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RESEARCH ARTICLE

Studies on Waste-to-Energy Technologies in India & a detailed study of Waste-to-Energy Plants in Delhi

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Abstract

Energy is the driving force for development in all countries of the world. The increasing clamour for energy and satisfying it with a combination of conventional and renewable resources is a big challenge. Another concern is that of urban waste accumulation. The rapid increase in population coupled with changing lifestyle and consumption patterns is expected to result in an exponential increase in waste generation of upto 18 billion tonnes by year 2020. While Indian urban growth has mushroomed, provision of urban services and amenities has fallen short, with the resultant urban sprawl giving rise to increased energy demand and environmental degradation. Therefore there is an urgent need to fulfill the energy requirements and to manage the waste that had been produced. Simultaneous solution to both the problems is Waste-to-Energy Technology, the objective of which is treating MSW to reduce its volume as well as generating energy and electricity to add value to the process. This paper focuses on Waste-to-Energy scenario in India with a detailed study of Waste-to-Energy plants in the capital city Delhi. It also overviews the techniques used for obtaining energy from waste along with evaluating the environmental, technical and socio-economic performance of the technology. Different types of waste-to-energy projects along with their working status in different states and union territories of the country, and the differences in their input and output units are described in the present paper. A comparison of different parameters affecting Waste to Energy technology and a state-wise comparison was conducted along with comparative study of waste-to-energy plants in Delhi.

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Introduction

Solid Waste is the discarded or the unwanted material in the form of garbage or refuse resulting from industrial, commercial, mining and agricultural operations, and from community activities. This solid waste is categorized as Municipal Solid Waste, Construction and Demolition Waste, Hazardous Waste, abandoned vehicles, etc. Municipal Solid Waste generation is at ever-increasing rate with the increase in economic prosperity and urban population. Reduction in the volume and mass of solid waste is a crucial issue and simultaneously, the country has a growing need for electrical power, particularly in the more industrial regions where the standard of living is increasing. Therefore, to reduce the amount of solid waste and producing energy at the same time can be contracted by a municipal waste to energy plant.

2.0 Status of Municipal solid waste (MSW) in India

MSW, commonly known as trash or garbage, is a waste consisting of everyday items that are discarded by the public. Typically the major components of MSW in India includes food and kitchen waste, green waste, paper, glass, bottles, cans, metals, certain plastics, fabrics, batteries, inert waste, dirt, rocks, debris, etc. MSW is generated from several sources like residential, commercial, institutional, etc. The composition of municipal waste varies greatly from country to country and region to region and changes significantly with time.

In India the biodegradable portion which mainly includes food and yard waste dominates the bulk of MSW by making up approximately 50% of the total MSW. Some facts about Indian MSW:-

- Solid waste generation in India is about 115,000 tons per day with a yearly increase of about 5% (according CPCB, India)
- Research studies reveal that the per capita generation rate increases with the size of the city and varies between 0.3 to 0.6 kg/day in the metropolitan areas. The estimated annual increase in per capita waste quantity is about 1.33% per year.
- The 11th Five Year Plan of India has envisaged an investment of approximately Rs. 2,000 crores for Solid Waste Management (SWM).

The large amount of Municipal solid waste can be used to generate energy. Several technologies have been developed that make the processing of MSW for energy generation cleaner and more economical than ever before. While older waste incineration plants emitted high levels of pollutants, recent regulatory changes and new technologies have significantly reduced this concern. United States Environmental Protection Agency (EPA) regulations in 1995 and 2000 under the Clean Air Act have succeeded in reducing emissions of dioxins from waste-to-energy facilities by more than 99 percent below 1990 levels. The EPA noted these improvements in 2003, citing waste-to-energy as a power source "with less environmental impact than almost any other source of electricity."

