DETAILED PROJECT REPORT ON
MUNICIPAL SOLID WASTE MANAGEMENT
FOR
SMART CITY AREA DEVELOPMENT PROJECT, AGRA, UTTER PRADESH

Submitted to
M/s Shah Technical Consultants Pvt. Ltd, Mumbai

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Acronyms

A&OE	:	Administrative & Office Expenses
ANN	:	Agra Nagar Nigam
BOQ	:	Bill of Quantities
BOT	:	Build Operate Transfer
CBO	:	Community Based Organization
CPCB	:	Central Pollution Control Board
CPHEEO	:	Central Public Health & Environmental Engineering Organisation
DPR	:	Detail Project Report
DTDC	:	Door to door collection
EIA	:	Environmental Impact Assessment
EMP	:	Environmental Monitoring/Management Plan
GoI	:	Government of India
HPC	:	High Power Committee
IEC	:	Information, Education and Communication
MoUD	:	Ministry of Urban Development
MoEF & CC	:	Ministry of Environment, Forests & Climate Change
MSW	:	Municipal Solid Waste
MSWM	:	Municipal Solid Waste Management
MT	:	Metric Tonnes
NARC	:	National Advisory for Review Committee
NGO	:	Non-Governmental Organization
NH	:	National Highway
O&M	:	Operation and Maintenance
PPP	:	Public Private Partnership
RDF	:	Refuse Derived Fuel
RWA	:	Resident Welfare Association
SBM	:	Swatch Bharat Mission
SH	:	State Highway
SHG	:	Self-Help Group
SLF	:	Sanitary Landfill Facility
SPCB	:	State Pollution Control Board
SWM	:	Solid Waste Management
TPD	:	Tons Per Day
ULB	:	Urban Local Body
VECs	:	Valuable Environmental Components

1. INTRODUCTION

1.1 Background

The management of municipal solid waste has become an acute problem due to enhanced economic activities and rapid urbanisation. Increased attention has been given by the government in recent years to handle this problem in a safe and hygienic manner. Municipal Solid Waste (MSW) management is one of the essential services for maintaining quality of life in urban areas and for ensuring better standards of health and sanitation. Presently, this service falls short of the desired level, as systems adopted are outdated and inefficient. Institutional weakness, shortage of manpower, financial resources, and improper choice of technology, inadequate coverage and lack of short and long-term planning are responsible for the inadequacy of service.

The Government of India launched its flagship "100 Smart Cities Mission" on June 25, 2015. Smart city is a city equipped with basic infrastructure to give a decent quality of life, a clean and sustainable environment through application of some smart solutions. Ministry of Urban Development (MoUD) has shortlisted Agra, a historical city of Uttar Pradesh as one of the smart cities under the competitive process of 'Smart City Challenge'. The Agra ABD covers about 2200 acres covering Agra Fort, Old city, Jama Masjid, Taj Mahal, Tajganj, roads connecting to Fathebad road, and inner ring road will be retrofitted

1.2 Status of MSW Management

Municipal Solid Waste (MSW) management is one of the essential services for maintaining quality of life in urban areas and for ensuring better standards of health and sanitation. Presently, this service falls short of the desired level, as systems adopted are outdated and inefficient. Institutional weakness, shortage of human and financial resources, improper choice of technology, inadequate coverage and lack of short and long term planning are responsible for the inadequacy of service.

For maximum efficiency and effectiveness of this service, it is necessary to tackle this problem systematically by analyzing the present scenario of the MSW management and come forward with a cost effective system which ensures adequate level of MSW management services to all class of citizens. The system will include collection, segregation, storage, transportation, processing and disposal of wastes in an environmentally acceptable manner in accordance with the Solid Wastes Management Rules, 2016. Growth and development of economy triggers expansion in urbanization. This often induces migration of population from rural & semi urban areas to big towns and cities. Unless a proper planning is undertaken well

ahead of time, the uncontrolled growth in urbanization can strain municipal infrastructures like water supply, sewage and solid waste disposal resulting in deterioration of environment and public health problems.

1.3 Initiatives to improve SWM

Government of India has taken up various initiatives for so as to improve the existing waste management practices. Some of the key initiatives are mentioned below:

a) Honorable Supreme Court of India Recommendations

In recent years, the current SWM system in India has received considerable attention from the Central and State Governments and local municipalities. The first initiative was taken by the Honorable Supreme Court of India in 1998, which resulted in the formation of a Committee to study the current status of SWM in Indian cities. This Committee identified the deficiencies/gaps in the existing SWM system in the country and prepared the "Interim Report on SWM Practices in Class I Cities". Class I are cities with a population ranging between one lakh to ten lakhs (1,00,000 – 10,00,000).

b) Municipal Solid Waste Management Rules

As a second initiative, the Ministry of Environment Forests & Climate Change (MoEF&CC), Government of India, published "Municipal Solid Waste (Management and Handling) Rules 2000" (MSW Rules 2000). These rules were developed in conformance with Sections 3, 6 and 25 of the Environment Protection Act, 1986 and aim at standardization and enforcement of SWM practices in the urban sector. They dictate that, "Every municipal authority shall, within the territorial area of the municipality, be responsible for the implementation of the provisions of these rules and infrastructure development for collection, storage segregation, transportation, processing and disposal of municipal solid wastes". In addition, "the CPCB shall coordinate with State Pollution Control Boards (SPCBs) and Pollution Control Committees (PCCs) in the matters of MSW disposal and its management and handling".

Further, after experience of 16 years this rules have been revised and framed with wealth of all resources which was lacking and need for successful implementation of MSW management in different areas. The rule is applicable for all waste generators and highlighted the role and responsibility of each administration for their effective implementation. The current MSW rule "SWM Rules 2016" has strategically emphasized to make ULB financial healthy with an objective of self-sustainable model.

c) Jawaharlal Nehru National Urban Renewal Mission

The Jawaharlal Nehru National Urban Renewal Mission (JNNURM) is the third notable initiative undertaken by Government of India. JNNURM provides funding for urban infrastructure development in 63 cities and towns of the country. This mission was initiated in 2006 and is slated to continue until 2011.

d) Urban Infrastructure Development Scheme for Small and Medium Towns

The primary objective of this scheme is to improve the urban infrastructure in towns and cities in a planned manner and to promote public–private partnership (PPP) in infrastructure development. This scheme was introduced in the year 2005-06 and will continue for seven years. This scheme is applicable to all cities/towns as per 2001 census, except the cities/towns covered under the JNNURM. One of the components of this scheme is to renew the old sewerage and solid waste disposal systems in inner (old) areas.

e) Swachh Bharat Mission

Swachch Bharat Mission (SBM) was launched on 2nd of October, 2014 with a vision to achieve a clean India as a tribute to the father of the nation, Mahatma Gandhi, on his 150th birth anniversary, in 2019. SBM is being implemented by the Ministry of Urban Development. M/o HUD, GoI and by the Ministry of Drinking Water and Sanitation (M/o DWS) for urban and rural areas with a given set of guidelines for improved sanitary services and capacity building initiatives. Municipal Solid Waste Management (MSWM) a major component of the SBM (urban)- "refers to a systematic process that comprises of waste segregation and storage at source, primary collection, secondary storage, transportation, secondary segregation, resource recovery, processing, treatment, and final disposal of solid waste."

Under the provisions of SWM, the local bodies are to prepare Detailed Project Reports in consultation with the state government based on the identified needs of the City Sanitation Plans. Provision also mentions clustering of smaller cities for attracting Private investment. The DPRs should be prepared in lines with Govt. of India's goals outlined in the NUSP 2008, SWM rules, advisories, CPHEEO manuals (including cost recovery mechanisms), O&M practices and Service-level Benchmark advisories released by M/o UD and Manual on Municipal Solid Waste Management, 2016. States will contribute a minimum of 25% funds for SWM projects to match 75% Central Share (10% in the case of North East States and special category states). 80% of the urban population to be covered by SWM services

(allowing for a 2% increase year on year) covering all statutory towns. Central government Grant / VGF may also be used to promote projects of waste to energy.

f) Fourteen Finance Commission Recommendations

Constituted by the President of India, under Article 280 of the constitution, the Finance Commission is to recommend on distribution of central tax revenues between the Union and the States. Supporting Local bodies through grant, subsequent to the passage of the 73rd and 74th constitutional amendments were first time announced in the 10th Finance Commission for providing basic services at the grassroots level and strengthening decentralization. The 13th Finance Commission has recommended two categories of Grants to Local Bodies namely (1) General Basic Grant and (2) General Performance Grant. The Basic Grants will be released on furnishing the U. Cs for the last releases and the General Performance Grant will be released on fulfilment of nine conditions by the State Government, as stipulated in para 10.16.1 of the report of the 13th Finance Commission by March of a particular financial year. Performance-related funds under the 13th Finance Commission have been linked to improvements in SLBs including SWM.

Further, in 2009, MoUD initiated Service Level Benchmarking (SLB) with respect to basic municipal services including solid waste management. SLB has been introduced in 30 states and across 4041 ULBs. Performance-related funds under the 13th Finance Commission have been linked to improvements in SLBs including SWM. The 13th Finance Commission also recommends that of all grants to be given to the ULBs, 50% should be for SWM (2010-2015). Moreover, the Ministry of New and Renewable Energy has funded five Waste-to-Energy plants for utilization of MSW. The grant recommended to ULBs in Uttar Pradesh also under such grant every local body is mandated preparing an Annual Development Plan where in the component integrated solid waste management under PPP mode (excluding purchase of equipment for collection and transport of garbage) is to be incorporated.

g) National Green Tribunal Recommendations

Action Plan for Management of Municipal Solid Waste (MSW)

CPCB has framed and notified the “Action Plan for Management of Municipal Solid Waste (MSW)” in compliance with the National Green Tribunal order dated 5th Feb-2015 in the matter of OA No. 199 of 2014. The Action Plan emphasizes on strengthening the planning exercise at national, state as well as city level by improvising through the waste management value chain. In addition to that, The Plan suggested the concept of regional cluster approach

as well as technology options on the basis of quantum of MSW generation which has been re-produced below in nutshell.

1.3.1 Initiatives taken at State Level

The Supreme Court of India has given directives to all States to comply strictly with Municipal Solid Waste Management Rules. The current system of Solid Waste Management (SWM) in most of the ULBs of Uttar Pradesh is that door to door collection of waste, collection from market and from community bins, transportation and disposal at the dump yard is being carried out without any segregation, processing and treatment. This has led to environmental degradation, air pollution, ground water table pollution and poses grave health hazards.

Uttar Pradesh Govt. has decided to implement Integrated Solid Waste Management in all Urban Local Bodies by following SWM Rules 2016. The solid waste is to be collected from every household from each ward of ULB and it is to be brought to the designated landfill facility of that ULB in covered vehicles. Then waste is to be weighed, segregated, material recovery and waste processing has to be done. The residual waste is to be scientifically disposed in the scientifically designed landfill. Since, the studied ULB have more than 10 MT/day of waste generation hence the standalone mode for integrated processing and disposal shall be feasible option for this ULB. Overall, the main objectives of the project are as under:

- To examine and review existing environmental, social, organization, technical and financial aspects of SWM project.
- To devise a system on zoning patterns that is customized to the local environment, is in-line with the appropriate global technologies/ socially viable best practices, and addresses the four set of components mentioned in above point.
- To recommend appropriate cost recovery mechanisms and targets and to suggest appropriate

This report of Agra Nagar Nigam shall be prepared in line with Solid Waste Management Rules 2016 and Manual on Municipal Solid Waste Management 2016 to achieve above mentioned objectives.

1.3.2 Initiatives taken at Local Level

Municipal commissioner is overall responsible for management of Municipal Solid Waste in their jurisdiction for cleanliness and management of municipal solid waste in the city. Their functions include collection, segregation, transfer and disposal of waste, and road-cleaning

activities. An effective Solid Waste Management has never been implemented, neither has any Scientific Landfill has been constructed.

The Mayor is the highest administrative body of Agra Nagar Nigam. Municipal Commissioner (Nagar Aayukt) is the In-charge of Agra Nagar Nigam and is assisted by Additional Municipal commissioner. Further below there are functional depts. Viz. Health & Eng., Accounts, Tax deptt, and Street Light dept. etc.

Further, the account section is led by Account Clerk while sanitary section is led by Sanitary Inspector and supervisors. The staff of the section includes driver, sweepers and other sanitary workers and they report to the sanitary inspector.

Currently, municipal workers collect un-segregated waste and they are dumping different lying area of city and at Kuberbur due to area in the city. Further, there is no any scientific landfill site for disposal of inert and residue material which is getting generated within jurisdiction of Agra Nagar Nigam.

2.0 SCOPE & OBJECTIVES

The overall scope and objective of this DPR on Management of MSW are to,

1. Assess the present status of MSW management system in ABD zone
2. Up gradation of the existing system with technological improvement for efficient and effective Management of MSW
3. Gap analysis in terms of Infrastructural requirements, Manpower, Machineries, Materials, vehicles etc.
4. Suggest suitable MSW Treatment and utility options
5. Estimation of Capital & Recurring Costs for Collection, transport to dump site.

3. PROJECT AREA AND EXISTING POPULATION AND MSW SCENARIO

3.1 History and importance of project area

Agra city is of historic importance, which is amply evident from the numerous historical monuments in and around the city. The Hindu epic Mahabharata refers to it as "Agraban", part of Brij Bhoomi, the homeland of Lord Krishna. The earliest recorded history of Agra is its establishment by a local king in 1475. The city was the capital seat of Mughals in ancient times. The heritage of the city is linked with the Mughal dynasty but numerous other rulers also contributed to the rich past of this city. Agra was founded by Sikandar Lodi in the 16th century. It grew into an important power centre under the Delhi Sultan Sikandar Lodi and he shifted his capital from Delhi in 1504. Babar also stayed in Agra for some time and introduced the concept of square Persian-styled gardens. Emperor Akbar built Agra fort and Jehangir did the beautification with gardens and palaces. The city has a proud possession of "Taj Mahal" as one of the Seven Wonders of the World, now declared as World Heritage Site. The post-Mughal era of Agra saw the rule of Jats, Marathas and finally the British taking over the city. In addition to its historic importance, Agra is a main center of political, economic, commercial and cultural activities.

The origin and growth of Agra can be traced to several hundred years, which witnessed a series of historical events leading to its present form, structure, character, culture and economy. The growth of Agra started with the imperial favour, as a seat of emperor of India. In the process of development, the city started influencing over the vast region and became the regional capital, which initiated its growth during the British and post-independence period.

