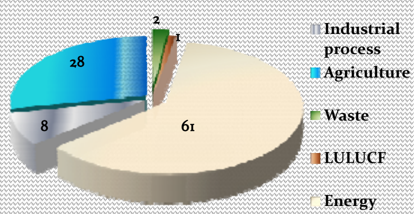
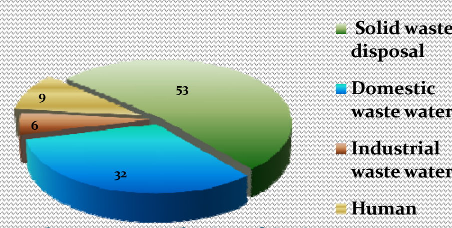
Harnessing of Energy from Municipal solid waste

Dr. CHHEMENDRA SHARMA
NATIONAL PHYSICAL LABORATORY
NEW DELHI.

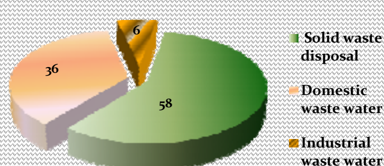
GHGs emissions & waste sector:



Percentage contribution of different sectors to the total GHGs emissions in India (In terms of CO_2 equivalent).



Total Percent contribution of GHGs in the waste sector (in terms of CO_2 equivalent).



Total Methane emissions from anthropogenic waste sources (in terms of CO_2 equivalent).

Source: NATCOM Final Report 2004

Waste Sector

- Serious management problem with growing urbanization
- Lack of proper landfill areas
- Contribute to the GHG emissions – could be trapped for energy utilization

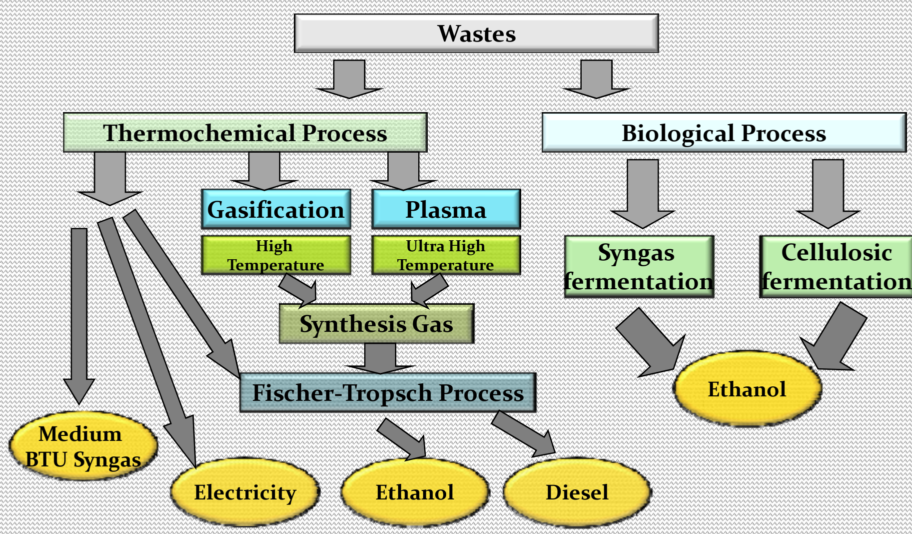
Waste treatment process:

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 Organic/ Volatile matter Fixed Carbon Total Inert Calorific Value	< 45% > 40% < 15% < 35% > 1200kc/kg
Bio-chemical conversion - Anaerobic Digestion* / Biomethanation	Decomposition of organic matter by microbial action	Moisture content Organic/Volatile matter C/N Ratio	> 50% > 40% 25-30

*In case of Anaerobic Digestion;
- high carbon content wastes (straw, paper, etc.) may be added, if C/N ratio is low.
- high nitrogen content waste (sewage sludge, slaughter house waste, etc.) may be added, if C/N ratio is high.

