

# Exploring the Possibilities of Converting Waste to Energy for Sustainable Management of Biomass at Small Scale

Dr. Vibha Upadhyaya<sup>1</sup>

Professor, Amity School of Architecture & Planning, Amity University Rajasthan, India<sup>1</sup>

**ABSTRACT:** The disposal of solid waste generated by urban population has become an issue of environmental concern. Indian cities generate thousands of tons of solid waste daily. The improper management and unavailability of suitable facilities for treatment of waste has resulted in the pollution of the environment and unhygienic conditions. Municipal Solid Waste is mainly biodegradable waste due to kitchen and garden waste. Transportation of waste to landfill site is a major component of Solid Waste Management and does not seem to be a feasible option given the decaying nature of biomass which creates a lot of nuisance while transportation. Also due to high cost involved in transportation, most of the time entire waste is not transferred to the landfill site or a central facility for treatment. Biomass is an important source of energy and vital alternative to fossil fuels, which can be utilized for a range of energy needs. Thereby a small-scale decentralized treatment facility near the origin of waste for the production of energy can be the best-suited method for municipal solid waste management. This article takes Jaipur Municipal area as a case study and explores the feasibility of small-scale treatment technology at waste generation site, while generating energy from it.

**KEYWORDS:** Sustainable, Municipal Waste, Biomass, Waste Management, Energy generation

## I. INTRODUCTION

Environment has not been a major concern until recent decades. Throughout the history, people have taken resources from nature, transformed them into products for their use and then discarded the left over.

Biomass is the oldest and the most commonly used renewable energy source, derived from the carbonaceous waste of various human and natural activities etc. Biomass is considered as an important source of energy and vital alternative to fossil fuels and can be used for a range of energy needs. Biomass based power generation is renewable, widely available, carbon neutral technology and has the potential to provide significant employment and income generation.

In urban areas, biomass is available in the form of municipal waste. Municipal solid waste (MSW) includes household waste and other waste in a city. It is an unavoidable by-product of human activities. It is simply no longer possible to avoid waste that we create in different forms viz; Solid, liquid or gaseous and disposing of them is becoming more and more of a burden. It includes residential and commercial wastes generated in notified municipal areas in solid or semi-solid form. It also includes treated bio-medical wastes but excludes industrial hazardous wastes. In major cities of India, the maximum components of MSW is biodegradable waste (45-50%), this is mainly due to kitchen and garden waste. However, this composition is changing rapidly due to urbanization and changing life style of people, consumption habits are changing, increasing dependency on packaged food etc. Solid Waste management is a most serious and most discussing issue now days. This is because the services are poorly performed, resulting in problem of health, sanitation and environmental degradation.

There is paucity of land in urban areas resulting in the need to transport the waste to far off areas, but many times due to high transportation cost and technical problems, the entire waste does not transport to the landfill site. Open burning as a common treatment at many places happens at ground level, the resultant emissions enter the lower level-breathing zone of the atmosphere, increasing direct exposure to humans. This is having a devastating impact on ecosystems and cultures. Hence proper management of solid waste is utmost important.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 6, June 2017

## II. EXISTING SITUATION OF WASTE MANAGEMENT IN JAIPUR

At present due to increasing population and commercial activities there is lot of waste generation but there is a lack of proper waste management in the city. Solid waste management has emerged as one of the most pressing urban environment issues for the city, as the majority of the city does not have a primary waste collection system.

In Jaipur, Municipal Corporation is responsible for solid waste management. Initially conservancy system existed for solid waste disposal in Jaipur. Presently it is a combination of formal and informal sector. Recognizing the problem of Collection, Segregation and transportation of waste, JMC is trying to intensify efforts to make efficient SWM. JMC has divided the administration in 8 different zones for decentralized waste management. According to JMC, the estimated quantity of waste generated in the entire city is around 1280 TPD but only 80% (around 1024 TPD) solid waste is collected every day which. However, there has been a significant increase in the generation of municipal solid waste in Jaipur over the last few decades.

