Composition of Municipal Solid Waste- Need for Thermal Treatment in the present Indian context

Background

The Municipal Wastes generated from residential, commercial, institutional segments get mixed up with traces of other wastes from hospital, industrial and municipal services including construction & demolition wastes. This mix up is declining with stricter enforcement of legislation.

The rate of waste generation is an index of socio-economic development and economic prosperity of the region. Increasing industrialization and raising incomes lead to greater use of resources and waste composition is influenced by factors such as extent of urbanization, standard of living and climate. Thus, waste quantities as well as composition are inextricably linked to the vibrancy of economic activity and resource consumption pattern of the society which generates the waste.

This paper aims presenting a well postulated technical concept of estimating heat value of municipal wastes, from the view point of assessing the waste's amenability for thermal treatment in the Indian context at the present juncture. The paper also seeks to reason out to forward ahead despite the purported failures of the past.

Change in waste composition as an index of economic development

As countries develop and become more urbanized, the waste composition undergoes a change – the notable feature of which is the increase in the paper, paper packaging, plastics, multi material packing items and 'consumer products.' Yet many researchers, policy makers, developers and municipal authorities in India are wary of considering "thermal treatment" for the Indian waste, citing its inherent 'Low heat value and high moisture content'. The divergence of the heat values considered for design and 'actual' for the erstwhile Timarpur Incineration Plant of 1987 is cited even today, despite the fact that over two and a half decades have passed since then.

Hence the need for deliberating on the way forward. The significant strides of economic progress achieved in the last two decades and resultant changing life styles reflecting on composition of waste today, is sought to be reviewed. The heat values of the municipal wastes of the cities of Mumbai, Delhi and Hyderabad are reviewed and the need for considering thermal treatment of municipal waste as technology option.

Statutory framework

Municipal Waste Management in India is regulated by "MSW Management & Handling Rules **2000"**[1]. These rules stipulate that all urban local bodies are responsible for proper collection, storage, transportation, processing and disposal of the municipal wastes. Only the residual inerts after due processing of waste are to be disposed off into a sanitary landfill in accordance with these rules. The rules advocate the use of composting, Biomethanation, pelletization with or without energy recovery and other thermal processes for adoption as processing techniques for municipal wastes.

However, there is an 'Institutional anathema' towards thermal treatment process, in particular the 'incineration process' which is perceived as a polluting and environmentally not desirable option on one hand and argument that Indian waste being not 'suitable' on account of an eternally inherent low heating value on the other.

Current status of Solid Waste Management

The MSW Rules came into being in year 2000, a reasonable time has since then passed allowing for the percolation of these rules, through the administrative hierarchy for implementation. However, the level of compliance for mandatory processing has been dismal. The level of compliance is put around 9% on the mandatory processing front in India[17]. None of the major metros have any projects of significant scale of Solid Waste processing into operation. Capacity built up in the compost processing sector is on rise but the problems on account of seasonal nature of business, applicability to large capacities in view of geographical limitations on marketing front persist.

Thus, it is not surprising that dumping of wastes and open burning continues at places like Hyderabad, Pimpri and elsewhere. The dump sites are an eyesore, inviting public indignation with open burning and leachate overflowing.

Most of the Indian cities including major metros as well as metros in making, are at cross roads in tackling the increasing urban wastes problem. In this regard, waste to energy could play a major role in the strategic options of Solid waste management.

Incinerators & Combustors

The waste was burned without recovering energy in the past and the units for burning waste were known as "incinerators"- a name no longer relevant and used to denote the sorry state of affairs of poor design, inadequate engineering and inept operation, with little control equipment in place for pollution abatement [2.] Modern combustors combine solid waste combustion with energy recovery using a moving grate which provides for 'turbulence' for thorough combustion [3]. The traditional term 'incineration 'has acquired a wrong connotation in the mind of public because of poor operation of the 'old' incinerators in the past. Therefore the term 'waste to energy' is used widely in its place [2].