Legend has it that Agra was founded during the region of Ugrasen, grandfather of Lord Krishna. The existence of Agra city was accounted for in 1080 A.D., by Khawaja M,S.Salman, a poet, as a flourishing city with a string fortress built amidst river and lake hills. This was ruined by the invader Muhammad Gazni in 1080 A.D., which reduced Agra to a small town. Agra continued as a village until the core of the present city, was laid by Raja Badal Singh around 1475 A D

Agra's golden era was during Akbar (1556-1605 A.D) and Shahjahan (1627-1658 A.D.) periods. Akbar rebuilt a much larger and more magnificent red sandstone fort at the site of Badalgarh Fort in year 1565. The topographically elevated site by the river was highly defensible. It is roughly semicircular in shape stretching half a mile along the

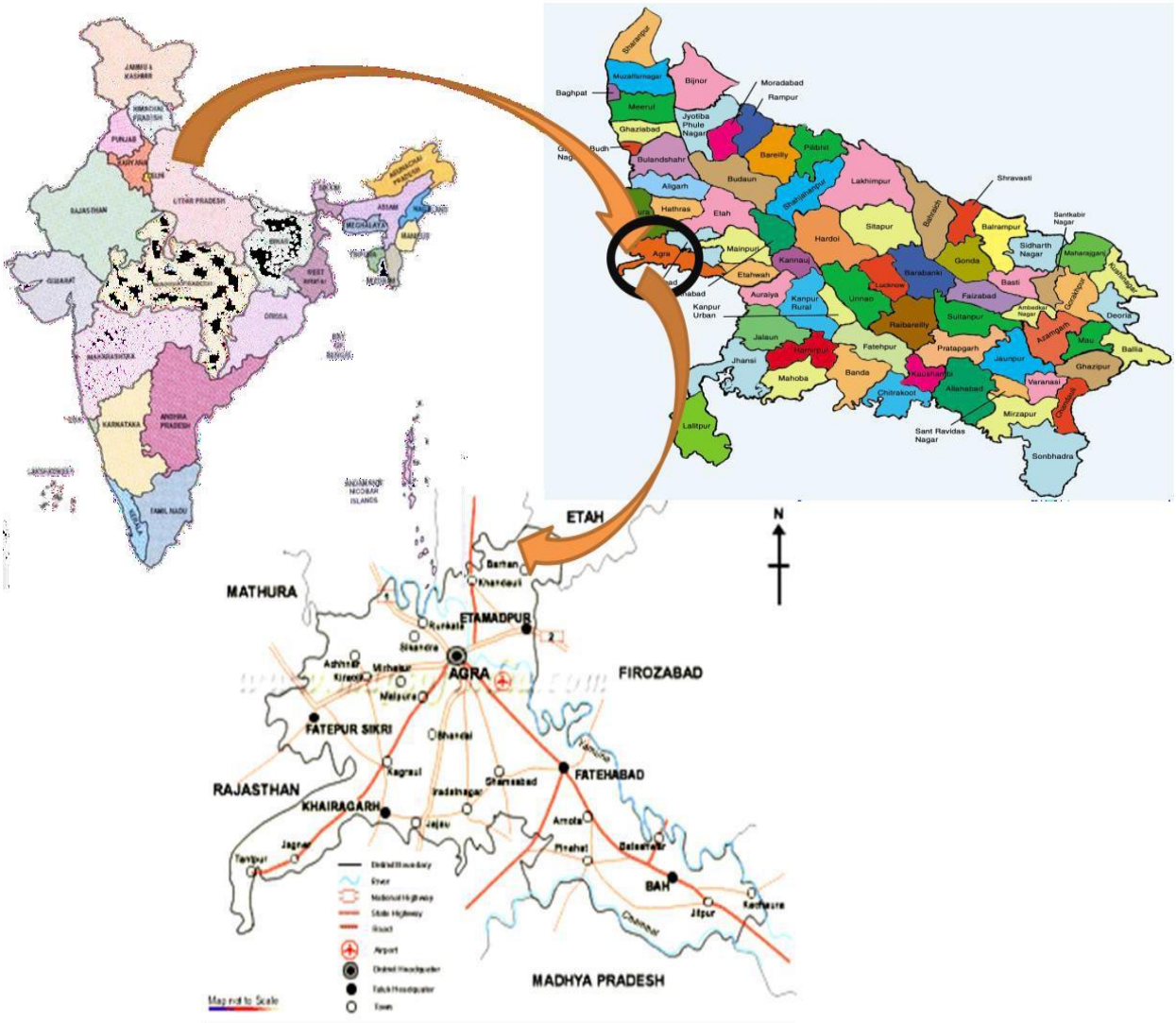
river. The seventy feet high walls along with bastions, battlements, towers and massive gates, housed palaces, mosque, and houses of officials, gardens and market squares. His Agra developed around the fort on the west bank of yamuna and was the nucleus of the 16^{th} and 17^{th} century mughal city. The pattern of development was very much like a small semi-circular ring encircling the fort towards its North west, west and south west while the eastern side fronted onto the Yamuna. A web of bazaars all radiating from the fort, adjoining a ring road can be discerned even in the present layout of Agra. This seems to be the oldest part of the city on the west bank, as we know it today. The population of Agra during Akbar`s time was about two lakhs and the accounts of Ralph Fitch, who visited Agra in 1585 A.D., give some idea of the city as it must have been at the time- "Agra is a very great city and populous, built with stone, having fair and large streets with river running by it. The road to Fatehpur Sikri was also constructed during this period.

3.2 Geographical and Climatic Condition

3.2.1 Geographical location

Being centrally located on the national map, Agra (aka Akbarabād) forms an important regional urban center and a prominent tourist destination in India. It is a Class I town, municipality and administrative head quarters of Agra District, falls under Agra division of Uttar Pradesh. The city of Agra is situated on the Western Bank of river Yamuna at about 200 Kms from Delhi in the state of Uttar Pradesh. City spatial extension falls at 27°12' N latitude and 78°12' E longitude.

Figure-1. Geographical location of Agra



Its borders touch Rajasthan to its west and south, the district of Firozabad to its East and the districts of Mathura and Etah to its North Agra lies on the parts of the Great Indo-Gangetic Plain region and the strata consist of mainly sandy soil. The sub-soil water level is generally 6 to 8m below ground level. The ground levels at Agra vary from RL 150 m to 170m. The city stretches for about 9.0 kms along the Yamuna River. The major part of the city is on the Western side of Yamuna and has grown beyond the river on the eastern side and is called the Trans Yamuna area while the original part is called as CIS Yamuna

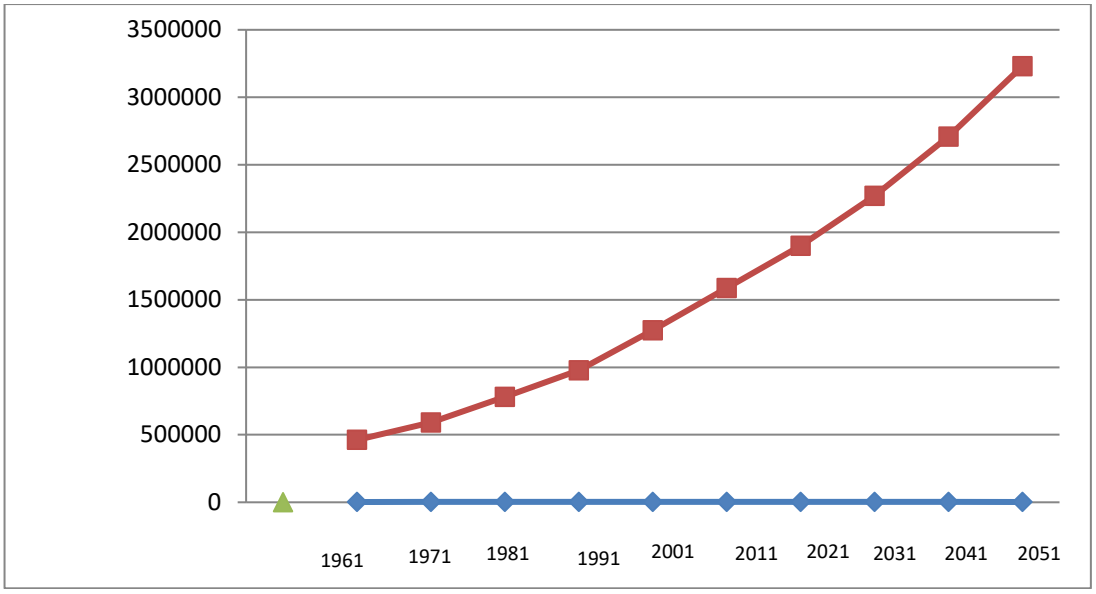


Figure-2: Projected Population Growth in Agra City from 1961 to 2051

3.2 .2 Climatic condition

The climate of Agra is extreme and tropical in nature with a varying temperature dropping to 3°C in winter and rises to 47°C in summer. Thick fog in December and January makes city suffer from travel delays. Rainy season starts lasts from June to September; annual rainfall of 686 mm is recorded. Winter starts in November and lasts till February.

3.3 Present Study Area of ABD in Agra

In Agra city, 9 wards have been selected for ABD under Smart Cities Mission. These wards were located around Taj Mahal and were selected to improve the existing quality at International Standard in order to attract pleasant tourism. The list of wards under ABD is given in Table 1

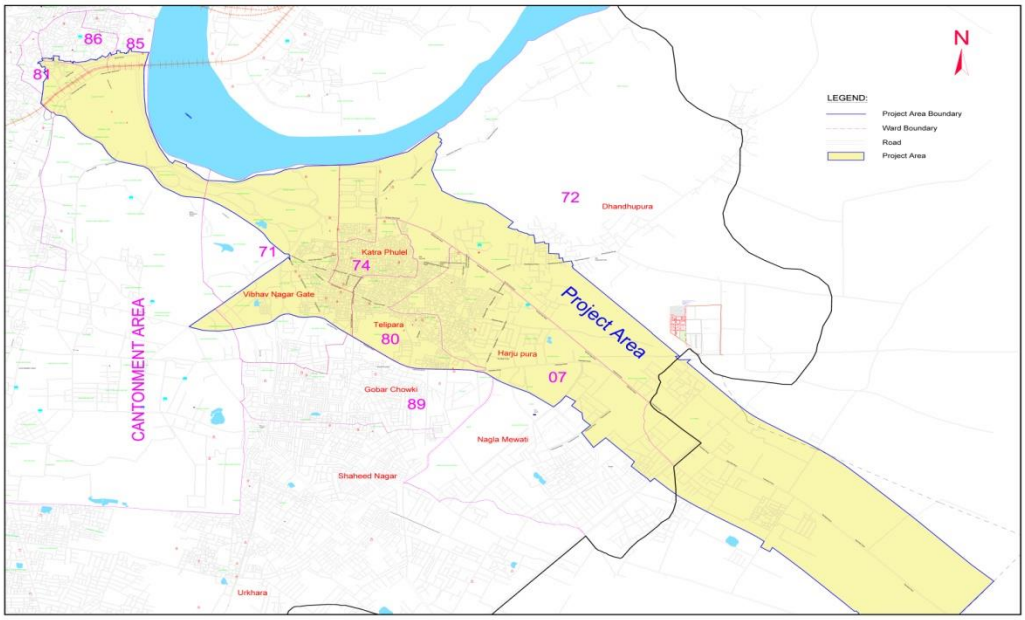


Figure- 3: Map showing the boundaries of Agra Smart City ABD area

Table 1: List of Municipal wards under ABD area

S. No	Name of the Ward	Ward Number
1	Nagla Mewati	07
2	Vibhav Nagar	71
3	Dhandupura	72
4	Katra Fulel	74
5	Telipada	80
6	Rawatpada	81
7	Motiganj	85
8	Pipal Mandi	86
9	Kalal Kheria & Mayapura	Village

3.4 Population and Household Profile in ABD area

It has been reported that the overall population of Agra City is 15, 87, 006 in 2017. A major issue in Agra is the floating population. Tourists and short-term migrants come and stay in Agra for varying periods of time. These pose challenges to the city administration with respect to sanitary facilities, toilets, solid waste management, sewage, water supply, transport etc. Furthermore, Agra attracts about 19-22 percentage of total population per day come from nearby villages and urban area for employment and other official/business/ personal purposes. The floating population is reported as 0.3 million per day (AJS, 2015).