3.0 Waste-To-Energy (WtE) or energy-from-waste (EfW)

WtE is the process of generating energy in the form of electricity and/or heat from the incineration of waste. WtE is an energy recovery process. Most WtE processes produce electricity and/or heat directly through combustion, or produce a combustible fuel commodity through gasification/pyrolysis process, such as methane, ethanol or synthetic fuels. Waste feedstock can include municipal solid waste (MSW), agricultural waste, industrial waste and even the gases that are naturally produced within landfills.

Factors influencing waste-to-energy technology

- Environmental Impacts: WTE is an end-of-pipe treatment of waste with additional potential for energy production from the process thus generating clean energy. However, there is the potential for odour and leachate production from waste and also contamination to the nearby environment by harmful gaseous emission.
- Technical Aspects: WTE requires high cost and sophisticated technology which is not presently available in India and is imported from US and Europe. Also, WTE projects require highly skilled technical expertise for both operation and maintenance.
- Socio- Economic Facts: WTE requires high investment, operation and maintenance costs and results in significant revenue generation from electricity sale which in turn can reduce the flow of fuel import to a considerable extent benefiting the country's economy.

3.1 WtE technologies

The various WTE Technologies available are as follows:

- Physical waste-to-energy technology: In this technology the waste is mechanically processed to produce forms more suitable for use as fuel, producing refuse-derived fuel (RDF) or solid recovered fuel (SRF). RDF is a fuel produced by either shredding solid waste or treating it with steam pressure in an autoclave. RDF consists largely of organic materials taken from solid waste streams, such as plastics and biodegradable waste. Burning RDF is more clean and efficient than incinerating MSW or other solid waste directly.
- Mass Combustion: Municipal waste can be directly combusted in waste-to-energy incinerators as a fuel with minimal processing, in a process known as "mass burn." Heat from the combustion process is used to

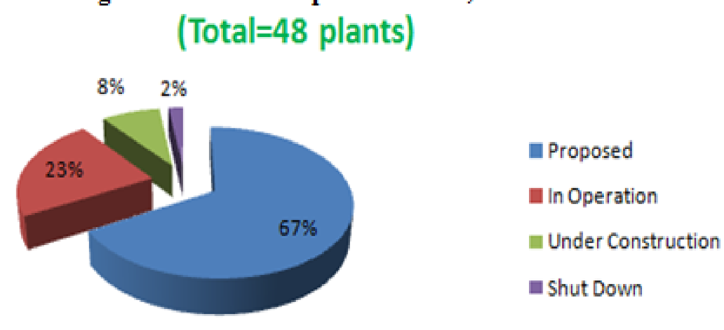
turn water into steam, which is used to power a steam-turbine generator to produce electricity. Next generation waste incinerators also incorporate air-pollution control systems, though ash or other pollutants captured in this process must still be disposed of.

- Pyrolysis and thermal gasification: Pyrolysis uses heat to break down organic materials in the absence of oxygen, producing a mixture of combustible gases (primarily methane, complex hydrocarbons, hydrogen, and carbon monoxide), liquids, and solid residues. Low-temperature pyrolysis can also be used to produce a synthetic diesel fuel from waste-film plastic. Thermal gasification takes place in the presence of limited amounts of oxygen. The gas generated can be used in boilers to provide heat, or it can be cleaned up and used in combustion turbine generators.
- Plasma-arc gasification: Plasma-arc gasification uses a plasma-arc torch to produce temperatures as high as 13,000 °F (~7200°C) to breaks down wastes, forming hydrogen and carbon monoxide which can be used to generate electricity directly.
- Methane capture: Land filling is still the primary method of disposal of municipal solid waste. If left undisturbed, landfill waste produces significant amounts of carbon dioxide (CO_2) and methane (CH_4) by the anaerobic digestion of organic matter. Landfill gas can be captured via a collection system, which usually consists of a series of wells drilled into the landfill and connected by a plastic piping system. The gas can then be burned directly in a boiler as a heat-energy source, or, if the biogas is cleaned by removing water vapour and sulphur dioxide, it can be used directly in internal-combustion engines, or for electricity generation via gas turbines or fuel cells.
- Biogas plants: Feedstock in Biogas plants could include food-processing waste or other agricultural waste such as manure. The process begins with the placement of waste and various types of bacteria into an airtight container called a digester. Then anaerobic digestion to produce biogas is done in a controlled environment. Advanced digester systems can now produce biogas with pure methane content higher than 95%. Biogas plants can transfer electrical energy to the main utility grid, or they can generate power for use on-site in applications like lighting, processing plants, etc. Biogas plants have been deployed in India, Israel, Australia, and elsewhere.
- Fermentation: Fermentation uses yeast to generate liquid ethanol from biomass waste.

3.2 Waste-to-Energy in India

The objective of WtE combustion is treating MSW to reduce its volume and generating energy and electricity during this process. In India installation of various WtE plants has been witnessed in the recent past and several projects are known to be under pipeline. In India total 48 WtE plants are present including 32 proposed, 4 under construction and 11 are in operation as presented in Fig.1 below. One of the plants is shutdown due to some technical problems in the plant.

Fig. 1 Status of WtE pants in India, 2013



In India, various WtE technologies are used considering the properties of the waste. Fig.2 shows the type of technologies used and the status of plants in India. Fig.2 shows that bio-methanation is the most widely used techonology in India. One reason behind this wide usage could be the high organic content in Indian MSW due to the presence of food waste. One of the RDF plant presently under construction is the Gazipur WtE plant and second one is the Ramky's Intergrated Waste Management Plant in Delhi. Both of these plants are part of the integrated waste management services.

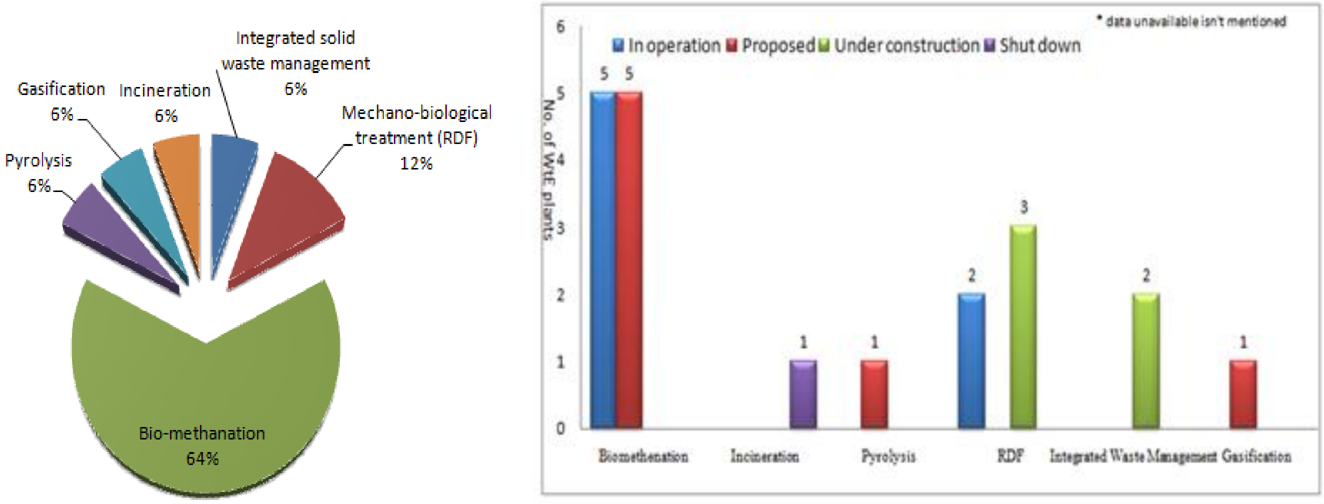


Fig. 2 Types and status of WtE Technologies used in India

A WtE plant is set up while considering the raw material availability and equipments required for the processing of that raw material. India, being a multi-state country has different raw material availability in different areas. 18 plants in the country are dependent on MSW for power generation whereas 15 plants use biomass. The plants with their corresponding usage of raw materials are given in the Fig 3. Incidentally one plant proposed in South Andaman will use coconut waste as raw material. There are 3 plants in Delhi and they all use MSW as raw material. The plant in Ludhiana, Punjab uses cattle dung & is running satisfactorily. It produces 2MW/day power by using 235TPD of the waste.

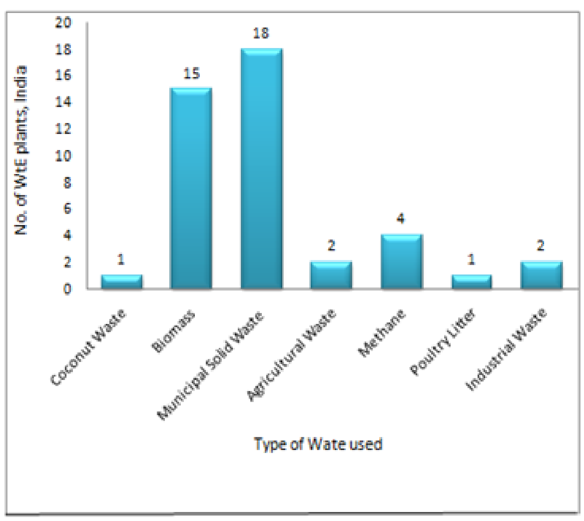


Fig 3: Review of Raw Material used by WtE plants in India, 2013

Currently Delhi is producing 16 MW/day power from waste & will be able to produce an additional 25MW/day after the completion of construction of two more projects. Gujarat is producing 3.5 MW/day power from waste. Each state equipped with WTE technology is producing power from waste and some of the project that are under proposed stage will be producing power from waste once completed. Chhattisgarh has 7 proposed projects that will be able to produce 119MW/day of electricity in the near future. Fig 4 shows the power generation in MW by each state in India.

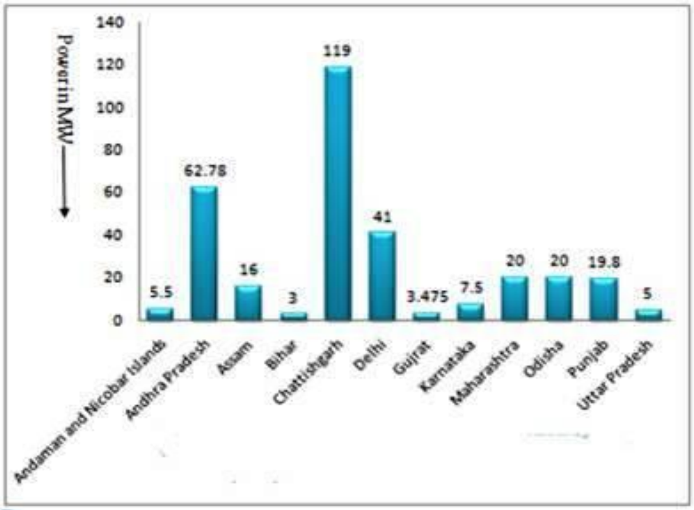


Fig 4 State-wise amount of Power Generation by WtE plants (Including operational & proposed plants), India, 2013

3.3 Waste-to-Energy in Delhi

Delhi city generates approximately 8,000 MT of Municipal Solid Waste (MSW) every day in 2013 at the rate of 500 g/capita/day. More than 65% of the MSW collected is disposed off in landfills. The remaining amount of MSW is sent for either composting or WtE plants for energy generation. For treatment and processing of MSW, currently there are three WtE plants as given in Fig. 5.