In Jaipur, the Municipal waste component mainly includes biodegradable waste, Plastic, rags, Paper, inert and Glass etc. the composition of waste in Jaipur as per (CPCB) is as follows:

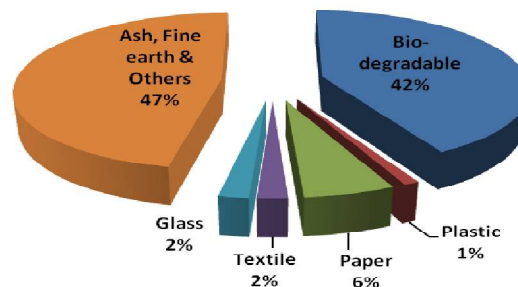


Figure 1 Composition of MSW in Jaipur

Source: Singh Amit, 2011, Municipal Solid Waste Management in Jaipur: Current Status and Way forward, state Pollution Control Board Rajasthan

Municipal waste consists of household waste, wastes from hotels and restaurants, construction and demolition debris, sanitation residue, and waste from streets etc.

### A. GENERATION OF WASTE IN JAIPUR

The daily estimated generation of municipal solid waste in Jaipur city is about 1000 to 1100 TPD (tonnes per day), which is collected through street sweepings and from communal waste storage sites. The quantity of waste generally transported each day is 900 TPD, which is about 85% of the waste generated in the city. Remaining solid waste transports through special weekly/fortnightly drives.

Table 1 Solid Waste Generation in Jaipur City

I	year	Population (Lakh)	Solid waste generation (MTD)
1	2001	23.23	1161.5
2	2011	30.73	1536.5
3	2015	34.75	1737.5
4	2021	40.85 (Projected)	2042.5*

Source: Compiled by Author (Census of India and Population Projections (\*As per CPHEEO manual Per capita waste generation in Jaipur is @ 0.5kg/capita/day))

MSWM of Jaipur city is that the main system of primary collection of waste is street sweeping. Some roads cleaned each day while some cleaned periodically, twice a week or once in a week, this street sweeping collect in the community bins. Domestic waste collection happens with traditional tricycles and further deposit in temporary bulk storage at open sites or garbage bins. In this system, residents deposit their waste into the nearest community bins located at street corners at specific intervals.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 6, June 2017

## B. COLLECTION OF WASTE

There is also no facility for separate collection of bulk waste. Door to door, waste collection practiced in the Nagar Nigam in which Private parties covers 84% area while, resident welfare associations covers 8% and NGO/CBOs further 8%. Numbers of establishment covered by Door to door service are:

Table 2 Waste generation in Jaipur MT/month

SI	Source	Waste Generation MT/Month
1	Households	39,000
2	Hotels & Restaurants	100
3	Commercial establishments (incl. offices, institutions)	900
4	Total	40000

Source : MDP 2025-Jaipur Region

Out of total waste generated waste collection is only 40,000 MT/month for processing and disposal, from which only 5000 MT/month further goes for Processing & recycling facilities while rest 35000MT/month of waste is disposed at disposal sites.

## C. TRANSPORTATION OF WASTE

There are varieties of vehicle in use for Transportation of waste such as Dumper plaser, tractor-trailer, Tipper trucks, compactor, three-wheelers, and handcartsetc. The transport vehicles are generally open and uncovered; thus during transportation, the waste tends to spill onto the road resulting in unhygienic conditions. The MSW collected from the dustbins and collection point's further transport to the disposal sites. In addition, there is lack of sufficient transfer stationtherefore, the same vehicle, which collects refuse from individual dustbins and communal bins, takes it to the disposal sites. This process increases the frequency of the vehicles from source to disposal sites and causes wastage of time, work force, fuel and money. In addition, transportation within the walled city becomes difficult due to the narrow width of the inner roads.

## D. DISPOSAL OF WASTES

There are three municipal landfill sites around Jaipurat Mathura-das-pura, Sewapura and Langariyawas, covering a total area of 859 Bigha. The waste generated in the city dumps at two landfill sites (Mathuradasapura, Sewapura) without any treatment; this unscientific disposal may be a lead to percolation of pollutantsinto the groundwater. The third site has a MSW processing plant with an installed capacity of 400 -500 TPD of MSW with generation of 130-140 TPD Refuse Derived Fuel (RDF) in the form of fluff. This plant is not able to fulfill the objective of waste management because; due to lack of waste segregation at source and collection point, more than 50% of waste is rejected pre and post processing..

