

Environmentally Sustainable Solid Waste Management Case Study of Gurgaon

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Abstract

Solid Waste Management is a major problem that world faces, where urbanization, industrialization and economic growth have resulted in increased municipal solid waste generation per person. Waste generation, its quantity & composition is essential for determining collection, processing & disposal options to be adopted and it is dependent on population, local economy, life styles, income levels etc. Due to the increasing population and prosperity, the generation rate of municipal solid waste (MSW) has increased significantly, resulting in serious problems on public health and the environment. Every single person in the world is affected by the municipal solid waste management (MSWM) issue. MSWM is reaching a critical level in almost all areas of the world and seeking the development of MSW strategies for a sustainable environment. It is observed that there are lack of appropriate skills, technological competencies and the lack of financial resources in India This paper basically has the objective to have sustainable solid waste management, so accordingly estimations are being made which projects the waste generation per capita per day in next 30 years in Gurgaon in the form of bio-degradable, non-biodegradable and recyclable wastes and how these wastes can be treated in the form of compost, bio-fuel, fuel pellets and generating power from the waste, then the economy value has been generated in order to see which method of treatment is more suitable for the sustainable solid waste management in the city. It provides an overview of solid waste management in Global, India and Gurgaon and how we can overcome the situation by proposing sustainable SWM in the state

Key Words: sustainable solid waste management; environmental degradation; resource consumption; bio-degradable waste; degradable waste; recycle waste; reuse; resource decoupling; compost; biofuel; fuel pellets; power

1. Introduction:

[1]Solid waste management is defined as the discipline associated with control of generation, storage, collection, transport or transfer, processing and disposal of solid waste materials in a way that best addresses the range of public health, conservation, economic, aesthetic, engineering, and other environmental considerations. It is a crucial function of local governments around the world, and directly affects public health, the environment, and livelihoods. These wastes are generated due to human as well as animal activities. Waste can be categorized based on material, such as plastic, paper, glass, metal, and organic waste. Categorization may also be based on hazard potential, including radioactive, flammable, infectious, toxic, or non-toxic wastes. Categories may also pertain to the origin of the waste, whether industrial, domestic, commercial, institutional, or construction and demolition.

In older days MSW does not affect the nature so adversely because the population was



less and land was more for dumping but now the population is increasing at a high rate and the open land and green cover is decreasing day by day leading to deterioration of environment rapidly. This led to an imbalance in the human-nature relationship, finally leading to environmental problems like soil, air, and water pollution and accumulation of municipal solid waste (MSW).

The primary goal of solid waste management is reducing and eliminating adverse impacts of waste materials on human health and the environment to support economic development and superior quality of life. Generation [2] of solid waste is natural phenomenon i.e. generated by living as well as non-living components. The amount of solid waste generation is directly proportion to population. Less population means fewer excreta while large population growth will enhance excreta in natural condition. People in order to fulfil their needs and requirements are deteriorating the environment since last five decades. Both biodegradable and non-biodegradable solid wastes are also associated with air pollution in atmosphere in form of inorganic particles and foul odour. Data of solid waste production from domestic and industrial sectors from different countries of the world is very alarming. The increasing volume and complexity of waste associated with the modern economy is posing a serious risk to ecosystems and human health. Poor waste management - ranging from non-existing collection systems to ineffective disposal -causes air pollution, water and soil contamination. Open and unsanitary landfills contribute to contamination of drinking water and can cause infection and transmit diseases. The dispersal of debris pollutes ecosystems and dangerous substances from electronic waste or industrial garbage puts a strain on the health of urban dwellers and the environment.

Around the world, waste generation rates are rising. In 2016, the worlds’ cities generated 2.01 billion tonnes of solid waste, amounting to a footprint of 0.74 kilograms per person per day [3]. With rapid population growth and urbanization, annual waste generation is expected to increase by 70% from 2016 levels to 3.40 billion tonnes in 2050. Managing the waste in developing countries has become a challenge in order to provide a sustainable and liveable environment. Awareness must be spread among the people to discharge waste according to rules and regulations provided by authorities. Effective waste management is expensive, often comprising 20%–50% of municipal budgets. Operating this essential municipal service requires integrated systems that are efficient, sustainable, and socially supported.

In China, the Waste wise Scheme encourages the private sector to initiate waste reduction activities. A working group comprising representatives from various industries, schools, hospitals, government departments and the Environmental Protection Department (EPD) has been formed to assist members and encourage more companies to join the scheme. Plastic bags are the main waste concern of supermarkets and convenience stores. Some initiatives have been introduced to reduce this problem and the problem of waste in general from these outlets. Hospitals are being encouraged to promote waste reduction and recovery and to join the Waste wise Scheme. The EPD has provided technical advice and organized workshops and seminars for managerial and frontline staff in public and private hospitals.

In Germany, The Stadtreinigung Hamburg (SRH, Stadtreinigung means city cleaning) is responsible for the municipal solid waste management in the city. The SRH is a city-owned institution, working as a private company. The function of the SRH is to be a solution-provider for waste collection, city-cleaning and disposal. Generation of municipal solid waste annually in the city of Hamburg is 20,098.49 lakh tons. The approach adopted towards solid waste management for households and commercials is done separately.

[4] The East Asia and Pacific region are generating most of the world’s waste, at 23 percent, and the Middle East and North Africa region is producing the least in absolute terms, at 6 percent. However, the fastest growing regions are Sub-Saharan Africa, South Asia, and the Middle East and North Africa, where, by 2050, total waste generation is expected to more than triple, double, and double respectively. In these regions, more than half of waste is currently openly dumped, and the trajectories of waste growth will have vast implications for the environment, health, and prosperity, thus requiring urgent action.

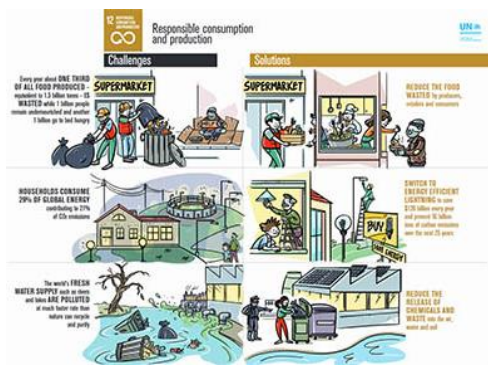


Figure 1: Sustainable Development Goals 12: Responsible Consumption and Production

Source: unep.org

Resource decoupling and impact decoupling are needed to promote sustainable consumption and production patterns and to make the transition towards a greener and more socially inclusive global economy.

To ensure sustainable consumption and production practices necessarily entails to respect the biophysical boundaries of the planet and to reduce current global consumption rates in order to fit with the biophysical capacity to produce ecosystem services and benefits. Sustainable growth and development require minimizing the natural resources and toxic materials used, and the waste and pollutants generated, throughout the entire production and consumption process.

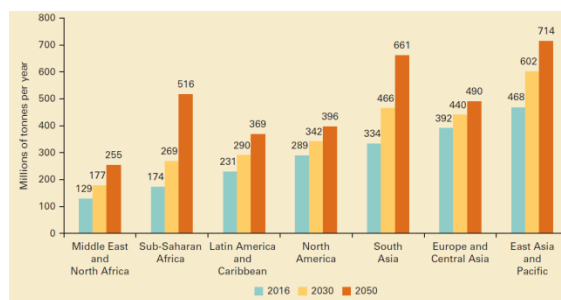


Figure 2: Projected waste generation, by region (millions of

Source: datatopics.worldbank.org/what-

1.1. Global Level Solid Waste Management:



waste/trends_in_solid_waste_management.html

1.1. India's Level Solid Waste Management:

Waste collection is a critical step in managing waste, yet rates vary largely by income levels, with upper-middle- and high-income countries providing nearly universal waste collection. Low-income countries collect about 48 percent of waste in cities, but this proportion drops drastically to 26 percent outside of urban areas. Globally, most waste is currently dumped or disposed of in some form of a landfill. Some 37 percent of waste is disposed of in some form of a landfill, 8 percent of which is disposed of in sanitary landfills with landfill gas collection systems. Open dumping accounts for about 31 percent of waste, 19 percent is recovered through recycling and composting, and 11 percent is incinerated for final disposal. Adequate waste disposal or treatment, such as controlled landfills or more stringently operated facilities, is almost exclusively the domain of high- and upper-middle-income countries.

[6] The urban growth in India is faster than the average for the country and far higher for urban areas over rural. The proportion of population residing in urban areas has increased from 27.8 % in 2001 to 31.80 % in 2011 and likely to reach 50% by 2030. It is estimated that Urban India generates about 1.5 Lakhs Tonnes per day. The per capita waste generation in major cities ranges from 0.20 Kg to 0.6 Kg. Generally, the collection efficiency ranges between 70 to 90% in major metro cities whereas in several smaller cities the collection efficiency is below 50%. The composition of MSW at generation sources and collection points in India is observed to mainly consist of a large organic fraction (40–60%), ash and fine earth (30–40%), paper (3–6%) and plastic, glass and metals (each less than 1%). It is also estimated that the Urban Local Bodies spend about Rs.500 to Rs.1500 per tonne on solid waste for collection, transportation, treatment and disposal. About 60-70% of this amount is spent on street sweeping of waste collection, 20 to 30% on transportation and less than 5% on final disposal of waste, which shows that hardly any attention is given to scientific and safe disposal of waste.

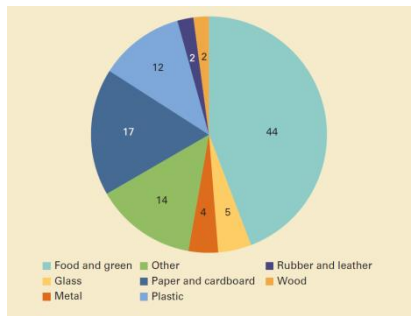


Figure 3: Global waste composition (percent)

Source: datatopics.worldbank.org/what-a-waste/trends_in_solid_waste_management

In most countries [5], solid waste management operations are typically a local responsibility, and nearly 70 percent of countries have established institutions with responsibility for policy development and regulatory oversight in the waste sector. Financing solid waste management systems is a significant challenge, even more so for on-going operational costs than for capital investments, and operational costs need to be taken into account upfront. Countries that advance from open dumping and other rudimentary waste management methods are more likely to succeed when they select locally appropriate solutions. Globally, most waste is currently dumped or disposed of in some form of a landfill. Some 37 percent of waste is disposed of in some form of a landfill, 8 percent of which is disposed of in sanitary landfills with landfill gas collection systems. Open dumping accounts for about 31 percent of waste, 19 percent is recovered through recycling and composting, and 11 percent is incinerated for final disposal.



Figure 5: Waste Disposal in India

Source: downtoearth.org.in

Waste management rules in India are based on the principles of "sustainable development", "precaution" and "polluter pays" [7]. These principles mandate municipalities and commercial establishments to act in an environmentally accountable and responsible manner—restoring balance, if their actions disrupt it. The increase in waste generation as a by-product of economic development has led to various subordinate legislations for regulating the manner of disposal and dealing with generated waste are made under the umbrella law of Environment Protection Act, 1986 (EPA). India is turning into one big garbage dump. The problem is assuming gigantic proportions and the numbers are staggering. Urban India is the world's 3rd largest garbage generator and by 2050 waste is expected to rise to 436 million tons up.

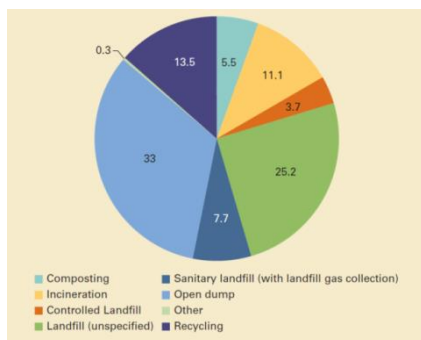


Figure 3: Global treatment and disposal of waste (percent)

[8] Out of the total municipal waste collected, 94% is dumped on land and 5% is composted. Central Pollution Control Board in its report which was released in 2009 indicates that around 62 million tons of solid waste is produced in our country every year, of which less than 20% or only 12 million tons are treated. This essentially means that the remaining 52 million tons of waste remain



‘untreated’ and contaminate land or make its way into rivers, lakes and wetlands. Total quantity of solid waste generated in urban areas of the country is about 1.15 lakh tonnes per day. Out of these 19643 tonnes of waste is generated in metro cities per day.



Figure 4: Total waste generated (Million Tonnes per year)

This essentially means that the remaining 52 million tons of waste remain ‘untreated’ and contaminate land or make its way into rivers, lakes and wetlands. Total quantity of solid waste generated in urban areas of the country is about 1.15 lakh tonnes per day. Out of these 19643 tonnes of waste is generated in metro cities per day. [9] The survey conducted by CPCB puts total municipal waste generation from Class I and Class II cities to around 18 million tonnes in 1997 (CPCB, 2000a). The solid waste generated in Indian cities has increased from 6 million tonnes in 1947 to 48 million tonnes in 1997 and is expected to increase to 300 million tonnes per annum by 2047 (CPCB, 2000a). More than 25% of the municipal solid waste is not collected at all, 70% of the Indian cities lack adequate capacity to transport it and there are no sanitary landfills to dispose of the waste. The existing landfills are neither well equipped nor well managed. Also, they are failed to protect against contamination of soil and groundwater.

Major cities	Waste Quantity (Tonnes per day)
Surat	1000
Pune	1175
Kanpur	1100
Ahmedabad	1302
Hyderabad	2187
Banglore	1669
Chennai	3036
Kolkata	2653
Delhi	5922
Mumbai	5320

Table 1: Waste Quantity (Tonnes per day) of Indian cities
Source: <http://cpcb.nic.in>

1.2. Gurgaon Solid Waste Management:

[10] Gurugram is a growing city which was formerly known as Gurgaon located in the Northern Indian state of Haryana. It is a second largest IT Hub and 8th largest city in India in terms of total wealth. Due to its rapid growth population is increasing adversely; even the migrants from other states are living here in order to have jobs. Gurugram city (Haryana state) has witnessed unprecedented urban growth over the past two decades, owing to the escalation in population, immigration and unorganized expansion. This

brings with it the challenges associated with urbanization, among which are generation of large quantities of Municipal Solid Waste (MSW) and its disposal. Gurgaon city’s solid waste generation has doubled in the last ten years due to rising population. [] Today Gurugram generates 650 metric tonnes (MT) per day of solid waste, according to non- governmental organization, Gurgaon First. A family of four generates a little more than 2kg of waste in a day. The city has so far followed a centralized approach to waste management. About over 90 per cent the waste in mixed form goes to the landfill at Bandhwari. Since treatment plant at Bandhwari has been dysfunctional, the waste pile has become a health and management hazard. Waste is collected and disposed of at Bandhwari by contractors who have service contracts with the authorities. Municipal Corporation Gurugram is the nodal body for waste management which has divided the city into four zones. It is manned by 3,648 sanitary workers, including permanent and contractual.

2. Literature Review:

The aim of the study is to minimize the solid waste generation and must be disposed properly without affecting the environment and maximizing the resource recovery and efficiency. The per capita waste generation in India varies from 200-500 per capita per day. Not only the waste is increasing but also various characteristics of wastes are also increasing. Solid waste must be segregated, collected, treated and disposed properly without affecting the environment [12].

Only about 75- 80% of the municipal waste gets collected and out of this only 22-28 % is processed and treated and remaining is disposed of indiscriminately at dump yards. The primary aim of sustainable solid waste management is to address concerns related to public health, environmental pollution, land use, resource management and socio-economic impacts associated with improper disposal of waste.

2.1. Salient Features of Solid Waste Management:

1. People must take initiative and dispose the waste properly without throwing, burning, burying the waste in open [13].
2. Door to Door collection of waste must be initiated.
3. The state government has banned the use of plastics; thus, it should not be used as it poses a major threat for environment due to its non-disposability.
4. There shall be complete prohibition on open burning of waste on lands including at landfill sites.
5. Convey the provisions of solid waste management under the byelaws to all the tourists visiting different areas in India i.e. by putting suitable hoarding at tourist places.
6. Non-recyclable wastes can be utilized as refuse-derived fuel in cement factories and power plants.
7. Waste generated can be used to generate the power.
8. 20-30% of Plastic waste can be transferred to use to construct roads by mixing it with other materials.
9. There must be awareness program for the segregation of wastes and shall promote recycling and reuse of waste with the objective of “Zero Waste”
10. No dumping in nallahs and roadside should be allowed, or else the offenders should be fined.



11. Used sanitary waste like diapers, sanitary pads should be wrapped securely in pouches provided by manufacturers or brand owners of these products or in a suitable wrapping material and shall place the same in the bin meant for dry waste / non- bio-degradable waste [14].
12. The bio-degradable waste should be processed, treated and disposed of through composting or bio-methanation within the premises as far as possible. The residual waste shall be given to the waste collectors or agency as directed by the local authority.
13. Every street vendor should keep suitable containers for storage of waste generated during the course of his activity such as food waste, disposable plates, cups, cans, wrappers, coconut shells, leftover food, vegetables, fruits etc. and deposit such waste at waste storage depot or container or vehicle as notified by the local authority.
14. All such manufacturers, brand owners or marketing companies should educate the masses for wrapping and disposal of their products.
15. Non-recyclable [15] waste having calorific value of 1500 K/cal/kg or more shall not be disposed of on landfills and shall only be utilized for generating energy either or through refuse derived fuel or by giving away as feed stock for preparing refuse derived fuel.

- **Prevention** – reducing [16] the percentage of waste that is produced in the first place
- **Recycling** – composting and reprocessing of waste materials
- **Recovery** – recovering energy through incineration of waste
- **Disposal** – incinerating waste without energy recovery and/or diverting waste materials to landfills.

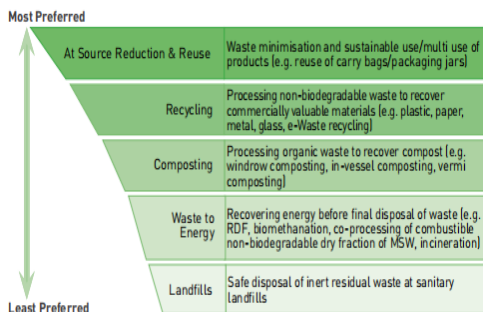


Figure 5: Integrated Solid Waste Management Hierarchy
Source: CPHEEO Part-1 SWM Manual

3. Case study of Gurgaon – The Millennium City:

Gurugram is one of the industrial and financial city of Haryana states, which is located in the National Capital Region (NCR), very near to New Delhi. Gurugram lies at latitude of 28° 27' 34.1892" N and longitude of 77° 1' 35.8824" E. Gurugram is located around 20 miles south-west of New Delhi, and its total population is around 1514,432 (Census, 2011), as per the census data city has witnessed rapid urbanization (total population 870,539, as per 2001 census report). According to the census report of 2011, Gurugram city is among the third highest per capita income cities of India and per capita income is most important parameter for calculating the Human Development Index (HDI). Gurgaon district has witnessed a phenomenal growth in all spheres of developments, particularly in industry and urbanization. With its rapid development, Gurgaon city has

emerged as a jewel in the crown of Gurgaon district and has made the district proud due to its achievements. However, behind the shine and glitter lies an ailing population. Soaring levels of air pollution in the city have become a serious threat to human health. According to HSPCB's annual report on solid waste management for the year 2018-19, which also states that of the total solid waste generated in Haryana (4,635.79 TPD), only 17.5% (815.93 TPD) is successfully treated and recycled, while about 78% (3,614.32 TPD) is sent to landfills.

Rapid urbanization along with increases in population has led to the deterioration of physical environment in Gurgaon. Effective Solid Waste Management is one of the major challenges faced by the local authorities. High volumes of waste generation, inefficient collection and transportation system and limited disposal options are continuously impacting the health, environment and quality of life in the area.

3.1. Population Projection:

Since last 20 years, Gurgaon growth has been rapidly increased. In the year [17] 2000, city has lots of barren lands green spaces (agricultural lands), waterbodies where water can easily seep but as the year passed city continued to grow depleting natural drainages lines and lakes. The current estimated population of Gurgaon, including the urban areas, the existing town, and the 17 villages surrounded by existing urban. Due to migration in the city in search of employments, the population is increasing at an annual growth rate of 5%. Using Arithmetic Projection method, population of Gurgaon is predicted for 2021, 2031, 2041, and 2051 (according to census 2011).As the population of the area starts growing on the backdrop of new projects, the physical and social infrastructure will further get a positive boost.

The population of Gurgaon is expected to increase drastically as shown in (Graph 4 Population Growth Projection 2021-2051) in next 5 years as it is becoming centre for employment, thus increase of waste generation at a high rate. In order to cater the population, more land is to be required to give shelter to these people and also fulfil their requirements.

Year	Population	Increment	Annual Growth Rate
1951	201727		
1961	259655	57928	3%
1971	348151	88496	3%
1981	471695	123544	4%
1991	606791	135096	3%
2001	874695	267904	4%
2011	1514432	639737	7%
		2,91,570	5%
Population Projection	AP	GP	Incremental increase
2021	18,06,002	21,59,016	19,78,067
2031	20,97,573	30,77,954	26,13,766
2041	23,89,143	43,88,017	34,21,529
2051	26,80,713	62,55,679	44,01,356

Table 2: Population Projection of Gurgaon (1951-2051)

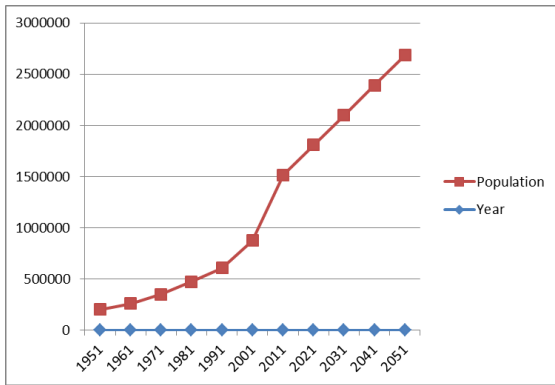


Figure 6: Population Growth Projection 2021-2051

India's waste management crisis has serious implications for its environment, economy and public health. We focus on creating technologies and solutions that minimize waste generation and convert all waste into useful products. This includes initiatives to promote a circular economy through resource efficient and cleaner production in industries and maximize resource recovery and recycling for landfill-free cities.

Population explosion, coupled with improved lifestyle of people, results in increased generation of solid wastes in urban as well as rural areas of the city. The solid waste from rural areas is more of a biodegradable nature & the same from urban areas contains more non-biodegradable components like plastics & packaging. The repugnant attitude towards solid waste & its management is, however, common in both the sectors. Universally 'making garbage out of sight' is the commonly followed practice.

Management of solid waste which generally involves proper segregation and scientific recycling of all the components is in fact the ideal way of dealing with solid waste. Solid waste management (SWM) is a commonly used name and defined as the application of techniques to ensure an orderly execution of the various functions of collection, transport, processing, treatment and disposal of solid waste (Robinson, 1986).

3.2. Estimation of Solid Waste in Different Decades

Various issue of solid waste management quantity in various decades has been estimated in the study. Solid waste generated by domestic, commercial and industrial activities is often indiscriminately disposed. Unscientific management of such wastes leads to serious environmental problems. High risks of spreading diseases like typhoid, cholera, dysentery, yellow fever, plague etc.

In our study, we have estimated the generation of solid waste in Gurgaon. The volume of waste generation has been increasing rapidly over the last few decades. According to MOHUA (Ministry of Housing and Urban Affairs) the solid waste generated per capita per day is about 0.5-0.9 and 147,613 metric tonnes of solid waste are generated per day. Planning Commission estimate Urban India will generate 2, 76,342 tonnes per day of waste by 2021. Therefore, as per our study we have taken 0.9 as the mean value for the per capita per day generation of solid waste in Gurgaon and increasing at a rate of 1.3% per annum.

Then we have divided the Solid waste Generation into 3 i.e. Biodegradable wastes, Non-biodegradable waste and Recycle waste constituting 52%, 32% and 17% respectively of total solid waste generated in Gurgaon in next 5 decades. Then we have (70%) of the solid waste generation.

Year	Population Projection (Acc. To Census)	Solid Waste Generation (acc.to AP) kg/capita/day	Non-Degradable (acc.to AP) kg/capita/day	Degradable (acc.to AP) kg/capita/day	Recycle Wastes (acc. To AP) kg/capita/day	Wet Waste kg/capita/day	Dry Waste kg/capita/day
2011	1866002	1625401.8	520128.576	845208.936	276318.306	1137781.26	487620.54
2021	2097573	1887815.7	604101.024	981664.164	320928.669	1321470.99	566344.71
2031	2389143	2150228.7	688073.184	1118118.924	365538.879	1505160.09	645068.61
2041	2680713	2412641.7	772045.344	1254573.684	410149.089	1688849.19	723792.51

Table 3: Estimation of Solid Waste Management in Gurgaon

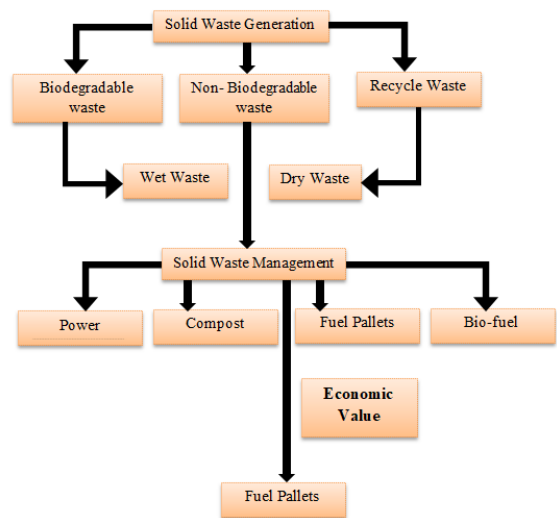


Table 4: Sustainable Solid Waste Management

In (Table 4: Sustainable Solid Waste Management), we have classified it into four management methods i.e. Power, Compost, Fuel Pallets and Bio-fuel respectively.

- Power:** Combustion of municipal solid waste (MSW) and many other wastes results in corrosive flue gases that attack boiler components such as super heater tubes. The normal method to convert the energy in waste into electricity is via a boiler, which makes steam, followed by a turbine/generator set.
- Compost:** Another method of treating municipal solid waste is composting, a biological process in which the organic portion of refuse is allowed to decompose under carefully controlled conditions. Microbes metabolize the organic waste material and reduce its volume by as much as 50 percent.

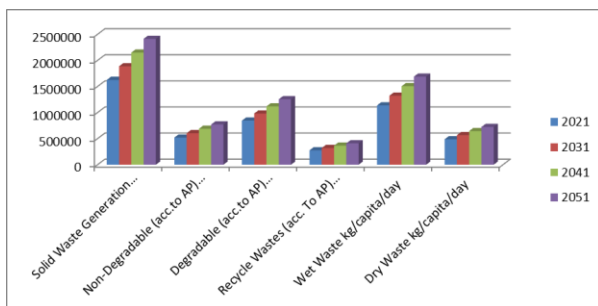


Figure 7: Waste Generation in Gurgaon in next 5 decades

3.3. Transformation of waste into Usable Products:



3. Fuel Pellets: Pelletization of municipal solid waste involves the processes of segregating, crushing, mixing high and low heat value organic waste material and solidifying it to produce fuel pellets or briquettes, also referred to as Refuse Derived Fuel (RDF) or Process Engineered Fuel (PEF) or Solid Recovered Fuel (SRF).

4. Biofuel: The first stage for converting of MSW to biofuels was a dilute-acid process. The main purpose of this process was to hydrolyze starch, resulting in a hydrolysate containing glucose.

Therefore, from this study our aim is to propose a sustainable method of solid waste management i.e. "higher the economic value higher will be the sustainability". We have calculated the economic value of all the methods that has been discussed and elaborated below:

Power generation:

2021: Solid Waste Generated (1625.40 Tonnes)

So, for every 100 tons it generates 1 MW Power

Therefore, for 1625.40 tons it will generate 16.25 MW Power

Cost:

1 MW Power cost = Rs. 4000

So, 16.25 MW Power Cost =Rs. 65,016

2031: Solid Waste Generated (1887.81 Tonnes)

So, for every 100 tons it generates 1 MW Power

Therefore, for 1887.81 tons it will generate 18.87 MW Power

Cost: with increase in 20% every decade

1 MW Power cost = Rs. 4800

So, 18.87 MW Power Cost =Rs. 90,614.88

2041: Solid Waste Generated (2150.22 Tonnes)

So, for every 100 tons it generates 1 MW Power

Therefore, for 2150.22 tons it will generate 21.50 MW Power

Cost: with increase in 20% every decade

1 MW Power cost = Rs. 5760

So, 21.50 MW Power Cost =Rs. 1, 23,852.67

2051: Solid Waste Generated (2412.64 Tonnes)

So, for every 100 tons it generates 1 MW Power

Therefore, for 2412.64 tons it will generate 24.12 MW Power

Cost: with increase in 20% every decade

1 MW Power cost = Rs. 6912

So, 24.12MW Power Cost =Rs. 1, 66,761.67

FUEL PELLETS

2021: Solid Waste Generated (1625.40 Tonnes)

40 Kg of waste = 15 Kg of Fuel Pellets

Therefore, 1625401.8Kg of waste =609525 g of Fuel Pellets.

Cost:

Per Kg Cost = Rs.35

Therefore, 609525 Kg of Fuel Pellets Cost =Rs. 21,333,375

2031: Solid Waste Generated (1887.81 Tonnes)

40 Kg of waste = 15 Kg of Fuel Pellets

Therefore, 1887815.7 Kg of waste =707928 Kg of Fuel Pellets.

Cost:

Per Kg Cost = Rs.45

Therefore, 707928 Kg of Fuel Pellets Cost =Rs. 31,856,793

2041: Solid Waste Generated (2150.22 Tonnes)

40 Kg of waste = 15 Kg of Fuel Pellets

Therefore, 2150228.7 Kg of waste =806332 Kg of Fuel Pellets.

Cost: -

Per Kg Cost = Rs.55

Therefore, 806332 Kg of Fuel Pellets Cost =Rs. 44,348,287

2051: Solid Waste Generated (2412.64 Tonnes)

40 Kg of waste = 15 Kg of Fuel Pellets

Therefore, 2412641.7 Kg of waste =904740 Kg of Fuel Pellets.

Cost:

Per Kg Cost = Rs.65

Therefore, 904740 Kg of Fuel Pellets Cost =Rs. 58,808,100

Compost Generation:

2021: Solid Waste Generated (1625.40 Tonnes)

1 Ton of waste = 83 Kg of Compost

Therefore, 1625.40 ton of waste =134.908 Kg of Compost.

Cost: with increase of 5% every decade

Per Kg Cost = Rs.10

Therefore, 134.908 Kg of Compost Cost =Rs. 13, 49,082

2031: Solid Waste Generated (1887.81 Tonnes)

1 Ton of waste = 83 Kg of Compost

Therefore, 1887.81 ton of waste =156.688 Kg of Compost.

Cost: with increase of 5% every decade

Per Kg Cost = Rs.15

Therefore, 156.688 Kg of Compost Cost =Rs. 23, 50,323

2041: Solid Waste Generated (2150.22 Tonnes)

1 Ton of waste = 83 Kg of Compost

Therefore, 2150.22 ton of waste =178.468 Kg of Compost.

Cost: with increase of 5% every decade

Per Kg Cost = Rs.20

Therefore, 178.468 Kg of Compost Cost =Rs. 35, 69,365

2051: Solid Waste Generated (2412.64 Tonnes)

1 Ton of waste = 83 Kg of Compost

Therefore, 2412.64 ton of waste =200.249 Kg of Compost.

Cost: with increase of 5% every decade

Per Kg Cost = Rs.25

Therefore, 200.249 Kg of Compost Cost =Rs. 50, 06,228

BIO-FUEL GENERATION

2021: Solid Waste Generated (1625.40 Tonnes)

1000 Tonnes of waste = 21.43 m³ of Compost

Therefore, 1625.40 tonnes of waste =34.832 m³ of Biofuel.

Cost: with increase of 20% every decade

Kg/m³ Cost = Rs. 45000

Therefore, 34.832 m³ =Rs. 15, 67,454

2031: Solid Waste Generated (1887.81 Tonnes)

1000 Tonnes of waste = 21.43 m³ of Compost

Therefore, 1887.81 tonnes of waste =40.45 m³ of Biofuel.

Cost: with increase of 20% every decade

Kg/m³ Cost = Rs. 54000

Therefore, 40.45 m³ =Rs. 21, 84,611

2041: Solid Waste Generated (2150.22 Tonnes)

1000 Tonnes of waste = 21.43 m³ of Compost

Therefore, 2150.22 tonnes of waste =46.079 m³ of Biofuel.

Cost: with increase of 20% every decade

Kg/m³ Cost = Rs. 64800

Therefore, 46.079 m³ =Rs. 29, 85,933

2051: Solid Waste Generated (2412.64 Tonnes)

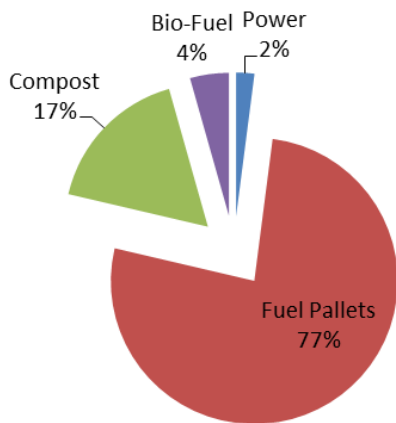
1000 Tonnes of waste = 21.43 m³ of Compost

Therefore, 2412.64 tonnes of waste =51.702 m³ of Biofuel.

Cost: with increase of 20% every decade

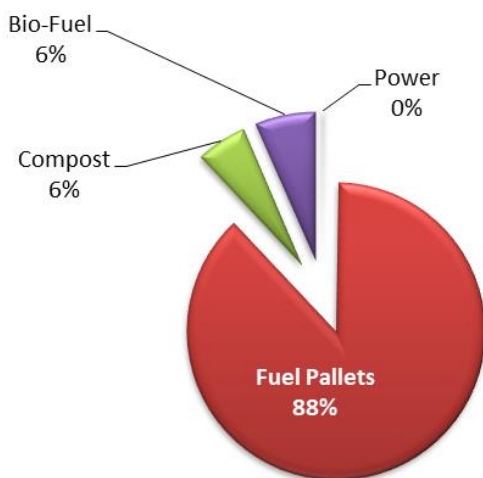
Kg/m³ Cost = Rs. 45000

Therefore, 51.702 m³ =Rs. 40, 20,415



Solid Waste Management

Figure 8: Sustainable Solid Waste Management



Economic Value Calculation

Figure 9: Economic Value Calculation

4. Conclusion:

The rapid urbanization process leads too many problems in which solid waste is one of the aspects which are changing the environment of Cyber City Gurgaon. The solid waste management is a low priority but can create social and environmental problem with risks to public health and environment. The existing solid waste management is constrained by institutional weakness, lack of proper funding, lack of proper management and operational systems, public apathy, lack of municipal will to become financially self-sufficient through municipal taxation and whole sole no administrative control on ultimate waste management stage i.e. disposal and processing system. Waste dumping is the only favourable method to urban local body without any further action. Day by day increasing trend practice of dump to dump yard won't sustain the function. So, there is a requirement of taking integrated policy and technology to use less land as land is precious. Different part of India's dump yard has started to reclaimed and process of SWM to reach zero waste city tag. Recycling, composting and ultimate power generation makes this city also zero waste city status.

To achieve financial sustainability, socio-economic and environmental goals in the field of waste management, there is a

need to systematically analyze the strengths and weaknesses of the community as well as the municipal corporation, based on which an effective waste managementsystem can be evolved with the participation of various stakeholders in India. All these above saidsuggestions are given in relation to India and will be effective only when we individually feel the responsibility of making environment clean. So, as per the study "higher the economic value higher the sustainability" Therefore, Fuel pallets is one of the sustainable method that is showing high economic value, thus it is recommended to use Fuel Pellets as a sustainable solid waste management.

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