Thermal Treatment Methods for waste

Thermal treatment of wastes can be accomplished by following major processes.

1. Incineration (RDF/Mass burn)
2. Pyrolysis
3. Pyrolysis /Gasification
4. Plasma Arc gasification

Incineration is widely used in Europe and Japan without any known adverse health impacts. Switzerland – a country with high environmental standards- incinerates about 75% of waste and Japan over 50% of the total waste.

One of the most effective means of dealing with wastes is to reduce their harmful potential and often convert them to energy form is Incineration [2]. The terms 'waste to energy' and 'incineration' used in this paper are referred to this modern practice of combustors. The thrust of paper is also limited to the thermal treatment of municipal waste through combustion of wastes on a pusher grate and does not refer the other thermal forms of treatment or energy recovery.

Over view of the Macroeconomic aggregates of Indian economy [4] :

The Indian economy has registered a robust growth pursuant to the liberalization policies unveiled in 1991. The growth of Gross Domestic Product for every decade since 1950 is given in table 1.

Table 1- Decade wise statistics of growth of GDP in India since 1950

Year	GDP in Rs Crores
1950-51	9719
1960-61	16512
1970-71	42981
1980-81	132520
1990-91	515032
2000-01	1925017
2007-08	4303654

Source : Hand Book of Statistics on the Indian economy by RBI 2007-08

India has maintained its position in the list of ten fastest growing medium-large countries in the world during the last two decades. India is the sixth largest growing economy continuously for over two decades in the world [5] as given in the table 2.

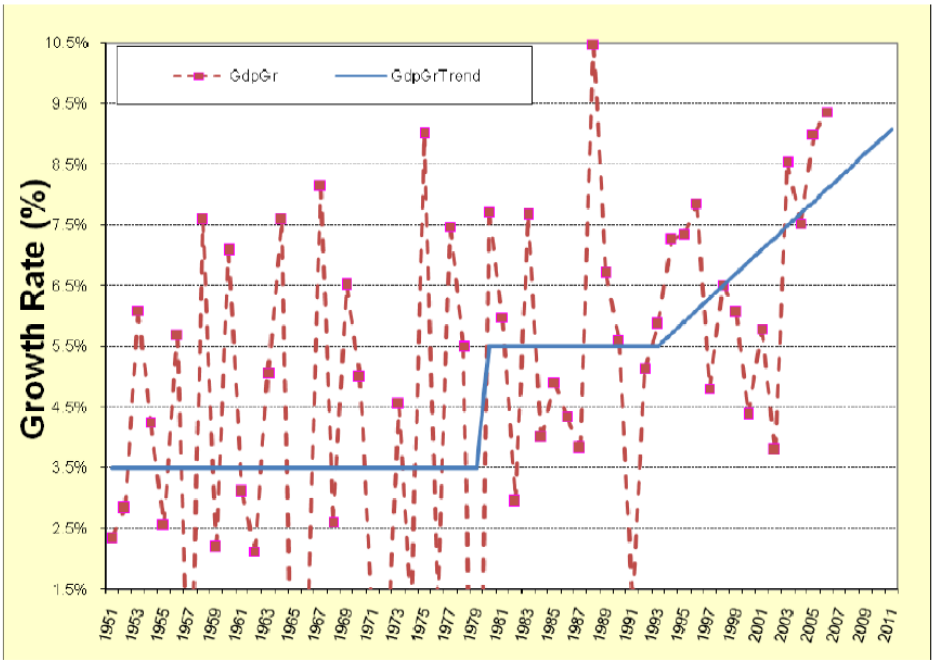
Table 2 : Growth trends for Medium – Large countries ;

Country	GDP		Per Capita GDP	
	Gr. Trend	Rank	Gr. Trend	Rank
China	10.1	1	8.8	1
Korea Rep.	7.7	2	6.6	2
Thailand	7.1	3	5.7	3
Singapore	6.9	4	5.1	4
Ireland	5.3	10	4.9	5
India	6.0	6	4.1	**6**
Vietnam	6.2	5	4.1	7
Chile	5.6	9	4.0	8
Indonesia	5.7	8	3.9	9
Hong Kong	5.3	11	3.7	10

Source: Discussion paper 'Macro economic management of the Indian economy' Arvind Virmani (Planning commission) Nov 2007 [5]. It is to be noted that only Chile and Ireland are countries outside Asia in the above table.

