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Evaluation of Potential of Energy from Jabalpur Municipal Solid waste(MSW) for ECO-Sustainability

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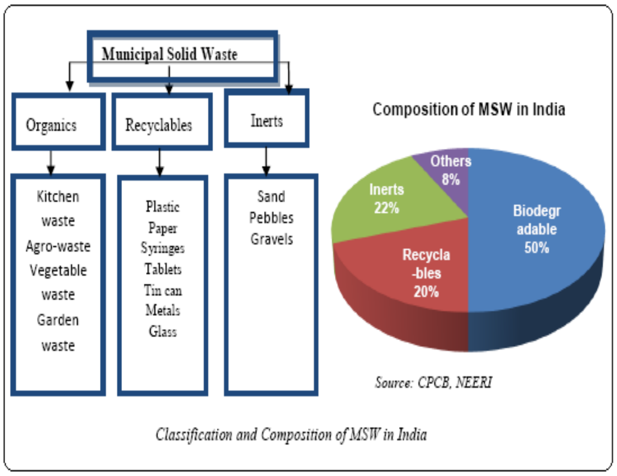
Abstract:
Waste disposal is one of the pressing problems.Millions of tons of municipal solid waste, hazardous/industrial wastes and agricultural wastes are handled daily throughout municipal areas. Each municipality confronts great challenges in disposing of its wastes in an efficient, cost effective and environmentally safe manner.Landfills in metropolitan areas are becoming full, and new ones are more difficult to open. Failure to effectively deal with these waste disposal problems could significantly impact the country's economy as well as the health and welfare of its people. Population growth creates waste disposal problems thus inadequate waste disposal creates health and environmental problems.Per capital solid waste disposal will continue to be high in municipal areas. Solid waste landfills are becoming a mounting problem – creating space limitations and significant health concerns.So, the main objective is to find cost effective & Eco- friendly manner for recovering material & energy which can reduce the enormous quantity of solid waste currently disposed on land. The increasing sensitivity of public opinion towards impact of environmental pollution on climate change & human health has aroused interest in renewable energy like wind, solar, biomass and MSW. On the basis of calculation shown below, the 396 TPD of MSW generated under Jabalpur Municiple Coprporation (As per 2001 census) may be used to generate around 5 MW of Power by both the way either thermo-chemical conversion or bio-chemical conversion.



Keyword:
Municipal Solid Waste, Refuse Derived Fuel, Calorific Value, Waste to energy

Introduction :

About Jabalpur :

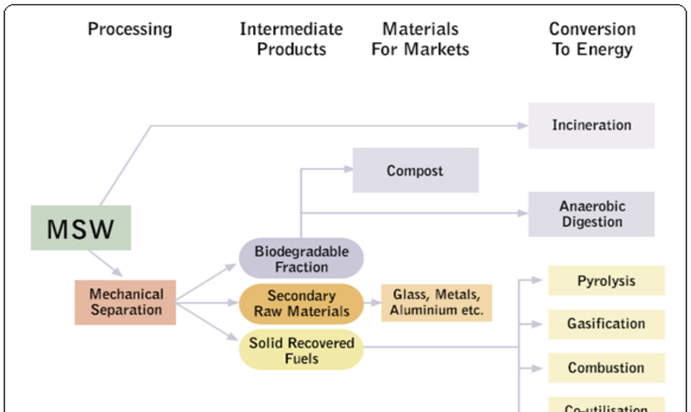
Jabalpur city is part of the Jabalpur congregation comprising of Jabalpur city, Jabalpur Cantonment and Khamaria Township. This ancient city (traditionally also known as "Mahakoshal") is located in central India, in the state of Madhya Pradesh. The population within the cantonment area and the premises of the three major defense establishments in and around the Jabalpur city limits is 1,08,269 as per the 2001 Census and population within the municipal corporation limits as per 2001 Census is 9,51,469.Jabalpur lies on the banks of the Narmada River and sprawls over the plains of its tributaries Hiran, Gaur, Ken & Sone. Geographically, the city is located at 23o10' North latitude and 79o57' East longitude, at an altitude of 393 meters above mean sea level (MSL).

About MSW :

Municipal Solid Waste (MSW) includes commercial and residential wastes generated in municipal or notified areas in either solid or semi-solid form. It consists of household waste, construction and demolition debris, sanitation residue, waste from streets and so forth. Some of the constituents of MSW are given in the figure below.