## E. ISSUE IN WASTE MANAGEMENT

Municipal waste management is a major issue as there is lack of integrated waste management. Urban Local Bodies spend around Rs.500 to Rs.1500 per ton on solid waste management in which, 60-70% of the amount is on collection alone while 20% - 30% on transportation, but there is hardly any amount is spent on treatment and disposal of waste. Other issues of municipal waste management in Jaipur are as follows:

- There is no segregation of dry & wet waste in Jaipur.
- Most of the drains beside the road and even main sewer lines chock due to indiscriminate dumping of garbage.
- There was lack of garbage collection facilities at community level in most of the area, leading to dumping of garbage nearby the living area.
- At many places, open burning of waste is in practice, which creates thick black smoke spread over large areas, polluting the environment.
- The existing garbage bins are very dirty, overflowing and not emptied regularly. People often threw the garbage outside the bins on roads. The stray animals and rag pickers sorting out garbage in public spaces create huge nuisance

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 6, June 2017

- Due to the absence of adequate storage capacity for generated refuse and poor discipline among the generators, waste continually dumps on the road.
- At most, of the places Garbage collection from the roadside bins and its transport to the dumping site, involves a lot of cost and creates unhygienic, unpleasant situation in city during transportation.
- Waste management is completely absent in highly congested areas in interiors of walled city, where waste is dumped into streets and drains. These situations cause unhygienic living conditions and water logging during rainy season.
- Management of MSW is going through a critical phase, due to the unavailability of suitable facilities for the treatment and disposal of the large amount of MSW generated daily in Jaipur city. The waste generated consequently release into the nearby environment.



Figure 2 Poor waste management in Jaipur city (Author)

Due to several legislative, environmental, economic and social constraints, the identification of the most sustainable disposal system for MSW is most important for Jaipur city. In addition, the management of the MSW needs to revamp to accommodate the changes in its quantity and quality to ensure the longevity of the environment.

### III. INTEGRATED SOLID WASTE MANAGEMENT

Various issue of waste management and consumption habits of modern consumer lifestyles are causing a huge worldwide waste problem, having a devastating impact on ecosystems and cultures throughout the world. Hence waste management is utmost important with 4R's concept i.e., Reduce, Reuse, Recycle and Recover.



Figure 3 4R's Concept of integrated waste management

Image Source: <http://csrno.ca/wp-content/uploads/2014/03/reduce-icon.jpg>

There are many renewable energy techniques available to convert the municipal waste in to energy. it ensures treatment of waste before their disposal, minimize the quantity of waste to be disposed, leading to less demand for land fill sites

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 6, June 2017

and saving on the cost of waste treatment and its transportation to landfill sites. This will also reduce environment pollution, as most wastes now find their way into land and water bodies without proper treatment.

## IV. TECHNOLOGY FOR PRODUCTION OF MUNICIPAL WASTE TO ENERGY

Biomass technologies break down organic matter to release stored energy from the sun. The process used depends on the type of biomass and its intended end use. Energy can be recovered from the organic fraction of waste (biodegradable as well as non- biodegradable). Energy from biomass can be produced in three different ways:

- Energy is produced by burning the biomass directly
- Thermo chemical process: in this biomass is converted to another chemical form by heating.
- Bio chemical process to ferment biomass anaerobically to obtain a gaseous fuel called biogas