It is an established fact that the Indian economy has registered a tremendous growth and that there is significant overall economic progress and growth of GDP in India. The GDP growth rate and the trend curve are shown since 1951 in the Figure 1[5].

Fig 1:

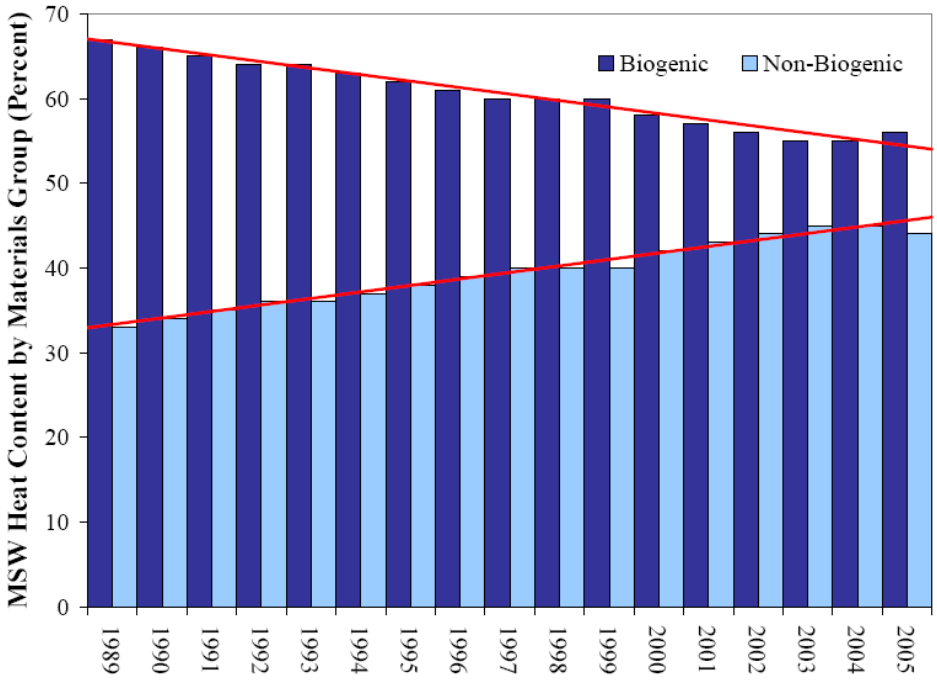


Correlation of Composition of Heat content with Economic rise/income levels

It will be relevant to examine the experience of USA , where the non biogenic component of the municipal waste is significantly increased over the biogenic component as per the data provided by the US Energy Department [6]. The increase in the non-biogenic component is an indication of the growing heat value of the waste.

The Fig 2 depicts the steady increase in the heat content of waste since 1989 in USA as documented by the Department of Energy in USA.

Fig 2:



Source: Methodology for allocating Municipal Solid Waste to Biogenic and Non Biogenic energy by Energy Information Department, US Dept of Energy in May 2007

Thermal treatment of Municipal waste for Energy recovery is a widely practiced technology option in Europe where constraint for land for disposal is acute, when compared to USA. Combustion of waste leads to a reduction of 90% by volume and 75% by weight, thus requiring lesser area of land for disposal. The Indian urban situation is to some extent akin to the European situation with acute paucity of land for Solid waste management. Planning waste to energy facilities is highly imperative for the Indian metros and major cities in order to minimize the increasing hauling costs of waste. Besides it will also conserve the limited land area available for the solid waste management.

Compositional changes of Waste in India

Many reports, papers and data bank in India do not give estimation of what waste composition/quality had been in the past, present and what would be in future, other than projecting the huge and daunting increase in sheer quantities. Rag picking is one activity that is feared to be causing a steep decrease in the heat value of the waste because of implied recycling activity.