Source: Handbook of Solid Waste Management and Waste Minimization Technologies

Converting Waste to Fuel by Thermo & Bio-chemical process



Various Thermochemical processes used for conversion of Solid Wastes:

Process	Conversion Product	Preprocessing Required	Comments
Incineration with heat recovery	Energy in the form of steam	None	Markets for steam must be available; proved in numerous full-scale applications; air-quality regulations may prohibit use.
Supplementary fuel firing	Energy in the form of steam	Shredding air separation and magnetic separation	If least capital investment desired existing boiler must be capable of modification; air-quality regulations may prohibit use.
Fluidized bed incineration	Energy in the form of steam	Shredding air separation and magnetic separation	Fluidized bed incinerator can also be used for industrial sludges.
Pyrolysis	Energy in the form of steam	Shredding, Magnetic separation	Technology proved only in pilot applications; even though pollution is minimized air-quality regulations may prohibit use.
Hydrolysis	Glucose, furfural	Shredding, air separation	Technology on laboratory scale only
Chemical conversion	Oil, gas, cellulose acetate	Shredding, air separation	Technology on laboratory scale only

Landfill Gas cleaning system:

Compound	Process type	Process alternatives available
H_2O	Adsorption	1. Silica gel 2. Molecular sieves, and Alumina
	Absorption	1. Ethylene glycol (at low temperature -20°F) 2. Selexol
	Refrigeration	Chilling to -4°F
Hydrocarbons (VOCs)	Adsorption	Activated carbon
	Absorption	1. Lean oil Absorption 2. Ethylene glycol, and 3. Selexol (All at low temperatures of -20°F)
	Combination	Refrigeration with ethylene Glycol plus activated carbon Absorption
CO_2 and H_2S	Absorption	1. Organic solvents 2. Alkaline salt solutions 3. Alkanolamines
	Adsorption	1. Molecular sieves 2. Activated carbon
	Membrane separation	Hollow fiber membrane

Only two ways to dispose of post-recycling solid wastes:

- MSW has a potential to generate biogas of about 150-250 cu.m/MT depending upon the quality of MSW.
- As a thumb rule it may be considered that about 50sq.mt of land is required for every MT/d of MSW per year basis with an active life span of 15years. (Max. Ht: 18mts)
- **Waste-to-Energy or WTE):**
  $C_6H_{10}O_4 + 6.5O2 = 6CO_2 + 5H_2O$
  Energy content/tonne MSW: 2,800 kWh
- **Controlled landfilling recovering methane:**
  $C_6H_{10}O_4 + 1.5H2O = 3.25\ CH4 + 2.75CO2$
  Methane generation: 75 standard m3/tonne MSW
  Energy content in methane/tonne MSW: 760 kWh

Experience in India so far :

Initially **RDF** plants were installed in India in the midnineties followed by larger ones later:

- ❑ 5 TPD plant in **Bangalore** (private entrepreneur) – MSW to pellets
- ❑ 80 TPD plant in **Mumbai** (1994, DST) – MSW to pellets
- ❑ 200 TPD plant in **Hyderabad** – MSW to pellets (1999, DST Technology), private company (SELCO) and upgraded to 1000 TPD with power Generation.
- ❑ **Vijayawada** (fluff) along with pelletisation plant at Guntur, pellets transported to Vijayawada followed by combined power generation – 5 MW power generation capacity, BOT operator (DST technology)
- ❑ RDF plant in **Jaipur** (fluff), BOT operator, baled fluff sent to cement plant for CDM benefits (500 TPD capacity)
- ❑ RDF plant in **Chandigarh** (fluff) – under construction, BOT operator, baled fluff sent to cement plant for CDM benefits (500 TPD capacity).

MSW pelletisation plant at Hyderabad (courtesy MNRE)

0.15 MW Power Project Utilizing Vegetable Market and Slaughterhouse Wastes at Vijayawada, A.P. (courtesy MNRE)

Project for generation of 5 MW power from MSW at Lucknow (courtesy MNRE)

Table: Scenario of municipal solid waste in four mega cities :

Parameter	Year	Mega-cities			
		Chennai	Delhi	Kolkata	Mumbai
Area (km2)		174.0	148.4	187.33	437.71
Population (million)	1981	4.28	6.22	4.13	8.23
	1991	5.42	8.42	11.02	12.6
	2001	6.56	12.87	13.2	16.43
Waste generation (kg /capita/d)	1994	0.66	0.48	0.32	0.44
	1999	0.61	1.1	0.55	0.52
Garbage pressure (tons /km2)	1999	17.529	4.042	16.548	13.708
Waste collection (Gg per day)	1999	3.124	5.327	3.692	6
Mode of disposal (%)	Landfilling	100	93	100	91
	Composting	-	7	-	9

Source: CPCB 1999.

