# GUIDELINES ON MUNICPAL SOLID WASTE (MSW) INCINERATION BASED WASTE TO ENERGY PLANTS

CENTRAL POLLUTION CONTROL BOARD
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## 1.0 Introduction

### 1.1 Background

Incineration-based Waste to Energy (WtE) systems are recognized as a technically viable and environmentally sound solution for the treatment of non-recyclable, high-calorific value municipal solid waste (MSW), particularly in urban areas facing space constraints and overburdened landfill sites. As per current estimates, urban India generates over 170,339 tonnes of MSW per day, of which a significant portion comprising plastics, paper, textiles, and other combustible residuals—cannot be effectively processed through biological methods such as composting or anaerobic digestion. These residual waste fractions, if disposed of unscientifically, pose substantial risks including uncontrolled methane emissions, leachate generation, fire hazards, vector breeding, and air quality degradation.

These plants are engineered to thermally process such waste and recover energy in the form of electricity or heat, while achieving a volume reduction. This contributes to reducing the load on landfills and aligns with the objectives of the Solid Waste Management Rules, 2016, which promote energy recovery from waste that is not suitable for material recovery. These plants also support circular economy principles by enabling resource recovery from residual waste and promoting the co-utilization of bottom ash in construction applications, subject to compliance with standards. The viability and environmental performance of WtE systems are dependent upon critical factors such as source segregation, pre-processing of waste to achieve requisite calorific value (≥1500 kcal/kg), installation of advanced air pollution control devices (APCDs) and continuous emissions monitoring systems.

Therefore, incineration-based WtE facilities can be developed and operated as integral components of an integrated solid waste management strategy, particularly for Tier-I and Tier-II cities where waste quantum, land scarcity, and environmental vulnerability necessitate high-efficiency waste treatment solutions.

However, the success of such plants depends on strict source segregation, robust pre-processing of waste to ensure adequate calorific value, compliance with emission norms, and integration with decentralized systems for biodegradable and recyclable waste streams. Therefore, while not a standalone solution, MSW incineration-based WtE plants are essential for managing India's residual waste in an environmentally responsible and energy-efficient manner.

Moreover, experience from various cities in India has shown that several WtE plants have faced operational, environmental, and social challenges, including emissions, non-compliance with environmental norms, and public resistance due to health concerns. These issues underline the need for a well-defined and enforceable regulatory framework that ensures environmentally sound incineration practices.

Keeping in view the necessity of WtE plants to address the complex MSW management confronting our local bodies and the socio-economic issues faced in operation & maintenance of the WtE plants, this document on "Guidelines on MSW incineration based WtE Plants" has been prepared by CPCB. The document provides details regarding the sources of waste streams from WtE plants, characterization of these waste streams as well as prevention & control measures for such waste streams. The document has been prepared with the objective to facilitate the stakeholders in addressing the various issues related to WtE plants

## 1.2 Need for Guidelines

The management of municipal solid waste through incineration-based WtE plants presents both an opportunity and a challenge for Indian cities. While such facilities can significantly reduce waste volume and generate renewable energy, improper planning, flawed technology selection, poor waste quality, and inadequate implementation of pollution control measures may lead to grave environmental concerns

In this context, the need for comprehensive guidelines become necessary to ensure that WtE incineration projects implement proper operation & maintenance practices as well as pollution control measures to ensure that they are environmentally safe, technically and economically viable. The present guidelines are developed to serve as a uniform reference for authorities, project proponents, operators, and regulators.

These guidelines aim to:

- **(a)** To provide guidance on waste preprocessing practices, technology configuration, emissions control, ash handling, and leachate management measures.
- **(b)** To ensure that WtE plants set up in the country are aligned with the provisions of Solid Waste Management Rules, 2016.

### 1.3 Scope and Applicability of the Guidelines

The Scope of the Guidelines is given below:

(a) Waste Stream and Feedstock

- Nature and characteristics of MSW suitable for incineration
- Pre-treatment and segregation requirements before incineration

(b) Process Design and Operation

- Technologies adopted for thermal treatment
- Design criteria for incinerators, boilers, and energy recovery systems
- Ash handling, air pollution control systems, and energy output

(c) Environmental Management

- Control and monitoring of emissions (Stack, ambient air)
- Fly ash and bottom ash management, leachate treatment
- Odour control measures
- Online monitoring requirements

(d) Regulatory and Legal Compliance

- Compliance with SWM Rules, 2016,
- Hazardous Waste Management Rules, 2016
- Siting criteria

These guidelines shall be applicable to:

(a) All existing, under-construction, and proposed MSW incineration-based Waste-to-Energy plants in India, irrespective of technology or capacity.

(b) Urban Local Bodies (ULBs) responsible for municipal waste management and planning of waste treatment infrastructure.

(c) Regulatory authorities, including SPCBs/PCCs and State Urban Development Departments, for enforcement, monitoring, and compliance checks.

### 1.4 Classification of Waste to Energy Plants as Blue Category projects

Recently, CPCB revised the system of categorization (Classification of Sectors into Red, Orange, Green, White and Blue Categories) as per which industries are now categorized into Red, Orange, Green, White, and Blue categories, based on a cumulative Pollution Index (PI). The PI score accounts for water pollution, air pollution, and hazardous waste generation. In the revised system of classification, Essential Environmental Services Sectors (EES) have been defined as those facilities which are essential to control, abate and mitigate pollution generated from Domestic and Industrial activities. Essential Environmental Services Sectors have further been subclassified as "EES for industrial waste" and "EES for domestic waste" The sectors falling under "EES for Domestic Waste "have been classified as Blue Category. and Waste to Energy plants which mainly handle municipal solid waste have been classified in blue category as per the revised classification system.

## 2.0 Regulatory Framework:

The Solid Waste Management (SWM) Rules notified by Ministry of Environment, Forest and Climate Change in 2016 delineate the provisions for Waste to Energy (WtE) plants. The relevant clauses are mentioned as under:

**(a) Rule 15 specifies Responsibility of Local Bodies as per which Local bodies shall:**

15 (v) facilitate construction, operation and maintenance of solid waste processing facilities and associated infrastructure on their own or with private sector participation or through any agency for optimum utilisation of various components of solid waste adopting suitable technology including the following technologies and adhering to the guidelines issued by the Ministry of Urban Development from time to time and standards prescribed by the Central Pollution Control Board. Preference shall be given to decentralised processing to minimize transportation cost and environmental impacts such a a)bio-methanation, microbial composting, vermi-composting, anaerobic digestion or any other appropriate processing for bio-stabilisation of biodegradable wastes; b)waste to energy processes including refused derived fuel for combustible fraction of waste or supply as feedstock to solid waste based power plants or cement kiln

15(y) make an application in Form-I for grant of authorisation for setting up waste processing, treatment or disposal facility, if the volume of waste is exceeding five metric tons per day including sanitary landfills from the State Pollution Control Board or the Pollution Control Committee, as the case may be;

**(b) Rule 16 specifies Duties of State Pollution Control Board or Pollution Control Committee as per which SPCB/PCCs shall**

16 (1)(e). issue authorization within a period of sixty days in Form II to the local body or an operator of a facility or any other agency authorized by local body stipulating compliance criteria and environmental standards as specified.in Schedules I and II including other conditions, as may be necessary;

16(4): The State Pollution Control Board or the Pollution Control Committee, as the case may be, shall monitor the compliance of the standards as prescribed or laid down and treatment technology as approved and the conditions stipulated in the authorisation and the standards specified in Schedules I and II under these rules as and when deemed appropriate but not less than once in a year.

**(c)** **Rule 21 (1) of SWM Rules, 2016** specifies that non-recyclable waste having a calorific value of 1500 kcal/kg or more shall not be disposed of in landfills and shall only be utilized for generating energy either through refuse derived fuel or by giving away as feedstock for preparing refuse derived fuel.

**(d)** **Schedule II (Part B)** specifies the standards for treated leachate prescribing 19 parameters viz. pH, Suspended Solids (SS), Total Dissolved Solids (TDS), Ammoniacal Nitrogen (N), Total Kjeldahl Nitrogen (TKN), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Arsenic (As), Mercury (Hg), Cadmium (Cd), Lead (Pb), Total Chromium (Cr), Copper (Cu), Zinc (Zn), Nickel (Ni), Cyanide (CN), Chloride (Cl), Fluoride (F) and Phenolic compounds

**(e)** **Schedule II (Part C)** specifies the emission standards from incinerators /thermal technologies in Solid Waste treatment/disposal facility for 11 parameters namely Particulate Matter, HCl (Hydrochloric Acid) , $SO_2$ (Sulphur Dioxides), CO (Carbon Monoxide) , TOC (Total Organic Carbon) , HF (Hydrofluoric Acid), NOx ( Nitrogen Oxides) , Dioxins & Furans , Hg (Mercury & Compounds, Cd+Th ( Cadmium , Thorium & Compounds), Sb+As, Pb+ Cr, Co, Cu, Mn+ Ni+ V (Antimony , Arsenic, Lead , Chromium , Copper , Manganese , Nickel , Vanadium & Compounds ). The same is applicable to WtE plants. The emission standards as specified in SWM Rules, 2016

**(f)** Further, the following are the major compliances to be ensured by the WtE plants as per Schedule II, Para C:

i. If the concentration of toxic metals in incineration ash exceeds the limits specified in the Hazardous Waste (Management, Handling and Trans boundary Movement) Rules, 2008, as amended from time to time, the ash shall be sent to the hazardous waste treatment, storage and disposal facility (TSDF).

ii. All the facilities in twin chamber incinerators shall be designed to achieve a minimum temperature of 950 degrees Celsius in the secondary combustion chamber and with a gas residence time in the secondary combustion chamber not less than 2 (two) seconds.

iii. Incineration plants shall be operated (combustion chambers) with such temperature, retention time and turbulence, as to achieve Total Organic Carbon (TOC) content in the slag and bottom ash less than 3%, or the loss on ignition is less than 5% of the dry weight.

**(g) Buffer Zone around WtE Plants**

The Solid Waste Management Rules, 2016 specified the terminology of Buffer Zone, as "no development zone to be maintained around solid waste processing and disposal facility, exceeding 5 TPD of installed capacity.. As per the Guidelines on the provision of buffer zone around waste processing and disposal facilities issued by the Central Pollution Control Board (CPCB) in 2020, WtE plants must maintain a designated buffer zone from surrounding land uses to minimize nuisance and health risks. These buffer zones act as protective barriers to reduce the impact of odour, air emissions, noise, and other pollutants on adjacent residential and ecologically sensitive areas. Further

**(h) Green Belt Development**

As per CPCB Buffer Zone Development Guidelines, green belt of minimum 10 m width should be developed within and all around the facility along the boundary. Vegetation, shrubs, trees, and berms with high density greenery can be incorporated into green belt. It has further been recommended that the following plant species can be selected for plantation in the green belt - Acacia nilotica (Babul), Deldergia Sissoo (Shishum), Acacia auriculiformis (Australian Babul), Azadirachta Indica (Neem), Lagerstroemia speciosa (jamun) & Prongamia pinnata (Karanji)

## 3.0. Status of Waste to Energy Plants

### 3.1 National Status

In 2007, the Municipal Corporation of Delhi (MCD) and the New Delhi Municipal Council (NDMC) facilitated the establishment of a 16 MW WtE project on a BOOT (Build-Own-Operate-Transfer) basis, creating an integrated municipal solid waste processing facility at Timarpur-Okhla. The first successful municipal solid waste (MSW) incineration-based Waste-to-Energy (WtE) plant in India, located at Timarpur-Okhla in Delhi, became operational in January 2012. As per information provided by SPCBs/PCCs in the matter of OA No. 536/2024, NGT, PB, there are presently 21 WtE plants in India. The list of Waste to Energy Plants set up in the country is given in **Table 1.0** below:

**Table 1.0 : Waste to Energy Plants set up in India**

| S.No. | State /UT & No of WTEs | Name of WTE plant & Location | Capacity to Process MSW (TPD) | Power generation (MW) |
|---|---|---|---|---|
| 1 | **Andhra Pradesh (02)** | Jindal Urban Waste Management, Visakhapatnam, A.P | 1372 | 15 |
| 2 | | Jindal Urban Waste Management, Limited Guntur , A.P | 1620 | 20 |
| 3 | **Delhi (04)** | East Delhi Waste Processing Company Ghazipur,Delhi | 1300 | 12 |
| 4 | | Tehkhand Waste to Electricity Project Ltd. Delhi | 2000 | 25 |
| 5 | | Timarpur Okhla, waste management Company Ltd. Delhi | 1950 | 23 |
| 6 | | M/S Delhi MSW Solutions Ltd.Delhi | 1300 | 24 |
| 7 | **Gujarat (02)** | Goodwatts WtE Jamnagr Pvt Ltd., Gujarat | NA | 7.5 |
| 8 | | Jindal WtE Pvt. Ltd .Ahmedabad., Gujarat | NA | 15 |
| 9 | **Haryana (01)** | Integrated Solid Waste Management Facility , Murthal ,Sonipat , Haryana | NA | 8 |
| 10 | **Karnataka (01)** | Bidadi Waste to Energy Plant, Bidadi, Karnataka | 600 | 11.5 |
| 11 | **Madhya Pradesh (02)** | Rewa MSW Energy Solution Pvt Ltd ,M.P | 500 | 6 |
| 12 | | Jabalpur MSW Pvt. Ltd Kathonda, Jabalpur , M.P | 600 | 11.5 |
| 13 | **Maharashtra (02)** | Anotny Lara Renewable Energy Private Limited, Waste to Energy, PimpriChinchwad, Mahararashtra | 700 | 14 |
| 14 | | Bhumi Green Energy Pvt. Ltd., Sangli, Maharashtra | NA | 10 |
| 15 | **Telangana (02)** | Hyderabad MSW Energy Solution Ltd, Telangana | NA | 19.8 |
| 16 | | Dundigal WtE Pvt. Ltd , Telangana | NA | 14.5 |
| 17 | **Uttarakhand (03)** | Sidharth Papers Ltd., US Nagar, Uttarakhand | 185 | 6 |
| 18 | | Siddheshwari Paper Udyog Pvt Ltd., Kashipur Uttarakhand | 185 | 6 |
| 19 | | Bahl Paper Mills Ltd., Kashipur, Uttarakahnd | NA | NA |
| 20 | **Uttar Pradesh (02)** | Rollz India Waste Management Pvt. Ltd., Deenanathpur, Ghaziabad | 75 | NA |

| | | | | |
|---|---|---|---|---|
| 21 | | Rollz India Waste Management Pvt. Ltd., Bahadarpur, Ghaziabad | 340 | NA |
| **Total** | | | 12727 | 248.8 |

### 3.2 Global Status

According to the World Bank (2018), global annual waste generation is expected to jump from 2.01 billion tonnes in 2016 to 3.40 billion tonnes over the next 30 years, and this trend is especially true in developing countries in Asia and Africa. There are over 1,700 thermal WtE plants worldwide. Over 80 per cent of thermal WtE plants are located in developed countries, led by Japan, France, Germany and the United States. The world's largest thermal WtE plants are in Shenzhen East, China and Dubai, United Arab Emirates. These two plants can process over 5,500 tonnes of waste per day each. The WtE plant in Shenzhen East has a capacity of generating 165MW of power and the plant in Dubai has a capacity of generating 185 MW of power. Thermal WtE plants are also emerging in developing countries in Asia Pacific, including China, Thailand, the Philippines, Indonesia and Myanmar.

The global status of MSW plants with incineration technology is illustrated in **Figure 1.0**

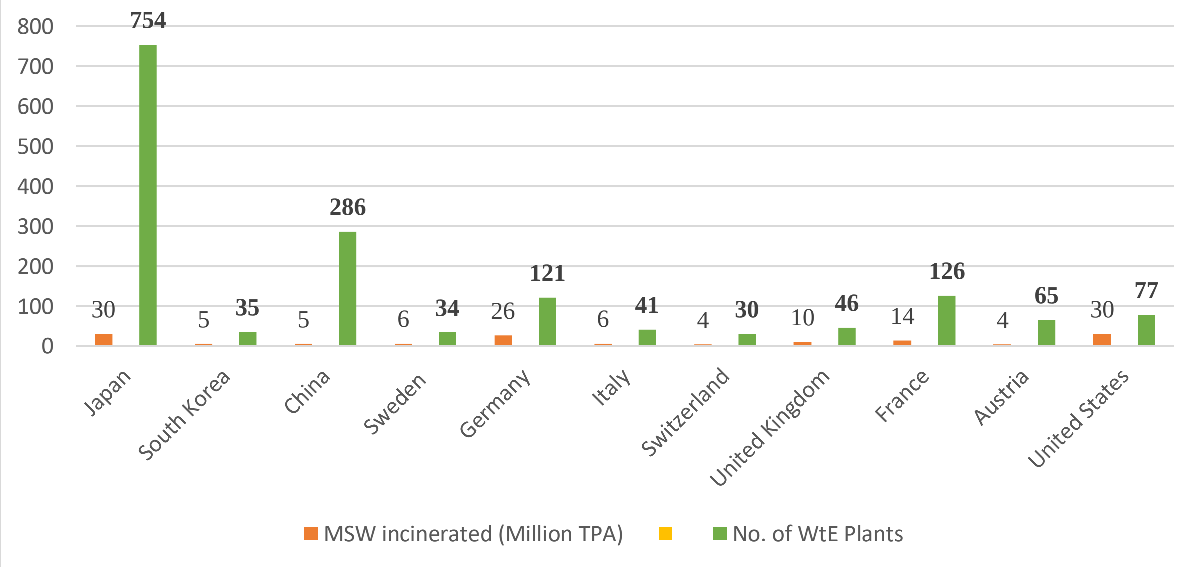


**Figure 1.0 Global Status of WtE Plants**

## 4.0. Production Process

Waste of different categories including wet & dry waste is generated in the Indian cities However, in the absence of a well-planned, scientific system of waste including waste segregation at source, the waste received at the Waste to Energy plants is generally heterogeneous in nature and typically comprises biodegradable waste (such as food and garden waste), recyclables (like paper, plastics, and metals), inert materials (dust, silt, construction debris), and non-combustibles (glass, ceramics). The characterization of waste received in a typical WtE plant is given in **Table 1A** below

**Table 1A: Characterization of Waste received in a typical waste to Energy plant**

| S.No. | Components | Percentage of intake of MSW |
|---|---|---|
| **1** | Compostable Fractions | 8-10% |
| **2** | Refused Derived Fuel (RDF) | 65-70% |
| **3** | Inerts | 11-12% |
| **4** | Recyclables | 1-2% |

In view of the characteristics of the waste received at the Waste to Energy plant, the waste is initially segregated though manual and mechanical means to enhance its combustion properties, following which it is sent to the boiler . The steam generated in the boiler is fed to the turbine through which power is generated.

The facilities are typically designed to handle 1300 Tons per day (TPD) to 2000 TPD of MSW with the power generation in the range of 12 MW to 25 MW. The system is designed to work on unsegregated MSW having calorific values in the range of 900-1200 Kcal/Kg and 1500 Kcal/Kg & above for segregated waste ( Refused derived Fuel).

- Waste Reception and Preprocessing
- Segregation of metals/inerts/recyclables etc.)
- Composting
- Incineration & Energy Recovery of waste

The process flow diagram of a typical WtE is given in **Fig 2** below:

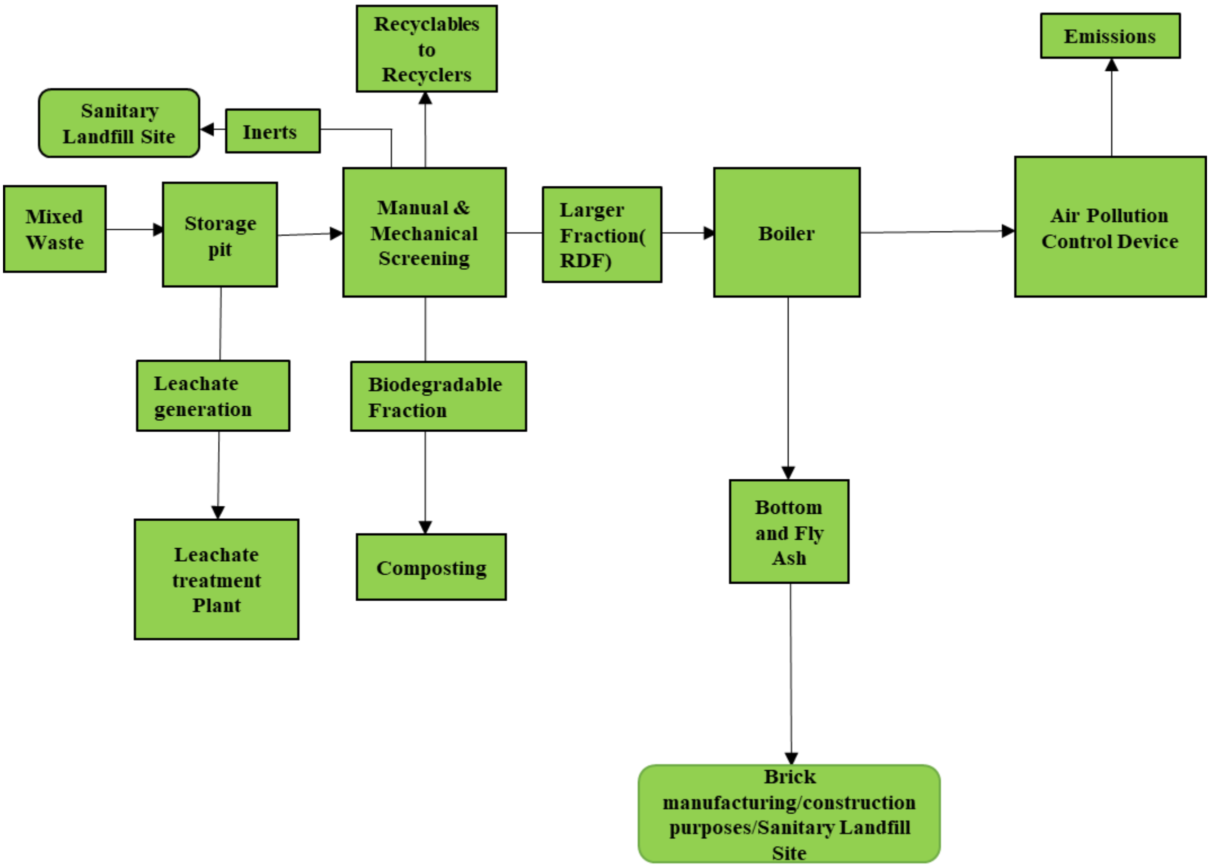


***Figure 2: Process Flow diagram of a WtE Plant***

### 4.1 Waste Reception and Preprocessing

The production process of a MSW incineration-based WtE plant is an integrated system that begins with the arrival of waste in closed compactors at the facility. The Municipal Corporation collect and deliver MSW at the WtE plant using truck, tipper and compactors These vehicles pass through a radioactive sensor to screen for hazardous materials, and then over a weighbridge to record the quantity of incoming waste. The waste is unloaded into an enclosed storage pit equipped with negative air pressure systems to contain odour The extracted air is directed to the boiler as secondary combustion air, which in turn also addresses the odour issues as the air is combusted at a high temperature of over 950°C. To initiate biological stabilization, bio-culture is periodically sprayed over the waste to facilitate the degradation of organic components. Simultaneously, hot air circulation within the storage area helps in moisture reduction, thereby improving the overall calorific value of the waste. A grab crane is used to mix and homogenize the waste in the pit, ensuring uniform feedstock characteristics.

*Figure 3: Weigh Bridge Section of a WtE Plant*

Following provisions are to be made in this section:

(a) Homogenisation of MSW to be performed by grab cranes in storage pit to ensure uniform quality of feed to boiler hopper. Continuous movement of waste shall be maintained in this process to prevent stagnation which may lead to odour and breeding of flies.

(b) Herbal disinfectant spraying shall be done in pre-processing section for odour and flies control. The herbal disinfectant utilised should be bio-degradable which should not interfere or interact in any of the chemical reactions with the MSW in the storage process.

(c) Pit floor area to be provided with sloping floors to collect the spills directly into RCC storage pits. Leachate generated from pit should be collected for treatment.

(d) The workers in pre-treatment and handling facilities shall be provided with personal protection equipment and herbal disinfection spray would be done to maintain safe working area for manual segregators.

(e) Negative pressure by a draft air fans to be provided to create suction condition in the storage pit . Further provision to be made to direct the sucked air to the boilers to eliminate odour issues.

(f) Hot air circulation to be maintained in the storage area -to reduce moisture reduction, thereby improving the overall calorific value of the waste

*Figure 4: Grab cranes in MSW storage area*

**4.2 Segregation of Waste**

The homogenized waste is transferred to a pre-processing system where it undergoes manual and mechanical segregation. This includes the use of magnetic separators to recover ferrous metals, shredders to reduce the particle size of the waste, and ballistic separators to divide the waste into three fractions: inert materials, compostable organics, and the high-calorific Refuse Derived Fuel (RDF). Inerts are sent to engineered landfills, recyclable materials to authorized recyclers, compostable material to composting and the RDF fraction is directed to the incinerator feeding system. Details of the above steps are given in the following sections:

**4.2.1 Manual Segregation**

Manual segregation is typically done on a conveyor belt system in a covered sorting area. Trained workers manually segregate large items such as metals, glass, electronic waste, rubber materials, and inert fractions that can adversely affect incineration efficiency or damage downstream equipment. This process ensures the removal of recoverable recyclables and minimizes the presence of materials that may lead to high ash content or emissions during combustion. Though increasingly being supplemented by mechanized systems, manual sorting remains vital in Indian WtE plants due to the heterogeneous nature and poor source segregation of MSW.

The effectiveness of manual sorting significantly affects the calorific value of the feedstock and the operational stability of the incineration process.

Proper occupational safety measures, including protective gear, dust suppression systems, and ventilation, are essential to safeguard worker's health during manual sorting operations.

*Figure 5: Manual Segregation*

*Figure 6.0 : Mechanical Segregation*

### 4.2.2 Mechanical Segregation

After manual segregation, the waste is transferred via conveyor belt to the mechanical segregation system, where it undergoes further automated sorting. Mechanical segregation in WtE plants involves the use of automated systems and equipment such as trommel, ballistic separators, magnetic separators, and shredders to separate different fractions of MSW based on size, density, magnetic properties, and composition. This process enhances efficiency, reduces manual handling, and ensures consistent quality of feedstock for incineration. Mechanical segregation typically carried out in a pre-processing area equipped with a range of specialized machinery.

Key components of a mechanical segregation system include:

**(a) Trommels**

Trommels are cylindrical rotating drums with perforated walls. These are used to separate waste based on particle size. Trommels of 4mm, 20mm and 50 mm can be used. Finer organic fractions pass through the perforated drum while larger materials move forward for further separation.



*Figure 7: Trommels*

### (b) Magnetic Separators

The magnetic separators are used to extract ferrous metals from the waste stream using powerful magnets. These separators are typically positioned along the conveyor belts following initial manual or mechanical segregation stages. The system operates by generating a strong magnetic field that attracts and separates ferrous materials such as iron and steel objects—nails, tins, and metal scraps from the mixed waste. This not only enhances the quality of the feedstock for incineration by removing non-combustible materials but also facilitates the recycling of valuable metals, contributing to resource recovery.

*Figure 8: Magnetic Separators*

*Figure 9: Shredders*

**(c ) Shredders:**

Shredders reduce the size of MSW before incineration. The primary function of shredders is to break down large, bulky, and heterogeneous waste materials into smaller, uniform fragments, which enhances the efficiency of processes such as mechanical sorting, drying, and combustion. By increasing the surface area and homogenizing the waste stream, shredding ensures more consistent thermal performance and complete combustion in the furnace. Proper shredding not only improves energy recovery but also reduces operational issues such as blockages, uneven feed rates, and incomplete incineration.

**(d ) Ballistic Separators**

Ballistic separators are advanced mechanical segregation devices used in WtE plants for the effective separation of MSW based on physical properties such as density, size, and shape. These separators typically consist of an inclined vibrating deck or paddles that move the waste material in a ballistic motion. As the waste travels across the separator, it is divided into three main fractions: flat and flexible materials (such as plastic films and paper), rolling and rigid items (such as bottles, cans), and fine inert materials (like sand, glass, and organics). This separation facilitates better recovery of recyclables, enhances the quality of refuse-derived fuel (RDF), and reduces the burden on incinerators by removing non-combustible fractions. Ballistic separators are often used in combination with other segregation technologies such as magnetic separators to achieve higher efficiency.

**Figure 10: Ballistic Separator**

**Waste Segregation stages in a typical WtE facility is illustarated in Figure 11**

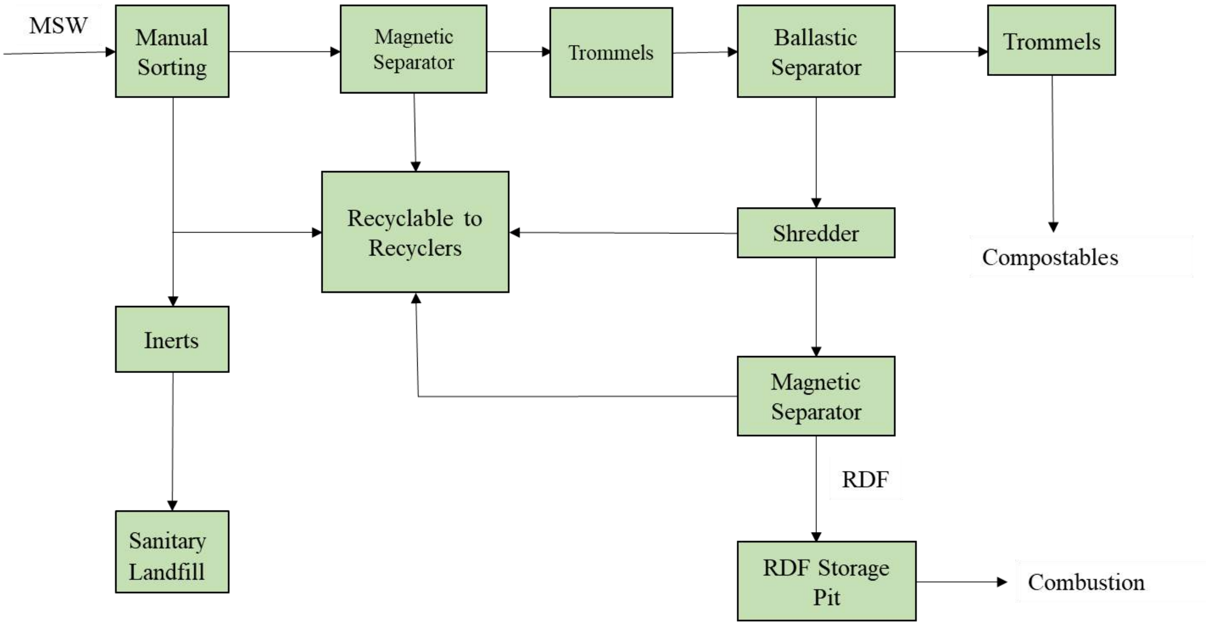


**Figure 11: Segregation steps in WtE facility**

### 4.3 Composting

The MSW received at the WtE unit consists of 8-10% of organic fractions. The biodegradable fraction is recovered through the segregation process is taken up for composting as it is unsuitable for direct thermal processing due to high moisture content, low calorific value, and potential to cause operational inefficiencies such as incomplete combustion, boiler corrosion, and increased pollutant load in flue gases..

Composting is carried out using one of several methods including open windrow composting for large land areas with cost-effective operations, aerated static piles for better odour control and reduced manual turning. Following composting, compost is packed in appropriate moisture-resistant bags

The following provisions have to be made in the Composting section of the WtE facility

(a) Collection of Leachate generated during the composting process through an engineered drainage network

(b) Recirculation of leachate to maintain pile moisture or sending it to Leachate Treatment Plant to meet discharge norms.

(c) The compost to be stored in a covered or enclosed area to prevent recontamination, moisture ingress, and odour emissions.

(d) Testing of Compost to ensure that it is meeting the norms prior to usage

*Figure 11 A: Composting trommel* *Figure 11 B: Composting bags*

*Figure 11 C: Enclosed area for composting*

**4.4 Incineration & Energy recovery**

The RDF fraction after segregation , is directed to the incinerator feeding system. The incinerator is typically a moving grate type furnace, where RDF is fed continuously into the combustion chamber. The process begins with drying, followed by primary combustion at temperatures of 950–1100°C, facilitated by primary air introduced below the grate. This is followed by secondary combustion using secondary air injected above the grate to ensure complete oxidation of volatiles and unburnt hydrocarbons. The bottom ash generated from combustion is collected at the end of the grate and quenched before further handling. The hot flue gases from the furnace pass through a waste heat recovery boiler, where heat is transferred to water to generate high-pressure steam. This steam is routed to a turbine generator to produce electricity, which is used in-plant.

Flue gas (containing gases & fly-ash) and bottom ash/residues are generated during the process of incineration of Waste. . The main constituent of flue gas is water vapour, nitrogen, carbon dioxide and oxygen. The flue gas also contains particulate matter (fly-ash) along with smaller amounts of CO, HCl, HF, $NO_X$ $SO_2$, VOCs, Dioxin & Furans and heavy metal compounds. A typical MSW incinerator generates bottom ash of about 20-30% by weight of the solid waste input. Fly ash quantities are generally much lower (2 to 3% by weight) compared to bottom ash.

Overview of a Incineration-cum- Energy Recovery section is given in **Figure 12 & 13**

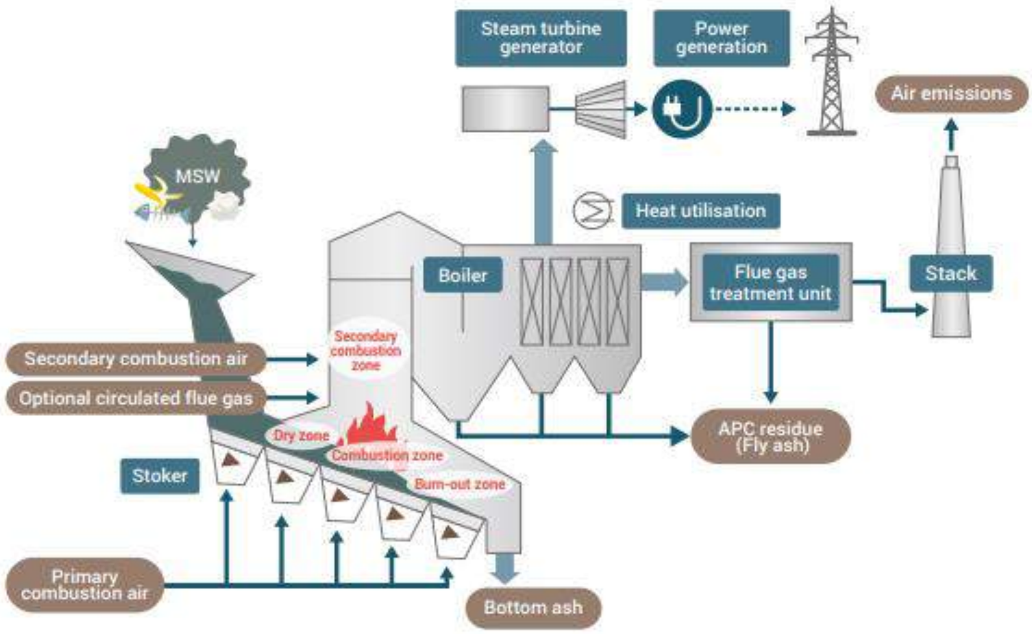


**Figure 12:Incineration cum Energy Recovery Section of WtE Plant**

***Figure 13: MSW incineration process***

#### 4.4.1 Incineration design considerations

During incineration, waste is fed onto a mechanically moving grate, which continuously transports it through distinct thermal zones drying, combustion, and burnout. This movement ensures complete combustion of the waste while maintaining a steady and controlled flow through the incinerator. The pre-treated MSW initially gets dried as it moves slowly on an inclined grate, the material gets dried and turns into high calorific combustible material in the last section of the grate. Combustion of the material first takes place on inclined reverse acting reciprocating grate inclined at 25 degrees. Complete combustion of any residual material takes place in last section of the forward acting grate inclined at 10 degrees. The following points to be considered , while design of incineration

(a) The speed of the moving grate can be controlled to respond to different level of moisture condition in the input material. In case of higher moisture more residence time is provided in the drying section.

(b) High moisture mass would be retained longer in the drying section whereas as low moisture mass would be retained longer in the combustion section. This ensures maintenance of fairly consistent output over a wider range of input quality.

(c ) The control of the stoker can be automated through a dedicated Program Logic Controller, based on furnace temperature inputs, however, the speed of the stoker can be regulated by the operator also to ensure complete combustion.

(d ) An incinerator must be designed for complete combustion of both solid residue and flue gas. A sufficient temperature and retention time are required for complete combustion. The design parameters for WtE plants are governed by specific technical provisions under Schedule II(C) of the Solid Waste Management (SWM) Rules, 2016. These parameters establish minimum requirements for combustion conditions, emission control systems, and residue handling, ensuring that WtE facilities not only recover energy effectively but also safeguard public health and the environment. As per the provision of SWM Rules, in order to prevent incomplete combustion of flue gas, a temperature of 950ºC or more and a retention time of two seconds or longer with enough turbulence are required in the secondary combustion zone, which also prevents dioxins from forming.

## 5.0 Environmental Issues

The key environmental issues related to WtE plant include :

**(i)** Boiler: Stack emissions,

**(ii)** Boiler: Solid Residue (Bottom Ash and Fly Ash)

(iii) Waste Handling : Leachate

(iv) Waste Handling : Odour

### 5.1 Boiler Stack Emission:

The flue gas generated from the boiler stack may contain following pollutants emitting from the stack:

- **Particulate Mack atter (PM):** Fine particles from combustion and ash carry toxic metals and organic compounds.
- **Oxides of Nitrogen (NOx):** Result from high-temperature combustion; contribute to smog and acid rain.
- **Sulphur Dioxide ($SO_2$):** Emitted from sulphur-containing waste (plastics, rubber); causes acid rain and respiratory issues.
- **Carbon Monoxide (CO):** Emitted under incomplete combustion conditions.
- **Volatile Organic Compounds (VOCs):** Evaporate during combustion of organic wastes.
- **Hydrogen Chloride (HCl) & Hydrogen Fluoride (HF):** Emitted from PVC and fluorinated plastics; corrosive and harmful.
- **Dioxins & Furans:** Toxic Persistent Organic Pollutants (POPs); released during low-temperature or incomplete combustion of waste.
- **Heavy Metals:** Lead, mercury, cadmium, arsenic present in batteries, paints, and e-waste become airborne or entrapped in fly ash.

The above emission parameters shall meet the standards as prescribed in the **Table 2** below:

**Table 2: Emission Standards as per SWM Rules, 2016**

| S.No. | Parameter | Emission Standards | |
|---|---|---|---|
| 1 | Particulates | 50 mg/Nm$^3$ | Standard refers to half hourly average value |
| 2 | HCl | 50 mg/Nm$^3$ | Standard refers to half hourly average value |
| 3 | $SO_2$ | 200 mg/Nm$^3$ | Standard refers to half hourly average value |
| 4 | CO | 100 mg/Nm$^3$ | Standard refers to half hourly average value |

| | | | |
|---|---|---|---|
| | | 50 mg/$Nm^3$ | Standard refers to daily average value |
| 5 | Total Organic Carbon | 20 mg/$Nm^3$ | Standard refers to half hourly average value |
| 6 | HF | 4 mg/$Nm^3$ | Standard refers to half hourly average value |
| 7 | NOx (NO and $NO_2$ expressed as $NO_2$ ) | 400 mg/$Nm^3$ | Standard refers to half hourly average value |
| 8 | Total Dioxin and Furans | 0.1 ng TEQ/$Nm^3$ | Standard refers to 6-8 hours sampling. Please refer guidelines for 17 concerned congeners for toxic equivalence values to arrive at total toxic equivalence. |
| 9 | Cd + Th + their compounds | 0.05 mg/$Nm^3$ | Standard refers to sampling time anywhere between 30 minutes and 8 hours |
| 10 | Hg and its compounds | 0.05 mg/$Nm^3$ | Standard refers to sampling time anywhere between 30 minutes and 8 hours. |
| 11 | Sb + As + Pb + Cr + Co + Cu + Mn + Ni + V + their compounds | 0.5 mg/$Nm^3$ | Standard refers to sampling time anywhere between 30 minutes and 8 hours. |
| ***Note.- All values corrected to 11% oxygen on a dry basis*** | | | |

**Note:**

*(a) Suitably designed pollution control devices shall be installed or retrofitted with the incinerator to achieve the above emission limits.*

*(b) Waste to be incinerated shall not be chemically treated with any chlorinated disinfectants.*

*(d) if the concentration of toxic metals in incineration ash exceeds the limits specified in the Hazardous Waste (Management, Handling and Trans boundary Movement) Rules, 2008, as amended from time to time, the ash shall be sent to the hazardous waste treatment, storage and disposal facility.*

*(e) Only low sulphur fuel like LDO, LSHS, Diesel, bio-mass, coal, LNG, CNG, RDF and bio-gas shall be used as fuel in the incinerator.*

*(f) The $CO_2$ concentration in tail gas shall not be more than 7%.*

*(g) All the facilities in twin chamber incinerators shall be designed to achieve a minimum temperature of 950°C in secondary combustion chamber and with a gas residence time in secondary combustion chamber not less than 2 (two) seconds.*

*(h) Incineration plants shall be operated (combustion chambers) with such temperature, retention time and turbulence, as to achieve total Organic Carbon (TOC) content in the slag and bottom ash less than 3%, or the loss on ignition is less than 5% of the dry weight.*

**5.2 Boiler: Solid Residue (Bottom Ash and Fly Ash)**

One of the critical by-products of WtE incineration technology is the generation of solid residues in the form of bottom ash, and fly ash. These residuals typically account for 20–30% of the input waste by weight and must be managed with caution due to their physical, chemical, and toxicological characteristics. If not handled, or disposed of appropriately, these residues can pose significant risks to soil quality, groundwater resources, and regulatory compliance.

Toxic leachate containing heavy metals can migrate into the subsoil and contaminate groundwater, .if the flyash is dumped in unlined ash ponds or open landfills, toxic

**5.3 Waste handling : Leachate**

Leachate generation during waste handling is a significant environmental concern. Leachate is the liquid that drains or 'leaches' from waste piles, particularly during storage and pre-processing stages, and it contains a complex mix of organic pollutants, heavy metals, suspended solids, ammonia, and dissolved salts. This contaminated liquid if not treated, can pose a serious threat to groundwater and surface water quality. The key factors contributing to the generation of leachate include

**(i) High-moisture MSW:**

Organic fractions and wet biodegradable components of MSW release leachate upon compression, biodegradation, or exposure to rainfall. This is particularly problematic in unsegregated waste streams.

**(ii) Overflow during monsoon**

During heavy rains, uncovered waste heaps and inadequate storm water diversion can cause leachate overflow, contaminating nearby land and water bodies.

**5.4 Waste handling : Odour**

Odour is a common and persistent environmental issue in WtE plants. Foul odours primarily originate from the tipping floors, waste storage areas, and pre-processing zones where biodegradable waste begins to decompose under anaerobic conditions. The problem is exacerbated during warm weather or when waste remains unprocessed for extended periods. Inadequate ventilation, poor housekeeping, and absence of odour control can lead to significant discomfort for plant workers and nearby residents. These odour emissions often result in public complaints, and social resistance.

## 6.0 Environmental Management Plan:

### 6.1 Air Pollution Control Measures

Air Pollution Control Devices (APCDs) which are also called flue gas cleaning system (FCGS). Are installed to ensure that the flue gas generated from the boiler meets the stipulated norms ( **Table 2.0 )** prior to being released to the environment. The air pollutants from the stack can be treated using the from the following steps:

**(i) Reduction of acidic gases (HCl, HF and SOx)**

These substances can be cleaned from the flue-gas using alkaline reagents such as lime. The alkali agent can be injected either as suspension or solution into the hot flue-gas flow in a spray reactor. Water is added at a controlled rate to the collected fly ash and reagent to ensure that it remains free flowing and not prone to stickiness or scaling. The reaction products generated are solid and need to be deposited from the flue-gas as dust in a subsequent stage that is bag filter.

**(ii) Reduction of NOx**

The reduction of NOx can be achieved by injecting a reducing agent typically ammonia or Urea into the furnace. The temperature in the combustion chamber to be sprayed should be above 800$^{o}$C. The process is known as Selective Non-Catalytic Reduction (SNCR) process.

**(iii) Reduction of Heavy metals and Dioxin & Furans**

To ensure the reduction of heavy metals and Dioxin &Furans, activated carbon should be injected into the gas flow. The carbon is filtered from the gas flow using bag filters. The activated carbon shows a high absorption efficiency for mercury as well as for Dioxin & Furan.

**(iv) Reduction of Particulate emissions:**

The application of a dust removal system is considered essential for all waste incineration installations to ensure compliance with emission norms and protect downstream air pollution control equipment. Among the various technologies, bag filters can be used due to their high efficiency across a broad range of particle sizes. While their effectiveness slightly reduces below 0.1 microns, the proportion of such fine particles in the flue gas from waste incinerators is generally low. To improve filtration performance and protect the filter bags from chemical corrosion, pre-coating with reagents such as lime and activated carbon can be employed.

The process flow diagram of an APCD of WtE plant is given in **Figure 15.**

*Figure 14: Bag House Filter*

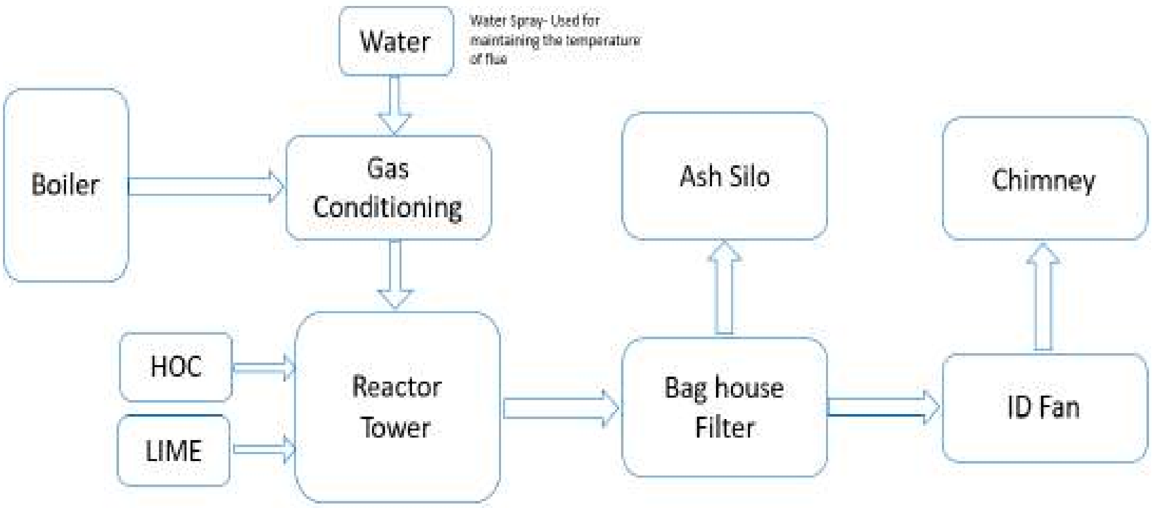


*Fig 15: Process flow diagram of APCD*

### (v) Boiler Stack

The flue gases are discharged through a tall stack (chimney) designed to provide adequate dispersion of residual pollutants into the atmosphere. The typical height of the stack is generally 60 m, depending on the plant capacity, local terrain, air dispersion modeling, and regulatory requirements. In some facilities, the stack height may even exceed 60 meters. The diameter of the stack usually varies between 1.5 to 3.5 meters, depending on the volume and velocity of flue gas flow.

Stack are designed based on the minimum exit velocity of flue gas for re-entrainment of pollutants. Generally, exit velocity of flue gases are between 9 m/s to 18 m/s. Stacks are also equipped with OCEMS for real-time measurement and reporting of regulated parameters. The flue gases emitted through the stack may contain pollutants including dioxins and furans

**Online Monitoring and reporting**

As per Directions issued by CPCB , all operational MSW incineration-based WtE plants are required to install and operate Online Continuous Emission Monitoring Systems (OCEMS) to enable real-time monitoring and reporting of critical air pollutant parameters. The installation shall be in accordance with the Guidelines for Continuous Emission Monitoring System prepared by CPCB. The OCEMS shall continuously monitor and record the parameters such as PM, NOx, $SO_2$, HCl, HF, Carbon Monoxide (CO), Carbon Dioxide ($CO_2$)

The treated flue gas is required to meet the standards as specified in Schedule II C of the SWM Rules 2016 as given at **Table 2.0** of this document.

The emission analysis results from 4 WtE facilities is given in **Table 3**. It is to be noted that all these four plants have established APCS as per details given in this section of the plant.

**Table 3: Stack Emissions Analysis of 4 WtE plants**

| S.No. | Parameters | Solid Waste Management Rules, 2016, | Measured Stack Emission mg/Nm³(Corrected to 11% $O_2$ as per SWM Rules) | | | |
|---|---|---|---|---|---|---|
| | | | Unit 1 | Unit 2 | Unit 3 | Unit 4 |
| 1 | SPM | 50 mg/Nm³ | 28 | 20 | 15 | 25.45 |
| 2 | Hydrogen Chloride | 50 mg/Nm³ | 0.72 | BQL | 1.3 | 0.74 |
| 3 | $SO_2$ | 200 mg/Nm³ | 18 | 22 | 27 | BDL |

| | | | | | | |
|---|---|---|---|---|---|---|
| **4** | $NO_X$ (NO and $NO_2$) expressed as $NO_2$) | 400 $mg/Nm^3$ | 179 | 153 | 128 | 146.1 |
| **5** | CO | 100 $mg/Nm^3$ | 25 | 30 | 34 | 0.773 |
| **6** | HF | 4 $mg/Nm^3$ | BQL* | BQL | BQL | BDL** |
| 7 | Total Organic Compounds | 20 mg/ Nm3 | 2.8 | 2.8 | 2.8 | 4.025 |
| **8** | Sb + As + Pb +Cr+Co+ Cu+ Mn + Ni+V+ their compounds | 0.5 $mg/Nm^3$ | 0.266 | 0.1212 | 0.1702 | 0.022 |
| **9** | Cd + Th +their compounds | 0.05 $mg/Nm^3$ | **0.055** | 0.086 | 0.028 | Cd- BDL |
| **10** | Hg | 0.05 $mg/Nm^3$ | 0.002 | 0.0008 | 0.0007 | BDL |
| **11** | Total Dioxin & Furans | 0.1 ng $TEQ/Nm^3$ | **0.598** | 0.0721 | 0.0031 | 0.053 |

It is observed that main parameter of concern in the stack emissions from the Boiler stack of WtE plant is Dioxin & Furan, Further, it is observed that WtE plants can comply with the stipulated norms with proper operation & maintenance of Air Pollution Control Devices.

### 6.2 Leachate Management

Waste storage areas in the WtE plants are to be provided with proper drainage systems, which include impervious flooring, gradient-based slopes, and covered waste storage areas to minimize rainfall ingress and facilitate gravity-based flow of leachate into collection channels. These channels are connected to leachate collection tanks or sumps equipped with level sensors and pumps for continuous monitoring and transfer.

Once collected, the leachate is conveyed to a dedicated Leachate Treatment Plant (LTP) for systematic treatment before reuse or further processing.

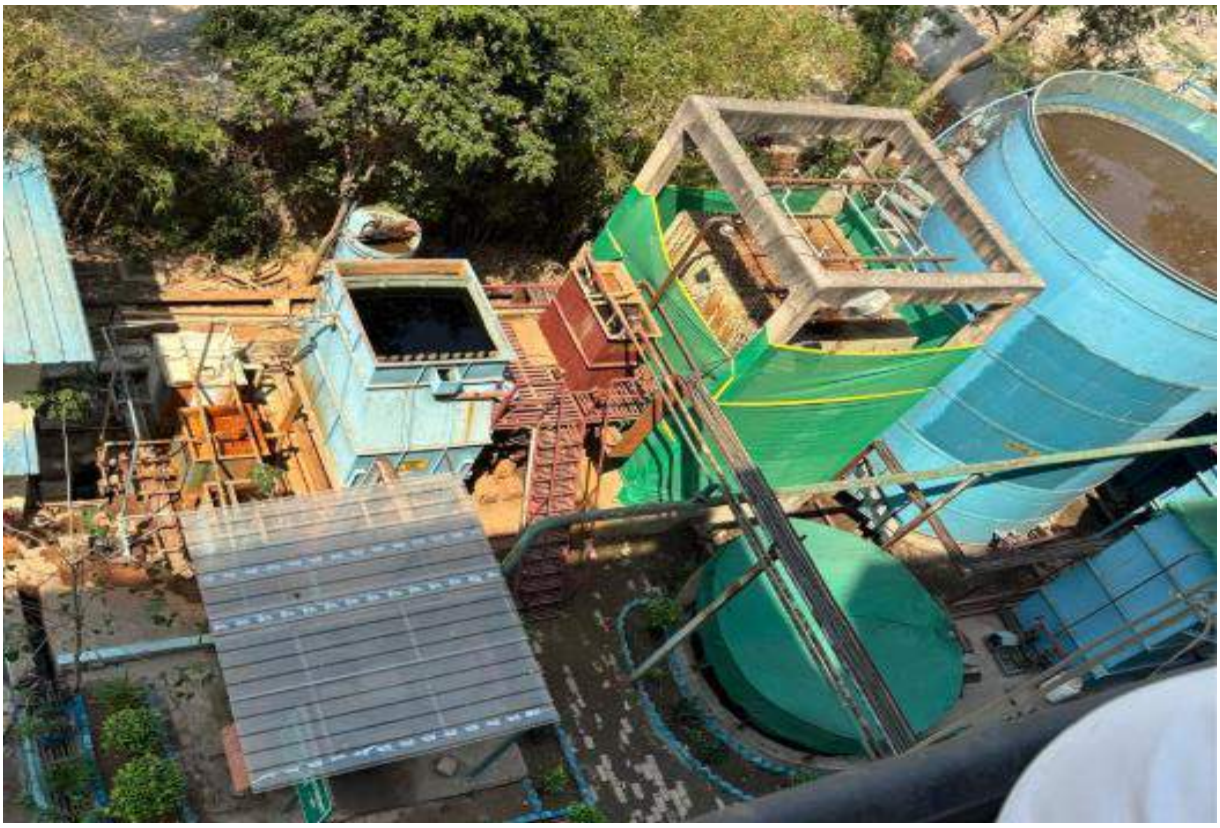

***Figure 16: A Leachate Treatment Plant***

The treatment process is typically multi-stage and may include a combination of mechanical, chemical, and thermal methods**:**

**Mechanical Pre-Treatment:** This stage involves coarse screening, oil-water separation, and sedimentation to remove suspended solids, grit, and floating materials. Equalization tanks are used to homogenize leachate characteristics and flow.

**Chemical Treatment:** Coagulation and flocculation processes are employed to remove colloidal particles, followed by pH correction and oxidation using agents like hydrogen peroxide or sodium hypochlorite for degradation of organics and heavy metals. Sometimes, advanced chemical dosing is used for precipitation of specific contaminants like chromium or arsenic.

**Biological Treatment (optional):** Depending on the organic load, aerobic or anaerobic biological reactors may be used to reduce BOD and COD levels. However, this step is less common in incineration WtEs.

*Figure 17: Leachate Collection Pond*

*Figure 18: Chemical Treatment*

**Different technologies available for treatment of leachate include the following :**

**(i)Membrane Separation via RO/PTRO:** Leachate is treated through Reverse Osmosis (RO) or Pre-Treatment RO (PTRO) systems. The permeate, which is relatively clean water, is reused within the plant, while the reject containing concentrated pollutants is routed to thermal treatment through Multi-Effect Evaporator (MEE).

**(ii) Thermal Treatment via Multi-Effect Evaporator (MEE):** The MEE is an advanced thermal treatment system widely used in WtE plants for the concentration and volume reduction of high-strength effluents such as leachate and RO reject water. MEE operates on the principle of multiple-stage evaporation under progressively lower pressure, utilizing the latent heat of vaporization from one effect (stage) to drive the next. In the first stage, the steam is used to heat and evaporate the effluent. The resulting vapour is then used as the heating medium in the second effect, and this cycle continues across all subsequent stages. This cascading use of heat significantly reduces overall steam consumption and operational costs.

In WtE applications, MEE systems are particularly effective for treating concentrated leachate, reverse osmosis (RO) reject, or high total dissolved solids (TDS) streams. The system separates the feed into two primary outputs: a condensate, which can be reused in plant processes (such as for ash quenching or for gardening purposes), and a concentrated residue, which contains the non-volatile dissolved and suspended impurities. In some cases, the concentrated stream may have sufficient calorific value to be reused as a supplementary fuel in the incinerator, promoting partial resource recovery.

*Figure 19: Multi-Effect Evaporator (MEE):*

(iii) **Thermal Treatment via Mechanical Vapour Recompression Evaporator (MVRE):**

It is an advanced thermal treatment technology used for the volume reduction and concentration of leachate. The MVRE system operates by compressing and reusing the vapour generated during evaporation, thereby significantly reducing energy consumption. This makes it a highly energy-efficient alternative for achieving Zero Liquid Discharge (ZLD) in effluent management.

In MVRE, the process begins with the heating of effluent (such as leachate or RO reject) to its boiling point. The vapour generated is then captured and passed through a mechanical compressor which increases its temperature and pressure. This compressed vapour is then reused as the heating medium in a heat exchanger, facilitating further evaporation of the incoming feed without the need for additional steam. The process continues in a closed-loop, wherein the heat of the vapour is continually recycled within the system. The condensate obtained, typically high in purity, is reused in plant operations, while the concentrated reject is either sent for secure landfill disposal or may be treated further, depending on its characteristics.