What is business for scrap and recycling today may not be worth in the course of time and in the cause of economic growth and not bound to maintain its efficiency if at all it is now.

Rag Picking activity at a waste dump site

Segregated waste through informal segregation

It is worth examining the changes in the composition of waste in India in the last two decades. The table 3 [7] gives the changing composition of Municipal Waste over the last two decades and is attributed to the changing life styles and increasing consumerism.

Table 3 [7] Physico-chemical characteristics of MSW in India :

Component	% of Wet Weight	
	1971-73 (40 cities)	1995 (23 cities)
Paper	4.14	5.78
Plastics	0.69	3.90
Metals	0.50	1.90
Glass	0.40	2.10
Rags	3.83	3.50
Ash and fine	49.20	40.30
Total Compostable Matter	41.24	41.80
Cal. Value Kcal/kg	800-1100	<1500
CN Ratio	20-30	25-40

Wastes to energy projects have a life time of 25 to 30 years and hence the due factoring of quality of waste with passage of time and growth is required.

Contemporary studies on WTE potential in India

It is attempted to review the heat value of municipal waste in three major cities of India from different studies, literature values & methods and estimate the same in the context of studying the relevance of thermal treatment for municipal waste as an option for disposal.

(a) The Mumbai City

Mumbai, the commercial and financial capital of India is spread over an area_of around 437.71 sq km and houses more than 12 million people. Financial and commercial institutions as well as the industrial houses in Mumbai provide considerable employment opportunities. The consequent large scale migration has resulted in very high densities of population and corresponding demand on its infrastructure[16].

Mumbai generates approximately 6,000 tons per day (TPD) of MSW at a per capital rate of 0.475 kilograms . Final disposal of the MSW in Mumbai since last many years is by open dumping method without any waste treatment[16].

The recyclable fraction mainly contains plastic, paper, cartons, thermocol, glass, rubber leather, metals, etc. Some of these constituents fall under combustible fraction. After separation of recyclables at source and at secondary storage, the remaining fraction is to the tune of 18.6%. Compared to other cities in India, this fraction is relatively high mainly due to the commercial and trading activities of Mumbai[16].

Arguing in favour of 'waste to energy' in India in her paper[8] , Ms. Perinaz Bhada suggests that Waste to energy in India can provide the single solution for mitigating the twin problems of overflowing garbage in urban areas and the lack of land as well as to provide sufficient energy in cities to meet peak demand. The composition of Municipal waste in Mumbai was determined in two different studies, one by CPCB & NEERI in 2005-06 and other by Municipal Corporation of Greater Mumbai (MCGM) around same time [8].

Table 4 [8]: Characterization of Mumbai waste by two studies of CPCB-NEERI and MCGM

Source	Compostable%	Recyclable%	Moisture%	C/N Ratio	Heat Value (KJ/Kg)
CPCB-NEERI	62.44	16.66	54	39.04	7,477*
MCGM	54	18.6	68	25.94	3,898

* High Heating Value

The heating value of waste given in these two studies, show significant variance as given in Table 4 [9]. The study by Ms. Perinaz Bhada[9] puts the heat value of Mumbai municipal waste as 9022 KJ/Kg based on the value of energy content given in Tchobanglous (1993). The table 5 depicts the heat value as determined based on the very composition of Municipal waste given in the report of ILFS[16], though the report of IL&FS puts the heat value as 3,898 KJ/kg.

Calculation of heat value of Mumbai MSW – Table 5

Component	Fraction of component %	Energy Content KJ/kg	Heating Value of component fraction KJ/Kg
Kitchen waste	39.24	4180	1640
Fruit waste	8.33	3970	331
Flower Waste	0.14	6050	8
Green grass	0.62	6050	38

Dry Grass/tree	9.58	15445	1480
Other organic material	3.79	4180	158
Cotton waste	2.48	15445	383
Wood chips/Furniture	0.95	15445	147
Plastic	10.14	32799	3326
Paper	7.52	15814	1189
Thermocol	0.19	38191	73
Glass	0.71	195	1
Rubber	0.52	25330	132
Leather	0.67	17445	117
Metals	0.19	-	
Inerts	14.93	-	
TOTAL	100		**9022**

The heat value of Mumbai waste translates to 2158 Kcal/Kg which can support combustion on a sustainable basis without any supplementary fuel requirement.