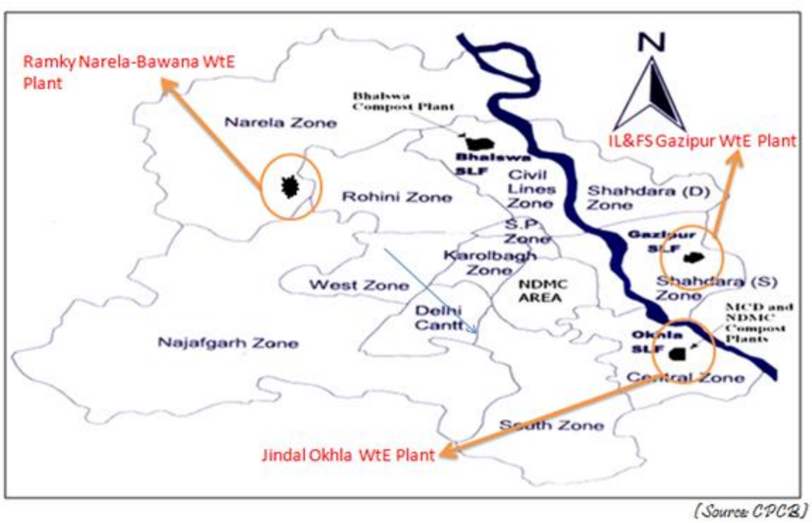


Fig. 5 Location of Delhi's WtE plants

Gazipur Plant (MSW→ RDF → Power)

The waste to energy plant at Ghazipur is under construction and proposes to adopt mass combustion of MSW as its working technology. The process would involve conversion of MSW to RDF & then combustion of RDF to generate electricity. In this plant, 12MW/day power will be generated with the input volume of 1300TPD of waste. The plant has a capacity of taking up 2000TPD.

Okhla plant (MSW Combustion)

The waste to energy plant at Okhla is in operation and operates on mass combustion of MSW as its working technology. In this plant, 16MW/day power is generated with the input volume of 1350 TPD of waste. In this plant segregation of waste takes place before combustion. Air Pollution Control Systems such as Turbosorp/Turboreactor and Fabric Filtration Air Quality Control System are provided in this plant to prevent emission of gases without treatment.

Narela-Bawana plant (MSW Combustion)

The Ramky waste to energy plant at Bawana is under construction and will operate on mass combustion of MSW as its working technology. In this plant, 12MW/day power will be generated with the input volume of 600TPD waste per boiler for 3 boilers. It is a part of Ramky's Integrated Waste Management Plant.

The WtE plants in Delhi, in general, are found to be following the process given below in the form of flowchart i.e. figure 6:

Figure 6 (a) RDF plant Process Flow

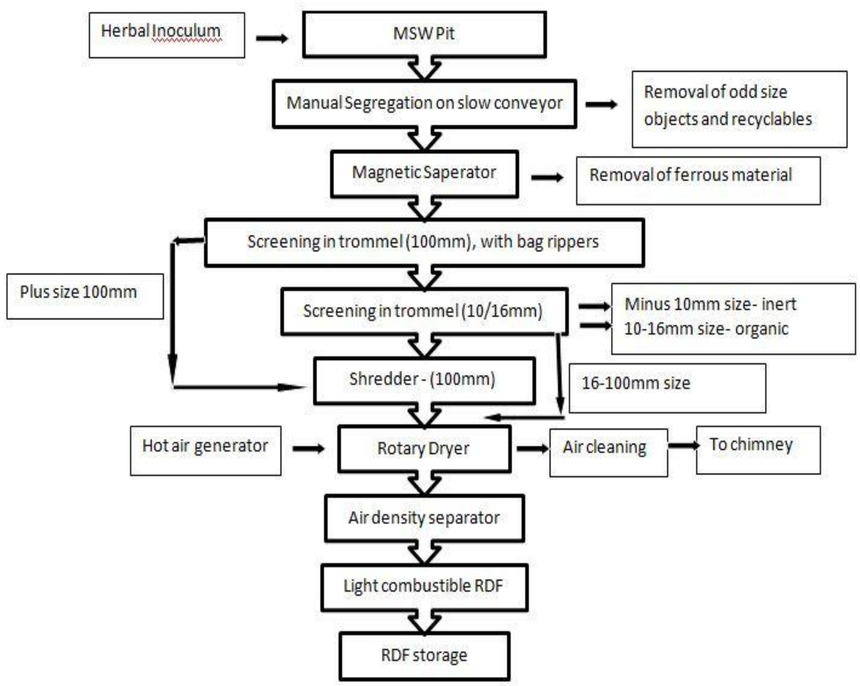
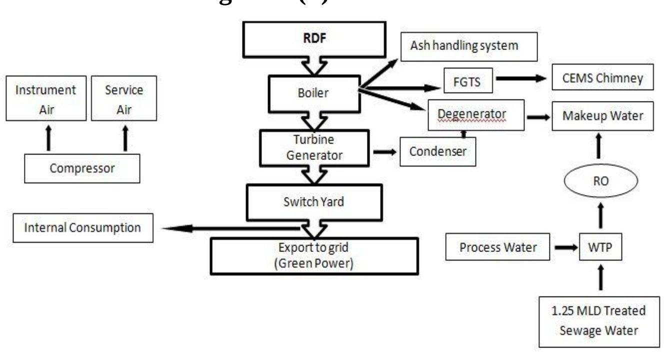


Figure 6 (b) Power Plant Process Flow



4.0 Environmental Impacts of WtE Technology

WtE projects in India are compliant with the European norms for emission standards i.e. Flue Gas Treatment System (FGTS) would include a Continuous Environment Monitoring System (CEMS), which will monitor the emission data through real time analysis and the results of the same will be directly uploaded online into the public domain. This will provide complete transparency to the whole system. Further, the ash coming out of power plant will be disposed of as per the Fly Ash Notification of the Ministry of Environment & Forests, Government of India, September, 1999. Non-combustible recyclable matter coming out of the pre-processing plant would be sold to Recycling units.

4.1 Emissions of Pollutants from WtE plant & Remedial Solutions

- Air Emissions: The unloading as well as processing of the waste would generate dust and odours. Unloading of MSW from dumper trucks will be carried out into a specially designed pit and immediately after unloading the MSW will be sprayed with microbial culture to retard further decomposition of MSW, reduce odors and prevent further propagation of disease vectors.
- Leachate: The municipal waste arriving at the site will be unloaded into covered pit. No leachate is expected from the pit in normal circumstances as the MSW will not have moisture exceeding 35-40%. The small quantities of washings/leachates as and when generated will be allowed to get collected in a sump and treated in a Leachate Treatment Plant (LTP).

4.2 Emissions of Pollutants from RDF plant & Remedial Solutions

- Air Emissions: The dry dust discharge from dryers will be collected by multi-cyclones and disposed. The diluted gases from HAG (Hot Air Generator) with fresh air coming out of multi-cyclones will be washed in Venturi-scrubbers. After scrubbing; the gases are passed through demister to remove entrained moisture. The ensuing gases are passed through Activated Carbon Bed for adsorption of Organics before letting them discharged through 30 m high outlet.
- Water Pollution: For RDF processing, water is used for scrubbing of dryer’s gases. The discharge water from the scrubber is neutralized and filtered to get pollutants below their standard norms and then used for in-house horticulture purposes. Other effluent generated from the RDF plant will include washings/leachate from MSW storage pit. The effluent will be very less in quantity and will be sent to in-house Leachate Treatment Plant (LTP).
- Solid Rejects: The solid rejects from the processing would consist of stone, sand, earth, ceramic, etc. which will be segregated and managed appropriately.
- Noise Pollution: There are a number of sources of noise pollution such as truck traffic, blowers, and shredders. Where necessary, enclosures would be provided to ensure that noise levels do not exceed the prescribed standards. For the workers’ safety earplugs would be provided and equipments would be maintained to ensure optimum working conditions.
- RDF Storage: The proposed facility will have appropriate storage for RDF fluff. To mitigate potential fire problems, adequate measures such as water hydrants with adequate pressure or dry powder type will be provided.

