3.6 Challenges using incineration, pyrolysis and gasification in India: It is a destructive distillation process where indirect heat when applied, volatiles get captured. Carbohydrate polymers like hemicellulose and cellulose are first degraded and then converted. It produces bio-oil which fulfils energy recovery and secondly it recovers solids left at the end of the process which fulfils the material recovery.

• Inadequacy in waste collections, low calorific value composition of waste, high moisture composition in the feedstock, poor planning, lack of inter institutional coordination and cooperation can be considered as the reasons for failure of the closed wte incineration plants (Mohapatra, 2015). • Segregation and pre-sorting is required to give a homogeneous product because if the quality of waste incoming is fluctuating then RDF buffers.

• Also, all incinerators whether including RDF or not demand mandatory 4-6 weeks annual shut-down for maintenance purposes (CPCB, 2016).

• Waste of high calorific value is needed as feedstock whereas if it is used for compost it will be more environmentally safe as well as cost effective.

• Specific quality of feedstock required is required in case of pyrolysis and gasification for commercial viability of the product and improved efficiency. For specific size and characteristics of waste, pre-treatment is required (CPCB, 2016).

3.7 Anaerobic digestion: Table 5 lists the plants and their methane producing capacity along with the type of waste used as raw material (Dhar et al, 2017). Apart from this, SSS-NIRE, at Wadala Kalan, District Kapurthala (Punjab) is an autonomous Institution of the Ministry which focuses on biomass energy research and its development. The centre for testing and certification of cookstoves with testing of available cookstove models as per new BIS norms has begun its operation. One natural draft cook stove model has been designed and developed at the Institute with different possible modifications using locally available materials and is in the process for approval. In addition, research projects on process development for bioethanol production from agricultural residues and biogas production and utilization of heat and power generation applications using potential alternative feedstocks continued (MNRE, 2017).

Table 5. Anaerobic digestion plants and their methane producing capacity (Dhar et al, 2017)

Plant	Capacity produced of CH4 (m3 /day)	Type of waste	Commissioned year	Comments
Satara, Maharashtra	25,000	Sugar	-	Installed under the Indo-German Partnership for Development and produces biogas from 600 m3
Talwade, Nashik, Maharashtra	500	Kitchen wastes	2011	NISARGUNA technology aided by MNRE and developed in

				2004 by BARC is used that produces 98% pure biogas
Sundarpur, Anand, Gujarat	5000	Agricultural wastes like potato peels, sugarcane waste, animal dung, potato peels	2015	-
Panjab	60	Kitchen waste, poultry waste, cattle dung	2011	Multistage Up-flow Anaerobic Sludge Blanket Reactor Technology is used that produces 98% biogas
Nigarguna, Mangalore	100-160	Kitchen waste originating from hotels, other vegetable wastes	-	Bio-waste of 2 MT is processed daily
Palayam, Thiruvananthpuram	30 kW/day of electricity	Vegetable and fish leftovers from market	-	Raw materials from 1,500

3.8 Landfill with gas recovery: In India total number of dumping sites is 2120 out of which the solid waste dumping sites converted into sanitary landfill are present in Chandigarh, Madhya Pradesh, Meghalaya, Sikkim, Tamil Nadu in India. There are total 21 such sites in actual practice in India and about 40 sites are reclaimed or capped for this practice.

4. Recent studies related to solid waste management in India Some of the recent research studies related to solid waste management in the global scenario as well as characteristics, quantity, viability and forecasting in India have been listed in brief in the following table 6. The table also specifies the area of study of each research work taken, the critical observations found and thereafter a summarized conclusion is then stated pertaining to the study conducted in the works.

Table 6. Recent research works related to solid waste management in India.

Study area	Description of the study	Critical observation	Comments
Waste to energy options -global scenario (Kumar et al, 2017)	Studied the current scenario of waste to energy technologies globally for developed and developing countries based on case studies in some countries.	1.Stated that unsanitary landfilling was the most commonly adopted practice for waste disposal in developing countries. 2.Potential of waste technologies has been realized in developed countries and is effectively practiced.	Framework provided for evaluating waste to energy practices may help meet energy demand as well as effectively manage waste disposal.
Characteristics and quantity of municipal solid waste in India (Kaushal et al, 2012)	Analyzed the changes in the trend in characteristics and quantities of municipal solid waste in major urban cities in India over the past four decades.	Highlighted the change in need of technologies with respect to changed pattern.	Quantity estimation may help better forecasting over efficient planning for successful management.
Skeptic views in Indian scenario on viability of waste to energy (Mohapatra, 2015)	Discussed issues related to waste to energy plants in India	Realized need to adhere the construction of waste to energy plants considering stringent emission standards furans and dioxins during incinerating.	Recognized hurdles and failure causes of running of waste to energy plants in India.
Review scenario of waste to energy in India (Dhar	Focused on reviewing recent scenarios of	1.Technical feasibility was proven at few places	1.Challenges can be overcome by segregation