(b) The Delhi City

The Municipal Corporation of Delhi (MCD) is among the largest municipal bodies in the world providing civic services to an estimated population of 13.7 Million citizens in the capital city of India covering an estimated area of 1,400 Sq km, some of which is most densely populated in the world. It is estimated that about 6500 Tons of waste is generated presently and the waste generation is poised to touch 18,000 TPD by 2021.

United Nations Office for Project Services (UNOPS) has contracted COWI of Denmark with Kadam Environmental consultants, India as local partner for implementing a project study and master plan for waste treatment and disposal for Delhi state under Public Private Partnership (PPP) mode.

The objective of the study is to converge on an optimal, economical and environmentally sustainable waste treatment and disposal plan for state of Delhi. Volume 6 [15] of the report pertains to MSW characterization and the report gives the composition of the waste at the landfill site as briefed in the following table.

Table 6 : Composition of waste reaching the landfill site [15]

Parameter	Average %	Range
Biodegradables	73.7	20.9-94.6
Recyclables	9.2	2.8-16.3
Inerts	10.8	0.0-72.2
Others	6.3	0.3-16.2
Ash	15.3	3.4-61.9
Moisture	47%	8-82
LCV (Kcal/Kg)	**1777**	191-4495
HHV (Kcal/Kg)	3927	2042-5315

It should be noted that the waste reaching the landfill, after completion of much rag picking activity, is characterized to have the LCV of 1777 Kcal /Kg (7427 KJ/Kg). This heat value can support combustion on a sustainable basis without any requirement of supplementary fuel.

(c) City of Hyderabad

Greater Hyderabad Municipal Corporation is one of the largest civic bodies in India and presides over capital of the state of Andhra Pradesh. GHMC covering an area of 638 sq.km, generating about 3800 T P D of solid waste has engaged SENES Consultants for preparation of a "Detailed Project Report" (DPR) for Integrated Solid Waste Management for the Greater Hyderabad region. The task includes quantification and characterization study of MSW generated in GHMC. Chapter IV of the DPR [14] (February 2009) give the average composition as given in table 7.

Table 7 – Average waste composition in Hyderabad[14]

Component	Average % Fraction
Food Waste	48.22
Paper	7.26
Plastics	8.61
Rags/cloths/cotton	5.70
Green waste , Coconuts	3.06
Rubber & synthetics	1.82
Leather	1.29
Metals, Glass & Ceramic	2.18
Stone, debris, boulders, silt , earth	21.42
Others	0.53

Heat Value of Municipal Waste of Hyderabad

Determining the heat value of Municipal waste can be carried out by using the data in Table 8 [3]. Primarily, the wastes shall be inspected and sorted to determine the component fraction in accordance with procedure prescribed in CPHEEO[10] manual. The heat value of the waste can be obtained by multiplying the respective heat value of that component with the corresponding dry weight fraction of the component in the waste. Typical moisture values are given in table 8 for each component.

Table 8 [3]:Typical heat values for Municipal waste components

Component	Moisture Percent		Heat Value Btu/lb	
	Range	Typical	Range	Typical
Food Wastes	50-80	70	1500-3000	2000
Paper	4-10	6	5000-8000	7200
Plastics	1-4	2	12000-16000	14000
Textiles	6-15	10	6500-8000	7500
Rubber	1-4	2	9000-12000	10000
Leather	8-12	10	6500-8500	7500
Wood	15-40	20	7500-8500	8000
Garden Trimmings	30-80	60	1000-8000	2800

Estimation of Heat value of the Municipal Waste for Hyderabad

The heat value of the MSW in Hyderabad is estimated as below with the help of literature values of Table 8.