Fig.1

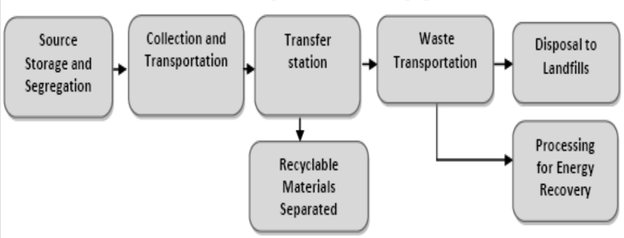
The term MSW describes the stream of solid waste ("trash" or "garbage") generated by households and apartments, commercial establishments, industries and institutions. MSW consists of everyday items such as product packaging, grass clippings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint and batteries. There are several state-of-the-art technologies for converting MSW to energy. Moreover Solid Recovered Fuel **(Refuse Derived Fuel - RDF)** offers significant environmental and market opportunities, is relatively clean and can be traded in the market for numerous energy applications replacing fossil fuels.



The Numerous Conversion Routes for MSW to Energy

Fig.2

The schematic sketch below illustrates the steps carried out in managing the solid wastes in India.



MSW Collection to Energy Value Chain

Potential for Recovery of Electrical Energy (MW) from Municipal Solid Wastes by Indian States

State/ Union Territory	Recovery Potential (MW)	State/ Union Territory	Recovery Potential (MW)
Andhra Pradesh	107.0	Maharashtra	250.0
Assam	6.0	Manipur	1.5
Bihar	67.0	Meghalaya	1.5
Chandigarh	5.0	Mizoram	1.0
Chhattisgarh	22.0	Orissa	19.0
Delhi	111.0	Pondicherry	2.0
Gujarat	98.0	Punjab	39.0
Haryana	18.0	Rajasthan	53.0
Himachal Pradesh	1.0	Tamil Nadu	137.0
Jharkhand	8.0	Tripura	1.0
Karnataka	125.0	Uttar Pradesh	154.0
Kerala	32.0	Uttaranchal	4.0
Madhya Pradesh	68.0	West Bengal	126.0

Source: TERI and MNRE

Fig.3

Table-1

Definition and Why RDF

RDF is combustible or, in other word, high calorific fraction recovered from MSW. There are other terms used for MSW

RDF Production Process

RDF production process has two subsystems called front end and back end. Front end or pre-processing subsystem is to receive the MSW and separate it into combustible and

derived fuel such as Recovered Fuel (REF), Packaging Derived Fuel (PDF), Paper and Plastic Fraction (PPF) and Process Engineered Fuel (PEF) (UNEP, 2005; Gendebien et al., 2003).

There is another definition defined by ASTM standard (2006) that RDF is a shredded fuel derived from MSW which metal, glass and other inorganic materials have been removed
and has particle size 95 weight % passes through a 2-in square mesh screen.

MSW composition is varied from different sources, seasons and living behaviors. Raw

MSW has high moisture content, low calorific value, wide range of particle size distribution and high ash content. These reasons make using raw MSW as fuel difficult and unattractive. RDF presents several advantages as a fuel over raw MSW. The main advantages are higher calorific value which also remains fairly constant, more uniformity of physical and chemical composition, ease of storage, handling and transportation, lower pollutant emissions and reduction of excess air requirement during combustion (Caputo and Pelagagge, 2002).

Classification of RDF

According to ASTM standards E856-83 (2006), RDF can be classified into 7 categories as follows;

RDF-1	Wastes used in as discarded form;
RDF-2	Wastes processed to coarse particle size with or without ferrous metal separation such that 95% by weight passes through a 6 in square mesh screen , namely Coarse RDF ;
RDF-3	Wastes processed to separate glass, metal and inorganic materials, shredded such that 95 % by weight passes 2 in square mesh screen, namely Fluff RDF;
RDF-4	Combustible wastes processed into powder form, 95 weight % passes through a 10 mesh screen (0.035 in square), namely Powder RDF;
RDF-5	Combustible wastes densified (compressed) into the form of pellets, slugs, cubettes or briquettes, namely Densified RDF;
RDF-6	Combustible wastes processed into liquid fuels, namely RDF slurry;
RDF-7	Combustible wastes processed into gaseous fuels, namely RDF syngas.

Table 2

noncombustible fractions in order to produce feed stock for back end system. Back end system refers to the conversion process which can be either thermal or biological system (UNEP, 2005).