Table 2 : Details of area, population, No. of households, density in the ABD area

S. No	Ward Number	Total Ward Area (Ha.)	Project coverage area (Ha.)	Percentage of coverage	Total no of Households as per 2011 census	No of Households in ABD	Total ward Population in 2017	Project converge area population	Population Density in Project area (Nos/ha)
1	Ward -7	353	161	46	2466	1134	19397	8923	55
2	Ward -71	200	120	60	2989	1793	17695	10617	88
3	Ward -72	796	183	23	1307	300	8684	1997	11
4	Ward -74	30	30	100	3557	3557	25530	25530	851
5	Ward - 80	66	66	100	3471	3471	22570	22570	342
6	Ward - 81	17	9	50	1606	803	5948	2974	330
7	Ward - 85	21	4	20	2576	515	14741	2948	737
8	Ward - 86	25	3	12	2189	263	12271	1473	491
9	Kalal Kheria & Maya pura (Village)	319	319	100	1088	1088	5442	5442	17
Total / Average		1827	895	23 to 100%	21249	12924	132278	82474	92

Table 3: Summary of area, population, No. of households, density in the ABD area, Agra

S.No	Item	Total / Average
1	Total Ward Area (Ha.)	1827
2	Project coverage area (Ha.)	895
3	% of coverage	49.0 %
4	Total no of House- holds in all wards as per 2011 census	21249
5	No of House-holds in ABD area	12924
6	Total ward Population in 2017	132278
7	ABD Project converge area population	82474
8	Population Density in Project area (nos/ha)	92

Table 4: No of waste generation sources in ABD area

S.No	Item	Quantity in numbers
1	No. of Households in ABD area	12924
2	Restaurant, Dhaba Hotel	692
3	Whole sale & Retailer shop	5450
4	Vegetable & Fruit shop	446
5	Meat & Fish shop	66
6	Institutions	223
7	Total waste generation Tonnes per day	93.0
	Per capita generation for Domestic waste (Kg/Day)	0.496

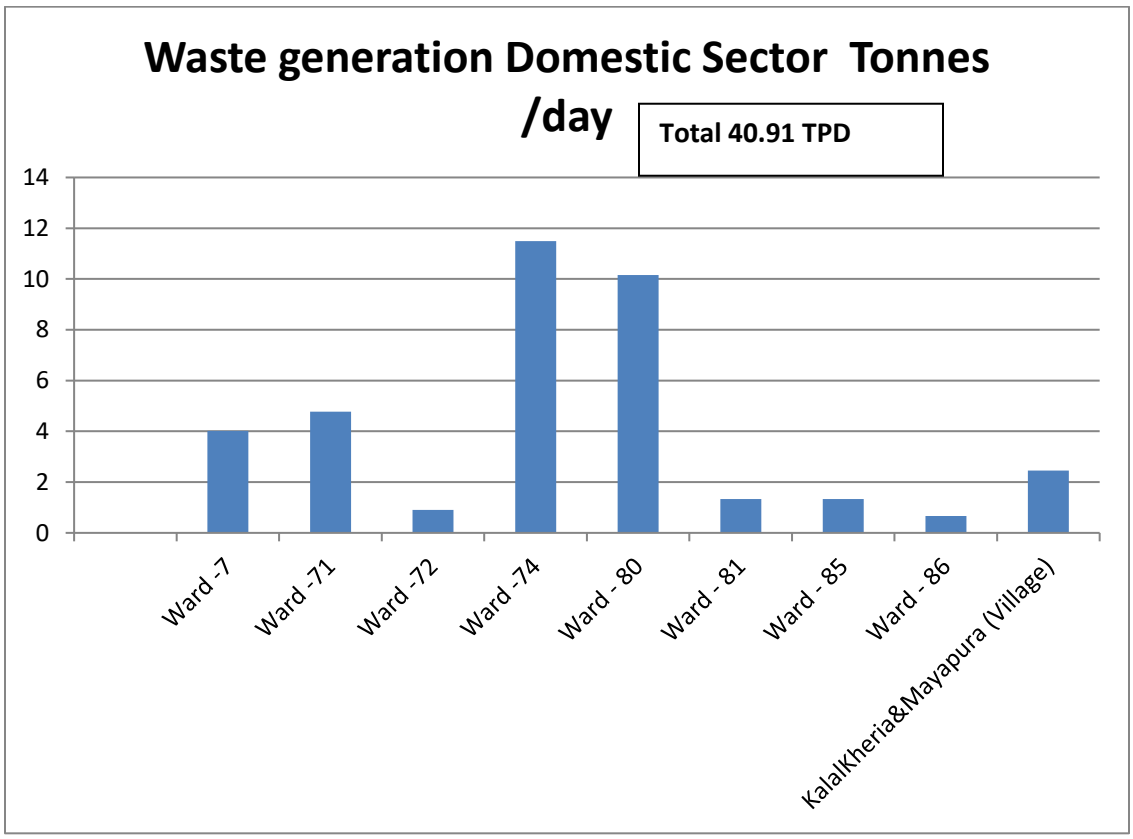


Figure-.4: Ward wise Waste Generation Domestic Sector of ABD (Tonnes /day)

Table 5: Projected Decadal increase in MSW generation in various sectors in ABD area, Agra

Waste Category	Year		
	2017	2027	2037
Domestic	40.91	48.92	58.41
Commercial	30.28	36.04	42.90
C&D Waste	13.59	16.22	19.33
Road sweeping	8.23	9.82	11.71
Total Tonnes/Day	**93**	**111**	**132**

A perusal of the Table 4 indicates that there are about 19 and 42 % increase in MSW generation in ABD in 2027 and 2037 respectively compared to 2017.

Table 6: Typical characteristics of MSW at Agra

S. No	Waste Category	% of composition
1	Biodegradable matter	50%
2	Glass	4%
3	Plastics	3%
4	Paper	5%
5	Metals	1%
6	Leather and rubber	1%
7	Rags	5%
8	Household hazardous	1%
9	Inert materials	30%
	Total	**100%**

4.0 CURRENT MANAGEMENT OF MSW IN INDIA

The present practices followed for the MSW management is categorised as follows:

- Collection from domestic & other establishments
- Collection in small dust bins
- Transfer to Big size Dust drums
- Transportation from Big size dust bins to Dump site through Trucks

The gap between generation and collection of waste is showing need to increase collection efficiency which may be carried out through primary collection through door to door or through providing adequate number of collection bins as well as of synchronization of vehicle fleet.

There is no any treatment process like composting or RDF production and it is simply dumped in open land .

To implement proper waste management, various aspects have to be considered such as Waste generation (source reduction), Waste handling and sorting, storage and processing at the source (onsite storage), Collection, Sorting, processing and transformation, transfer and transport, and Disposal (The Expert Committee, 2000). Figure-5, shows the interrelationship between the functional elements in solid waste management.

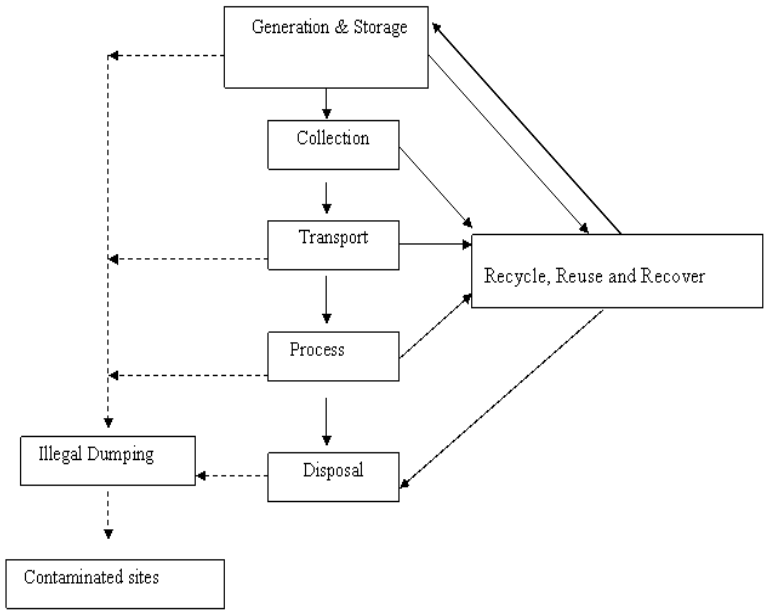


Figure-5: The Municipal Solid Waste Stream

4.2. Waste Generation

Waste generation encompasses activities in which materials are identified as no longer being of value (in their present form) and are either thrown away or gathered together for disposal. Waste generation at present is not very controllable. However, reduction of waste at source is included in system evaluations as a method of limiting the quantity of waste generated. The compositional terms that are used can vary a lot, from relatively simple descriptions in terms of organic to more complicated schemes, using many or all of the constituents, such as paper, plastic, glass, metal etc.

The composition of the waste is a description of the contents of the waste. In addition to providing important information about the way to handle the waste, the composition tells us about the people who generated the waste. The composition of waste varies widely from place to place, especially country to country.

Table 7: Relative composition of household waste in low, medium and high-income countries

Parameter	Low-income countries	Medium-income	High-income countries
Organic (putrecible),	40 to 85	20 to 65	20 to 30
Paper, %	1 to 10	15 to 30	15 to 40
Plastics, %	1 to 5	2 to 6	2 to 10
Metal, %	1 to 5	1 to 5	3 to 13
Glass, %	1 to 10	1 to 10	4 to 10
Rubber, leather, etc., %	1 to 5	1 to 5	2 to 10
Other, %	15 to 60	15 to 50	2 to 10
Moisture content, %	40 to 80	40 to 60	5 to 20
Specific weight, kg/m3	250 to 500	170 to 330	100 to 170
Calorific value, kcal/kg	800 to 1100	1000 to 1300	1500 to 2700

Source : **(INTOSAI working group on environmental auditing, 2002)**

To illustrate the information that can be deduced from information on composition, we can start with Table 7 that shows the average composition and amounts of waste for low, medium and high-income countries.

The most striking difference that can be seen is the difference in organic content which is much higher in the low income countries than the high income countries and the paper and plastic content which is much higher in higher income countries than low income countries. This shows the difference in consumption pattern, cultural and educational differences

In higher income countries the usage of disposable material, magazines and packaged food is used in higher quantity that results in a waste having higher calorific value, lower specific density, and lower moisture content. In case of lower income countries the usage of fresh vegetables to packaged food is much higher and mostly materials that are reusable are used. This results in a waste composition that has high moisture content, high specific weight and low calorific value. This shows how waste statistics can be used to describe the life style of the people and also their income.

4.3. Waste Handling, Sorting, Storage, and Processing at the source

Waste handling and sorting involves activities associated with management of wastes until they are placed in storage containers for collection. Handling also encompasses the movement of loaded containers to the point of collection.

- Sorting is an important component of waste management and best-done onsite. However, there are various stages of sorting. These can be identified as the following:
  - At the source or house hold level
  - At the community bin (municipal bin)
  - At transfer station or centralised sorting facility
  - At waste processing site (pre-sorting and post sorting)
  - At the landfill site
- Sorting Operations can be carried out in three ways:
  - Manual sorting
  - Semi-mechanised sorting
  - Fully mechanised sorting

- Onsite storage is of primary importance because of public health concerns. Open ground storage, make shift containers should always be avoided and only closed containers should be used. Processing at the source involves backyard composting. Storage of wastes can be done at three levels:
  - At source
  - At community level
  - At transfer stations

4.3.1. Collection

This includes gathering the solid wastes and recyclable materials and transport of these materials to either the processing facility, transfer facility or the disposal site.

Types of Collection

i. Community bins - they are placed in convenient locations, where the community members carry the waste and throw it in. This method is comparatively cheaper to other methods. This is the most widely adopted method in western countries. For this method to be adopted it is important that the Bins are covered, they are aesthetic, they are attended to regularly, kept clean, easy to handle and separate bins are provided for recyclable, mixed, paper and biodegradable waste.

ii. Door-to-Door collection – The waste is placed at the doorstep at a set time when the waste collector arrives. In this method, it is the collector of the waste has the responsibility to collect the waste separately. This method is very convenient for the householder, however requires homeowner cooperation and scheduled service for homeowner cooperation.

iii. Block collection - the collection vehicles arrive at a particular place or a set day and time to collect waste from the households. Households bring their waste containers and empty directly into the vehicle. This method requires a higher homeowner cooperation and scheduled service for homeowner cooperation.

iv. Curbside collection – the homeowner is responsible for placing the containers to be emptied at the curb on the collection day and for returning the empty containers to their storage location until the next collection (Tchobanolous, G et al 1993). Street cleansing is another type of collection method mainly for collection of street litter.

4.3.2. Sorting, processing and transformation of Solid Waste

This functional unit encompasses the recovery of the sorted materials, processing of solid waste and transformation of solid waste that occurs primarily in locations away from the source of waste generation.

Sorting of the mixed waste usually occurs at a material recovery facility, transfer stations, combustion facilities and disposal sites. Sorting includes separation of bulky items, separation of waste components by size using screens, manual separation of waste components, and separation of ferrous and non-ferrous metals.

Waste processing and transformation solid waste processing reduces the amount of material requiring disposal and, in some cases produces a useful product. Examples of solid waste processing technologies include material recovery facilities, where recyclable materials are removed and/or sorted; composting facilities where organics in solid waste undergo controlled decomposition; and waste-to-energy facilities where waste becomes energy for electricity.

Land filling continues to be required even if solid waste processing technologies are employed because all of these technologies produce some sort of residue or handle only a portion of the waste stream. For example, land filling is still required for ash and bypass Waste (waste that can't be burned) from waste-to energy facilities. Thus, solid waste processing technologies do not replace land filling; rather they are a part of an integrated system that reduces the amount of material that requires landfill disposal.

The different types of processing techniques are given below

Recycling and reuse - the process, by which materials otherwise destined for disposal are collected, reprocessed or remanufactured and are reused. The recycling and reuse (the use of a product more than once in its same form for the same or other purpose) sector of waste management in cities of Asian developing countries is potentially high. Its economic assessment is a difficult task since it is practised in an informal way.

Composting is a biological process of decomposition carried out under controlled conditions of ventilation, temperature, moisture and organisms in the waste themselves that convert waste into humus-like material by acting on the organic portion of the solid waste (Sathishkumar, et al 2002). It produces a sludge, which is high in nutrients and can be used as a fertilizer. This is one element of an integrated solid waste management strategy that can be applied to mixed municipal solid waste (MSW)

or to separately collected leaves, yard waste or food waste. There are various methods of composting, which are:

Bangalore method - This is an anaerobic method conventionally carried out in pits. The waste and the soil is alternatively laid out in layers and then is covered with a solid layer to prevent flies, odour and water seepage. This material is allowed to decompose for 4 to 6 months after which the stabilised material is taken out and used as compost.

Indore method - this method is similar to Bangalore method, however to ensure aerobic condition the material is turned at specific intervals. First turn is given manually after 4-7 days. 2nd turn is given after 5-10 days and further turning is normally not required and the compost is ready in 2 to 4 weeks.

Windrow composting is a common method of composting, it involves the stabilization of organic solid waste through aerobic degradation. The waste is piled in heaps with approximately a height of 3 m, width of 1.5 m and varying lengths. The waste is left for 60 days for decomposition with weekly turnings to aerate the heaps. After which, it can be sieved and the compost is obtained.

Vermicomposting is a comparatively new method in composting; it involves the stabilisation of organic solid waste through earthworm consumption that converts the material into earthworm castings. Vermicomposting is the result of combined activity of microorganisms and earthworms.

Energy recovery Processes

The main Parameters, which determine the potential of recovery of energy from wastes (including MSW), are:

- Quantity of waste, and
- Physical and chemical characteristics (quality) of the waste

The important physical parameters requiring consideration include:

- Size of constituents
- Density
- Moisture content

Smaller size aids in faster decomposition of the waste. Waste of high density reflects a high proportion of biodegradable organic matter and moisture. Low-density wastes, on the other hand, indicate a high proportion of paper, plastic and other combustibles.

High moisture content causes biodegradable waste fraction to decompose more rapidly than in dry conditions. It also makes the waste rather unsuitable for thermo-chemical conversion (incineration, pyrolysis / gasification) for energy recovery, as heat must first be supplied to remove moisture.

Bio-chemical conversion: This process is based on the enzymatic decomposition of organic matter by microbial action to produce methane gas or alcohol. It is preferred for wastes having high percentage of organic biodegradable (putriscible) matter and high level of moisture/water content, which aids microbial activity.

Biogasification also called biomethanisation is the process of decomposing biomass with anaerobic bacteria to produce biogas. This process produces Biogas containing approximately 60:40 mixtures of methane (CH_4), and carbon dioxide (CO_2) and simultaneously generating an enriched sludge fertilizer- with an energy content of 22.5 MJ/m^3. In Anaerobic digestion (AD) the organic fraction of municipal solid waste offers the advantage of both a net energy gain by producing methane as well as the production of a fertilizer from the residuals (Edelmann, W *et al* 2000).

Landfill gas recovery: The waste deposited in a landfill gets subjected, over a period of time to anaerobic conditions and its organic fraction gets slowly volatilised and decomposed. This leads to production of landfill gas containing about 45-55% methane, which can be recovered through a network of gas collection pipes and utilised as a source of energy.

Thermochemical conversion: Incineration - is one of the most effective means of dealing with many wastes, which reduces their harmful potential, and often to convert them to energy form (Tchobanoglous, *et al* 2002). Incineration is the controlled burning of waste in a purpose built facility. It involves the process of direct burning of wastes in the presence of excess air at the temperatures of about 800°C and above (The Expert Committee, 2000). The process sterilizes and stabilises the waste. For most wastes, it will reduce its volume to less than a quarter of the original. Most of the combustible material is converted into ash and carbon dioxide (Sathishkumar, *et al* 2002). In practise, about 65-80 % of the energy content of the organic matter can be recovered as heat energy, which can be utilised either for direct thermal applications, or for producing power.

Pyrolysis is also referred to as destructive distillation or carbonisation. It is the thermal decomposition of organic matter at high temperature (about 900°C) in an inert (oxygen deficient) atmosphere or

vacuum, producing a pyroligenous liquid having high heat value and is a feasible substitute of industrial fuel oil.

Gasification involves thermal decomposition of organic matter at high temperatures in presence of limited amounts of air/oxygen, producing mainly a mixture of combustible and non-combustible gas (carbon monoxide, hydrogen and carbon dioxide). This process is similar to Pyrolysis, involving some secondary /different high temperature (> 1000°C) chemistry which improves the heating value of gaseous output and increases the gaseous yield (mainly combustible gases $CO+H_2$) and lesser quantity of other residues.

Depending on the physical and chemical characteristics of the waste the treatment process can be chosen. In table 5 the desirable range of important waste parameters for each process is given.

Table 8: Desirable range of important waste parameters for technical viability of energy recovery

Waste treatment method	Basic principle	Important waste parameters	Desirable range
Thermo-chemical conversion ▪ Incineration ▪ Pyrolysis ▪ Gasification	Decomposition of organic matter by action of heat	Moisture content	< 45%
		Organic/volatile mater	> 40%
		Fixed carbon	< 15%
		Total Inerts	< 35%
		Calorific value (Net calorific value)	> 1200k-cal/kg
Biochemical conversion Anaerobic digestion/ Bio-methanisation	Decomposition of organic matter by microbial action	Moisture content	> 50%
		Organic volatile matter	> 40%
		C/N ratio	25-30

Source : (The Expert Committee, 2000)

4.3.3. Transfer and transport

This involves two steps :

- The transfer of wastes from smaller collection vehicle to larger transport vehicle
- subsequent transport of the wastes usually over long distances, to a processing or disposal site. The transfer usually takes place at a transfer station.

4.3.4 Disposal

Non-engineered disposal : This is the most common method of disposal in low-income countries, which have no control, or with only slight or moderate controls. They tend to remain for longer time and environmental degradation could be high, include mosquito, rodent and water pollution, and degradation of the land.

Sanitary Landfill is a fully engineered disposal option, which avoids harmful effects of uncontrolled dumping by spreading, compacting and covering the wasteland that has been carefully engineered before use. The four minimum requirements for setting up a sanitary landfill are full or partial hydrological isolation, formal engineering preparation, and permanent control and planned waste placement and covering. Land filling relies on containment rather than treatment (for control) of wastes. Appropriate liners for protection of the groundwater, leachate collection and treatment, monitoring wells and appropriate final cover design are integral components of an environmentally sound sanitary landfill

Municipal Solid Waste Management systems in India

The Stakeholders involved in the management of MSWM are :

- The Ministry of Environment and Forests : The Ministry of Environment and Forests is responsible for general aspects related to waste management, and draws up, coordinates the environmental policy and overseas the implementation of the federal legislation regarding waste management.

- Central Pollution Control Board: Coordinate the activities of the State Pollution Control Boards and provide technical assistance and training to the personnel. Disseminate information sponsor research relating to waste management. To perform functions prescribed by the Government.
- State Pollution Control Board: Plans a comprehensive program for the prevention, control or abatement of air pollution and water pollution. To inspect, at all reasonable times, any control equipment or process. Prior to installation of a landfill or incinerator, permission from SPCB must be obtained.
- City Corporation: City Corporation issues permits and creates policy for waste management. Provides waste management services or operates disposal, recycling, or composting facilities. Often contracts out services to the private sector.
- Private Formal Sector : Private Formal Sector- participates in performing the functions of collection and transportation of the waste and may operate disposal, transfer, and recycling facilities
- Private Informal Sector : Private Informal Sector – collection of the recyclable waste, transfer to the recycling facility and recycling of waste
- Donor Agency: Donor Agency- helps in sponsoring of innovative projects and projects in low-income areas.
- Service Users - the people who use the service of municipal waste management

The municipal waste management system involving the stakeholders and the relationship between these stakeholders has been represented in Figure-6

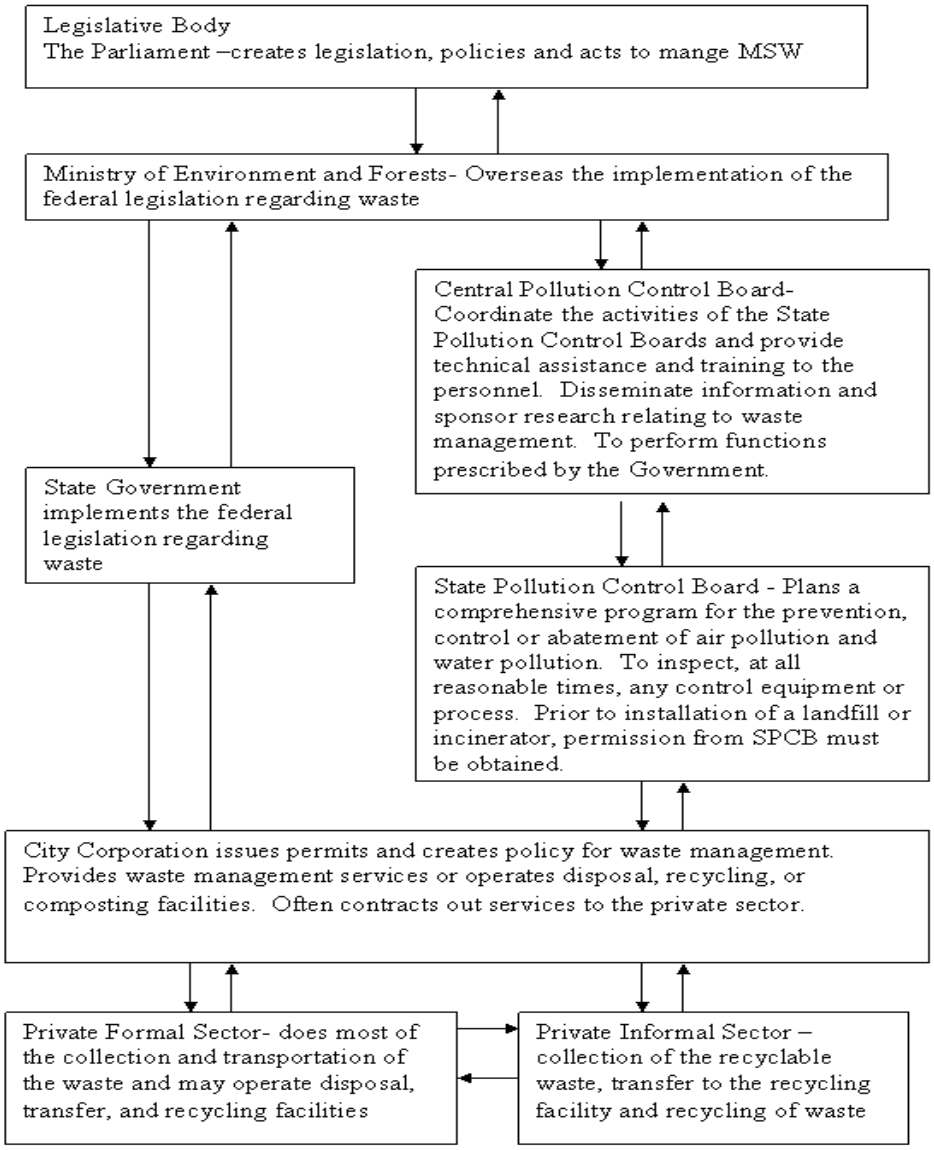


Figure-6: Municipal Solid Waste Management System in India

5.0 LEGAL & ADMINISTRATIVE FRAME WORK ON SW MANAGEMENT

5.1 Leal Frame Work

Legislation concerning waste is usually differentiated according to the type of waste. International conventions often cover nuclear and hazardous waste, whereas non hazardous waste, often called solid waste is usually more regulated at the national level. From an environmental angle the following environmental rules, regulations and acts would be the most relevant for MSWM:

The management of MSW attracts the following acts & rules

- The Water (Prevention & Control of Pollution) Act, 1974
- The Air (Prevention & Control of Pollution) Act, 1981
- he Environment (Protection) Act, 1986
- The Public Liability Insurance Act, 1991
- S.O. 1357(E) [08-04-2016] : Solid Waste Management Rules, 2016
- G.S.R. 320 (E) [18-03-2016] : Plastic Waste Management Rules 2016
- G.S.R. 338 (E) [23-03-2016] : e-waste (Management) Rules, 2016
- S.R. 317(E). [29-03-2016] : Construction and Demolition Waste Management Rules, 2016

- Municipal Solid Waste (Management & Handling) Rules 2016, notified by the ministry of Environment and Forests & Climate Change, Government of India vide notification no. S.O.1357(E) dated 8th Ap2016. The guidelines given in this law covers all the functional elements of municipal solid waste management.
- The Water (Prevention and Control of Pollution) Act, 1974. Two aspects have to be kept in mind of this law in regard to MSWM. Firstly, a consent from the state pollution control board for establishment of a sanitary landfill site and compost plant is essential and secondly, no water pollution should be caused by the leachate that is emitted by the sanitary landfill site or a compost plant.
- The Air (Prevention and Control of Pollution) Act, 1981 and amendments thereon. The aspects to be considered in this law with respect to MSWM is the need for obtaining consent from the State Pollution Control Board for establishment of the processing plants and disposal site and from an environmental aspect would be the pollution caused by incineration plants, compost plants and landfill sites.
- The Environmental (Protection) Act, 1986 and its subsequent notifications. The aspect in regard to MSWM would be the EIA notification, 2006, which states that for any project to be authorized an EIA report should be submitted and Environmental clearance is to be obtained.

5.2 Agra Nagar Nigam (ANN) Administrative Set-up

The main organization which is responsible for urban governance and civic management is the Agra Nagar Nigam. The corporation has a democratically elected leadership from the constituencies within the geographic jurisdiction of the corporation boundaries.

The Municipal Commissioner is the highest executive head of the Agra Nagar Nigam. The

Health (Swasthya Vibhag) and Engineering (Nirman Vibhag) departments are the two executive departments responsible for implementation of the SWM plan and civil infrastructure in the town, respectively.

The Engineering department works in coordination with the Health department and undertakes civil and infrastructure development activities for the city. The Nagar Swasth Adhikari and the Executive Engineer are the senior officers of the Health and Engineering departments respectively, who report to the Municipal Comissioner.

Sanitary wards being headed by sanitary inspectors. The sanitary inspector is responsible for managing the fleet routes, collection procedure, allocating diesel to vehicles, street sweeping and de-lineation of responsibility of the supervisors and safaikaramchari

6.0 CURRENT MANAGEMENT OF MSW IN ABD AREA

6.1. The present practices followed for the MSW manage net is categorised as follows:

- Collection from domestic & other establishments
- Collection in small dust bins
- Transfer to Big size Dust drums
- Transportation from Big size dust bins to Dum site through Trucks

Table 5: Typical characteristics of MSW at Agra

S. No	Waste Category	% of composition
1	Biodegradable matter	50%
2	Glass	4%
3	Plastics	3%
4	Paper	5%
5	Metals	1%
6	Leather and rubber	1%
7	Rags	5%
8	Household hazardous	1%
9	Inert materials	30%
	Total	**100%**

The present collection and transportation of MSW to dump site in ABD area are pictorially shown below depicted figures

Fig ure-7: Primary Collection of household waste on streets at ward 74

Figure-8: Street sweeping at Tajganj Area

Fig ure-9: Collection of household waste from street to waste storage area at ward-7

Figure-10 : Collection of household waste from street to waste storage area at ward-74.

Figure-11: Solid wastes thrown on streets at ward 86

Figure-12 : Mini lorries are deployed to collect the waste from small storage area in the wards

Figure-13: Storage area for waste at Ward 74.

Figure-14: Trucks transferring the waste from the storage area to the dumping site.

Figure-15: weighing Bridge at the dumping site.

Figure-16: Dumping area at Kuberpur

Figure-17: Solid waste are dumped without any segregation at the dumping yard

Figure-18: Household waste are thrown in a common place on street at Kalal Kheria village

Figure-19: Household waste are thrown in a common place on street at Mayapura

Figure-20: Solid waste from households are dumped at nearby the village

7.0 PRESENT SCENARIO OF MSW LANDFILL SITE

7.1. Existing Land Fill site:

Sanitary Land filling is a necessary component of solid waste management for the ultimate disposal of the rejects from resource recovery and recycling facilities as well as a repository for items which cannot be used in a viable manner for any other purpose. The existing Sanitary Landfill was constructed at Kuberpur with a total area of 64736 Sqm. (16 acres) in year 2011. Currently, the site does not have proper landfill management system except unscientific disposal of MSW. The site is having facility to measure weight of waste through computerized weigh bridge system and data is being recorded. It is reported that there are 60 to 70 truck loads are received every day with total load of 350 to 400 tonnes per day. Further it may be noted that there are sheds with condemned machineries.

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Disposal of Waste at Dump site, Kuberpur,

There was one scientific disposal site. It exists for disposal of inert/composting residue/non-biodegradable/non-recyclable material. Scientific Landfill Site is totally closed. Presently waste is being thrown in Kuberpur, near Yamuna Express. The total area is 71.7 acres .

Table 9. Area Utilization Plan at Proposed Landfill Site, Kuberpur

Total area of Landfill site- 71.7 acres as per contour map.	
Technological option existing or in	Allotted area
Existing Compost Plant (Non-functional)	5 acre
Waste to Energy Plant (Awarded)	11.25 acre (4.5 hectare)
Existing landfill (Proposed Capping)	16 acre
C&D waste plant (Awarded)	4 acre
Available area for New SLF development	35.7
Arrangement of during implement of plant Commission Period Landfill	6.74 Metric Tonnes (924 TPD x730 Days)

8.0 PROPOSED ACTION PLAN FOR EFFECTIVE IMPLEMENTATION AS PER SWM RULES 2016

8.1 Theme of action plan Required

States and Union territories are required to prepare action plans for cities and towns based on the population and waste generation. Steps/action need to be taken could be indicated in a phased manner. Cities generating solid waste more than 500 t/d are suggested to formulate action plan which may include the following components;

- ✓ Modernization/ mechanization of waste storage and transportation facilities;
- ✓ Privatization/ contract with 'operators' for collection of waste from various sources and its transportation; and
- ✓ Seeking support of Private entrepreneurship in setting up of waste processing and disposal facility.

The cities with estimated waste generation of more than 500 t/d includes; Ahmedabad, **Agra,** Bangalore, Bhopal, Chennai, Delhi, Hyderabad, Jaipur, Kanpur, Kolkata, Lucknow, Mumbai, Nagpur, Pune, Surat and other cities. The indicative action plans required for MSW management as per CPCB guidelines are given in Table 10 below:

Table 10. Indicative Action-Plan

Components to be covered for action plan and indicative guidelines are as under;

S.No	MSW Generation-> (T/day)	>500	100-500	50 -100	<50
1	Authorization	Should apply for authorization and seek from SPCBs/PCCs	Should apply for authorization and seek from SPCBs/PCCs	SPCBs/PCCs to prioritize based on State/ UT-specific requirement	To be perused in a phased manner
2	Collection of Waste	Comply with Schedule- II of the Rules and comply within six months	Comply with Schedule-II of the Rules and comply within six months	Comply with Schedule-II of the Rules within six months	Comply with Schedule-II within a year
3	Segregation of waste	Launch mass awareness programme	Launch mass awareness programme	Launch mass awareness programme	Launch mass awareness programme
4	Storage of Waste Or MRF	Set up waste storage facilities which would be combination of conventional as well as mechanized system	Set up waste storage facilities which would be combination of conventional as well as mechanised system	Set up waste storage facilities which would be combination of conventional as well as mechanise system	Set up conventional bin system and maintaining them in hygienic manner

5	Transportation of waste	Vehicles used for Transportation of waste. Storage facilities should synchronize with transportation System. Strict compliance with Schedule-II to be ensured	Vehicles used for Transportation of waste. Storage facilities should synchronize with transportation System. Strict compliance with Schedule-II to be ensured	Vehicles of smaller size and easy to maintain be used	Economic type of vehicles including local means considering hygienic Aspect, be preferred.
6	Processing of waste Schedule II & IV	• Adopt combination of waste processing technologies, as single technology may not take care of such Quantities of waste. • Processing plants should be set up as per Schedule-I of SWM Rules 2016	• Adopt combination of waste processing technologies, as single technology may not take care of such Quantities of waste. • Processing plants should be set up as per Schedule- I SWM Rules 2016	Considering technical capabilities of local bodies and garbage quantities up to 100 t/d, aerobic process could be feasible solution with better segregation, bio-gas plants can be set up	Aerobic biological method for stabilization o f waste can be a viable solution. Also, Bio-gas plants may come which can cater energy demand.

7	Disposal of waste (Schedule-III)	Rejects of waste processing plants to be disposed off as per Schedule-III Of the Rules. In case of mixed waste, land filling may be continued following specifications laid down in Schedule III of the Rules	Rejects of waste processing plants to be disposed off as per Schedule-III Of the Rules. In case of mixed waste, land filling may be continued following specifications laid down in Schedule III of the Rules	Simpler-easy to operate landfills be preferred	Simpler-easy to operate landfills be preferred

A detailed Action plan for segregation, collection, transportation, and treatments options as per SWM Rule 2016 in the following aspects are prepared and provided in DPR. In this report, highlights are given for covering toe following aspects.

- Segregation of waste at source
- Plan for Primary waste collection
- Direct Collection of bulk & Garden Waste
- Sweeping of Streets and Public Spaces:
- Drain cleaning
- Secondary Storage and Transportation...
- Transfer Station System between Primary and Secondary System

9.0 TREATMENT OPTIONS

The various types of MSW treatment systems are broadly classified as follows

- Composting,
- Refuse Derived Fuel(RDF),
- Waste to energy plant
- Incineration
- Pyrolysis
- Sanitary land fill system

9.1. Identification of MSW processing technologies

The most important objective of municipal waste management is a safe disposal of the waste, generated daily. This would involve the following activities:

- Separation of recyclable fractions and recycling the same
- Beneficial utilization of organic fraction of the waste
- Disposal of inerts into a scientifically designed landfill

The disposal of waste involves *processing* to separate or utilize the waste fractions organic and inorganic, of which the recyclables are sent for recycling whereas the organics which dominate the proportion go to aerobic composting, vermicomposting or waste to energy conversion. These different options re quire many inputs for decision making processes and would involve different capital investments. A careful consideration of waste quantity generated is also an important part of this decision making.

In the following sections the processing techniques and methodologies in use are explained, subsequently an optimum model of waste processing and disposal for the ANN is arrived.

9.2. MSW Processing Techniques

There are several MSW processing technologies which are being followed in various parts of the world. Further, it is to mention that out of the various

processing technologies, the technologies which are being used / considered for use in Indian conditions are: (i) Composting, (ii) Anaerobic digestion to recover bios and electricity, (iii) Refuse Derived Fuel and (iv) Pyrolysis, as below under different technical groups

Table 11 :List of Identified MSW Processing Technologies

Waste Processing Technology Group	Waste Processing Technology
Biological Processing Technologies	Aerobic Digestion (Composting) Anaerobic Digestion (Biomethanization) Landfill as Bioreactor (Bioreactor Landfill)
Thermal Processing Technologies	Incineration (Mass burn) Pyrolysis / Gasification Plasma Arc Gasification
Physical Processing Technologies	Refuse Derived Fuel (RDF) Densification/Pelletization Mechanical Separation Size reduction

9.2.1 Biological Processing Technologies

Biological technologies operate at lower temperatures and lower reaction rates, this technology is mainly used for the conversion of organic waste. MSW consists of dry mater and moisture. The dry matter further consists of organic (i.e. whose molecules are carbon – based) and minerals also referred to as the ash fraction. The organic can be further subdivided into bio degradable or refractory organics such as food waste and non bio degradable such as

plastic. Biological technologies can only convert biodegradable component of the MSW. Various biological pro cessing technologies are briefly described below.

9.2.2. Composting:

Composting is a natural microbiological process where bacteria break down the organic fraction of the MSW under controlled condition to produce a pathogen free material called "compost" that can be used for potting soil, Soil amendments (for example, to lighten and improve the soil structure of clay soils) and mulch. The microbes, fungi, and microorganisms materials is placed into one or more piles (windows) and the natural microbial action will cause the pile to heat up to

6580^{0}C, Killing most pathogens and weed seeds. A properly designed compost

heap will reach 70^{0}C within 6 to 10 days, and slowly cool off back to ambient temperatures as the biological decomposition is completed. Systematic turning

of the material, which mixes the different components and aerates the mixture, generally accelerates the process of breaking down the organic fraction and a proper carbon/nitrogen balance maintained (carbon to nitrogen or C/N ratio of

20:1) in the feedstock insures complete and rapid composting. The composting

Process takes about 45 to 90 days.

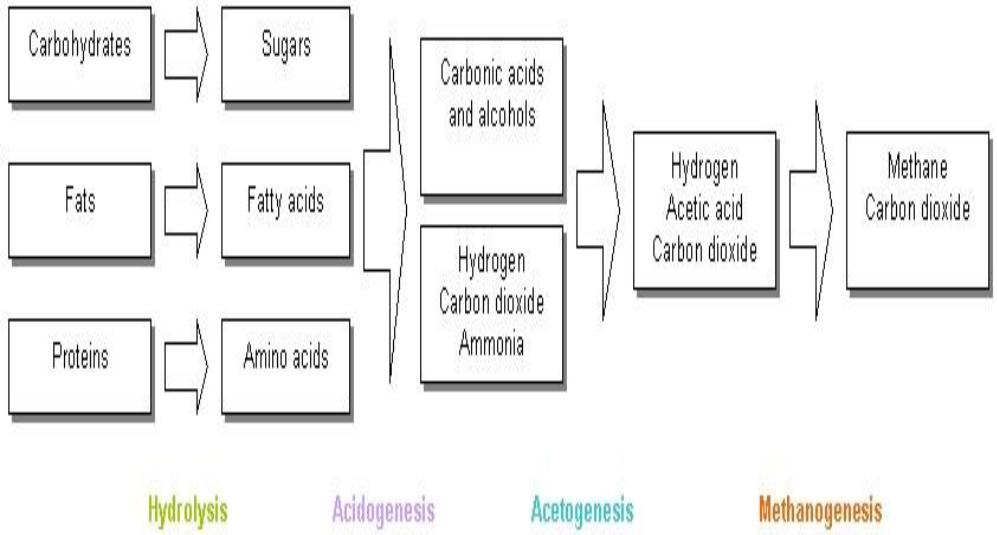
There are two fundamental types of composting techniques i.e. open or windrow composting, this is done in outdoors with simple equipment and is a slower pro cess. The other is closed system composting, where the composting is performed in an enclosure (e.g., a tank, a box, a container or a vessel).

9.2.3. Anaerobic Digestion:

In Anaerobic Digestion biodegradable material is converted by a series of bacterial groups

into methane and CO2. A first group break down large organic molecules into small units like sugar this step is referred to as hydrolysis, another group of bacteria converts the resulting smaller molecules into volatile fatty acids mainly acetate, but also hydrogen (H2) and Co2 This process is called acidification. The last group of Bacteria, the methane producers or methaogens, produce biogas (methane and CO2) from the acetate and hydrogen and CO2 . This biogas can be used to fuel boilers or reciprocating engines with minimal pre-treatment. In addition to biogas, anaerobic bioconversion generates a residue consisting of inorganic, nondegradable organics, non degraded bio degradable, and bacterial biomass. If the feedstock entering the process is sufficiently free of objectionable materials like colourful plastic, this residue can have market value as compost. Anaerobic Digestion process is also referred to as Biomethanization process. A pictorial representation of this process is as below

Figure-21: Process of Biomethanization



9.2.4. Bio Reactor Landfill:

A bioreactor landfill is a wet land fill designed and operated with the objective of converting and stabilizing biodegradable organic components of the waste within a reasonable time frame by enhancing the microbiological decomposition processes. The technology significantly increases the extent of waste decomposition, conversion rates and process effectiveness over what would otherwise occur in a conventional wet landfill. Stabilization in this context means that landfill gas and leachate emissions are managed within one generation (twenty to thirty years) and that any failure of the containment systems after this time would not result in environmental pollution. There is better energy recovery including increased total gas available for energy use and increased green house reduction from reduced emissions and increase in fossil fuel offsets. These factors lead to increased community acceptance of this waste processing technology. Management of a bioreactor landfill requires a different operating protocol to conventional landfills. Liquid addition and recirculation is the single most important operational variable to enhance the microbiological decomposition processes.

Other strategies can also be used to optimize the stabilization process, including waste shredding, pH adjustment, nutrient addition and temperature management.

9.2.5. Thermal Processing Technologies

Thermal technologies are those technologies that operate at temperature greater than 200^0C and have higher reaction rates. They typically operate in a temperatures greater than 200^0 C to 500^0 C. Thermal technologies include advanced thermal recycling (a state of the art form of waste to energy facilities) and thermal conversion (a process that converts the organic carbon based portion of the MSW waste stream into a synthetic gas which is subsequently used to produce products such as electricity, chemicals, or green fuels). The calorific value of garbage will help to identify the treatment technologies like Waste to Energy and other thermal processes. These technologies are briefly described below.

9.2.6. Incineration:

Mass burn Systems are the predominant form of the MSW incineration. Mass burn systems generally consists of either two or three incineration units ranging in capacity from 50 to 1,000 tons per day; thus facility capacity ranges from about 100 to 3,000 tons per day. It involves combustion of unprocessed or minimally processed refuse. The major component of a mass burn facility include

1. Reception of Refuse, handling and storage systems;
2. Combination and Steam generation System (a boiler);
3. Flue gas cleaning system;
4. Power generation equipment (steam turbine and generator);
5. Condenser cooling water system and
6. Residue hauling and Storage system

9.2.7. Pyrolysis:

In Pyrolysis, at high temperature of 700^0 C to 1200^0C, thermal degradation of organic carbon based materials is achieved through the use of an indirect, external source of heat, in the absence or oxygen free environment. This thermally de composes and drives off the volatile portions of the organic materials, resulting in a Syngas composed primarily of Hydrogen (H2), Carbon monoxide (CO), Car bon dioxide (CO2) and Methane (CH7). Some of the Volatile components form tar and oil which can be removed and reused as a fuel. Most Pyrolysis systems are closed systems and there are no waste gases or air emission sources (if the syngas is combusted to produce electricity, the power system will have air emissions control systems. The syngas can be utilized in boilers, gas turbines, or internal combustion engines to generate electricity or used as raw stock in chemical

industries. The balance organic material that are non-volatile or liquid that is left as a char material, can be further processed or used for its adsorption properties (activated Carbon). Inorganic materials form a bottom ash that requires disposal, although some pyrolysis ash can is used for manufacturing brick materials.

9.2.8. Gasification:

In Gasification process, thermal conversion of organic carbon based materials is achieved in the presence of internally produced heat, typically at temperatures of

660^0 to 1800^0C, and in a limited supply of air/oxygen (less than stoichiometric,

or less than is needed for complete combustion) to produce a syngas composed primarily of H2 and CO. Inorganic materials are converted either to bottom ash (Low temperature gasification) or to a solid vitreous slag (High temperature gas ification that operates above the melting temperature of inorganic components). Some of the oxygen injected into the system is used in reactions that produce heat, so that pyrolysis (endothermic) gasification reactions can initiate after which the exothermic reactions control and cause the gasification process to be self-sustaining. Most gasification systems, like Pyrolysis are closed systems and do not

generate waste gases or air emission sources during the gasification phase. After cooling and cleaning in emission control systems, the syngas can be utilized in boilers gas turbines or internal combustion engines to generate electricity or to make chemicals.

9.2.9. Plasma arc Gasification:

In Plasma Arc Gasification process using alternating current (AC) and /or direct current (DC) electricity is passed through graphite or carbon electrodes with

steam and /or oxygen/air injection (less than stoichiometric) to produce an electrically conducting gas (a plasma) typically at temperatures greater than 2,200^{O}C. This system converts organic carbon based materials including tar oil and char to syngas composed primarily of H2 and CO and inorganic materials to solid vitreous slag. Like pyrolysis and conventional Gasification, Plasma Arc Gasification is a closed system therefore there are no waste gases and no emission sources in the Plasma Arc Gasification process. After cooling and cleaning in emission control systems the syngas production by plasma arc gasification can be utilized in boilers gas turbines or internal combustion engines to generate electricity or to make chemicals. The final emission production is CO2 and water. The furans and dioxins in the emission are extremely low and lower than the recommended USEPA or EU emission norms.

9.2.10. Liquid Plastic plant:

HBE, has developed a process to convert mixed plastic waste into the more useable liquid form, Liquid RDF, using a process called catalytic pyrolysis. In effect, the process proposes to provide an integrated plastic waste processing facility which offers an economical and environmentally responsible alternative to the usual approaches of landfill disposal, incineration and recycling.

9.2.11. Physical Processing Technologies

Physical technologies involve altering the physical characteristics of the MSW feedstock. The MSW is subjected to various physical processes that reduce the quantity of total feedstock and increase its heating value. It may be dandified or palletized into homogeneous fuel pellets and transported and combusted as a supplementary fuel in utility boiler. These technologies are briefly described below.

9.2.12. Refused Derived Fuel:

The RDF process typically includes through preparation of recyclables shred ding, drying and densification to make a product that is easily handled. Glass and plastics are removed through manual picking and by commercially available separation devices. This is followed by shredding to reduce the size of the remaining feedstock to about eight inches or less for further processing and handling. Magnetic separator is used to remove ferrous metals. Eddy current separators are used for aluminium and other nonferrous metals. The resulting mate rial contains mostly food wastes non separated paper, some plastics (recyclable and non recyclable) green wastes wood and other materials. Drying to less 12% moisture is typically accomplished through the use of forced air. Additional sieving and classification equipment may be utilized to increase the removal of contaminations. After drying, the material often undergoes densification processing such as palletizing to produce a pellet that can be handled with typical conveying equipment and fed through bunkers and feeders. The RDF can be immediately combusted on site or transported to another facility for burning along or with other fuels. The densification is even more important when RDF is transported offsite to

another facility in order to reduce volumes being transported. RDF is often used in waste to energy plant as the primary or supplemental feedstock or co-fired with coal or other fuels plants in kilns of cement plants, and with other fuels for industrial steam production.

Mechanical Separation:

Mechanical separation is utilized for removing specific material or contaminants from the inlet MSW stream as a part of the pre treatment process. Contaminants may include construction and demolition (C&D) debris, tyres; dirt wet paper, coarse materials and fine materials. Generally MSW reaching the dumping sites is non segregated mixed waste containing C&D debris and other contaminants. Therefore it is essential to remove these contaminants from the incoming MSW by mechanical separation before proceeding the waste further by either biological physical and thermal technologies (except Plasma Arc Technology).

Most of the rural towns it is seen that C&D debris (more than 90%) is reused and the rag pickers take away most of the recyclable material at the collection points only. Therefore the MSW reaching the dumping ground does not require the elaborate mechanical separation process. This MSW has high organic content fit to be directly used for various technologies after manual sorting only.

Size Reduction:

Size reduction is often required to allow for more efficient and easier handling of materials particularly when the fees stream is be used in follow on processes. Sizing processes include passive moving and vibrating screens and trammels. In order to reduce the size of the entire stream or portions of it mechanical equipment such as shredders is utilized. This allows for other physical processes such as dryers magnetic and eddy current separators and densification equipment to work more efficiently. Magnetic and eddy current separators may be installed both up and downstream of shredders to increase the recovery of metals.

9.3.1. Governing factors for choice of Technology

The decision to implement any particular technology needs to be based on its techno – economic viability, sustainability, as well as environmental implications keeping in view the local conditions and the available physical and financial resources. The key factors are

- The origin and the quality of the MSW
- Quantity of Waste generated
- Distances between the various municipalities falling in the particular zone/cluster
- Market for the finals products Compost / anaerobic digestion Sludge / power
- Commercial fertilizer Prices Prevailing
- Land Price, Capital and labour cost
- Capabilities and experience of the technology provider.

It needs to be ensured that the proposed facility should fully comply with the Environmental regulations laid down in the SWM Rules 2016 issued by MOEF&CC, New Delhi.

9.3.2. Selection of the most suitable technology for ANN

The composition of urban waste has rapidly undergone a radical change in the fast few years in the country in tune with the growth of the economy resulting in the increasing use of packaging material comprising of paper and plastics.

At Present about 765TPD of waste comprising domestic Road sweeping and Construction & Demolition(C & D) waste is being generated from Agra city, out of which 93 TPD is generated in ABD area alone consists of huge quantities of compostable and combustible materials.

The typical composition of MSW characteristics of Agra are shown as below.

Table 12: Composition of MSW

Item	Item wise Generation %

ORGANIC WASTE: Leaves , Fruits, Vegetables, Food Waste, Fine organic Matter, Hay and Straw etc	52.0
RECYCLABLES: Rubber and leather, Plastics, Rags, Pa per, Wooden Matter, Coconuts, Bones, Straw, fibers	23.0
INERT MATTER: Ash, crockery, earthen ware (pots), Stones and Bricks, Metals, Glass, sand, silt from drains etc.	25.0
TOTAL	100

The organic component of waste can be converted into useful product(s) and re cyclables can be effectively recycled through a suitable technological option de pending on the composition of the waste.

Considering the waste characteristics and quantity of waste being generated the following treatment technologies are proposed for Agra

- **Aerobic Windrow Composting**
- **Refuse Derived fuel(RDF) used to generate Power (WTE)**
- **Scientific land filling**

It is pertinent to mention that, recently State Government has also expressed its interest in setting up of a Waste to Energy plant (WTE) in Agra.

10. FINANCIAL FRAMEWORK

10.1 Public-Private-Partnership - The Concept

Public-Private-Partnership or PPP is a mode of implementing government programmes/schemes in partnership with the private sector. The term private in PPP encompasses all non-government agencies such as the corporate sector, Pvt. Ltd., voluntary organizations, self-help groups, partnership firms, individuals and community based organizations, PPP, moreover, subsumes all the objectives of the service being provided earlier by the government, and is not intended to compromise on them. Essentially, the shift in emphasis is from delivering services directly to service management and coordination.

The potential benefits expected from PPP are mentioned as below: -

Cost-effectiveness- since selection of the developer/ service provider depends on competition or some bench marking, the project is generally more cost- effective than before.

Higher Productivity- by linking payments to performance, productivity gains may be expected within the project.

Accelerated Delivery – since the contracts have incentive and penalty clauses vis-a-vis implementation of capital projects this leads to accelerate delivery of projects.

Clear Customer Focus - the shift in focus from service inputs to outputs create the scope for innovation in service delivery and enhances customer satisfaction.

Enhanced Service in social sector- services in social sector require a great deal of commitment than sheer professionalism. In such cases involvement of private sector with dedicated workers can provide the good services.

Recovery of User Charges- Innovative decisions can be taken with greater flexibility on account of decentralization. Wherever possibilities of recovering user charges exist, these can be imposed in harmony with local conditions.

The government may collaborate with the private developer/service provider in any one of the following ways:

as a funding agency: providing grant/capital/asset support to the private sector engaged in provision of public service, on a contractual/non- contractual basis.

as a buyer: buying services on a long term basis.

as a coordinator: specifying various sectors/forums in which participation by the private sector would be welcome.

The funding pattern and collaboration between the public sector and the private sector could take any one of the following forms:

- Public funding with private service delivery and private management.
- Public as well as private funding with private service delivery and private management
- Public as well as private funding with public/private service delivery and private service delivery and public/private/joint management
- Private funding with private service delivery and private management

10.2. Involvement of PPP in SWM

Solid Waste Management (SWM) is one of the obligatory functions of the urban local bodies in the country. The local bodies are, therefore, required to provide adequate services for all the three components i.e. collection, transportation and safe disposal of waste in environment friendly manner in adherence to applicable regulatory guidelines.

Area of Involvement

Solid waste for a project area shall be done in integrated manner i.e. from Door-to-Door collection to final and safe disposal. The private entrepreneur getting contract shall be awarded through an integrated package for solid waste management which scope of work shall include:

- Door-to-Door collection
- Transportation of waste from primary storage depot to processing plant
- Processing of waste
- Final disposal of waste

However, local body may also encourage NGOs/RWA to involve into this sector and organize the segregated waste collectors in doorstep collection of waste and provide them an opportunity to earn their living. The local body can give incentive in cash or kind to these organizations in their effort of organizing waste collectors in primary collection of recyclable and/or organic waste. The involvement of these group ensure collection of source segregated waste which play an important role to make the entire practices effective and successful.

10.3. Financial Management Plan:

Any proposed solid waste management system will require provision of financial resources for its smooth running. Various measures should be taken to make the system self-supporting. These involve both short term as well as medium term action as outlined below: -

1. For mobilizing financial resources for SWM, the percentage allotment for SWM from the total annual budget of municipal agency may be immediately increased by necessary budgetary reallocation. Where ever municipal bodies are not able to generate sufficient revenue, State government/Central government shall take responsibility to provide necessary fund allocation.

2. For increasing budgetary allocation, the top priority should be given to SWM among the essential services. Simultaneously action should be taken to improve efficiency of user charge collection, by introducing incentives for increased tax collection and penalising the defaulters.

3. Different commercial establishments hotels including kiosks, eating houses, hotels, restaurants, star hotels and retail markets. The charge should be based on weight basis and the rates should vary depending on the size of establishment and its grade.

4. Industries which are within the municipal limits should be permitted to dispose of their non – hazardous waste on municipal sites of on cost recovery basis.

5. To increase the efficiency in service delivery, the feasibility of involving the private sector should be explored. However, the ultimate responsibility should lie with the municipal agency.

6. Generation of revenue from compost and recyclable material should be emphasized and other source of fund like CSR shall be incorporated in long term management plan.

7. For an efficient recovery of solid waste user charge, combined bills along with the other municipal services like, electricity/ water supply should be raised as it is being practiced in other countries.

8. Municipal bodies should raise the financial resources through all available means to meet both direct and indirect costs of solid waste management.

9. Rationalization of property tax structure and revision at specific interval should be carried out.

10. Wherever specialized services (hospitals, commercial areas etc.) Or house-to-house collection are provided, the element of full cost recovery should be introduced.

11. Central/ State Government may consider exemption of machineries, plants, and vehicles for Solid Waste Management from customs, excise and local taxes.

12. Long-term plans should provide for rising of resources for capital expenditure during various years through adoption of a rational mechanism such as sinking fund.

13. Tax incentives should be provided for waste recycling and processing industries by Central/ State Government. As permitted by Govt. 100% depreciation should be availed of in the first year for the purchase of plant and machinery for solid waste processing.

For improving solid waste management practices in city, the SWM Rules 2016 have clearly laid down the measures to be taken by the municipal authorities. The Polluters Pay Principle has also emphasized to make SWM model self-sustainable. With keeping in view of these new rules it is necessary to incorporate suitable provisions in the state law to ensure public participation and for providing for minimum level of service.

Local law also needs to provide for punishment on the spot to those who do not adhere to the directions given for maintaining appropriate solid waste management system in the city. Furthermore, Agra Nagar Nigam shall implement provision of collection of user fee charges after necessary approval from elected board of Nagar Nigam

for effective and sustainable solid waste management of the city.

10.4. Financial Analysis and OHM Cost

This section presents of Capital and O & M cost **only for collection & transport of MSW from ABD area to dmp site at Kuberpur,** Agra under Smart City scheme for one year. The Capital cost estimate for machineries works out as 48.00 lakh and O & M cost including labour wages works out as 252.5 lakh per one year and the grand total including 25 % of miscellaneous & Contingency expenditure **is 3,75,,62,500 (Rs Rs Three Crore Seventy five lakh Sixty Two Thousand five hundred only per year.**

The detailed capital cost and O&M cost is presented below in following Tables :

Table 13: Capital cost on machineries f or collection & transport to Dump site

S.No.	DETAILS	AMOUNT IN Rs.	SUB TOTAL IN RS.
A	**HAND CART COST**		
	Total Population in ABD area as on 2017	82474	
	No. Handcarts required /1000population	1	
	Handcart Unit cost in Rs.	7000	
	Total no of handcarts required for 82474 population +some extra	100	
	Total cost of 100 Handcarts in Rs.	700000	700000
B	**TRICYCLE COST**		
	No of tricycle required/1000 population	1	
	Total no of tricycle required for 82474 population + some extra	100	
	Tricycle Unit cost in Rs.	9000	
	Total cost of 100 tricycles in Rs.	900000	900000
C	**METALLIC CONTAINER**		
	No of Metallic Container required/5000 population	1	
	Total no of Metallic Container required for 82474 population + some	20	
	Unit cost of Metallic Container t in Rs.	60000	
	Total cost of Metallic Container in Rs.	1200000	1200000
D	**TRUCKS**		
	Total No of trucks required for 100 metallic containers @ 10 container	2	
	Unit cost of truck in Rs.	1000000	
	Total cost of 2 trucks in Rs.	2000000	2000000
	GRAND TOTAL FOI CAPITAL MACHINERY COST IN RS.		**48,00,000**

Table 14: O & M COST ON LABOUR & SUPERVISORY COST

S.NO	DETAILS	AMOUNT IN RS	SUB TOTAL IN RS
A	**OPERATION OF HANDCARTS**		
	No of labours required for operation of 100 hand carts	100	
	Hand carts labour salary /month in Rs	8000	
	Hand carts Total Salary for labours/ month	800000	
	Hand carts Total Salary for labours per year	9600000	9600000
B	**OPERATION OF TRICYCLES**		
	No of labours for operation of 100 tricycles	100	
	Tricycle labour salary /month in Rs	8000	
	Tricycle Total Salary for labours/ month	800000	
	Tri cycle Total Salary for labours per year	9600000	9600000
C	**Road Sweeping Labour expenses approx.90 km @ Rs 6000/ labour**		
D	**SUPERVISORY STAFF SALARY**	10	
	No of supervisor for managing total 200 labours	20000	
	supervisors salary /month in Rs	200000	
	Total Salary for supervisor/ month	2400000	2400000
	Total Salary for supervisor per year		
E	**TRANSPORT COST**	1000	
	Transport cost per trip for 25 km distance in Rs.	10	
	No. of trips per day each 25 km distance in Rs.	10000	
	Total cost of transportation per day	3650000	3650000
	Total cost of transportation year (365 days) in Rs.		
I	**GRAND TOTAL FOR LABOUR & SUPERVISORY COST PER YEAR**		**2,52,50,000**

Table 15: Summary statement of Capital and O & M cost only for collection & transport of MSW from ABD area to dump site at Kuberpur, Agra under Smart City scheme for one year

S.NO.	DETAILS	COST ESTIMATE IN RS.	Cost Per tonne of Waste Rs.
I	**Total for capital machinery cost in Rs.**	**48,00,000**	**51613**
II	**Total for labour & supervisory cost per year**	**2,52,50,000**	**744**
III	**Total for capital labour & supervisory cost per year for capital & o & m cost / year**	**3,00,50,000**	**--**

IV	**Add miscellaneous & Contingency expenditure @ 25 % of Grand Total (III)**	**+75,12,500**	**--**
	Grand Total Cost Estimate (III +IV) in Rs.	**3,75,62,500**	**--**

Rs. Three Crore Seventy five lakh Sixty Two Thousand five hundred only

11. ENVIRONMENTAL HEALTH AND SOCIAL ASPECTS

11.1 Introduction

Inefficient storage, collection, treatment and disposal of waste lead to pollution of ground, water and air which result in creation of breeding grounds for vectors, pasts, rodents, etc., causing public health problems. Proper planning for collection, transportation, treatment and disposal of solid wastes are, therefore, extremely essential for the protection of environment and health and for the social well-being of the people.

The urban poor often residing in informal settlements and slums having very little access or no access to solid waste management services suffer the most on account of improper solid waste management services. Many slum dwellers live close to the landfills in several cities; but fortunately situation in ANN is far better and does not require any rehabilitation of people.

The challenges of solid waste management will increase in next ten years on account of rapid growth of the city and its sub urban areas as well as per capita increase in waste generation. This calls for concerted efforts on the part of administration and all stakeholders to reduce, reuse and recycle the waste.

11.2 Control of communicable diseases

House flies play an important role in the transmission of enteric infections which cause diarrhoea and dysentery, disease transmission by house flies is common when waste is not properly handled and more so when it is allowed to decay without any preventive measures. Presence of human excreta in the waste emanating from the slums adds to the problem. All these problems will get mitigated by closure of the existing dumps and construction of the engineered landfill.

11.3 Contamination due to heavy metals

Poorly operated disposal sites invariably contaminates ground water with nitrates, heavy metals and other chemicals besides it emanates oxides of sulfur and nitrogen in the air due to incineration of waste. Construction of engineered landfill and closure of the open dumps would substantially control the situation and stop further contamination of ground water and soil with heavy metals, chemicals, etc.

11.4 Impact of poor solid waste management

There are many negative impacts that result out of improper solid waste management which are listed below and which are planned to be minimized through improved solid waste management system in the city.

Uncollected waste often ends up in drains causing blockages which result in flooding and in sanitary conditions.

1. Flies, breeds in some constituents of solids waste and they spread diseases.
2. Mosquitoes breed in blocked drains and cause malaria, dengue, etc.
3. Rats finds shelter and food in waste dumps and they spread diseases.
4. Open burning of waste causes air pollution.
5. Aerosols and dusts can spread fungi and pathogens from uncollected waste.
6. Uncollected waste degrades the urban environment and aesthetic of the city.
7. Dangerous items like broken glass, needles, health care waste mixed with municipal solid waste pose risk of injury and consequent health problems.
8. Several health care items find their way in municipal dumps get recycled without sterilization and cause infection and serious health problems.
9. Polluted water i.e. leachate growing from the waste dumps contaminate ground water.
10. Liquids and fumes emanate from unauthorized dumping of chemical waste at the dump site cause problems of health.
11. Landfill gas escapes in the atmosphere and quite often gets trapped resulting in fires at the landfills.
12. Methane gas gives rise to green house gases and leads to climate change.
13. Fires often take place at the landfills and cause air pollution in the surrounding areas.
14. All the above ill effects and adverse impacts are proposed to be controlled by scientifically managing the waste at the treatment plant and disposing of the rejects emanating from the treatment plant at the engineered landfill.

11.5. Procedure for Environmental Impact Assessment (EIA) Clearance

All MSW project proponents (ANN and private contractors) should follow the steps laid out in the EIA Notification, 2006

The entire environment clearance process consists of five stages:

1. Screening
2. Scoping
3. EIA Study
4. Public consultation
5. Appraisal

11.6. Environmental Management Plan

EIA is a detailed multistage process to identify and quantify specific impacts of the proposed project on the environment or ecosystem. Public consultation is an important step in the EIA approval process. Concerns of locally affected people and others who have a plausible stake in the environmental impacts of the project or activity are solicited. These concerns are to be addressed in the project's EMP.

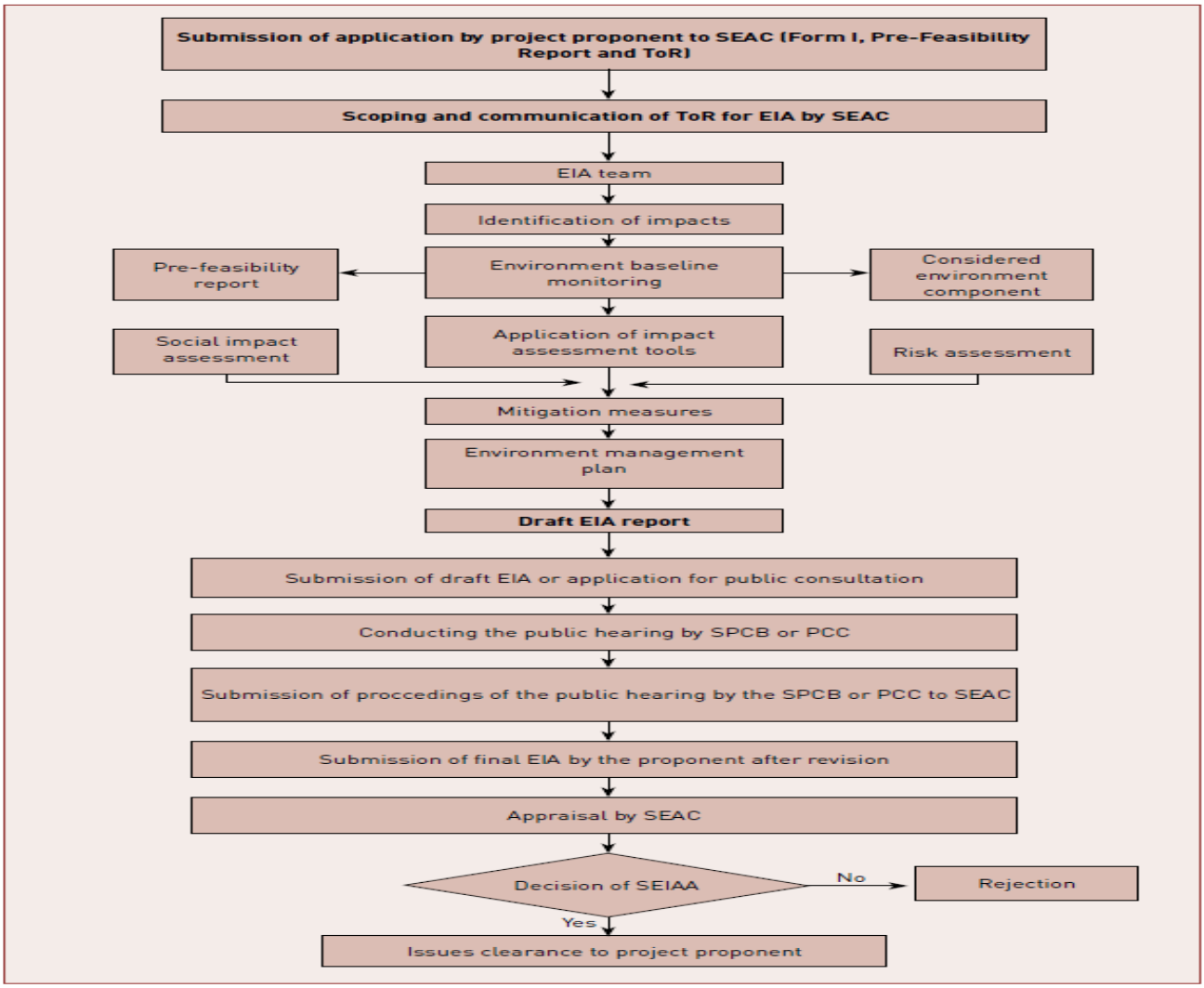
However, all these stages might not be required in some cases.

Screening- Screening is a process of categorising the project into A or B, and into B1 or B2 under Category B.

Scoping- Potential environmental and health-related impacts of the proposed facility are assessed during this phase. Results of the scoping exercise shall also be used to:

1) identify alternative project designs or sites,
2) obtain local knowledge of site and surroundings, and
3) prepare a plan for public or community involvement.

Figure-22: Steps for conducting Environmental Impact Assessment



5 Adapted from Technical EIA Guidance Manual for Common Municipal Solid Waste Management Facility. Infrastructure Leasing & Financial Services (IL&FS) (2010).

Environmental management plan is prepared in order to minimize adverse impact on the environment due to various activities of solid waste management. The following measures are planned to be adopted for the protection of environment.

1. The bins used for collection of biodegradable waste shall be of closed type so that waste is not exposed to open atmosphere.
2. Collection of domestic waste shall be organized on a day to day basis (24 x 7) to ensure no putrefaction of organic matter takes place.
3. All the secondary waste storage site shall be covered, put on the paved floor and attended on a day to day basis by hydraulic system avoiding manual and multiple handing of waste.
4. All the workforce engaged in primary collection, transportation, treatment and disposal shall have protective gears.
5. All the waste stored in secondary storage bins shall be transferred mechanically in covered vehicles and transported in a covered manner leaving no scope of exposure of waste to the atmosphere.
6. Waste collected from secondary waste storage depots shall be taken to scientifically designed transfer stations where waste will be directly transferred into a large hauling vehicle avoiding multiple and manual handling of waste.
7. The entire waste brought to the transfer points shall be transported on a day to day basis in large covered vehicle to the treatment plant.
8. All the organic matter shall be treated at a scientifically designed compost plant and waste to energy plant well protected by a buffer so that it does not pose any problem of health and environment in the neighbourhood.
9. The rejects from the treatment plant and inert received from the city shall be scientifically disposed of at the engineered landfill on a day to day basis where waste shall be spread, compacted and covered as per the MSW Rules 2000 giving no rise to foul odour.
10. Regular monitoring of carbon monoxide, methane, hydrogen sulphide shall be carried out.
11. Entire area surrounding the treatment plant and disposal site shall have a green cover to protect the environment.

11.7. EMP for the project is developed for two different phases: -

1) Construction/Development phase

2) Operation phase

Responsibility to implement the EMP shall rest with PPP operator however its monitoring shall be done by ANN and project monitoring agency.

11.7 EMP during Construction Phase:

Table 16. Environmental Management Plan during Construction Phase

Activity	Possible	Significance	Mitigation measure
Construction of concrete platforms, landfill and offices	Soil Contamination	Low	Limited use of paints and corrosives on site. Material stored under shed
	Surface Water	Low	Avoiding any runoff from site to open drains
	Ground Water	Moderate	Use of temporary check dam to store water
	Air pollution	Moderate	Water sprinkling and Taurpolin coverage. Idling time reduction Improved maintenance
	Noise pollution	Low	Use of High grade machinery (Hydraulic operated)
	Social Impact		Employment to local labours
Vehicles for constructi	Air Pollution	Moderate	Regular Maintenance of vehicles & Equipment's
	Noise	Moderate	Proper planning of routes to avoid sensitive areas
Site clearing	Impact on flora & fauna	None	No endemic or endangered species in the area so no
Generation of		None	Will be used as daily cover over landfill

11.8 Environmental Management Plan during Operation Phase:

Table 17. Environmental Management Plan during Operation phase

Activity	Possible Impact	Significance	Mitigation measure
Collection and Transportation of Wastes	Air pollution Traffic Congestion near site Traffic congestion in the	Moderate low Moderate	Use of vehicles following latest standards of emission norms. Regular maintenance and phasing out of old vehicles. Use of Bigger Compacters to ensure lesser number of rounds where lead distance is more. Planning routes of vehicles to avoid sensitive areas. Route rotation and identification of alternate routes Uni-directional pathways for incoming and outgoing vehicles Roads in the vicinity are of sufficient
Stacking of Wastes on site	Foul Odour Bird Menace	Moderate	Waste stacking in sheds and immediate segregation of wastes Spray of sanitizers Development of green belt
Composting	Soil Contamination Odor generation Ground water pollution	None moderate None	Windrows made on concrete platforms Inoculum spread over heap, Regular windrow Puncturing, Regular cleaning of compost facilities, roads, equipment and surrounding area, storage under shed. Development of green belt Continuous draining of Leachate, treatment and re- use Recirculation of leachate in composting Reuse of water from ETP Development
Waste segregation	Soil Contamination	None	Windrows made of concrete platforms

Landfilling	Odour generation Landfill gas Ground water pollution Gas Emission	Moderate High Low	Daily and intermediate covering of waste by soil and construction debris. Covering by tarpaulin. Spray of biological odour killing agents. Development of green belt Provision of base line system, leachate collection and removal system Laying of ground with GCL/CL and HDPE liner Elaborate system of Leachate Collection Treatment facilities for leachate Emissions of CH4 will be controlled by flaring of CH4 to produce CO2 which has lesser GWP
Closure of Landfill	Soil Erosion	None	Provision of Vegetative Cover
Development of Green Belt	Positive impacts on Flora, Fauna, Biodiversity, Ground water table hydrological		
Use of DG Sets	Air Pollution Noise Pollution	Low Low	Use of control equipment like acoustic enclosure. Sufficient stake height Use limited to instances of power unavailability No activity during night hours

11.9 Environmental Management System and Monitoring Plan

For the effective and consistent functioning of the project, an Environmental Management System (EMS) should be established at the site. The EMS should include the following:

- An Environmental management cell
- Environmental Monitoring
- Personnel Training
- Regular Environmental Audits and Corrective Action
- Documentation – Standard operating procedures Environmental Management Plans and other records

11.10 Environmental Management Cell

Apart from having an Environmental Management Plan, it is also necessary to have a permanent organizational set up charged with the task of ensuring its effective implementation of mitigation measures and to conduct environmental monitoring. The major duties and responsibilities of Environmental Management Cell shall be as given below:

1. To implement the environmental management plan,
2. To assure regulatory compliance with all relevant rules and regulations,
3. To ensure regular operation and maintenance of pollution control devices,
4. To minimize environmental impacts of operations as by strict adherence to the EMP
5. To initiate environmental monitoring as per approved schedule.
6. Review and interpretation of monitored results and corrective measures if any
7. Monitored results are above the specified limit.
8. Maintain documentation of good environmental practices and applicable environmental
9. laws as ready reference. Maintain environmental related records.
10. Coordination with regulatory agencies, external consultants, monitoring laboratories.
11. Maintain of log of public complaints and the action taken

11.12. Environmental Monitoring

Monitoring of the Municipal Solid Waste operations i.e. the physical environment and the public health in the vicinity of the Integrated Municipal Solid Waste Management Facility is an integral part to design, construction and operation of the facility.

The purpose of environmental monitoring is to evaluate the effectiveness of implementation of Environmental Management Plan (EMP) by periodically monitoring the important environmental parameters within the impact area, so that any adverse effects are detected and timely action can be taken.

Air Environment

For the proposed project, the air emissions are from windrow process, DG sets and vehicular movement. DG set is proposed as standby to use during power failure for emergency needs using diesel as fuel and hence are not expected to contribute emissions to the environment on regular basis. Ambient air quality in and around the project site (nearby villages) will be monitored for important parameters

Noise Environment

Monitoring of the noise levels and exposures is essential to assess the Environmental Management Plan implemented to reduce noise levels. A good quality integrated sound level meter and noise exposure meter may be procured for the same. Audiometric tests will be conducted periodically for the employees working close to the noise sources. Noise levels will be monitored within the project site on regular intervals.

Water Environment

Leachate, domestic sewage, water from peizometers, nearby bore wells, nearby surface waters will be analyzed regularly for the parameters given below. They are as follows:

1. pH
2. EC
3. Suspended Solids
4. Dissolved Solids
5. Oil and Grease
6. Chloride

7. Sulphate
8. Sulphide
9. COD
10. BOD
11. Nitrates
12. Phosphates

Land Environment

The soil in the neighbouring areas will be analyzed for the relevant parameters. The average canopy height of the greenbelt, number and types of plant species will be monitored. Air and noise pollution attenuation achieved by the greenbelt will also be evaluated. It would be ensured that trained and qualified staff supervises the monitoring of ambient air, stack gases, effluents, noise etc. to see that prescribed standards laid down are obtained. The post project monitoring schedule/plan is given in Table 18.

Table 18 : Environmental Monitoring Plan

Environmental	Locations	Frequency	Parameters
Ambient Air Quality	Nearby habitations, upw downwind,	Thrice a year, F samples	PM_{10} , $PM_{2.5}$ SO_2, NO_2, CH_4 , H_2S, Ammonia, Odour
Noise	Within site (DG set, Compost yard, SLF	Thrice a Year, Three samples	Noise Levels
Ground water / surface waters	Piezometers around the landfill, groundwate surface water f nearby	Monthly Once	IS 10500: 20121 drinking water Parameters
Leachate	Windrow, compost plant, Secured landfill,	Monthly once	SS, TDS, pH, BOD, COD, As, CN, Cl
Landfill gas	Landfill area	Included in air	Methane & CO2
Plantation	Greenbelt	Half yearly	Survival of plants and replacement of immature plants
Compost	Final product	Monthly Once	As, Cd, Cr, Cu, Pb, Hg, Ni, Zn, C/N ratio, pH

11.13. Record keeping and reporting

Record keeping and reporting of performance is an important management tool for ensuring sustainable operation of the proposed facility. Records should be maintained for regulatory, monitoring and operational issues. Typical record keeping requirements for the proposed facility is summarized in Table 19.

Table 19 : Record keeping requirements

Parameter	Particular
Solid Waste Handling and Disposal	✓ Daily quantity of waste received ✓ Daily quantity treated and recycled ✓ Daily quantity sent for landfill
Waste Water	Daily quantity of treated sewage received Daily quantities of treated effluent recycled ✓ Quantity and point of usage of treated wastewater
Regulatory Licenses (Environmental)	✓ Environmental Permits / Consents from state pollution ✓ control board
Monitoring and Survey	✓ Records of all monitoring carried out as per the finalized ✓ monitoring protocol.
Accident reporting	Date and time of the accident Sequence of events leading to accident ✓ Chemical datasheet assessing effect of accident on health and
Others	Log book of compliance Employee environmental, health and safety records ✓ Equipment inspection and calibration records

Environmental Audits and corrective action plans

To assess whether the implemented EMP is adequate, periodic environmental audits will be conducted. These audits will be followed by Corrective Action Plans (CAP) to correct various issues identified during the audits.

Anticipated Social Impacts and Mitigation Measures

Inefficient storage, collection, treatment and disposal of waste lead to pollution of ground, water and air which result in creation of breeding grounds for vectors, pasts, rodents, etc., causing public health problems. Proper planning for collection, transportation, treatment and disposal of solid waste is, therefore, extremely essential for the protection of environment and health and for the social well being of the people.

The urban poor often residing in informal settlements and slums having very little access or no access to solid waste management services suffer the most on account of improper solid waste management services. The challenges of solid waste management will increase in next ten years

on account of rapid growth of the city and its sub-urban areas as well as per capita increase in waste generation. This calls for concerted efforts on the part of administration and all stakeholders to reduce, reuse and recycle the waste.

11.14. Management Framework for socio-economic environment

Principles adopted of social development

The social management plan has been designed to take proactive steps and adopt best practices,

which are sensitive to the socio- cultural setting of the region. Basic principles adapted to

prepare social management plan are;

- Community wellbeing
- Community investment
- Community engagement
- Indigenous relation
- Local business development
- Local recruitment
- Health and safety

- Education and training

Goals of project for social development

The project envisages addressing the wider goal of environmental protection through a social investment strategy for the communities around the proposed project. By investing in social projects in the neighboring community, seeks to increase the benefits to the local population and contribute towards meeting community's expectation of benefits from the project.

These are taking into perspective concerns of the local community and requirement of the overall population of ANN.

- Proper disposal of Municipal Solid waste
- Improvement in general health standards
- Demand for employment opportunities
- Training Rag pickers and low level workers at plant
- Improvement in living status of the local people.

Employment opportunities

Project will provide job opportunities to those people from adjoining areas during construction and operation phase that fulfils the desired requirements on preferential basis.

11.15. Anticipated Social Impacts

Table 20 : Potential Social Impacts and Mitigation Measures

S. N	Type of Impact	Likely hood	Positive/ Negative	Impact Beef	Reason for occurrence/ non-occurrence	Mitigation Measure	Impact After Mitigation meas	Monitoring mechanism
A	Change to population							
	Increased cultural diversity	Unlikely	Positive	Low	Maximum labour involvement is in the range of 90 to 100 and local labour involvement will be preferred even outside labour have same cultural values.	Not required	-	Labour record maintained by project concessionaire
iii.	Decline in local population	Possible	Negative	Low	Labour involvement for the project is in the range of 90 to 100 and allied activity like marketing and sale of products like compost may require more	Local labour involvement will be preferred and therefore no major inflow of outside population is anticipate	Low	Labour record maintained by project concessionaire
					sale of products like compost may require more people engagement.			

ii.	Potential stress on small business	Unlikely	Negative	Low	Sanitation services will not have impact on local business	Not Required	-	Stake holders meeting and annual report
iii.	Local business difficulty faced by competition for labour	Unlikely	Negative	Low	Sanitation services will not create competition for labour as sanitation workers generally not engaged construction labourer and vice versa	Not Required	-	Stake holders meeting and annual report
D	Impact on							
	Effect on agricultural land	Unlikely	Negative	High	Site at present is a barren land with no agricultural activity	Not Required	-	-
ii.	Increased vehicular movement	Possible	Negative	Medium	Waste collection and transportation services requires a good number of vehicles plying daily on road	Identification of alternate routes, route rotation can mitigate this effect	Low	Traffic study, Stake holders meeting and annual report
E	Impact on community values, lifestyle and wellbeing							
i.	Improvement in community wellbeing	Certain	Positive	High	Waste management services will improve Health, hygiene, cleanliness in city	Not required	-	Annual report and project records

ii.	Increased community concern regarding project	Possible	Negative	Medium	Public perception of increased odor and dust level in vicinity to waste processing and landfill site	Setting up office of PIO, complaint handling cell, IEC activity and involvement of local community organizers, ward parshad	Low	Stake holders meeting and annual report
iii.	Reduced perception of safety	Unlikely	Negative	Low	No such perception raised by public during consultation			
F	Impact on community infrastructure and Services							
i	Increased demand on emergency services	Possible	Negative	Low	Inflow of outside population may increase the demand	involvement of Local labour	Low	Stake holders meeting and annual report
ii.	Increased demand on medical services	Possible	Negative	Low	Inflow of outside population may increase the demand	involvement of Local labour	Low	Stake holders meeting and annual report
iii.	Community displacement	Unlikely	Negative	High	Not anticipated as WPLFS site have no population within 300 m area	Not required	-	
G	Impact on Health, Safety and Environment	Certain	Positive	High	Waste management services will improve Health, hygiene, cleanliness in city	Not Required	-	Annual report and project records

11.16. Training to Informal Sectors

The waste received at the project site is a mixed waste, which reduces the efficiency of the proposed Compost plant, thus it is necessary to make people aware of the benefits of the segregated waste. So it is planned to carry out awareness campaigns on segregation of waste at source from time to time for the residents.

Training will be provided to Rag pickers operating on present dumpsite for safe handling of waste. These upgraded Rag pickers shall be incorporated by PPP operator for manual sorting of waste at processing plant.

Workers involved in non mechanical work at plant will be trained and provided with protective gears. Informal recyclers and dismantlers will also be taken into loop and they will be educated to adopt scientific methods and safe technology to recycle.

12.0 Environmental and Health risk scenarios

Potential hazards of solid wastes are numerous to the living community when it is improperly managed. Solid wastes have the potential to pollute all the vital components of living environment (i.e., air, land and water). Some of the hazards caused by solid wastes are listed below;

1. Uncollected wastes often end up in drains, causing blockages that result in flooding and unsanitary conditions.
2. Open and overflowing bins attract stray dogs, which has been a major cause of the spread of rabies.
3. Open waste bins also attract stray and domestic cattle. Cattle in the city causes nuisance by blocking the traffic on the roads. Cattle that graze on the waste from bins end up eating the plastic along with the vegetable matter, which proves to be fatal for them. The milk obtained from the cattle that feed on waste can be contaminated and can prove to be unsafe for human health.
4. Flies breed in some constituents of solid wastes, and flies are very effective vectors that spread disease.
5. Mosquitoes breed in blocked drains and in rainwater that is retained in discarded cans, tire and other objects. Mosquitoes spread disease, including malaria and dengue.
6. Rats find shelter and food in waste dumps. Rats consume and spoil food, spread disease, damage electrical cables and other materials and inflict unpleasant bites.
7. The open burning of waste causes air pollution; the products of combustion include dioxins that are particularly hazardous.
8. Aerosols and dusts can spread fungi and pathogens from uncollected and decomposing wastes.
9. Uncollected waste degrades the urban environment, discouraging efforts to keep streets and open spaces in a clean and hygienic condition. Plastic bags are in particular an aesthetic nuisance.
10. Waste collection workers face particular occupational hazards, including strains from lifting, injuries from sharp objects and contact with pathogens when manually handling the waste.

11. Dangerous items (such as broken glass, razor blades, hypodermic needles and other healthcare wastes, aerosol cans and potentially explosive containers and chemicals from industries) may pose risks of injury or poisoning, particularly to children and people who sort through the waste.
12. Heavy refuse collection trucks can cause significant damage to the surfaces of roads that were not designed for such weights.
13. Waste items that are reused without being cleaned effectively or sterilized can transmit infection to later users. (Examples are bottles and medical supplies.)
14. Polluted water (leachate) flowing from waste dumps and disposal sites can cause serious pollution of water supplies, ponds and lakes. Chemical wastes (especially persistent organics) may be fatal or have serious effects if ingested, inhaled or touched and can cause widespread pollution of water supplies.
15. Waste that is treated or disposed of in unsatisfactory ways can cause a severe aesthetic nuisance in terms of smell and appearance.
16. Liquids and fumes, escaping from deposits of wastes (perhaps formed as a result of chemical reactions between components in the wastes), can have fatal or other serious effects.
17. Methane (one of the main components of landfill gas) is much more effective than carbon dioxide as a greenhouse gas, leading to climate change.
18. Fires on disposal sites can cause major air pollution, causing illness and reducing visibility, making disposal sites dangerously unstable, causing explosions of cans, and possibly spreading to adjacent property.
19. Former disposal sites provide very poor foundation support for large buildings, so buildings constructed on former sites are prone to collapse.
20. Rag pickers working on landfill are prone to many diseases like respiratory infections such as lung impairment. In a study carried out by Chittaranjan national Cancer Institute, Kolkata compared the health of Delhi's rag pickers with that of the control subjects from east Delhi slums. Nearly 75.5 rag pickers from the sample group of 98 had higher frequency of upper respiratory symptoms (sinusitis, running or stuffy nose, sore throat, common cold, fever) and 81.6 per cent showed lower respiratory symptoms

(dry cough, cough with phlegm, wheezing, and chest discomfort) and breathing problem.

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