Table 9 : Estimated Heat Value for Hyderabad

Component	Dry weight	Heat Value(Kcal)
Food Waste	14.6	16074
Paper	6.82	27299
Plastics	8.43	65632
Rags/cloths/cotton	5.13	23176
Green waste , Coconuts	1.224	1904
Rubber & synthetics	1.78	7432
Leather	1.61	4837
TOTAL Heat Value		144558 Kcal

The heat value is, thus 1445 Kcal/Kg for the Hyderabad waste and is amenable for combustion on a sustained basis without requiring supplementary fuel. The World Bank's guide on 'Incineration of Municipal Waste' recommends that a min. Heat value (LCV) of 6000 KJ/Kg **(1435 Kcal/Kg**) during all the seasons for sustained combustion for adopting the Thermal treatment process[13].

It can be noted that the cities of Mumbai, Delhi and Hyderabad have recorded phenomenal growth in the last two decades as also other cities of India. Thus, the increase in Solid Waste can not be only quantitative, but also has also to be qualitative as per the trends, convention and literature study and in correlation to the increased economic activity of the societies.

Timarpur Plant

The case study of plant for incineration at Timarpur is often cited against option of waste to energy. The Annexure 15.1 of CPHEEO manual[10] contains a case study of the plant and describes the same as a pilot /R&D plant for thermal treatment of 300 TPD of waste with 3.75 MW of envisaged power generation. The plant was on trial run and was operated for a few months, subsequently closed down in 1990 due to a mismatch of the quality of incoming refuse with the plant design of 1460 Kcal/Kg of NCV.

The Plant was based on the technology supplied on Turn key basis by M/s Volund of Denmark.

A well developed and controlled waste management system is considered a pre requisite for a waste incineration project to be successful and effective. Waste to energy projects are complex than conventional fossil fuel based plants and require skilled personnel. The MSW rules have come into being only in year 2000, almost more than a decade after the closure of the Timarpur plant. The reasons for the 'failure' are reportedly not entirely on account of low heat value but also on short comings of the solid waste management systems in vogue at that time.

It is also pertinent to note that incineration of waste has celebrated the centenary in September 2003 with Municipality of Fredericksburg celebrating its centenary for having supplied the district heating to its citizens in 1903. The history of incineration has thus celebrated its centenary in year 2003 in Denmark[13].

The economic progress achieved by India has to be correlated with the quality of garbage for due consideration of thermal processing with or without pre-processing as a technology option. It is more than two decades since the closure of the Timarpur plant and opposing incineration based on the experience of twenty five years of old history is not justified.

Needless to say that technologies mature over a period of time and even failures of space science programs have not deterred the Indian scientific community.

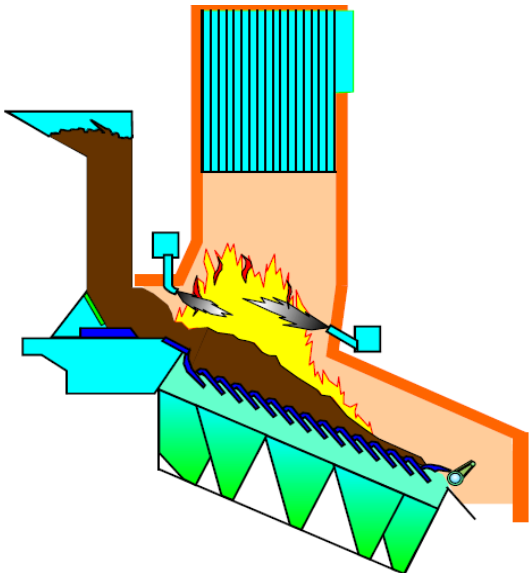
Conclusion

Composition of waste is established to be changing in quality with increasing heat value, changes in life styles set in. The change is evident in Mumbai , the commercial capital of India and Delhi, the capital city. Towards south, the city of Hyderabad has registered a strong growth. It is attempted to highlight the compositional changes that are taking place in these cities though the other cities of India like Bangalore, Chennai and Ahmedabad do not lag behind.