4.3 Control Methods for Air Emissions to be employed in WtE plant

- SPM: The power plant boiler will be provided with high efficiency bag filters, which will remove the dust content and the clean flue gas will be discharged through chimney of minimum height of 60m. Adequate number of bag house and filters shall be provided so that SPM levels can be consistently maintained at 30 mg/Nm^3.
- Oxides of Sulphur: According to the CPCB norms the Chimney height of the boiler is calculated using the formula $Height = 14 X Q^{1/3}$ where Q= Qty. of Sulphur Dioxide in kg/hr. Accordingly, the required stack height works out to be 52 meters, and on a conservative side the stack height for the boiler will be 60 m . Lime injection will also be done to neutralize the highly acidic gases. The emission of SO_2 is expected to be below $50mg/Nm^3$.

- Oxides of Nitrogen: For the control of NO_x, Thermal $DeNO_x$ method shall be installed. Under this system, urea solution will be injected in controlled manner into the furnace in a region having optimum gas temperature to achieve optimum reduction. Waste to Energy plants equipped with SNCR has achieved NO_x reductions of about 45%.
- Carbon Monoxide: By efficient combustion with proper distribution of primary and secondary air and continuous agitation of fuel on the grate with minimum excess air, CO concentration can be minimized. The Boiler must have a Gas recirculation system to re-circulate the flue gas thus enabling the reduction in unburnt carbon. Thus, provision of a gas recirculation system will increase the Boiler efficiency.
- Dioxin and Furans: The dioxin and furans emission is controlled in four stages in the entire project flow:
  - ✓ Extensive segregation techniques to remove all chlorinated plastics such as PVC, rubber, etc. so that it doesn't form part of the RDF.
  - ✓ Furnace design with 2 sec retention and temperature of $850^{O}C$ after secondary air injection will ensure destruction of any Dioxin formed.
  - ✓ Controlling the SPM levels to further control any potential emission of dioxins and furans, The SPM level will be maintained at 30 mg/Nm3, which is much below the national standards and will control dioxins/furans to a great extent.
  - ✓ Powdered activated carbon will be injected into flue gases before entrainment into bag filters to enable adsorption of any dioxins/furans. The activated carbon injection system will remove residual fraction of dioxins and furans if any, from the flue gases.

REFERENCES

1. Ministry of New and Renewable Energy, MNRE. National Master Plan for Development of Waste-to-Energy in India. Ministry of Environment and Forests. 2003.
2. Ranjith Kharvel Annepu, Master of Science in Earth Resources Engineering Department of Earth and Environmental Engineering Fu Foundation School of Engineering and Applied Science Columbia University in the City of New York January 10, 2012
3. Waste-to-Energy Research and Technology Council (WTERT).
4. United States Environmental Protection Agency.
5. Central Pollution Control Board, Ministry of Environment and Forests, Government of India, New Delhi.
6. Ministry of Urban Development, Government of India, New Delhi.
7. National Environmental Engineering Research Institute (NEERI).
8. Ecoprog Waste to Energy 2013/2014 – The World Market for Waste Incineration Plants.
9. Karnataka Waste-to-Power (KWP) report.
10. www.coenrady.com
11. Sustainable Solid Waste Management in India by Ranjith Kharvel Annepu.
12. Municipal solid waste management in Indian cities – A review by Science Direct
13. Waste to energy basics- A Cleantech Report
14. http://www.bioenergyconsult.com
15. www.wikipedia.com
16. www.google.com
17. www.googleimages.com
18. Graphical Analysis : by Preeti Jain, Author