RDF production line consists of several unit operations in series in order to separate unwanted components and condition the combustible matter to obtain required RDF characteristics. General unit operations are screening, shredding, size reduction, classification, separation either metal, glass or

wet organic materials, drying and densification. These unit operations can be arranged in different sequences depending on coming MSW composition and required RDF quality (Caputo and Pelagagge, 2002).

Source of Generation	Population	Waste Generated, Kgs/Day)
Garha	155,261.00	65,000
Gorakhpur	140,032	58,000
Sanjay Gandhi Market	83,999	35,000
Civil Lines	84,036	35,000
Ghanta Ghar	79,939	33,000
Bhantallaiya	120,274	50,000
Cherital	172,551	72,000
Ranjhi	115,355.00	48,000

Table 3

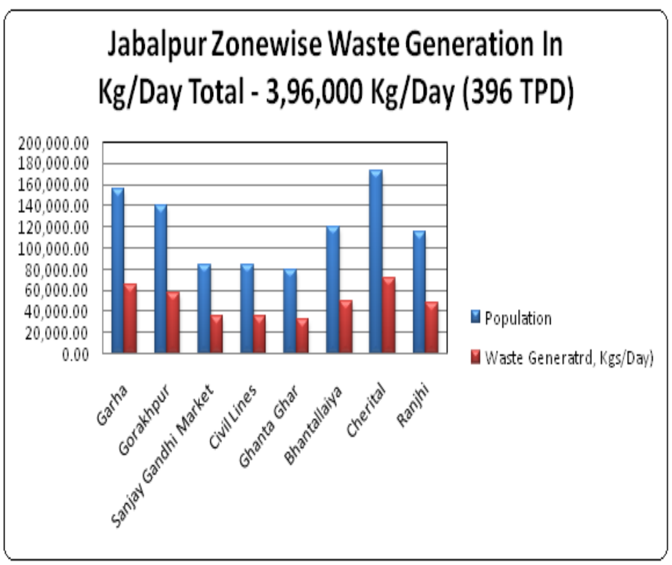
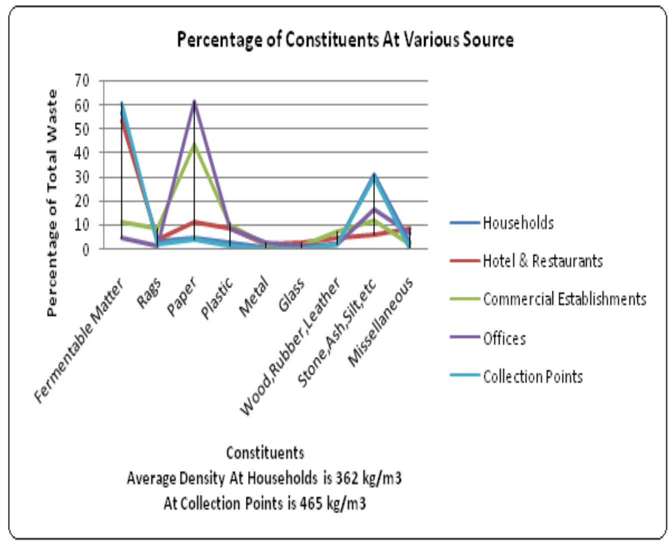


Fig.4

Sourcewise Percentage of Consituents :

Zonewise Waste Generation

The Jabalpur City population as per the census data 2001 showing is 932484. It is spread over an area of 122 sq.kms. The entire city is currently divided into 60 election wards and 8 Zones. The Jabalpur Municipal Corporation is responsible for collection, transportation, treatment and disposal of Municipal Solid Waste generated under MSW rule 2000. (**Source Municipal Corporation of Jabalpur)**



Source: Indo US Fire Project (Jabalpur Municipal Corporation) - Fig.5

`Constituents	Households	Hotel & Restaurants	Commercial Establishments	Office	Collection Points
Fermentable Matter	56.69	53.36	11.7	4.7	60.34
Rags	2.87	3.66	8.8	1.39	2.14
Paper	4.04	11.21	43.69	61.64	4.18
Plastic	2.27	8.64	10.3	8.9	1.32
Metal	0.38	1.8	2.5	2.5	0.1
Glass	0.42	2.62	1.52	1.57	0.12
Wood,Rubber, Leather	2.03	4.49	7.24	2.2	2.18
Stone,Ash, Silt,etc	30.9	5.76	12.11	16.47	29.54
Missellaneous	2.13	8.46	2.04	6.73	0.2