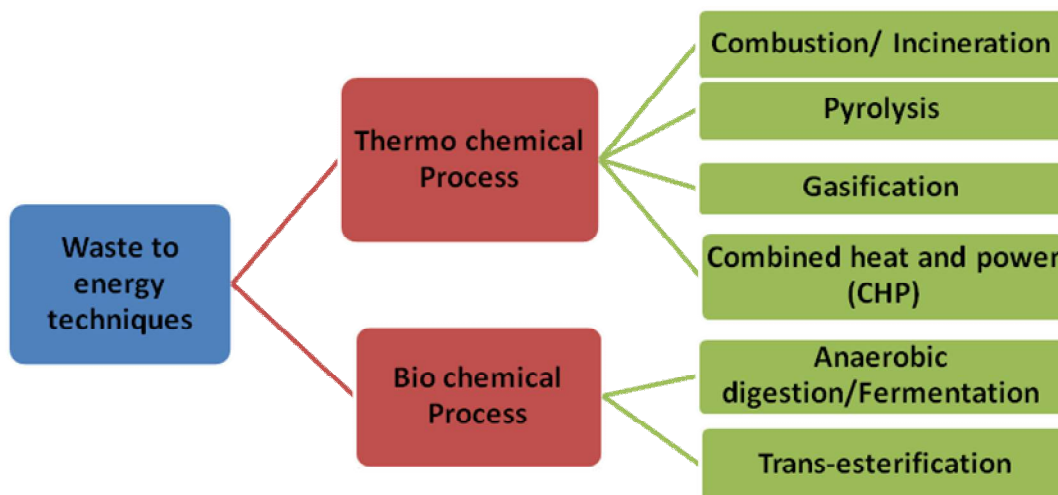


Figure 4Municipal Waste to energy technologies; compiled by author

Technologies for biomass energy are broadly classified based on principles of thermo & Bio chemical process. Each of these technologies has its uniqueness to produce a major calorific product and a mixture of by-products. **Combustion / Incineration** The basic process in this is oxidation; it is a mass burn technology with heat recovery to produce steam and/or electricity.

- **Pyrolysis** is a Process of chemical decomposition induced in organic materials by heat in the absence of oxygen.
- **Gasification** process includes heating biomass in an environment where the solid biomass breaks down to form a flammable gas, which can be cleaned and filtered to remove problem chemical compounds.
- **Refuse-derived fuel (RDF)**: It is a fuel produced by shredding and dehydrating municipal solid waste with a Waste conversion technology, it largely consists combustible components of municipal waste such as plastics and biodegradable waste. RDF processing facilities are usually located near landfill sites with an optional combustion facility.
- **Anaerobic digestion/ Bio-methanation** is a process that produces biogas from decomposed waste. The biogas can be used to power electricity generators or to produce heat. The anaerobic digestion process reduces the volume of organic matter from the waste stream, therefore reducing the amount of waste that needs to be put in a landfill or incinerated.
- **Aerobic Composting**: it is a process of composting in presence of air, in this organic matter is turned into compost by microorganisms living in the municipal waste.

Most of the technologies available in the market like incineration, Pyrolysis, gasification, and aerobic digestions have been imported and their suitability to Indian waste and environment need to be checked. Issues like non-segregation, high moisture content and large percentage of inert in Indian waste as compared to the western countries. This creates issues in effectiveness of these technologies.

Sanitary landfill technique including Gas-to-Energy recovery for management of waste is suitable for developing countries like India owing to the flexibility and relative simplicity of the technology. However, it needs a large land area for Sanitary Landfills (12 Ha for 100TPD<sup>1</sup>), but there is shortage of land in urban area, and in far away rural area, waste from city needs to be transported, which

## International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 6, June 2017

involves lot of funds and create unhygienic conditions. It needs WTE plant additionally to treat hazardous waste and involves a high operation and maintenance cost.

In India, majority of the Large scale Waste to energy plant based on aerobic composting (MBT) and anaerobic (bio-methanation) have encountered initial failures due to non-segregation of waste at source. In addition, other reasons are lower waste collection than the designed capacity, negligence in allocating funds for maintenance of WtE plant and other local conditions. However, anaerobic digestion has been successful at smaller scales, for waste from household kitchens, restaurants or hotels. Anaerobic digestion is the most suitable process to treat organic waste at small scale as it works only for waste segregated at source, which is not the case with large-scale plant, as it is not a good option for mixed waste.

### V. WASTE TO ENERGY TECHNOLOGY AT SMALL SCALE

The wastes to energy (WtE) conversion technologies convert residual wastes into clean energy, in place of sending these wastes directly to landfill. Waste to energy conversion technology explores the systems, technology and impacts of waste to energy conversion. Energy can recover in the form of usable heat, electricity, or fuel by conversion of non-recyclable waste materials through a variety of processes.

Moreover, new small-scale waste-to-energy plants will not only generate energy but also bring down the transportation cost and help in effective waste management. Waste to energy conversion technologies can not only generate significant energy but also mitigate the growing energy deficit in India.

**Table 3 Area, Costing and technical specification for small scale waste to energy plant**

Technology	Area (SqM)	Costing (Per ton/day)	Environmental issues	Waste suitability	Feasible Capacity (per day)	Limitations
<b>Composting</b>	120 SqM	4 Lakh	Impurities in compost due to mixed waste, traces of heavy metals, leachate runoff	Suitable for MSW Characteristics of India	50 TPD and above	Large Land Requirement, Non acceptance of compost as soil enricher in some areas of the Country Process depends highly on factors such as waste quality, & climatic conditions.
<b>Anaerobic digestion/ Biomethanation</b>	80 SqM	15 Lakh	Problems if mixed feedstock	Suitable for MSW Characteristics of organic waste in India	1 TPD at small scale and above 50 TPD at larger scales of pure organic waste	The technology requires pre-segregated homogenous biodegradable waste as mixed waste retards efficiency of the process. Hence applicability is limited to highly organic and homogenous waste streams like Market wastes
<b>Gasification/ Pyrolysis</b>	200 SqM	17 Lakh	Ash handling and Air Pollution	Not Suitable for MSW characteristics in India but Workable with use of Auxiliary Fuel	500 TPD and above	Requires waste with high calorific value, Expensive flue gas remediation methods to attain achievable outputs
<b>Combustion/incineration</b>	80 SqM	25 Lakh	Ash handling and Air pollution (emission of particulate matter, chlorinated compounds dioxins/furans )	Not suitable, due to high moisture in our waste	500 TPD and above	Expensive Technology, waste criteria must have low moisture content and high calorific value, which is not found in Indian Waste, Costly flue gas remediation methods to attain achievable outputs.
<b>Refuse derived fuel</b>	60 SqM	4 Lakh	Problems in burning exhaust	Not Suitable for MSW characteristics in India but Workable with use of Auxiliary Fuel	100 TPD and above	Fluff/ Pellets can be used as fuel in large industries, e.g. in cement kilns with necessary permissions from the PCBs and required pollution control measures

Source: Toolkit for Solid Waste Management, Jawaharlal Nehru National Urban Renewal Mission, 2012, Ministry of Urban Development, Government of India

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 6, June 2017

A small-scale decentralized approach to waste management is beneficial to avoid huge expense and negative environmental impact associated with the long distance transfer of waste. This type of facility has a very small footprint (2000 SqM to 8000 SqM for 300 TPD waste<sup>2</sup>) hence, can built in urban areas without creating nuisance. The problem of waste treatment can address at a local level, close to the waste source, rather than spending huge amounts on transporting waste, which creates traffic congestion and produces greenhouse gases.

As per the above table 3, Out of all technologies, **Combustion/incineration** is not suitable for Indian waste due to high moisture content while for Gasification, Pyrolysis and **Refuse derived fuel** Auxiliary Fuel is needed. Hence, for high moisture organic waste Characteristics in India **composting** and anaerobic digestion is most suitable. Further for composting, feasible capacity of plant is minimum 50 TPD which needs a land area of minimum 6000 SqM, which may not be available near residential areas, also, there is probability of impurities in compost due to mixed waste and Process depends highly on waste quality, quantity & climatic conditions, which makes it unfeasible in spite of its low cost. However, in anaerobic digestion the minimum feasible capacity is one TPD with land requirement of 80 SqM, which can be easily located anywhere in walled city at household as well as community level.

Anaerobic digestion of kitchen waste to produce biogas and liquid slurry on a small scale has been very successful in Indian condition. The small-scale units are flexible and portable also. The cost for a 3-5 member household kitchen waste is INR 21000 per unit that can generate one cubic meter of biogas every day. Biogas mainly constitutes methane and carbon dioxide and the unit can be connected directly to a cooking stove. The capacity of these biogas units is enough for households in these two cities and each unit occupies only 1.25 m<sup>2</sup> of space. For waste to energy plant, this technology can generate One cubic meter of gas can produce 1.5 KW of electricity using a generator and can be used for street lighting.

In the WtE technologies, risks of environmental pollution and health hazard are much lower than open burning of waste. In addition, cost of transportation and nuisance is much reduced. However, regular inspection is necessary to increase the life cycle of WtE plant and avoid damages. Also, Cost of WtE is high than composting. However, electricity produced from WtE plants has better product demand and no marketing issues like compost. It can be connected to the grid and it provides better pollution control compared to mixed-waste composting, which pollutes the environment. There are various technologies available for treatment and processing of waste in an environmentally sound manner. The life cycle of plant is around 20–30 years and payback period is about to be 4–5 years. It will improve the quality of life of urban population and avoid environmental pollution.

## VI. FINDINGS

The problem of waste treatment can address at a local level, close to the waste source, rather than spending huge amounts on transporting waste, which creates traffic congestion and produces greenhouse gases. A small-scale local level approach to waste management is beneficial because the long distance transfer of waste involves lot of expenses and negatively impact environmental. In comparison to the traditional mass burn incinerators, this type of facility has a very small footprint to build in urban areas without looking out of place. MSW, collection and transportation costs often account for the largest proportion of MSW treatment costs, which may be as high as 70% and may preclude consideration of certain technologies e.g. Sanitary Land filling at far away sites.

- Solid waste management is a major issue in city hence PPP (Public Private Partnership) mode shall adopt for its effective implementation.
- More open/green spaces to create by using sites of some dilapidated buildings with provision of adequate maintenance for existing green/open spaces.
- Household, commercial complexes, Hotels, restaurants and other significant waste generating sources shall be encouraged to install small-scale waste to energy plant.
- Use of treated compost product from mixed wastes shall use for gardening purposes while Ash from WtE facilities shall be used to make bricks.
- Regulatory Measures for Conservation of Surface Water and ground water shall be adopted
- Community awareness programmes need to initiate to make people hygiene conscious.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 6, June 2017

## VII. CONCLUSION

Harnessing the unexploited potential from waste will not only enhance the safe disposal of waste, reduce burden on fossil fuel but would also reduce the greenhouse gas emission. Although the energy generation from organic and biomass has now been growing prolifically, the growth can be substantially improved over time.

In WtE, Environmental pollution or health risks are much lower than open burning of waste emitting acid gases, Solid residues that endanger human health and environment. A successful SWM may lead to opportunities in other wastes in the future like industrial waste, biomedical and hazardous waste. However, the cost of WTE is higher than other renewable energy sources due to high capital, replacement and maintenance cost. Also proper segregation, moisture reduction is necessary before treating.

The main problems to implementation of the system include lack of citizen awareness and commitment, no segregation of waste, corruption, technology, and funding. For implementation of an ideal solid waste management, enforcement from authorities and support for public is essential. For public participation is needed for any successful project. An important step to motivate and engage the public is via continuous public awareness campaigns, which include promotion of the R-4 slogan (Reduce, Reuse and Recycle, Recover), advertisement on publicity boards, through local media and interactive workshops etc. Various issues related to solid waste management need to discuss during public awareness and motivation campaigns.

Informal sector people shall integrate into the formal system for management of waste by employing waste pickers for door-to-door collection of wastes and at material recovery facilities to increase recycling of waste. They shall be allowed to sell the collected recyclables waste for additional income. Training workshops need to organize, for informal sector to achieve an efficient and integrated municipal waste management. Household, commercial complexes, Hotels, restaurants and other significant waste generating sources shall be encouraged to install small-scale waste to energy plant.

## ACKNOWLEDGEMENT

The research performed in this article forms a part of Ph. D. Research of author Dr. Vibha Upadhyaya.

## REFERENCES

1. Singh Amit, Municipal Solid Waste Management in Jaipur: Current Status and Way Forward, state Pollution Control Board Rajasthan, 2011
2. Upadhyaya Vibha, Application of Small Scale Renewable Energy Techniques in Traditional Buildings of Jaipur, 2016, International Journal of Research and Scientific Innovation
3. Central Public Health and Environmental Engineering Organization, CPHEEO SWM manual, 2014
4. Govt of India, Census of India 2011
5. Government of Rajasthan, Energy Department Policy for promoting generation of electricity from biomass, 2010
6. Jaipur Development Authority, Master Development Plan-2025 for Jaipur Region
7. Ministry of Urban Development, Government of India, Toolkit for Solid Waste Management by Jawaharlal Nehru National Urban Renewal Mission, 2012
8. <http://w2es.com/turnw2e.php> Advanced technology for practical waste management and alternative energy generation, TurnW2E™ waste to energy system
9. <http://localbodies.up.nic.in/swm/chap15.pdf>
10. <http://csrno.ca/wp-content/uploads/2014/03/reduce-icon.jpg>
11. <http://www.waste-management-world.com/articles/print/volume-14/issue-6/wmw-special/a-billion-reasons-for-waste-to-energy-in-india.html>
12. [http://www.biomassenergycentre.org.uk/portal/page?\\_pageid=75,37257&\\_dad=portal&\\_schema=PORTAL](http://www.biomassenergycentre.org.uk/portal/page?_pageid=75,37257&_dad=portal&_schema=PORTAL)