et al, 2017)	organic waste potentials, technol-ogies and the variety of challenges associated with them in India.	in India. 2.Challenges include- high capital cost, source segregation, operating and maintenance cost, skilled manpower and variations in climatic conditions. 3.Operating biogas plants were not shut due to failure of technology but due to unworthy costbenefit analysis and non-customization of plants considering local situations.	at source, appropriate technology adoption. 2.Focus should be more on field trial of waste to energy technologies. 3.Stakeholder's synchronization should be motivated. 4.Public awareness to encourage citizens' participation.

5. Conswclusions

The facilities for waste to energy that have been established in India are not sufficient to cope with the waste generation statistics. New research works like NISARGRUNA technology, bioethanol production from agricultural residues and potential alternative feedstocks need to be promoted and implemented to evolve methods that are required keeping in mind the current Indian waste scenario. For faster rate of decomposition organic waste size of particle should be less, high density instead of low density (such as plastics, paper, cardboard). In case of anaerobic digestion suitability increases with high moisture content. In India, organic material in waste is high (40- 60%), inert content is also high (30-50%) along with high moisture content (40-60%) and low calorific value (of about 800-1100 kcal/kg). The main consideration of any fuel economy is its heating value so this should also the attention should be paid to improving the calorific value in the existing plant setups.

Nomenclature

CPCB Central Pollution Control Board

CPHEEO Central Public Health and Environmental Engineering Organisation

IEA International Energy Agency

MNRE Ministry of New and Renewable Energy

MSW Municipal solid waste

NEERI National Environmental Engineering Research Institute

SSS-NIRE Sardar Swaran Singh National Institute of Renewable Energy

WTE Waste to energy

Acknowledgement

This work was supported to me in my Masters Research program under the guidance of Dr.(Prof). MOHIT KUMAR AGARWAL DEAN (SoAP) at Babu Banarsi Das University, Lucknow, U.P. I would like to thank him for his extraordinary support and collaboration in completion of my work.

References

ASME., 2008. Waste-to-energy: a renewable energy source from municipal solid waste. American Society of Mechanical Engineers. White paper submitted to Congress, New York, 2008. Beyene H.D., Werkneh A.A. and Ambaye T.G. 2018. Current updates on waste to energy (WtE) technologies: a review. Renewable Energy Focus, Vol. 24, pp 1-11. https://doi.org/10.1016/j.ref.2017.11.001 CPCB., 2016. Consolidated annual review report on implementation of solid wastes management rules, 2016- annual review report 2015-16. Reported by Government of India Ministry of Environment, Forests and Climate Change along with Central Pollution Control Board India. CPHEEO., 2014. Municipal solid waste management manual. Reported by Central Public Health and Environmental Engineering Organisation issued by Ministry of Urban Development, India. May 2014. Dhar H., Kumar S.and Kumar R. 2017. A review on organic waste to energy systems in India. Bioresource Technology, Vol 245, pp 1229-1237.

http://dx.doi.org/10.1016/j.biortech.2017.08.159 Kaushal R.K. and Chabukdhara M. 2012. Municipal solid waste management in India-current state and future challenges: a review. International Journal of Engineering Science and Technology, Vol. 4, pp 1473-1489. ISSN : 0975-5462. Kaza S., Yao L., Tata P.B. and Woerden F.V. 2018. What a waste: a global snapshot of solid waste management to 2050. Urban Development Series (Washington, DC: World Bank). doi:10.1596/978-1-4648 -1329-0. Kumar. and Samadder S.R. 2017. A review on technological options of waste to energy for effective management of municipal solid waste. Waste Management, Vol. 69, pp 407–422. https://doi.org/10.1016/j.wasman.2017.08.046 MNRE., 2017. Ministry of New and Renewable Energy Annual Report 2016-17. Ministry of New and Renewable Energy, India. Mohapatra. 2015. National Conference on Waste-to-Energy in India organised by Toxics Link, 2015. NEERI., 2005. Waste generation and composition in 59 cities- annual review report 2004-05. Surveyed by National Environmental Engineering Research Institute issued by Central Pollution Control Board, India.