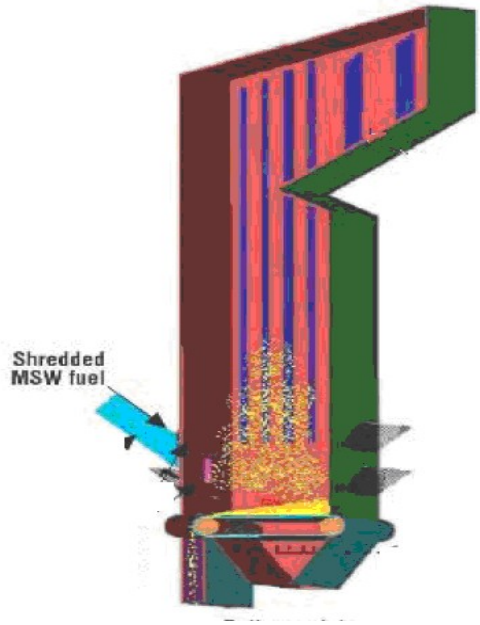
There is a strong need to study the qualitative changes of municipal wastes rather than recording and predicting the mere quantitative growth only. There is need for revisiting the methodologies for estimation of the heat value. A conservative approach for design of heat value may still be adopted while considering new facilities to start with and the experience of first generation waste processing as well as waste to energy plants of Andhra Pradesh should be kept in mind while planning for new facilities such as incorporation of a moving grate in place of a traveling grate and ram based fuel feeding systems.

The RDF based plant at Vijayawada has all the technical ingredients of a good incineration system, but for the fuel feeding and moving grate.

Schematic View of Pusher Grate



Schematic View of Traveling Grate



Summary

- 1.2 Million tones of MSW is generated by about 28% of Indian urban population with 7 cities having 4 Million + population and 35 cities having more than 1 Million+ population.

- Growing urbanization is pressuring the local governments on making the land available for SWM.

- Thermal processing through combustion is an effective answer for restricting the quantity of residue to be disposed to SLF.

- The community's overall preparedness for sharing the cost of SWM disposal is central to the growth of the WTE industry.

- Opportunity exists for capacity building in Wt E sector with proper environmental safeguards.

One of the Key Conclusions & recommendations from the report[12] of the 'Expert committee for inspection and evaluation of the project for energy recovery from MSW at Lucknow' set up by Ministry of New & Renewable Energy in pursuance of the orders of Hon'ble Supreme Court of India is….

"The operational problems of one plant should not form the basis to judge the efficacy of a particular technology option or for rejecting a technology as a whole."

(The views expressed by the author are his personal and need not necessarily be construed as that the company he is employed with.)

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Abbreviations :

MCGM	:	Municipal Corporation of Greater Mumbai, India
IL& FS	:	Infrastructure Leasing & Financial Services Ltd , India
CPCB	:	Central Pollution Control Board , India
NEERI	:	National Environment Engineering & Research Institute, India
MSW	:	Municipal Solid Waste
CPHEEO	:	Central Public Health And Environmental Engineering Organization, Government of India
MoUD	:	Ministry of Urban Development
MNRE	:	Ministry of New & Renewable Energy (formerly Ministry of Non Conventional Energy Sources) , Government of India
RBI	:	Reserve Bank of India
EIA	:	Energy Information Department, Department of Energy, USA
GDP	:	Gross Domestic Product
GHMC	:	Greater Hyderabad Municipal Corporation
MCD	:	Municipal Corporation of Delhi
SLF	:	Sanitary Landfill
SWM	:	Solid Waste Management
HHV	:	Higher Heating Value
LHV	:	Lower Heating Value
RDF	:	Refuse Derived Fuel
WTE	:	Waste to Energy
LCV	:	Lower Calorific Value
DPR	:	Detailed Project Report

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