Fig. (a) Variation in the daily MSW collection in different months from 1996–2003 in Chennai; (b) increase in MSW and population growth in Chennai. (Source: Jha et al. 2008)

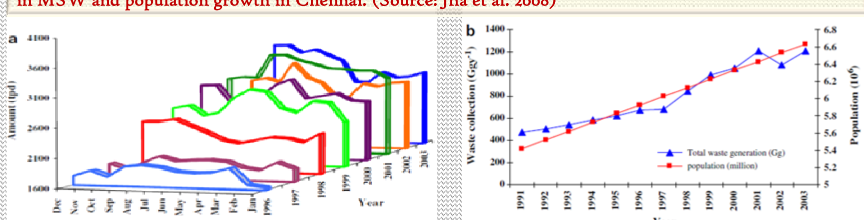
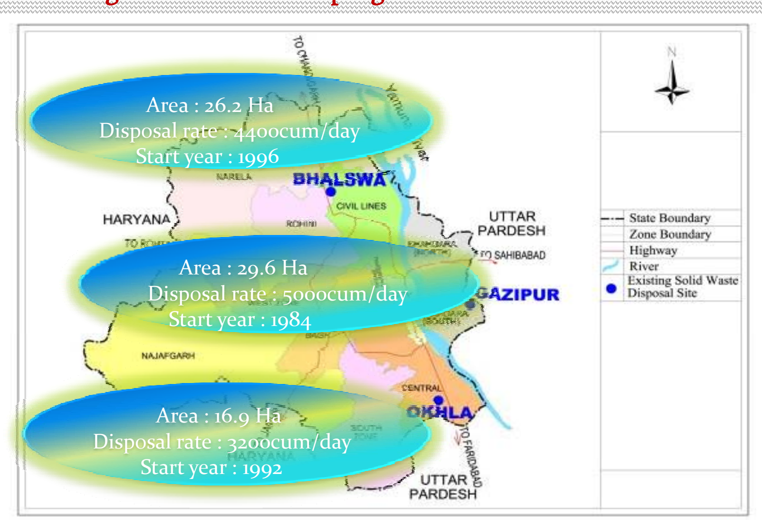


Table: GHGs emission from landfills in Chennai :

Sampling site (Chennai)		Kodungaiyur (KDG)		Annual Average (ton/y)	Perugundi (PGD)		Annual Average (ton/y)
Year of Study		Dec. 2003	Sep. 2004		Dec. 2003	Sep. 2004	
Study of Methane	CH_4 flux range ($mgm^{-2}h^{-1}$)	2.4 -23.5	1.0 - 10.5	13.8	0.90 - 9.94	1.8 - 433	101.6
	CH_4 Emission (ton /y)	17.9± 9.9	9.7± 3.6		7.27 ± 2.7	196 ± 145	
Study of Carbon dioxide	CO_2 flux range ($mgm^{-2}h^{-1}$)	39 -906	106 -242	627.0	102 to 544	12.3 to 964.4	533
	CO_2 Emission (ton /y)	924.0 ± 358.0	330.0 ± 67		0.506 ± 0.123	0.560 ± 0.435	
Study of Nitrous Oxide	N2Oflux range ($mgm^{-2}h^{-1}$)	142 - 384	6 - 460	0.49	15 - 155	2.7 -1200	0.49
	N2OEmission (ton /y)	0.65 ± 0.17	0.32 ± 0.02		70.20 ± 0.05	0.78 ± 0.52	

Source: Jha et al. 2008

Existing Solid waste dumping sites in Delhi:



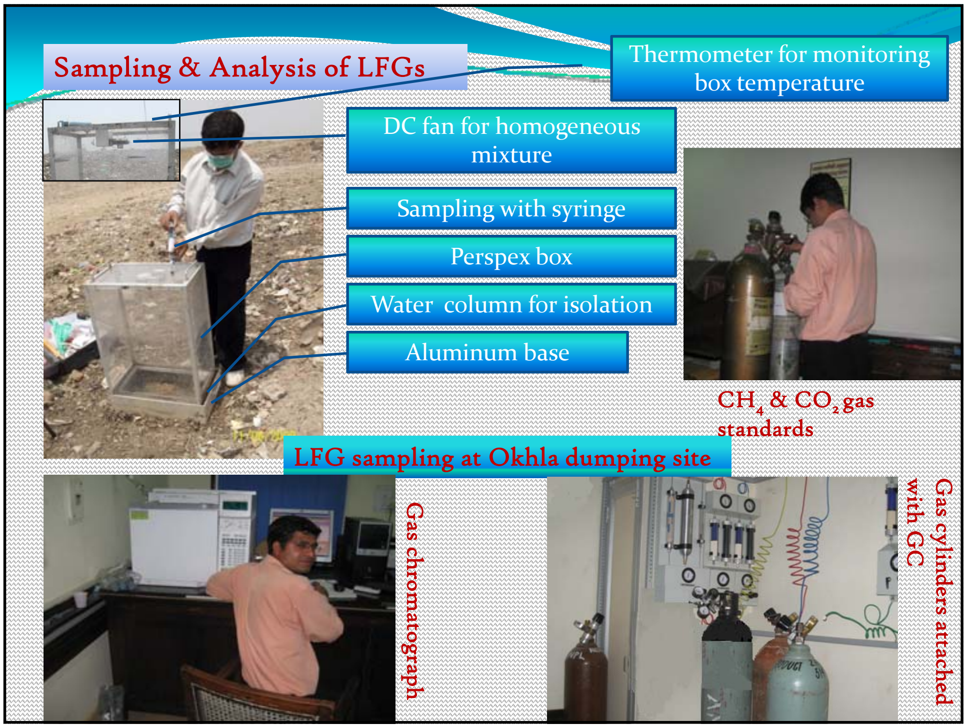


Table: Power Generation Potential- Ghazipur

Year	LFG emissions (50% recovery rate)	CH_4 emissions (50% of LFG)		Power generation
	TPA	TPA	cum/hr	MW
2010	6102	3051	520	Flaring
2011	6012	3006	512	2.0
2012	5922	2961	504	2.0
2013	5834	2917	497	2.0
2014	5747	2873	490	1.9
2015	5661	2831	482	1.9
2016	5577	2789	475	1.9
2017	5494	2747	468	1.9
2018	5412	2706	461	1.8
2019	5332	2666	454	1.8

Source: SENES Report-2008

Table: Power Generation Potential- Okhla

Year	LFG emissions (50% recovery rate)	CH_4 emissions (50% of LFG)		Power generation
	TPA	TPA	cum/hr	MW
2010	7946	3973	677	2.7
2011	7635	3817	650	2.6
2012	7335	3668	625	2.5
2013	7048	3524	600	2.4
2014	6771	3386	577	2.3
2015	6506	3253	554	2.2
2016	6251	3125	533	2.1
2017	6006	3003	512	2.0
2018	5770	2885	492	2.0
2019	5544	2772	472	1.9

Source: SENES Report-2008

Table: Power Generation Potential- Bhalswa

Year	LFG emissions (50% recovery rate)	CH_4 emissions (50% of LFG)		Power generation
	TPA	TPA	cum/hr	MW
2010	10897	5449	928	3.7
2011	10470	5235	892	3.5
2012	10059	5030	857	3.4
2013	9665	4833	823	3.3
2014	9286	4643	791	3.1
2015	8922	4461	760	3.0
2016	8572	4286	730	2.9
2017	8236	4118	702	2.8
2018	7913	3957	674	2.7
2019	7603	3801	648	2.6

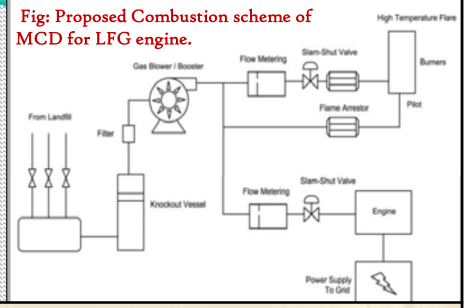
Source: SENES Report-2008

11/06/2009

Recent Developments:

Govt. of Delhi is going to facilitate Energy from waste in the year 2010 before Commonwealth games. Ghazipur dumping site generates 1200 TPD of solid waste having the potential of generation of 8-10 MW of energy/day.

Fig: Proposed Combustion scheme of MCD for LFG engine.



RDF to energy: