TALLINN UNIVERSITY OF TECHNOLOGY
SCHOOL OF ENGINEERING

Department of Materials and Environmental Technology

# WASTE MANAGEMENT - CURRENT STATUS AND DOMESTIC AEROBIC COMPOSTING IN BENGALURU, INDIA

JÄÄTMEKÄSITLUS- HETKESEIS JA KODUNE AEROOBNE KOMPOSTEERIMINE BENGALURUS INDIAS

MASTER THESIS

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Tallinn, 2017

# AUTHOR’S DECLARATION

I hereby declare, that I have written this thesis independently. No academic degree has been applied for based on this material. All works, major viewpoints and data of the other authors used in this thesis have been referenced.

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TALLINNA TEHNIKAÜLIKOOL
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# JÄÄTMEKÄSITLUS- HETKESEIS JA KODUNE AEROOBNE KOMPOSTEERIMINE BENGALURUS INDIAS

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Tallinn, 2017.a

**AUTORIDEKLARATSIOON**

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# MASTER THESIS ASSIGNMENT PLAN

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**Master´s thesis topic:**

"Waste management - current status and domestic aerobic composting in Bengaluru, India" (in English)

"Jäätmekäsitlus- hetkeseis ja kodune aeroobne komposteerimine bengalurus indias" (in Estonian)

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**Aim and tasks of the master´s thesis:**

To understand the effectiveness of aerobic composting at home and the willingness of participants to follow aerobic composting at home after the study.

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# List of Abbreviations and Acronyms

| | |
|---|---|
| MSW | -Municipal Solid Waste |
| WTE | -Waste to Energy |
| TPD | -Tonnes per Day |
| WHO | -World Health Organisation |
| MT | -Metric Tonne |
| UT | -Union Territory |
| KG | -Kilogram |
| RDF | -Refused Derived Fuel |
| CPCB | -Central Pollution Control Board |
| NEERI | -National Environmental Engineering Research Institute |
| MWh | -Mega Watt hour |
| KW | -Kilo Watt |
| WEC | -World Energy Council |
| BNEF | -Bloomberg New Energy Finance |
| CC | -Conventional Composting |
| VC | -Vermi Composting |
| BM | -Biomethanation |
| GPCD | -Grams per capita per day |
| GOI | -Government of India |
| MOEF | -Ministry of Environment and Forest |
| JnNURM | -Jawaharlal Nehru Urban Renewal Mission |
| UIDSSMT | -Urban Infrastructure Development Scheme for Small and Medium Towns |
| MNRE | -Ministry of New and Renewable Energy |
| MTPD | -Million tonnes per day |

# 1. Introduction

Solid waste management dates back to human civilization (Christensen, 2011) [4], it started as a way of sanitary and cleaning the city wherein they disposed wastes in dumps or set them on fire. This was then steered on to Modern Waste Management followed by the new chemicals.

Urbanisation and economic growth have led to increasing amount and complexity of generated solid waste (Gidde et al., 2008 [09], Rathi, 2007 [20]). Thus, generated solid waste cannot be just lying in the landfills.

Solid wastes are classified as:

1) Municipal,
2) Industrial wastes,
3) Construction and Demolition wastes, and
4) Other types of wastes, as shown in figure 1 below

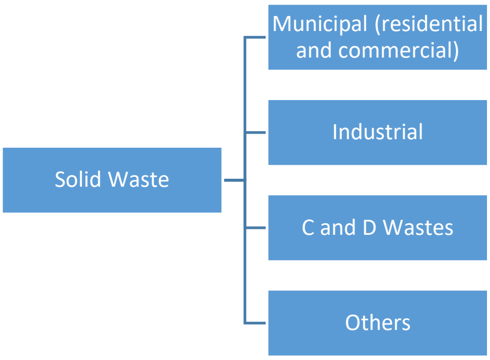


**Figure 1:** *Classification of solid wastes*

European countries and the USA and other developed countries have been following Waste Management strategies by recycling, and WTE than landfilling the wastes. These nations do follow Sanitary landfills which can protect land and groundwater.

India being a developing country has 1,342,512,706 (worldometers.info [18]) population as of 19th May 2017. Due to the changes in the pattern of livelihood and the nature of living, urbanization has bloomed. In addition to this changes, economic growth due to industrialisation has resulted in rapid increase in urbanization. Urbanization and increase in population has led to increase in waste generation in the urban areas. According to previous research by Jha et al., (2011) [13], Herat, (2009) [12] and Tchobanoglous et al., (1993) [23], Municipal solid waste generally includes degradable (paper, textiles, food waste etc), partially degradable (wood, disposable napkins etc) and non-degradable materials (leather, plastics, rubbers, metals, glass, and electronic waste).

As per reports of Ministry of Environment and Forests (MOEF), by Javadekar in 2016 [10], 62 million tonnes of Waste is generated annually at present in India. Bengaluru, a metropolitan city in India is studied in this study. As per Bruhat Bengaluru Mahanagara Palike (BBMP, Bengaluru's municipal governance) 2017 reports [22] Bengaluru is been treating only around 20% of total waste generated.

In spite of having four waste processing facilities following composting and Biomethanation up to a capacity of 1800 MTPD in Bengaluru (BBMP report, 2017 [22]). It is been impossible to achieve any better in terms of treating more waste or reducing the landfill due to the fact that the waste generated is not efficiently segregated, collected and transported to waste to energy (WTE) facilities.

Some people have been putting effort in segregating the waste at source since the 1st of February 2017 after it has been made compulsory BBMP reports, 2017 [22]. Although this is not achieved completely yet, because, most of the population in both residential and commercial places ignore this. Secondly, they are unsure on how else they can utilise the raw materials in hand at home to help reduce landfilling. WTE methods especially aerobic composting can be easily followed at home, to reduce landfilling of compostable waste.

However, most of the middle class group families in Bengaluru would hesitate to spend money to buy any materials necessary to carry out aerobic composting at home.

Also, there is a dearth of study on the usefulness of aerobic composting at home in Bengaluru.

Considering all these factors and the recent landfill mess in Bengaluru, it prompted me to undertake a study to see if aerobic composting at home with the materials already available in the household have any positive impact on families and on reducing the amount of waste that goes to landfill and would these families be interested in following this every day to help our environment?

In depth literature review, current status of waste generation in Bengaluru, waste management status in Bengaluru, and aim of the study are discussed in the upcoming sections below.

## 2. Waste generation in India

There are very finite number of studies or reports that shed light on the current status of waste generated in India. And most of those reports are paid reports. Thus, I have enlisted classic studies and have paid more attention on the city of Bengaluru in later section of this thesis.

MOEF, 2016 [10] reported that, 62 million tonnes of Waste is generated annually at present. Out of which, Compostable waste or bio-degradable waste (Food and kitchen waste) constitutes nearly 48 million tonnes, plastic wastes of 5.6 million tonnes, 0.17 million tonnes of biomedical waste, 7.9 million tonnes of hazardous waste and 0.15 million tonnes of e-waste, as shown in figure 2 below.

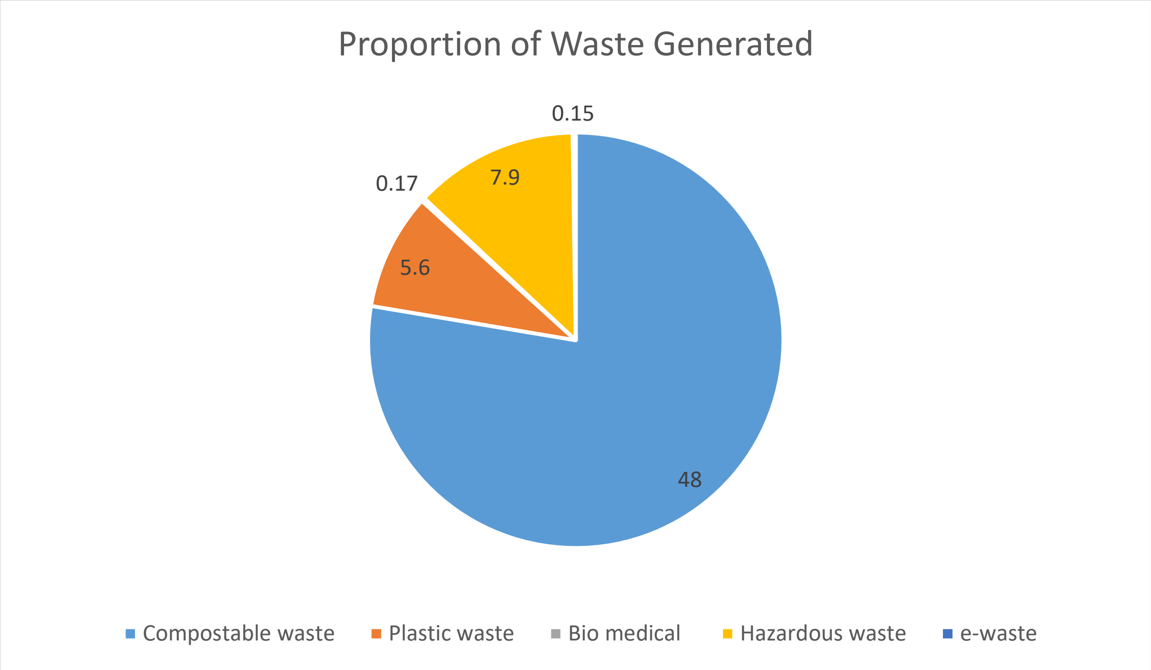


**Figure 2**: *Proportion of different types of waste generated*

*Source: Ministry of Environment and Forests (MOEF), by Javadekar in 2016 [10].*

A study by Joshi and Ahmed, 2016 [14] showed that Municipal Solid Waste (MSW) in India has approximate 77% of compostable wastes, 11% inert waste and 12% recyclable wastes. It also states that in totality Indian waste consists of Nitrogen content (0.64 ± 0.8) %, Phosphorus (0.67 ± 0.15) %, Potassium (0.68 ± 0.15) %, and C/N ration (26 ± 5) %.

All of which equates to per capita waste generation of 200 grams to 600 grams per day. It is also seen that per capita waste generation is increasing by about 1.3% per annum, thus, in turn leading to annual rise in waste generation is around 5% each year.

Ministry of Environment and Forests (MOEF), by Javadekar in 2016 [10] reported that the total quantity of waste collected is only around 43 million tonnes per annum equating to 75-80% of the waste generated, among this nearly 27% of waste which is 11.9 million tonnes per annum is treated and the remaining 73% of waste collected that is 31 million tonnes per annum is dumped in landfill sites as illustrated in the bar graph below (figure 3).

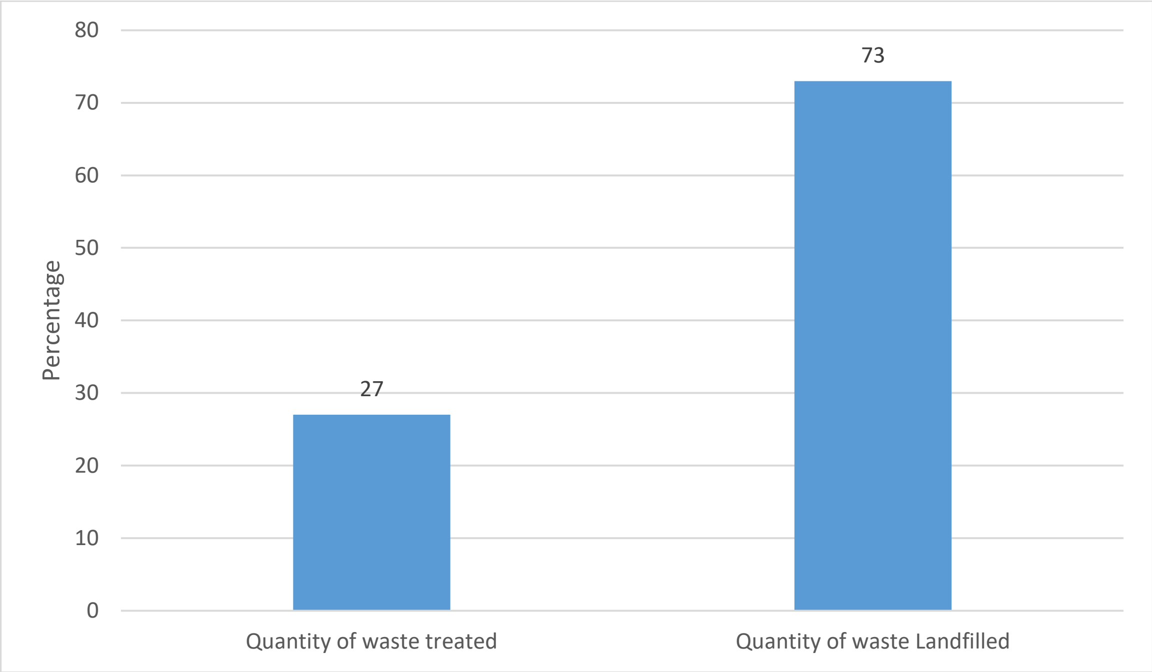


**Figure 3:** ***Amount of waste landfilled***

*Source: Ministry of Environment and Forests (MOEF), by Javadekar in 2016 [10]*

Indian cities mostly rely on unscientific disposal of waste. Planning Commission Report, 2014 [16] speculates that by 2031 and 2050, Indian urban centres will generate 165 and 436 million tonnes of waste per year respectively. Considering an average per capita waste generation per day being 450 gram, it is estimated that by 2013, India requires about $23.5 \times 10^7$ cubic meter of landfill space which equals to area of 1,175 hectare of land per year. And that by 2050, it would be increased to 43,000 hectares for landfills piled in 20 meter height.

Numerous study by many researchers (Noorjahan et al., 2012 [15], Chatterjee, 2010 [3], Das and Bhattacharya, 2013) [7], have all reported that there has been improper management of solid waste in different cities in India. The other reasons being: irregular sweeping of streets, utilizing open trucks to transport waste, uncontrolled and unscientific dumping of wastes in land resource which causes air pollution and ground water contamination and also becomes a place for disease spreading insects to increase in number. In India, the health risk from open landfill of wastes is more than the risk of Malaria.

According to the Report of the Task Force of Planning Commission [16], the untapped waste has a potential of generating 439 MW of power from 32,890 tonnes per day of combustible wastes/biodegradable wastes including Refused Derived Fuel (RDF), 1.3 million cubic metre of biogas in a day, or 72 MW of electricity from biogas and 5.4 million metric tonnes of compost per year to aid agriculture.

# 3. Status of Waste generation in Bengaluru, Karnataka

Currently, collection of waste efficiency in Karnataka is around 37% which is less than national average and makes it stand at second but last state/region in waste collection efficiency.

Bengaluru is draped over the Deccan Plateau and is situated at an altitude of 949 meters (3113 ft.) above sea level, thus it has possibly the best climate in India. Bengaluru is spread across 800 square kilometres and has a population of 9.6 million. According to BBMP, 2017 reports [22], Bengaluru generated about 3000 - 3500 tons of Solid Waste daily. Out of which, 58.5% of the Bengaluru's waste generation comes from households, commercial places contribute 41.5% of it. This means that the Per Capita waste generation per day in a household is 309g. However, only 20.1 % of the generated waste is treated (700 TPD of waste is treated out of 3500 TPD of generated wastes). The capital city of the county (State), Bengaluru has numerous steps taken to achieve improvement in MSW management. BBMP is the corporation which is in charge of undertaking necessary steps and guides MSW management.

As an in charge local authority, BBMP takes care of street sweeping, collection, transportation, processing and disposal of MSW. BBMP has a system of door to door collection of MSW, which is then is processed prior to landfilling.

## 4. Waste management

Holistic waste management focuses on all of the following steps in certain chronological order. The waste management hierarchy gives top priority to preventing the generation of waste in the first place by using less materials or by designing long life materials. Once waste is generated, it prioritises re-use by cleaning or repairing or by refurbishing materials or parts. After this recycling is given priority in which waste is converted into new materials. Next step in hierarchy is recovery (such as energy recovery) using anaerobic digestion, using waste to energy (WTE) methods such as incineration with energy recovery, composting, gasification, biomethanation and pyrolysis all of which produce energy or fuels. The last step of resort is disposal (landfill) using landfilling and incineration without energy recovery. Such systematic waste management is illustrated in figure 4 below.

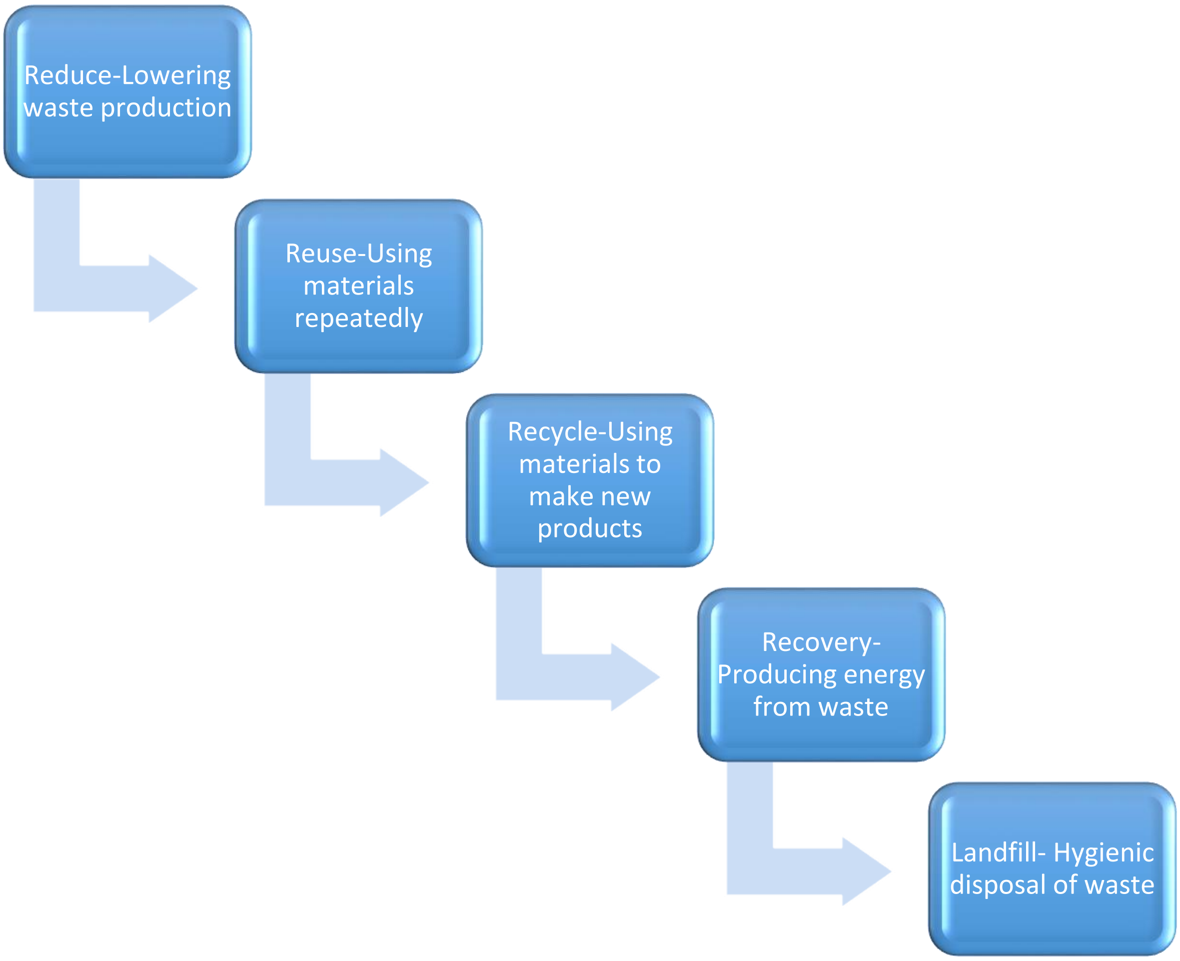


**Figure 4:** *Waste management hierarchy*

The hierarchy shows the movement of a material in successive steps of waste management, and the life-cycle of each of the product. Each stage of the waste management hierarchy offers opportunities for innovative intervention methods to rethink the need of the material, to redesign in such a way to minimise its waste production, to extend its use to decrease waste generation and to recover the energy from it.

## 4.1. Current status of waste management in India

Reduce: Increase in population and urbanisation in India has led to production of MSW in increasing quantities day by day. Though Government has made policies, none have made any improvement in this sector. In addition, there have been changes in the types of wastes released to landfills too. Though this is the most logical option to reduce the amount of waste produced. Efficient packaging can be one of the ways in achieving this.

Reuse: India is been very dependent on plastics in the form of shopping covers, bottles etc. However, all these reusable materials still end up in landfills.

Recycle: Recycling is a way of converting used materials/wastes into new materials that can be used. This leads to less reliability on raw materials in order to make new products, also helps in waste management and reduce water, land and air pollution. However, Indian government realised the importance of recycling and is been promoting recycling lately. In order to enforce recycling at primary level, Government of India has already made new rules that the shops should use paper bags or reusable bags for commercial purpose. Also, if they are issuing plastic bags then they should be below 50 microns (Plastic Waste Management Rules, 2016) [17].

In spite of this effort from government, recycling of wastes in household is still not followed in major cities.

Unsegregated waste always gets dumped at community waste bins, and thus, optimal recycling of waste is impossible. However, rag-pickers do sort out glass, plastics etc and sell them to recycle.

Recycling can be utilised to manage plastic waste. The utility and strength of plastic reduces every time plastic is recycled. Later, plastic can be turned into fuel by liquid fuel or used in polymer blend bitumen roads.

However, due to technical and economic limitations of recycling of materials, design of the product, lack of source segregation, most of the MSW generated in India ends up in landfills.

Recovery: India has been relying a lot on non-recyclable materials and increase in urbanisation and with the emerging Information Technology (IT), generation of waste is out of control and such non-recyclable wastes can only be handled by following efficient way of waste to energy (WTE) technologies.

India has been relying on Biomethanation and composting methods of WTE mostly and rest of the waste generated is landfilled.

Landfill: Wastes which are left after recycling and recovery are landfilled. Landfill is a carefully engineered structure where wastes are isolated from groundwater and air. Sanitary landfill consists of clay liner to separate the trash from environment.

Developing new sanitary landfills or either expanding existing landfill are carried out in the states such as Andhra Pradesh (Vijianagaram), Delhi (3 sites), Gujarat (8 sites), Haryana (Sirsaand Ambala), Karnataka (12 sites.), Madhya Pradesh (Gwalior and Indore), Maharashtra (6 sites), Punjab (Adampur), Rajasthan (Jodhpur), and West Bengal (17 sites) (CPCB, 2013) [02]. Till date, India has 59 landfill sites and 376 are under implementation and nearly, 1305 sites have been identified for future use.

Efficient conversion of wastes to energy seems to be a sort after method to reduce landfilling and also reduce the dependency of India on coal for its country’s energy requirements.

## 4.2. Types of WTE technologies

WTE technologies can be mainly classified as below:

1. Bio-chemical method of WTE technologies: Most suitable for wet wastes consisting of organic matter.
2. Thermo-chemical method of WTE technologies: Controlled combustion of waste which gives heat to produce steam which in turn produces power using steam turbines. Most suited for low moisture feedstock. Has high conversion rates.

India generates about 48 million tonnes of compostable waste (food and kitchen waste), out of total 62 million tonnes of wastes generated annually (Javedkar, 2016) [10]. Thus, the commonly followed methods of WTE in India are Composting and Biomethanation, which are discussed in detail below and a short overview of thermos-chemical method of WTE technology is given as well.

### 4.2.1. Types of Bio-chemical conversion of Bio-Degradable wastes

The bio-chemical method followed to process wastes and convert into electricity, is as illustrated in the figure 5 below.

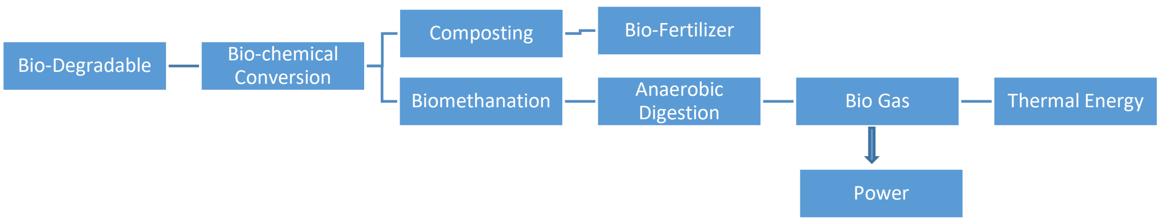


**Figure 5:** *Types of Bio-chemical conversion of Bio-Degradable wastes*

#### 4.2.1.1. Composting

Composting is a biochemical conversion of biodegradable MSW in aerobic condition, during which biological conversion of organic or biodegradable matter occurs in the presence of air and heat. The resulting end product called compost or humus has high nutrient value, it is dry, dark, brown, crumbly and earth smelling. The volume of this however is much less nearly 40-50% when compared to the volume of the raw materials that were used, this is mainly due to the water respiration and biochemical breakdown. Composting method is advanced recently, such that consortium of microbes and odour masking agents are used to reduce the processing time.

The resulting compost has following merits:

i) Benefits to our garden soil: improves quality of soil, structure of soil so that it can retain nutrients, moisture and air.
ii) Reduces the landfill pile
iii) Reduces the need of artificial fertilizers
iv) Provides nutrients to soil
v) Reduces the pests
vi) Maintains soil pH

Aerobic composting is widely practised even in small scale at home. However, in India there is little awareness and there is no segregation of wastes at source and people expect government to harness the energy from waste. Creating awareness can go assist in reducing landfill. However, even when following aerobic composting at home one should remember to consider some of the following important factors that can affect aerobic composting:

I) Carbon to Green Ratio(C:N): In order to ensure proper decomposition of organic materials a proper ratio of C:N is essential. Carbon or brown represents dry materials which provide carbon and similarly, nitrogen or green materials are wet organic materials which provide nitrogen and heat to the process. Literature shows that adequate C:N ratio is 30:1 as this creates balance and assists microorganisms to digest the raw materials well [19]. The chemical composition of brown and green is referred to here and not the actual volume. Since, identifying the exact C:N from different types of waste differ, the best practice is to use 2 parts of green to 1 parts of carbon.
II) Air: Turning the mixture once a while gives enough aeration, porous tank helps, using straw and dry leaves too helps to achieve this.
III) Moisture: Microorganisms need adequate water to live and carry on decomposition. Again moisture level required depends on materials used, the best practice is to ensure that the raw mixture is wet to touch and squeezes out one or two drops of water.
IV) Temperature: Temperatures between $32^0$C and $60^0$C enables rapid decomposition. Outside temperatures also influences the decomposition. In spring, summer decomposition is faster than in winter.

V) Particle size: Neither large nor powdered. More surface area that is available for microorganisms ensures good microbial activity, hence, shredding the materials to smaller pieces works best.

Resulting compost will be usually half the volume of the raw material used depending on all the above factors discussed and also the method used.

#### 4.2.1.2. Vermicomposting

Vermicomposting is where earthworms are added to semi-decomposed organic waste. As it is well known that earthworms can consume at least five times of organic matter each day than their actual body weight.

Firstly, biodegradable waste is decomposed via microbial activity. Earthworms consume the organic fraction of wastes and excrete (Vermi casting), which is then sieved and used as bio-organic fertilizer as shown in figure 6 below.

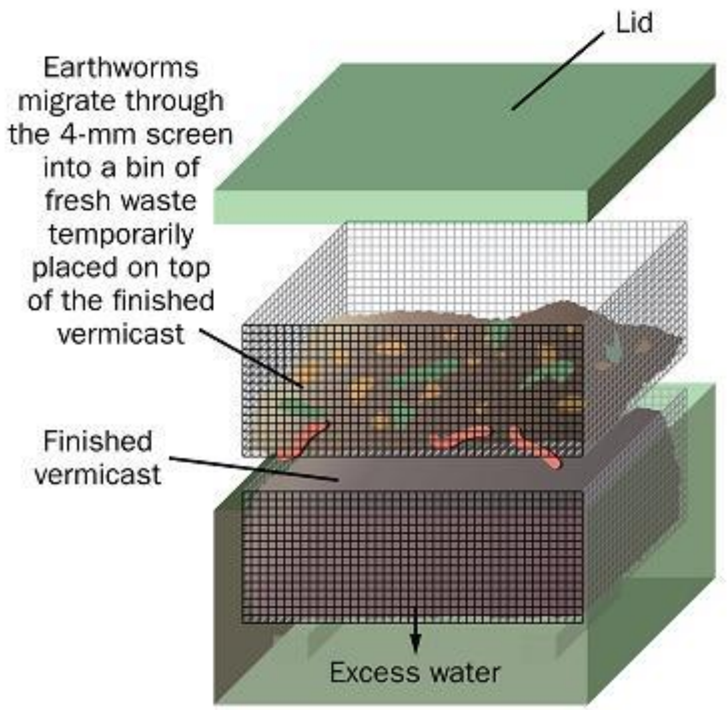


**Figure 6:** *Vermicomposting*

*Source: Ontario Ministry of Agriculture, Food and rural affairs, Canada [11]*

The vermicompost can be composed to improve soil health and moisture retaining capacity and thus it is known as bio-organic fertilizer.

### 4.2.1.3. Biomethanation

Biomethanation is anaerobic digestion which converts organic materials into biogas, a gaseous combustible mixture, of methane ($CH_4$) as illustrated in figure 7. Using this method, biodegradable municipal waste is biologically treated to recover nutrients and energy. Biomethanation consists of a chain of biochemical transformations as follows:

a. First Stage: This consists of hydrolysis, acidification and liquification.
b. Second Stage: In this stage Acetate, Hydrogen and Carbon di oxide are transformed into Methane.

Thus the process results in biogas with high methane content (55-75%) which can be used as fuel. This process also gives manure as end product along with Biogas which is of better quality than that of composting technology. In addition to these, Biomethanation also produces organic slurry, which can be used as organic fertilizer.

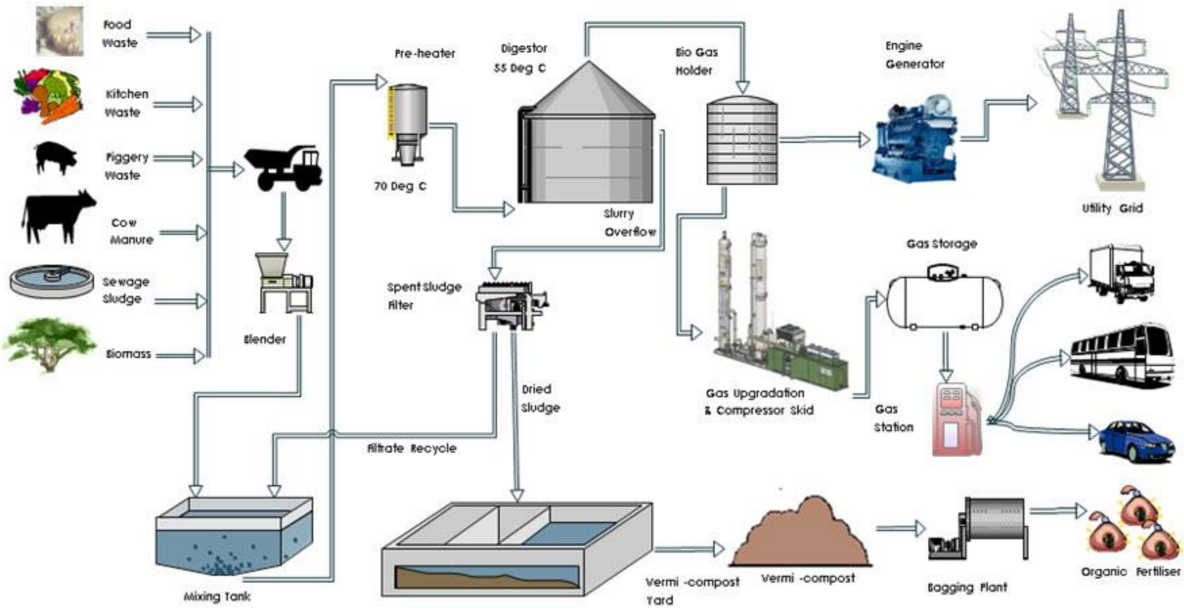


**Figure 7:** *Overview of Biomethanation process*

*Source: Closed looped systems India private limited [05]*

Biogas consists of Methane, Carbon di oxide (30-45%) and traces of Nitrogen, Oxygen, Hydrogen sulphide, Hydrocarbon, Ammonia, Water vapour and Siloxanes. According to Becidan (2007) [01] organic fraction of MSW can be treated well using anaerobic digestion.

The end product Biogas can also be converted into Bio methane by removing carbon di oxide from Biogas and used as transportation fuel or it can substitute natural gas even in industrial applications. About 1 cubic metre of Methane can produce 9,000 kilo calories of heat. In a cogeneration engine both heat and electricity can be produced from Methane gas.

Biomethanation can be used to manage segregated organic wet waste from kitchen, hotels and markets. Biomethanation can be employed in a centralised manner in small towns and in a decentralised manner in large cities.

Among these two methods, Composting is easily achievable in any home and can reduce pile of wastes that end up in landfill.

### 4.2.2. Types of Thermal processing of Combustible wastes

The bio-chemical method followed to process wastes and convert into electricity, is as illustrated in the figure 8 below.

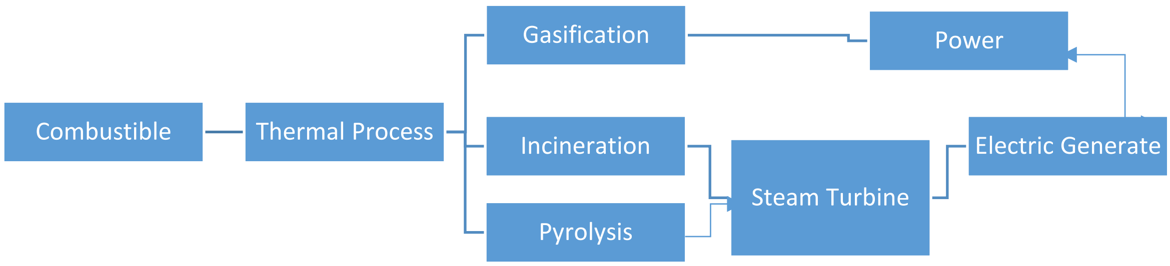


**Figure 8:** *Types of Thermal processing of Combustible wastes*

#### 4.2.2.1. Incineration

In this type of thermal processing, complete combustion of waste occurs to recover heat which is used to produce steam, that is then used to produce power through the steam turbines as shown in figure 9.

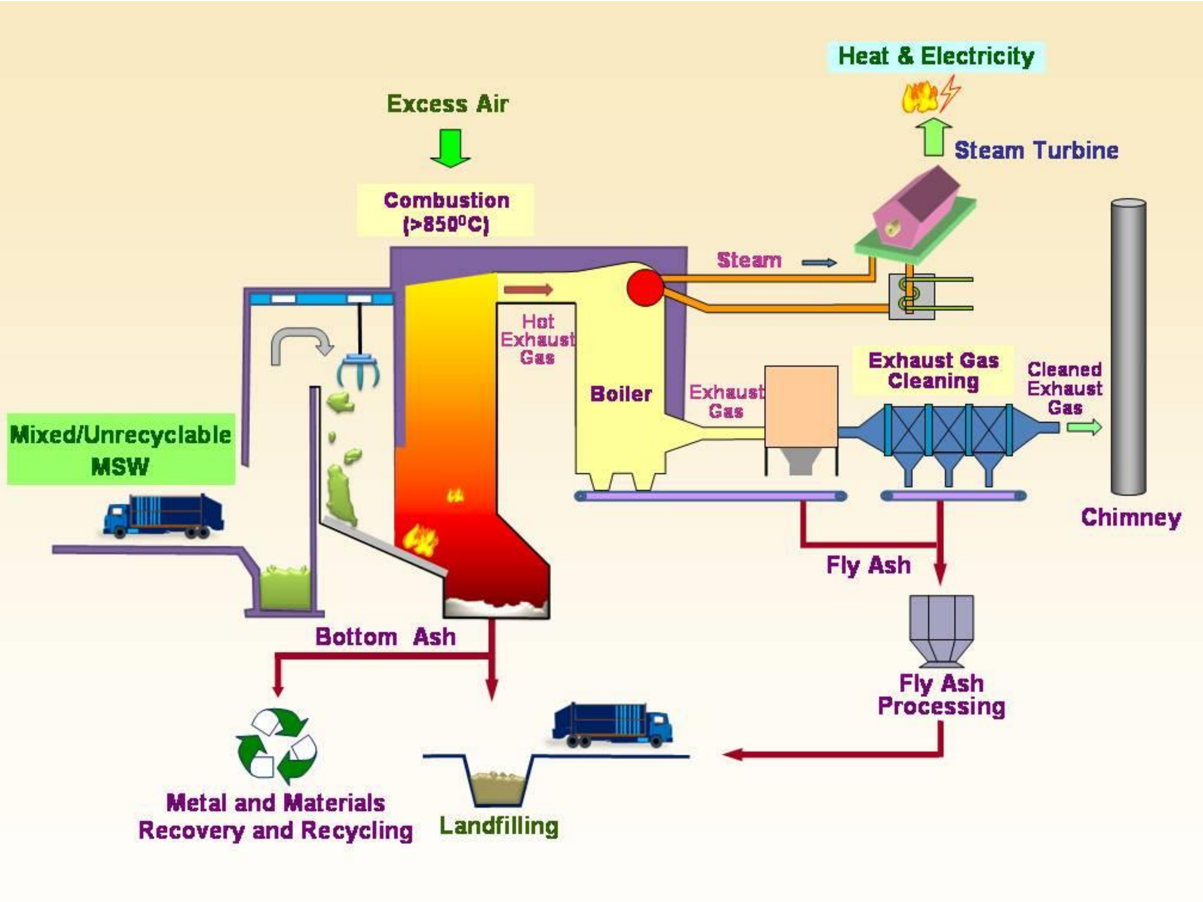


**Figure 9:** *Incineration Process*

*Source: Environment Protection Department, HK [08]*

The efficiency of incineration depends on temperature, time and turbulence. This efficiency could be improved up to some extent if the combustible wastes are first converted in to Refused derived fuel (RDF). Using RDF can boost WTE plants in India, since RDF is easily transportable, also it can be prepared in small decentralised facilities.

### 4.2.2.2. Pyrolysis

This process uses heat to combustible polymeric materials without oxygen (Figure 10). This produces combustible gases (such as methane, hydrocarbon, hydrogen and carbon monoxide), and residues. The residues are liquid residue (bio-oil or tar) and solid residue (carbon black or biochar). Carbon black can be used as catalyst or to absorb carbon di oxide from coal power plants. Fast pyrolysis is used for the production of Bio-oil, whereas slow pyrolysis of bio char. The calorific value of pyrolysis is more for RDF than MSW.

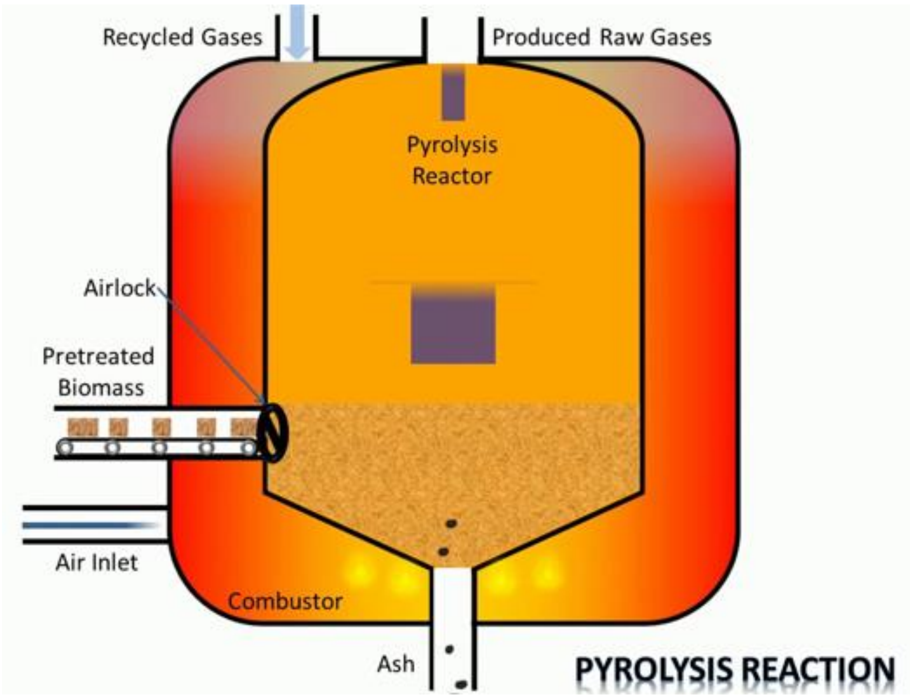


**Figure 10:** *Pyrolysis Process*

*Source:* Renewable and Sustainable Energy Reviews *[06]*

This procedure uses lower temperature value (about 650 degree Celsius) than gasification. The gas produced is used in boilers to produce heat or in turbine generators. This procedure minimises emission and organic wastes. Bio-Oil is of high viscosity and density and also it is highly oxygenated. It can be combusted in boilers or gas turbines.

### 4.2.2.3. Gasification

This is a type of bio mass conversion to energy, this procedure results in combustible gas, synthetic fuels and it also converts organic materials into carbon monoxide, hydrogen and carbon dioxide (Figure 11). This procedure uses high temperature up to 1800 degree Celsius.

The resulting syngas is used in chemical industry or to produce heat and electricity. Syngas can be used to produce various Bio-automotive fuels, methanol, chemicals and ammonia etc.

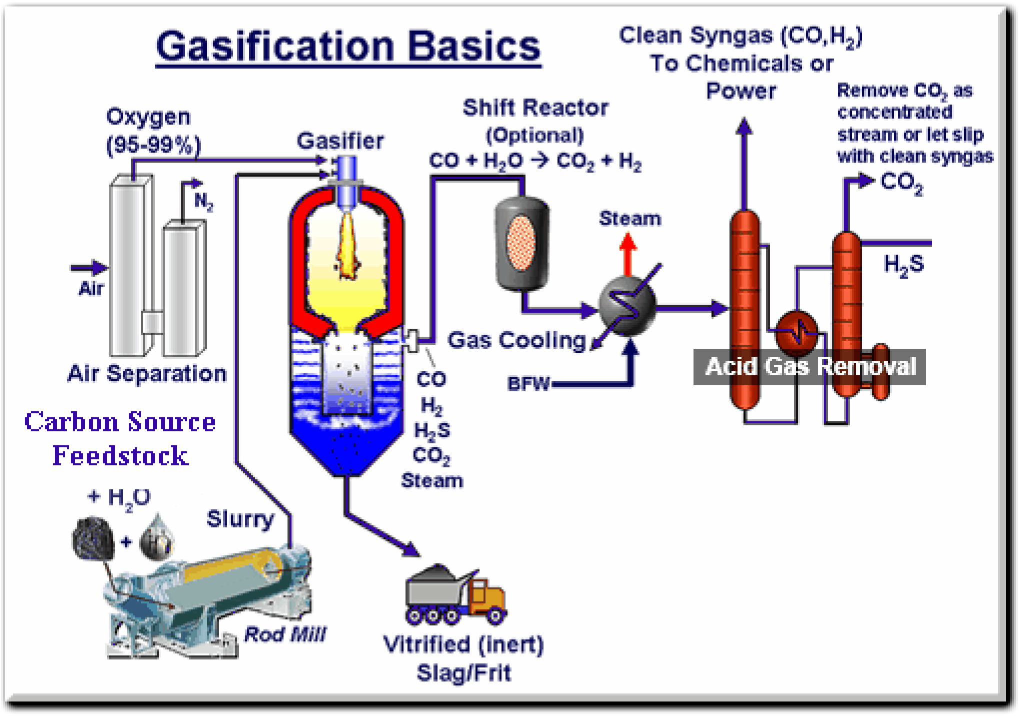


**Figure 11:** *Overview of Gasification*

*Source: Waste 2 energy world [24]*

Gasification of wastes produces efficient power and reduces emission. The resulting gas is then processed in furnace and in internal combustion engine. The efficiency of gasification is higher than incineration.

# 5. Current waste management status in Bengaluru

Bengaluru being a metropolitan city, has been developing rapidly in industrialisation, which has led to increase in population moving and living in Bengaluru. BBMP has taken several steps to streamline the MSW management in the city. The present status based on BBMP report, 2017 [22] is as below:

BBMP has made a compulsory procedure to segregate waste at home since the 1st of February 2017 (BBMP report, 2017 [22]). However, not all the wards have been following this strictly yet. BBMP ensures waste management by following the steps below:

1. Collection of waste: Nearly 80% of the waste collection and transportation has been outsourced. Primary waste collection is carried out using two main types of vehicles, which are pushcarts and autos. An auto are provided for every 1000 households and a pushcart for every 200 households.

   a) House to House collection
   b) Vegetable/ Fruit Market Waste
   c) Construction Demolition Waste

2. Segregation of Waste: Households are asked to segregate wastes generated into wet and dry waste. Currently only about 30% of waste is segregated at source

3. Storage of waste: Bengaluru has litter bins only in the commercial areas. Households are not provided with the bins and the waste collected from door to door of the households is brought to a common area which is then transported to the disposal sites using lorries/trucks.

4. Transportation of the waste: There are 670 vehicles that are used for the transportation of MSW to the processing and landfill sites. These vehicles consists of 240 compactors, 430 lorries/trucks.

5. Processing of waste. The wet and dry wastes are processed differently. Wet wastes are processed using decentralised approach. Following decentralised wet waste processing plants are in place currently in Bengaluru.

i. Bio–methanization units: about 16 plants of 5 ton capacity Bio–methanization plants each are being established, out of which 4 are currently functional. The resulting biogas is used to power the street lights in that area

ii. Pelletisation: Organic waste is converted into biofuel using palletisation in a 40MTPD unit in Gandhinagar, Bengaluru west zone by M/s CIPL Resurge Private Limited (CRPL) since Dec 2014.

iii. Organic Waste Convertor: Also organic waste convertors are being used in a decentralized way to process small quantity of wet waste.

Dry wastes are collected and further segregated and then recycled.

The processing facilities located in Bengaluru presently are as shown in table 1 below.

**Table 1:** *Present Solid Waste Processing and Disposal Site Details*

| Sl No | Name of the Agency and Location | Capacity of the plant | Technology Adopted |
|---|---|---|---|
| 1 | M/s Terrafirma (Doddabalapura) | 1000 MTPD | Integrated system where composting, biomethanization is followed |
| 2 | KCDC ( Kudlu) | 300 MTPD | Composting |
| 3 | M/s MSGP Infra Tech Private Limited | 500 MTPD | Compost , RDF, Pellets |
| 4 | BBMP at<br>a) Lakshmipura<br>b) Bingipura | <br>250MTPD<br>850 MTPD | Landfill |
| 5 | Mavallipura | 70 MTPD | Composting |

*Source: Details of solid waste management processing projects of BBMP [21]*

*MTPD- Million tonnes per day*

Based on the data given above, composting and biomethanation are the main two types of WTE methods used in Bengaluru. Landfilling is also as popular as the WTE methods used. Among the above mentioned locations, landfilling unprocessed waste is carried out in Bingipura presently. Hygienic landfilling is not carried out in Bengaluru as of now.

Current processing capacity of some of the above mentioned plants are as detailed below in table 2.

**Table 2:** *Actual processing capacities of the plants*

| Sl No | Name of the Agency and Location | Capacity of the plant | Technology Adopted | Remarks |
|---|---|---|---|---|
| 1 | M/s Terrafirma (Doddabalapura) | 1000 MTPD | Integrated system where composting, biomethanization is followed | Agreement executed in the year 2008 |
| 2 | KCDC ( Kudlu) | 300 MTPD | Composting | Presently receiving 200-250 MTPD of wet waste. |
| 3 | M/s MSGP Infra Tech Private Limited (Doddabalapura) | 500 MTPD | Compost , RDF, Pellets | The plant has started operation from 15-10-2014 and presently taking 400MTPD |

*Source: Details of solid waste management processing projects of BBMP [21]*

As mentioned above, composting and biomethanation are observed mostly as the favourable WTE technology.

As of 2017, Bengaluru has 189 Dry Waste Collection Centres, 11 Bio-methanation plants (with a capacity of 5 TPD), 7 Organic Waste Converters/Tank Composting Units, 4 Leaf litter processing Units, 2 Coconut Waste Processing Units, 10 Integrated Waste Processing Plants (of which 6 are BBMP built Plants) and 3 Sanitary Landfills (BBMP website [22]).

## 5.1. Expansion of processing capacity of waste

To achieve 100% processing of waste, Government has sanctioned six new facilities. These new facilities are being set up at the following locations in Bengaluru and they are listed below in table 3.

**Table 3:** *Details of new Processing Plant Facilities being established.*

| Sl.No | Name of the Location | Extent of Area in acres | Approximate Processing Capacity of the plant in MT |
|---|---|---|---|
| 1 | K.C.D.C Kudlu (Extension) | 30 | 500 |
| 2 | Kannahalli, Sy. No: 85, Kannahalli village, | 29 | 500 |
| 3 | Seegehalli ,Sy. No: 48, Seegehalli village, | 7 | 150 |
| 4 | Chikkanagamangala, Sy. No: 39, Chikkanagamangala | 31 | 500 |
| 5 | Subbarayan Palya, Sy. No: 143, Kumbalagodu village, Kengeri | 10 | 200 |
| 6 | Lengaderanahalli, CA site no 5, Bhanashankari 5th Block | 9 | 200 |
| 7 | DoddaBidrukalu,Sy. No 75, Yeshwanth Pura Hobli. | 10 | 300 |
| | | | **2350** |

*Source: Details of solid waste management processing projects of BBMP [22].*

Out of these facilities, plants at Subbarayan Palya, Chikkanagamangala and KCDC are expected to start functioning in three months' time.

Once all the above facilities are made fully functional, the Bengaluru city will have facilities catering to the requirement of Waste Management for next 10 years provided if Bengaluru manages to segregate, collect, transport and treat the waste generated appropriately.

However, current situation is different. BBMP has good number of waste processing facilities to treat the wastes collected, yet, BBMP is unable to recycle or recover energy completely from the waste generated.

Following all the steps discussed above, BBMP is still unable to effectively process the waste generated due to the lack of holistic approach towards waste management. The WTE plants are clearly are not been used to their optimal level and to their fullest capacity, as the waste reaching such WTE plants itself is less.

In Bengaluru, at present the streets are filled with unsanitary pile of waste, unsegregated waste collected from residential and commercial places.

# 6. Aim of the study

In Bengaluru, MSW generated is usually directly disposed on low lying area in routine way violating the practices of sanitary landfilling. If we could follow simple steps at home to recycle and recover energy at nominal costs, we can reduce the landfill.

However, people still think that any recovery or reuse of wastes is the responsibility of government. But, little most of us know and understand our part in making this effective by supporting the government. People are now willing to do what they can towards reducing landfill, but they are not aware of how they can achieve this. People have been putting effort in segregating the waste at source since the 1st of February 2017 after it has been made compulsory. However, they need more directions on how else they can utilise the raw materials in hand at home and to make them comprehend the usefulness of WTE methods especially aerobic composting at home, which is proven to be easy to follow.

There have been many procedures available online on achieving aerobic composting easily at home. In addition, some of the organisations sell composting pots and necessary ingredients like microbes, remix powder along with it to do composting at home. However, most of the middle class group families in Bengaluru or India would not show interest on these composting pots as they have to spend money to buy these out of their pockets.

Also, there is a dearth of study on the usefulness of aerobic composting at home in Bengaluru.

Considering all these factors and the recent landfill mess in Bengaluru, it prompted me to undertake a study to see if aerobic composting at home with the materials already available in the household have any positive impact on families and on reducing the amount of waste that goes to landfill and would these families be interested in following this every day to help our environment?

# 7. Method

In Bengaluru, 10 houses from middle class economy group from Basaveshwaranagar, Bengaluru, India were selected. The reason for choosing middle class economy group was because it was shown in the past that the middle class economy group generated a median quantity of wastes which was not too high or low in any country (urban development series-knowledge papers).

In Bengaluru, there are families with small and large of members but middle class economy group families usually range between 2 – 6 members in any family. Hence, the chosen 10 households, constituted of 4 members in each family to represent the median. Their consent was obtained before starting data collection by explaining the current study, the usefulness of this study, the merits of following composting and its positive impact on our environment. However, none of the participants or families were willing to give their consent in taking pictures inside their home as they were very conservative and traditional families.

The weight of waste generated which was going to public waste bins for landfill was measured for one full week at two different times:

a) First recording: once at the beginning of the study prior to following composting at home (from here on termed as first recording) and

b) Final recording: the later one after 8 weeks of following composting at home (from here on termed as final recording).

## 7.1. First recording

Before data collection, families were informed to segregate wastes into 3 main categories, into kitchen or biodegradable or compostable waste (raw vegetables and fruit peels, green clippings were asked to put in one bag and cooked food in other bag), recyclable wastes and biomedical/sanitary/inert waste. The segregated waste was then individually measured and later together to obtain the total weight of the waste that goes to landfill.

During the first week of recording, families were closely taught on how to do aerobic composting at home using materials available in any household at any point of time. Following the first recording, families were asked to follow composting at home using kitchen waste except cooked food (as cooked food takes longer than usual to compost and requires store bought bio cultures to compost, also known to produce foul smell). All of these families follow vegetarian diet, so, all the kitchen waste was either vegetable or fruit waste without any meat.

During first recording, all of the compostable wastes were weighed together. While following composting, cooked food was excluded and the rest of the compostable waste was utilised. As cooked food was not wasted much, proportion of cooked food was negligible.

The materials used for composting are given below:

a) Four old flower pots made of clay were taken and holes were drilled about 1.5 cm each at every 12cm around the pot (to provide aeration and drainage).
b) Brown or Carbon: shredded hay, shredded dry leaves, coffee grounds, shredded thin cardboard (glossy paper with ink was not used)
c) Green or Nitrogen: kitchen wastes such as vegetable peels, fruit peels, grass clippings, egg shells cracked and broken to small pieces (cooked food not used)
   Carbon to Nitrogen ratio was maintained at 30:1 (this is the chemical composition of brown and green and not the actual volume of the ingredients used. Thus, for this study 2 parts of green to one part of brown was used).
d) Garden soil (microorganisms in soil accelerate composting rate and to mask the odour)
e) A lid to cover the pot in order to retain moisture and heat, to avoid fruit flies and attracting pets at home.
f) Some water to sprinkle as when required to keep the mixture moist
g) Rake: to turn the mixture to provide aeration.

## 7.2. Aerobic composting method:

Since none of the families were willing to give their consent in taking pictures inside their home, the photographs shown in this section are all taken from Ecowalkthetalk website [26].

Composting pots were first filled with the first layer of dry leaves to avoid excessive moisture leak. Then on top of this, went a layer of soil about 6 cm thick. The figure 12 shows the pots that were similar to the ones used in the present study for composting.

**Figure 12:** *Composting pots*

*Source: Ecowalkthetalk website [26]*

i) Then everyday kitchen waste was added to this pot, similar to as shown in the figure 13 below.

**Figure 13:** *Kitchen waste*

*Source: Ecowalkthetalk website [26]*

This was then covered with a layer of soil, similar to the figure shown below (figure14) ensuring that the kitchen waste was not seen to minimise the fruit flies and odour. Also, lid was covered all the time to prevent rain getting in and to prevent pets from exposing contents.

***Figure 14:*** Soil covering compostable waste

*Source: Ecowalkthetalk website [26]*

ii) This was repeated every day when they had new kitchen waste until the pot was full but the contents were stirred occasionally (at least 2 times a week) to make sure appropriate aeration was occurring.

iii) Once the first pot was full, then they were asked to move to next pots similarly. After 8 weeks, it was observed that the first pot was well composted. The signs that the families were looking for were to see if the compost was not lumpy and wet but crumbly in texture and smelt like earth. Sieve was used to get a fine grains of compost which was then utilised in garden to grow vegetables and plants. The resulting compost looked similar to the compost in the picture given below (figure 15).

**Figure 15:** *Compost ready after 8 weeks*

*Source: Ecowalkthetalk website [26]*

During 8 weeks' time period, families were asked to weigh kitchen waste before utilising that into composting in order to ensure that the weight of kitchen waste was not varying vastly across.

## 7.3. Final recording

After 8 weeks of composting, waste that was going to public bins for landfill for one week was recorded. Also, recorded the opinion of families on following composting, the perceived benefits, and their willingness to follow composting even after the study is completed using a questionnaire given below, developed just for this study. Questionnaire was developed in Kannada language (local language). But for thesis I have shown the English version of the same.

## 7.4. Questionnaire to find the usefulness of composting at home

Table below (table 4) shows the questionnaire that was used to find out the usefulness of aerobic composting at home and to know whether participants were willing to continue following composting at home after the study was concluded. Kindly answer the following questions by ticking the most appropriate answer

**Table 4:** *Questionnaire developed to study the importance of aerobic composting at home and to assess the willingness of the participants in following aerobic composting at home*

| **Sl No** | **Question** | **Answer** | |
|---|---|---|---|
| | | **Yes** | **No** |
| 1 | Do you think composting at home is affordable? | | |
| 2 | Do you think the procedure is easy? | | |
| 3 | Does it give any foul smell? | | |
| 4 | Did you utilise the manure produced? | | |
| 5 | Do you think that following composting at home is worth? | | |
| 6 | Did you see the waste going to landfill reduce after following composting? | | |
| 7 | Will you be happy to follow composting post study? | | |
| 8 | Will you recommend composting at home to your friends and family? | | |

After one week, I have been in touch with all of those families again and just had informal oral communication to see if they are following composting and how do they find it in general. All of the results are discussed in the next section.

# 8. Results

## 8.1. First recording

The results prior to following composting or the first recording revealed that the total amount of waste generated by all the houses in one week was 20.19 kilograms (kg) and on an average each household generated about 2.01kg of waste in one week.

The total weight of waste that was going to landfill in a week from all the houses was 20.19 kg. The details of wastes generated during the first recording for a week from all the households are given in the bar graph below (figure 16).

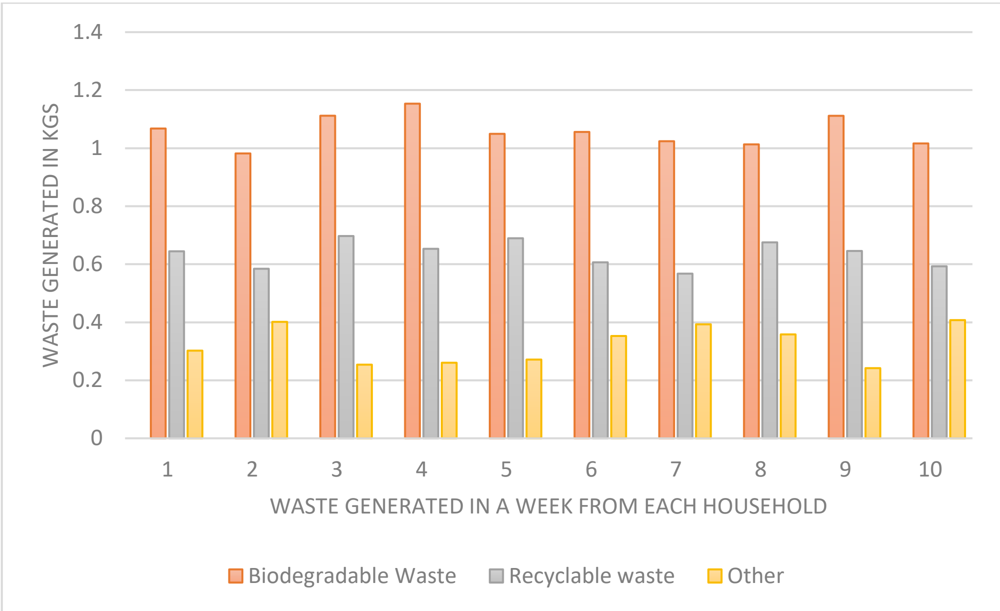


**Figure 16:** *Weight of different types of wastes generated by each household in one week during first recording.*

Hence, the total weight of biodegradable waste generated by all the 10 families in a week was 10.59 kg (which was roughly 52.44% of the total waste), including cooked food which weighed about 0.29kg. Thus, the remaining amount of compostable waste which was 10.3 kg was utilised for aerobic composting. The total weight of recyclable waste was 6.36 kg (about 31.49%) and other types of wastes weighed 3.24 kg (about 16.06%). These details of average composition of different types of wastes from all the households in a week's time are detailed in the pie chart below (figure 17).

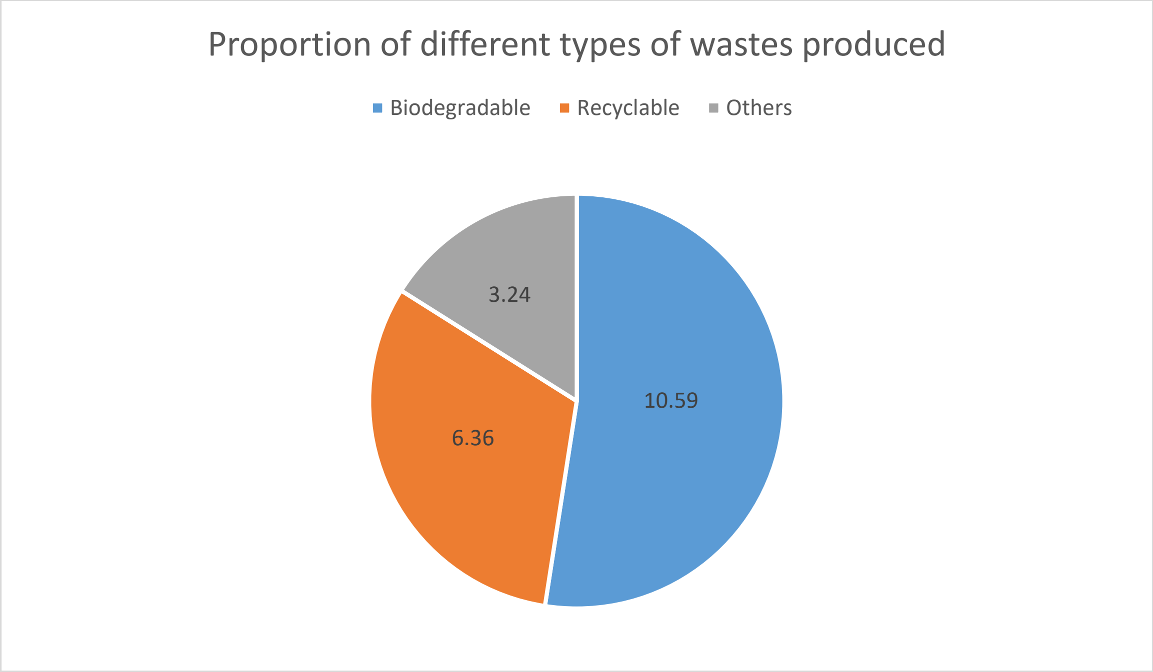


**Figure 17:** *Percentage composition of biodegradable, recyclable and other wastes in a week during first recording from all of the 10 households*

Kitchen wastes excluding cooked food was utilised in converting them to compost using composting pots at home. Rest of the types of wastes, were picked up by waste collectors which was eventually landfilled.

## 8.2. Composting

About 10.3 kg of waste was utilised in composting (based on the first recording from all the 10 households in any given week), however, the weight of kitchen waste that went into composting weighed on an average of 10.2 kg over the period of 8 weeks during composting. During this 8 weeks of composting, the waste ended up in the public bins was reduced as most of the biodegradable waste was used to produce compost using aerobic composting. By the end of 8 weeks, compost produced by aerobic composting from all households summed up to 5.1 kg.

## 8.3. Final recording

The amount of waste generated was measured and it was not significantly different from the first recording and the details are recorded as final recording and are given below (figure 18).

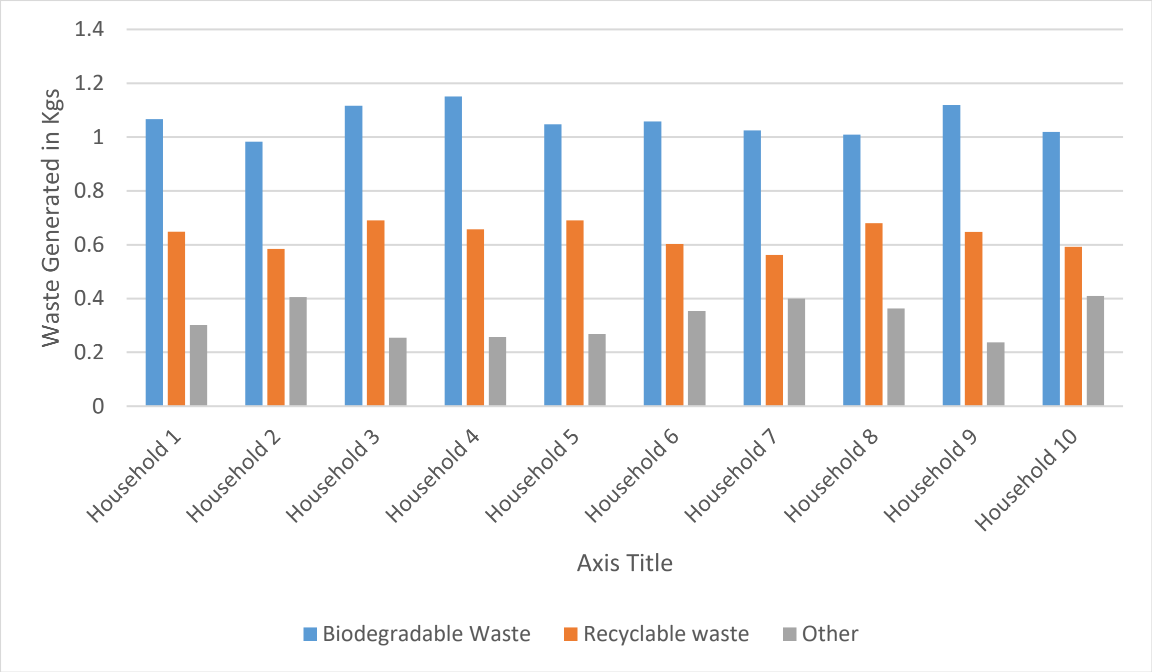


**Figure 18:** *Weight of different types of wastes generated by each household in one week during final recording.*

Thus, the waste generated in final recording week from all the 10 families was 20.22 kg. This waste generated was 0.03 kg more than the waste generated from all the families in week one from all the 10 families during the first recording.

The individual weight of biodegradable, recyclable and inert wastes during the final recording from all the houses were 10.6 kg (52.42%), 6.36 kg (31.45%) and 3.26 kg (16.12%) respectively and is as depicted in the pie chart shown in figure 19 below.

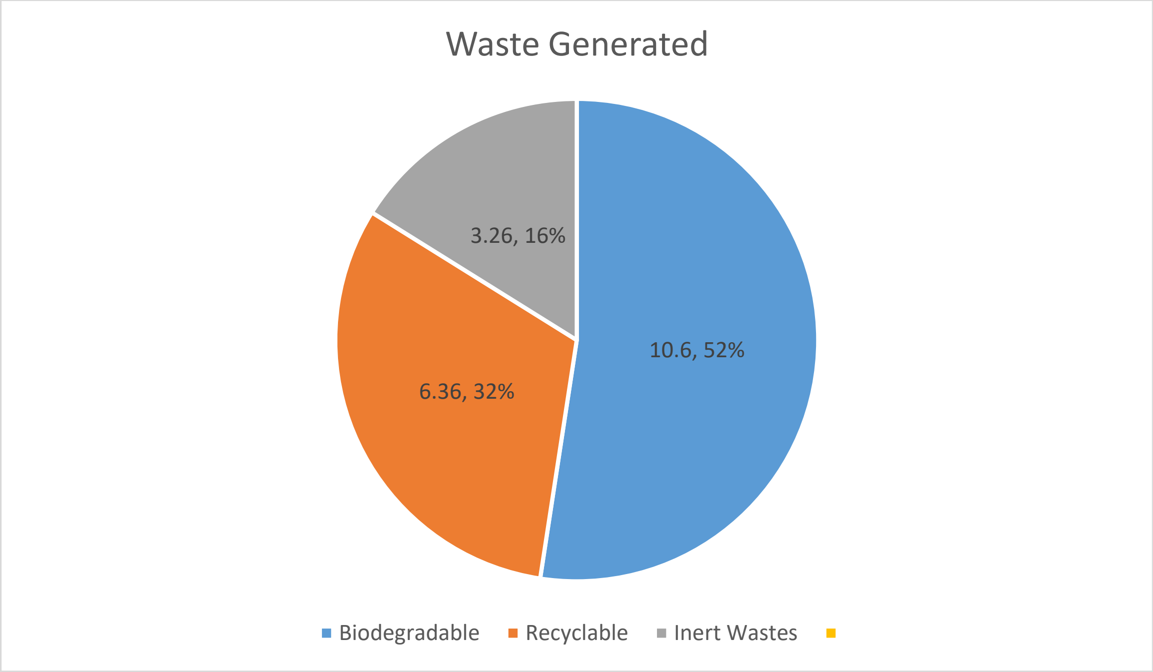


**Figure 19:** *Percentage composition of biodegradable, recyclable and other wastes in a week during final recording from all of the 10 households*

Again, the variation between first and final recording was measured and it was insignificant. Biodegradable waste was about 0.01 kg more than when compared to first recording. Recyclable waste was same as the first recording. Inert waste was 0.02 kg more than the first recording.

The amount of wastes landfilled during final recording were measured too and it was about 9.62 kg in total as opposed to 20.19 kg during first recording (figure 20). It was seen that there was a significant reduction in the quantity of waste going to landfill in a week after following composting at home. The reduction seen was by nearly 52%.

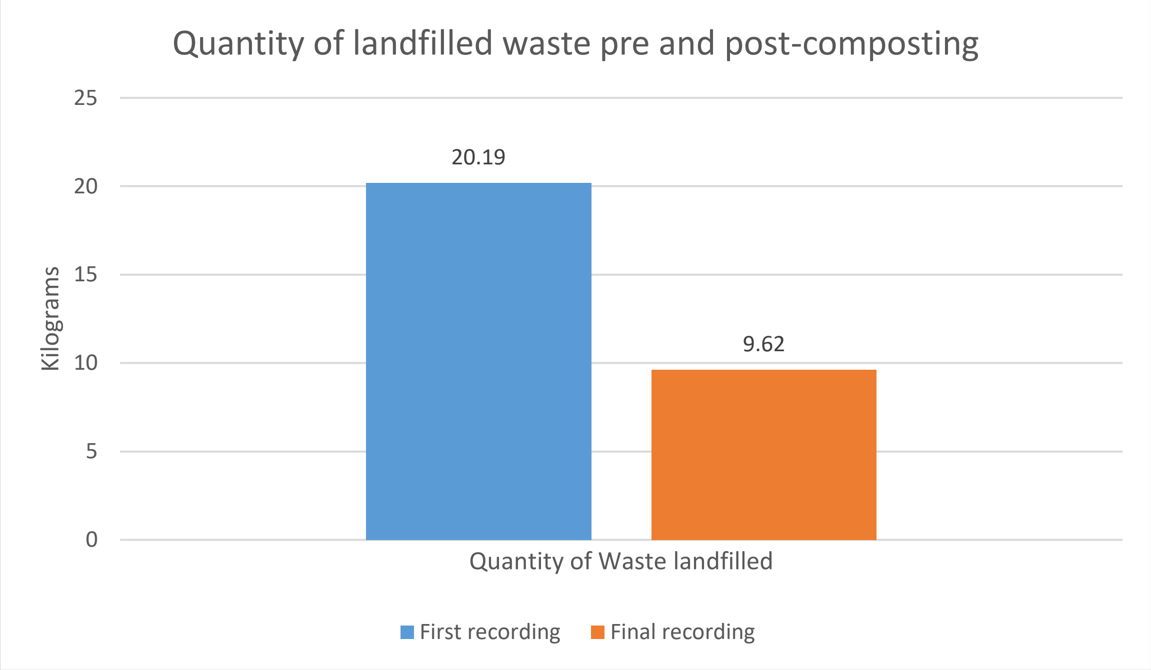


**Figure 20:** *Amount of waste landfilled during first and final recording*

## 8.4. Questionnaire results

The questionnaire results showed various outcomes. All families could see the benefit, however, 9 out of 10 families were willing to continue to follow composting at home after the study. This questionnaire did not ask for reasons though.

To conclude, the quantity of waste landfilled in 10 households who come from middle class economy dropped by about 52% after following simple composting at home using biodegradable wastes. And, nearly 90% of these participated families had shown interest in continuing this practice and are doing so even after the study was concluded.

Projecting the results to the rest of the city, we can conclude that even if 90% of Bengaluru's population follow aerobic composting at home, then we can reduce half of landfill in Bengaluru city and make it clean garden city.

# 9. Conclusions

Waste management started as a hygiene method for disposal of waste. Due to increase in population and urbanisation amount of waste produced sore up high. Urbanisation and economic growth have led to increasing amount and complexity of generated solid waste (Gidde et al., 2008 [09] and Rathi, 2007 [20]). By 2011 the amount of non-degradable wastes had increased significantly such as plastics, metal, paper etc. Ministry of Environment and Forests, by Javadekar in 2016 [10], reported that 62 million tonnes of Waste is generated annually at present. Out of which, Compostable waste or bio-degradable waste (Food and kitchen waste) constitutes nearly 48 million tonnes

Various study (Noorjahan et al., 2012 [15], Chatterjee, 2010 [03], Das and Bhattacharya, 2013) [07], have all reported improper management of solid waste in different cities in India.

Complete waste management focuses on preventing the generation of wastes, reuse, recycle, recovery (WTE methods) and landfilling in the same chronological order. This methodology enables novel materials or designs to minimise wastes and also encourages to recover energy using novel WTE methods. However, due to insufficient knowledge in India waste generated is not reused or recycled and large quantity (73%) of waste generated ends up in landfill and very small quantity (27%) is processed using WTE.

WTE technologies can be mainly classified as: Bio-chemical method of WTE technologies which follows aerobic and anaerobic digestion of wet wastes including organic matter to produce biogas. Thermo-chemical method of WTE technologies which follows controlled combustion of fairly dry wastes to produce steam. Composting and Biomethanation are the most common type of Bio-chemical processing of wastes.

Composting is a biochemical conversion of biodegradable MSW in aerobic condition, during which biological conversion of organic or biodegradable matter occurs in the presence of air and heat resulting in rich compost. Composting can be easily carried out in small scale in every home domestically while carefully considering the factors that might affect aerobic composting.

Biomethanation follows hydrolysis, acidification and Liquefaction. After this Acetate, Hydrogen and Carbon di oxide are converted into Bio gas containing Methane 55-75% and compost. In anaerobic composting, the organic matter in Bio chemical wastes are covered in soil for 8 months. Micro-organisms then produce methane and other products.

Incineration is a type of Thermo-chemical WTE technology, in this method wastes are combusted to produce steam using the heat. Pyrolysis is an anaerobic combustion of wastes to produce Biochar or bio-oil. Gasification converts bio mass into combustible gas or syngas at high temperatures.

India has been relying on Biomethanation and composting methods of WTE mostly and rest of the waste generated is landfilled.

Karnataka is one among the few counties which have announced policy related to allotting land, garbage supply and purchasing power to set up WTE projects. Bengaluru, its capital city has taken numerous steps to achieve waste management. Bengaluru's local authority BBMP is in charge of undertaking necessary steps and guides waste management. According to BBMP report, 2017 [22] Bengaluru generated about 3000 - 3500 tonnes of Solid Waste daily in at present. BBMP has taken following steps such as door to door collection of wastes using pushcarts, segregating dry and wet wastes, storage of wastes, transportation of wastes, processing of wastes using biomethanation, pelletisation etc.

Bengaluru has four waste processing facilities up to a capacity of 1800 MTPD which mainly follow composting and Biomethanation (BBMP report, 2017 [22]). However, these facilities are not functioning to their complete capacity due to the fact that the waste generated is not efficiently segregated, collected and transported to WTE facilities. Thus, following all these steps, BBMP is unable to effectively process the waste generated due to the lack of holistic approach towards waste management.

Present study attempts at studying the effectiveness of using aerobic composting at home in reducing landfill and willingness of participants in following aerobic composting in their homes.

Ten families from middle class economy group from Basaveshwaranagar, Bengaluru were chosen and after taking their consent, study was undertaken. Families were informed to segregate wastes at home into kitchen waste, recyclable waste and other types of wastes. And the weight of all the kitchen or compostable waste, recyclable waste and other wastes were measured for one week. It was found that the overall weight of total waste generated was 20.19kg.

Families were taught how to follow composting with only vegetable peels, fruit peels and green clippings as compostable wastes which was about 10.3 kg, using materials that are easily available at home. After 8 weeks of aerobic composting at home, rich compost was formed, which weighed at 5.1 kg. Later, the weight of waste landfilled was measured. It was seen that the amount of waste landfilled after following composting was reduced by about 52%.

Then, participants were asked to fill a questionnaire to assess the usefulness of aerobic composting at home and their willingness in following composting at home even after concluding the study. Nearly 90% of the participants showed interest in and are still following composting at home.

We can conclude that when people are made aware of what they can contribute to our environment by following aerobic composting at home, they were able to see its benefits in reducing landfill by a little over than half which in a long run can prove to significantly help Bengaluru in being clean city. Projecting the results to the rest of the city, even if 90% of Bengaluru's population follow aerobic composting at home, then we can reduce half of landfill in the city.

Further studies can be conducted by taking large group and in turn create awareness in Bengaluru.

# 10. Resume in English

With an increase in population in India to 1.3 billion as of May 2017, amount of wastes generated has grown enormously. Effective ways of managing wastes has been followed by Europe, USA, etc. extensively.

Main objective of the current study was to throw light on the importance and effectiveness of following aerobic composting at home in reducing landfill in Bengaluru, Metropolitan city of India.

Review of Literature showed that India produces 62 million tonnes of Waste annually at present. Out of which, Compostable waste or bio-degradable waste (Food and kitchen waste) constitutes nearly 48 million tonnes. Thus India should focus on complete waste management which has a systematic approach starting from reducing the generation of waste, reusing them, recycling, energy recovery using WTE methodology and finally hygienic landfilling. India has been practising only unhygienic landfilling and has finite number of WTE plants which has scarcity of segregated wastes reaching them for energy recovery.

Indian cities including Bengaluru have not put their best effort in achieving efficient waste management. Bengaluru generates about 3000 - 3500 tonnes of Solid Waste daily. Bengaluru has been only processing 20.1% of the waste generated. BBMP, Bengaluru's local authority is still lacking its efficiency when it comes to holistic waste management. Though Bengaluru has four WTE plants the capacity of 1800 MTPD, it is still unable to recover energy considering the amount of waste it generates. This is because of the fact that the waste generated is unhygienically and illegally landfilled rather than processing them accordingly.

In Bengaluru waste generated is not segregated at source and waste is disposed at a communal open place than transporting them to designated WTE facilities which has led to air pollution, water pollution, increase in the number of insects and diseases.

Present study attempts at studying the effectiveness of using aerobic composting at home in reducing landfill and to know whether the participants will follow aerobic composting in their homes even after concluding the study.

Ten families from middle class economy group from Basaveshwaranagar, Bengaluru were approached and after taking their consent, study was undertaken. Families were informed to segregate wastes at home into kitchen waste, recyclable waste and other types of wastes. And the total weight of all these different types of wastes were measured individually and then together for one week. The overall weight of total waste generated was 20.19kg.

Families were taught aerobic composting how to follow this at home and with only vegetable peels, fruit peels and green clippings as compostable wastes which made up to 10.3 kg, and using other materials that are easily available in any home. Following aerobic composting at home for 8 weeks resulted in a rich compost of 5.1 kg in total from all 10 families. After which, the weight of waste landfilled was measured. It was seen that the amount of waste landfilled after following composting was reduced by about 52% from 20.19 kg to 9.62 kg.

Then, the opinions of the participants about composting, its usefulness and their willingness in following composting even after the study was investigated using a questionnaire. Nearly 90% of the participants showed interest in and are still following composting at home.

This shows that if people are made aware of these simple steps to utilise waste at home to recover, it can reduce landfill pile significantly.

Future studies can be conducted by taking large group and in turn create awareness in the city.

# 11. Resume in Estonian

India rahvastiku arvu jõudmisega 1,3 miljardini (2017. Aasta mai seisuga), on oluliselt kasvanud ka jäätmete tekkimine. Euroopa, USA jt on ulatuslikult järginud efektiivse jäätmekäsitluse meetodeid.

Käesoleva uurimuse peamine eesmärk oli näidata aeroobse komposteerimise rakendamise tähtsust ja efektiivsust kodudes, selleks, et vähendada prügilate suurust India metropolis Bengalurus (Bangalore).

Kirjandus analüüsis selgus, et India toodab hetkeseisuga 62 miljonit tonni jäätmeid aastas. Sellest komposteeritava jäätme või biolaguneva jäätme ( toidujäätmete jms) osakaal on ligi 48 miljonit tonni. Seega India peaks keskenduma täielikule jäätmekäsitlusele, millel oleks süstematiseeritud lähenemine, alustades jäätmete tekitamise vähendamisest, selle taaskasutamisest, ümbertöötlemisest, energia tagastamisest kasutades jäätmeenergia (WTE – waste-to-energy) meetodeid ja lõpetades jäätmete hügieenilise ladustamisega prügilasse. India on siiani praktiseerinud vaid ebahügieenilist jäätmete ladustamist ning omab vaid teatud hulk jäätmeenergia jaamu, ning nendelgi on puudus sorteeritud jäätmetest, mis sobivad energia tagastamiseks.

India linnad nagu Bengaluru ei ole andnud endast parimat, et saavutada efektiivne jäätmekäsitlus süsteem. Bengaluru toodab igapäevaselt umbes 3000 – 3500 tonni tahket jäädet. Bengaluru on töödelnud vaid 20,1 % tekkinud jäätmetest. BBMP, Bengaluru kohalik administratiivorgan, ei oma siiani efektiivset tegevuskava, mis puudutab täielikku jäätmekäsitlust. Olenemata sellest, et Bengalurus on 4 jäätmeenergia jaama jõudlusega 1800 tonni päevas, ei suuda need piisavalt energiat toota võrreldes sellega, kui palju jäätmeid juurde tekib. Seda põhjusel, et jäätmed on toodetud ebahügieeniliselt ja illegaalselt prügilaks ladestatud, selle asemel, et neid vastavalt sorteerida ja töödelda.

Bengalurus on probleemiks õhu ja vee saaste, putukate arvukuse ja haiguste kasv, mis on tingitud asjaolust, et tekkivaid jäätmeid ei sorteerita kohe allikas ja prügi jäetakse avalikesse kohtadesse, selle asemel, et transportida seda ettenähtud jäätmekäsitlus jaamadesse.

Käimasolev uurimus üritab mõista, kui efektiivne on aeroobse komposteerimise kasutamine prügilate vähendamise eemärgil ning näha, kas uuringus osalejad järgivad aeroobse komposteerimise meetodeid oma kodudes ka pärast uuringu lõppu.

Uuringus tarbeks saadi kümne Basaveshwaranagaris Benglurus elava, keskklassi kuuluva perekonna nõusolek. Perekondadel instrueeriti tekkiv jääde sorteerida köögi- ehk toidujäätmeteks, taaskasutatavateks jäätmeteks ja ülejäänud muudeks jäätmeteks. Kõikide jäätmete hulgad kaaluti eraldi ära. Tekkinud jäätmete kogukaaluks oli 20,19 kg.

Perekondadele õpetati aeroobset komposteerimist ning kuidas seda kodus praktiseerida kasutades juur- ja puuviljade koort ning muud toidu orgaanilisi osi, millest tekkiv jääde moodustas 10,3 kg, kasutades veel muid kodudes leiduvaid materjale. Kodude kasutatud aeroobse komposteerimise tulemuseks pärast 8-t nädalat praktiseerimist oli rikkalik kompost kogukaaluga 5,1 kg 10 pere kohta. Pärast mida mõõdeti ladestunud jäätmete hulk. Selgus, et komposteerimise tagajärjel vähenes ladestunud jäätmete hulk umbes 52 %, 20,19 kg pealt 9,62 kg-ni.

Järgnevalt küsiti osalejate arvamust komposteerimise, selle kasulikkuse kohta ning kas nad oleksid nõus komposteerima isegi pärast uuringut, mis oli küsitlejate poolt läbi viidud. Peaaegu 90 % vastanutest näitas üles huvi ja jätkasid komposteerimist oma kodudes.

Sellest võib järeldada, et tõstes inimeste teadvust lihtsate sammude näol, näidates, kuidas kodustes tingimustes jäätmeid töödelda, võib see oluliselt vähendada ladestuvate jäätmete kogust.

Edasisi uuringuid võib läbi viia võttes suure grupi inimesi ja läbi nende tõstatada teadvust linnas.

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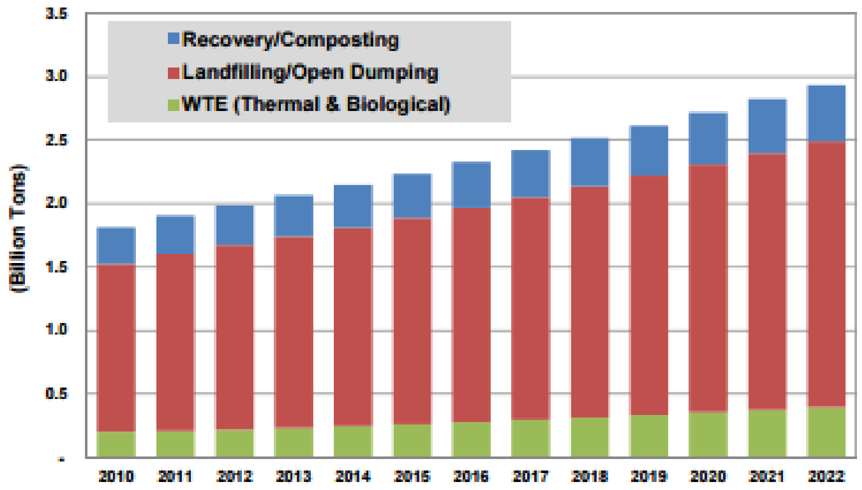
# APPENDICES

Despite these efforts, landfilling remains the world's preferred method for managing and treating waste, despite its negative impact on the environment. In 2011, an estimated 1.4 billion tons of MSW was landfilled or dumped in open pits worldwide. A shift away from this trend over the next decade will necessitate considerable economic and political will. Given the scale of the challenge, the preference for landfilling is expected to remain mostly unchanged over the next decade, even under Pike Research's more optimistic WTE forecasts.

***Chart 1.1 MSW Management by Disposal Method, World Markets: 2010-2022***




*(Source: Pike Research)*

Despite landfilling's dominance, innovative waste management policies, coupled with changing economic conditions, are driving the growth of WTE capacity worldwide. This trend creates attractive business opportunities for providers of WTE technologies and related components. Although public opposition to incineration projects is still a major barrier to more widespread WTE deployment, today's mass burn facilities are far more advanced than the incinerators of old. Equipped with innovative emission control technology not possible just a decade ago, these facilities are getting a second look.

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