Table4

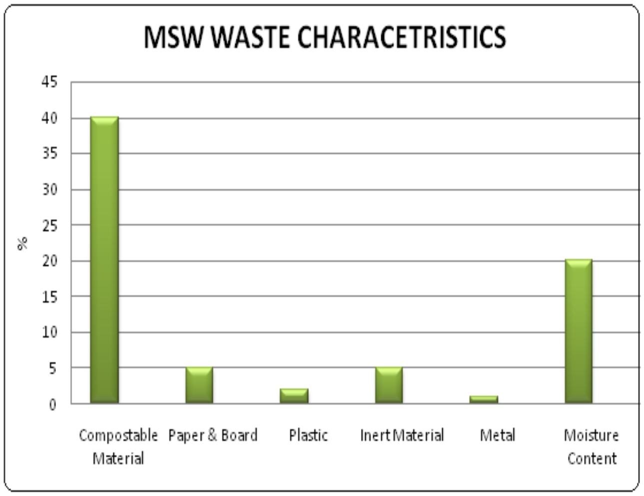


Fig.6

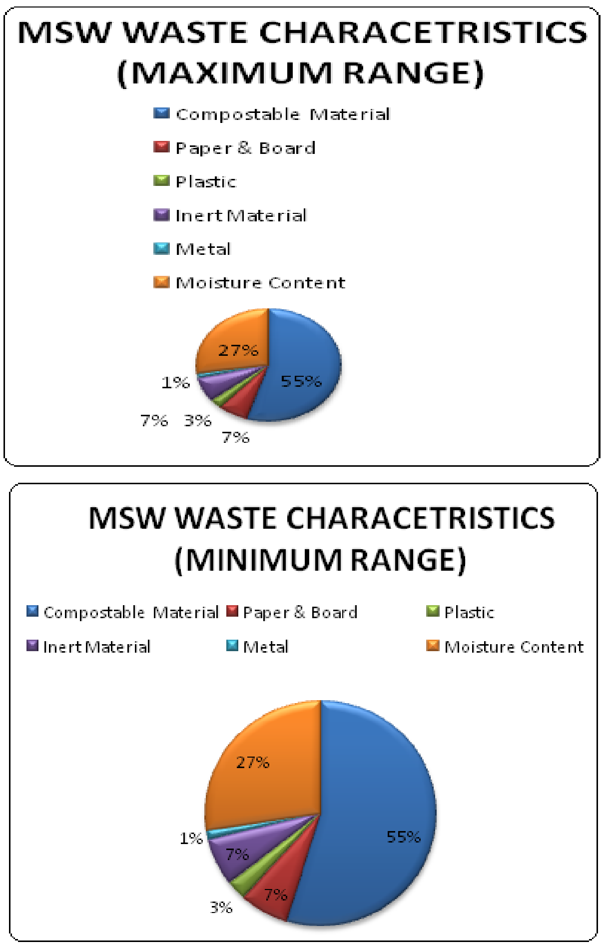


Fig.7
Waste Composition average in Indian Cities

Table 7

Waste composition averages in sample Indian cities

Description	Percentage composition
Compostable /or biodegradable matter	30% - 73% (can be processed)
Inert/reject material	40% - 55% (to go to landfill)
Recyclable materials	10% - 36% (can be recycled)

Source: CPCB in assistance with NEERI

Table 5

Broad indicators of Physical & Chemical Characteristics in sample Indian cities

S. No	Parameters	Range in Indian cities*
	PHYSICAL CHARACTERSTICS	
1	Moisture Content (%)	20 – 40%
2	Calorific Value (kcal/kg)	800 – 1,000 kcal/kg
3	Density (kg/m^3)	-----
	CHEMICAL CHARACTERSTICS	
3	Nitrogen as N	0.5 – 0.7%
4	Phosphorus as P_2O_5	0.5 – 0.8%
5	Potassium as K_2O	0.5 – 0.8%
6	C/N ratio	< 30

*Source: CPHEEO manual. Note *59 metros & state capitals*

Table 6

Waste parameters for technical viability of energy recovery from MSW

Waste Treatment Method	Basic Principle	Important Waste Parameters	Desirable Range*
Thermo-chemical conversion - Incineration - Pyrolysis - Gasification	Decomposition of organic matter by action of heat	Moisture content	< 45 %
		Volatile matter	> 40%
		Fixed Carbon	< 15%
		Total Inert	< 35 %
		Calorific Value	> 1200 k-cal/kg
Bio-chemical conversion - Anaerobic digestion/ biomethantion	Decomposition of organic matter by action of heat	Moisture content	> 50%
		Organic/volatile matter	> 40%
		C/N ratio	25-30

Source: CPHEEO manual on SWM

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Methodology:
Evaluation of Potential of Energy Recovery options from Jabalpur MSW considered here are incineration of RDF (Refuse Derived Fuel Fluff / Pallets) and Biomethanation. A rough assessment of the potential of recovery of energy from

Total waste quantity	W tonnes
Net Calorific Value	NCV k-cal/kg.
Energy recovery potential (kWh) W	NCV x W x 1000/860 = 1.16 x NCV x
Power generation potential (kW) W	1.16 x NCV x W/ 24 = 0.048 x NCV x
Conversion Efficiency	25%
Net power generation potential (kW)	0.012 x NCV x W
Assuming NCV of MSW is around	1200 k-cal/kg., then
Net power generation potential (kW)	**14.4 x W = 14.4x396 5702.4 KW 5.8 MW**

Table 8

In bio-chemical conversion, only the biodegradable fraction of the organic matter can contribute to the energy output:

Total waste quantity	W (tonnes)
Total Organic / Volatile Solids	VS = 50 %, say
Organic bio-degradable fraction	approx. 66% of VS = 0.33 x W
Typical digestion efficiency	60 %
Typical bio-gas yield: B (m3)	0.80 m3 / kg. of VS destroyed 0.80 x 0.60 x 0.33 x W x1000 = 158.4 x W
Calorific Value of bio-gas	5000 kcal/m3 (typical)

Size of constituents
Density

Smaller size of the constituents aids in faster decomposition of the waste. Wastes of the high density reflect a high proportion of biodegradable organic matter and moisture. Low density wastes, on the other hand, indicate a high proportion of paper, plastics and other combustibles.

High moisture content causes biodegradable waste fractions to decompose more rapidly than in dry conditions. It also makes

Volatile Solids

MSW through different treatment methods
can be made from knowledge of its calorific value and organic fraction, as under:

thermo-chemical conversion all of the organic matter, biodegradable as well as non-biodegradable, contributes to the energy output :

Energy recovery potential (kWh)	B x 5000 / 860 = 921 x W
Power generation potential (kW)	921 x W/ 24 = 38.4 x W
Typical Conversion Efficiency	30%
Net power generation potential (kW)	**11.5 x W = 11.5x396 4554 KW 4.6 MW**

Table 9

In general, 100 tonnes of raw MSW with 50-60% organic matter can generate about 1- 1.5 Mega Watt power, depending upon the waste characteristics. So, if we follow this thumb rule and calculate the power generation on assumption that 1.25 MW per 100 Tonnes, then it will be 4.95 MW which is almost nearer the calculated value on considering Calorific Value.

Parameters affecting Energy Recovery:
The main parameters which determine the potential of Recovery of Energy from Wastes (including MSW), are:

- Quantity of waste
- Physical and chemical characteristics (quality) of the waste.

The actual production of energy will depend upon specific treatment process employed, the selection of which is also critically dependent upon (apart from certain other factors described below) the above two parameters. Accurate information on the same, including % variations thereof with time (daily/ seasonal) is, therefore, of utmost importance.
The important **physical parameters** requiring consideration include:

Moisture content

Table 10

the waste rather unsuitable for thermo-chemical conversion (incineration, pyrolysis/ gasification) for energy recovery as heat must first be supplied to remove moisture.

The important **chemical parameters** to be considered for determining the energy recovery potential and the suitability of waste treatment through bio chemical or thermo-chemical conversion technologies include:

Fixed Carbon content
Inerts,

Calorific Value
C/N ratio (Carbon/Nitrogen ratio)
Toxicity

Table 11

The desirable range of important waste parameters for technical viability of Energy recovery through different treatment routes is given ABOVE.

Finding & Conclusion

On the basis of calculation shown above, the 396 TPD of MSW may be used to generate around 5 MW of Power by both the way either thermo-chemical conversion or bio-chemical conversion.The capacity may be incresed by mixing of biomass in RDF Fluff.

Ref. :

- IEA Bioenergy ExCo 2003:02
- www.eai.in
- www.urbanindia.nic.in
- www.mppcb.nic.in
- www.jmcjabalpur.org
- www.waste2power.net