This integrated approach ensures Zero Liquid Discharge (ZLD) in many WtE facilities, aligning with environmental norms. Further, the treated leachate shall be disposed on land/public sewer/Inland surface water when the parameters are in accordance with the standards as prescribed in **Table 4** below:

**Table 4: Standards for Parameters in Treated Leachate as per SWM Rules, 2016**

| S. No | Parameter | Inland Surface Water | Public Sewers | Land Disposal |
|---|---|---|---|---|
| 1 | Suspended Solids (mg/l, max) | 100 | 600 | 200 |
| 2 | Dissolved Solids (Inorganic) (mg/l, max) | 2100 | 2100 | 2100 |
| 3 | pH Value | 5.5 to 9.0 | 5.5 to 9.0 | 5.5 to 9.0 |
| 4 | Ammonical Nitrogen (as N) (mg/l, max) | 50 | 50 | - |
| 5 | Total Kjeldahl Nitrogen (as N) (mg/l, max) | 100 | - | - |
| 6 | Biochemical Oxygen Demand (BOD, 3 days at 27°C) (mg/l, max) | 30 | 350 | 100 |
| 7 | Chemical Oxygen Demand (COD) (mg/l, max) | 250 | - | - |
| 8 | Arsenic (as As) (mg/l, max) | 0.2 | 0.2 | 0.2 |
| 9 | Mercury (as Hg) (mg/l, max) | 0.01 | 0.01 | - |
| 10 | Lead (as Pb) (mg/l, max) | 0.1 | 1.0 | - |
| 11 | Cadmium (as Cd) (mg/l, max) | 2.0 | 1.0 | - |
| 12 | Total Chromium (as Cr) (mg/l, max) | 2.0 | 2.0 | - |
| 13 | Copper (as Cu) (mg/l, max) | 3.0 | 3.0 | - |
| 14 | Zinc (as Zn) (mg/l, max) | 5.0 | 15 | - |
| 15 | Nickel (as Ni) (mg/l, max) | 3.0 | 3.0 | - |
| 16 | Cyanide (as CN) (mg/l, max) | 0.2 | 2.0 | 0.2 |
| 17 | Chloride (as Cl) (mg/l, max) | 1000 | 1000 | 600 |
| 18 | Fluoride (as F) (mg/l, max) | 2.0 | 1.5 | - |
| 19 | Phenolic Compounds (as $C_6H_5OH$) (mg/l, max) | 1.0 | 5.0 | - |

The treated leachate analysis report of four WtE plants is given in **Table 5.0** below. It is informed that these WtE Plants have installed leachate treatment plant as per details given in this section.

**Table 5.0 : Treated leachate analysis in 4 WtE Plants**

| S. No. | Parameter | Land Disposal *(mg/l max) (Schedule II (B) of SWM Rules, 2016) | Measured Values (mg/L) | | | |
|---|---|---|---|---|---|---|
| | | | Unit 1 | Unit 2 | Unit 3 | Unit 4 |
| 1 | Suspended Solids (mg/l max) | 200 | 10 | 8 | 22 | 11 |
| 2 | Dissolved Solids (Inorganic) (mg/l max) | 2100 | 44 | **2406** | 17 | 1948 |
| 3 | pH Value | 5.5-9.0 | 9.0 | 8.1 | 8.3 | 9.1 |
| 4 | Ammonical Nitrogen (as N) (mg/l max) | - | 1365 | 1 | 3.5 | 3 |
| 5 | Total Kjeldahl Nitrogen (as N) (mg/l max) | - | 1386 | 1.7 | 5.5 | 10 |
| 6 | Biochemical Oxygen Demand (3 days at 27°C) (mg/l max) | 100 | **1528** | 8 | 39 | 18 |
| 7 | Chemical Oxygen Demand (mg/l max) | - | 3260 | 56 | 106 | 131 |
| 8 | Arsenic (as As) (mg/l max) | 0.2 | 0.004 | 0.006 | BDL | BDL |
| 9 | Mercury (as Hg) (mg/l max) | - | 0.02 | 0.005 | 0.004 | BDL |
| 10 | Lead (as Pb) (mg/l max) | - | BDL | BDL | BDL | BDL |

| | | | | | | |
|---|---|---|---|---|---|---|
| 11 | Cadmium (as Cd) (mg/l max) | - | BDL | BDL | BDL | BDL |
| 12 | Total Chromium (as Cr) (mg/l max) | - | BDL | 0.02 | BDL | 0.008 |
| 13 | Copper (as Cu) (mg/l max) | - | BDL | 0.01 | BDL | 0.008 |
| 14 | Zinc (as Zn) (mg/l max) | - | BDL | 0.02 | BDL | 0.067 |
| 15 | Nickel (as Ni) (mg/l max) | - | BDL | 0.04 | BDL | 0.026 |
| 16 | Cyanide (as CN) (mg/l max) | 0.2 | 0.09 | BDL | BDL | BDL |
| 17 | Chloride (as Cl) (mg/l max) | 600 | 26 | **760** | 2 | **780** |
| 18 | Fluoride (as F) (mg/l max) | - | 0.1 | 0.2 | BDL | 0.66 |
| 19 | Phenolic Compounds (C6H5OH) (mg/l max) | - | 2.8 | BDL | 0.09 | BDL |

It is observed that the main parameters of concern in the treated leachate discharged from the WtE include TDS, Chloride & BOD**.** It is further observed that the treated leachate can meet the stipulated standards, provided adequately designed Leachate Treatment Plant (LTP) is installed and proper operation & maintenance practices are followed in running the LTP.

### 6.3 Bottom Ash and Fly Ash Management

#### 6.3.1 Bottom Ash

Bottom ash is collected from the combustion chamber in WtE plants after the incineration of MSW and contains inert and unburned materials A typical MSW incinerator generates bottom ash of about 20-30% by weight of the solid waste input.

To ensure that the bottom ash is non-hazardous, the concentrations of heavy metals must be within the limits prescribed under the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 as given in **Table 6** below. The bottom ash can be reused/recycled/disposed in sanitary landfill , if it is found to be non-hazardous, otherwise it has to be disposed off in secured landfill.

Further, as per provisions of SWM Rules, 2016, the Incineration plants shall be operated (combustion chambers) with such temperature, retention time and turbulence, as to achieve total Organic Carbon (TOC) content in the slag and bottom ash less than 3%, or the loss on ignition is less than 5% of the dry weight.

The steps involved in recycling of non-hazardous bottom ash include the following

(a) **Extraction of ferrous particles**: A magnetic separator can be employed to extract ferrous materials from the bottom ash. The ash can be spread out on a moving belt or vibrating conveyor and all ferrous particles can be extracted using a suspended magnet. The remaining ash can be sent to the bottom ash handling facility, where it is cooled and further processed.

**(b)Recycling of Bottom ash**: Ash recycling plant is to be setup for recycling bottom ash. The output of the this plant includes Aggregate (8-20 mm), Coarse sand (3-8 mm), Fine sand (1-3 mm), Silt & Large objects (> 40 mm). The generated bottom ash is transported to the receiving platform of the ash recycling unit. From there, it is fed into a primary segregation unit equipped with screening mechanisms, where the material is crushed and classified into different size fractions. Oversized objects are removed at this stage. The crushed material is then segregated into three size categories: 20–40 mm, 8–20 mm, and <8 mm. The 20–40 mm fraction is directed to a cone crusher, which reduces it to the 8–20 mm range. The fraction below 8 mm is washed with water to form a slurry, which is subsequently processed in a sand washer. After washing, the <8 mm fraction is separated into coarse and fine sand. These fractions can be utilized for the brick manufacturing and construction purposes. The remaining silt and fines are utilized as landfill cover material.


*Fig 18: Bottom Ash handling*

**6.3.2 Fly Ash**

Fly ash quantities are generally much lower (2 to 3% by weight of the solid waste input ) compared to bottom ash. Fly ash is normally collected using bag filters . It consists mainly of an injected alkaline agent and salt compound with an acidic gas, such as sulphur dioxide and hydrogen chloride, as well as dust containing harmful components such as heavy metals and dioxins.

*Fig 19: Fly Ash handling*

As in case of bottom ash, to ensure that the fly ash is non-hazardous, the concentrations of heavy metals must be within the limits prescribed under the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 as given in **Table 6** . The flyash can be reused/recycled/disposed in sanitary landfill , if it is found to be non-hazardous, otherwise it has to be disposed off in secured landfill. If found non-hazardous , it can be used as secondary raw material in applications such as road construction, pavement sub-base layers, and construction materials, provided it undergoes appropriate pre-treatment. Pre-treatment techniques generally include dry treatment (such as crushing, screening, and metal separation), wet treatment (including washing to reduce soluble salts and fine particles).

The Fly Ash and Bottom Ash shall be transported in properly covered vehicles to prevent fugitive emissions. Adequate precautions must be taken during loading, unloading, and transportation to avoid any dispersion of particulate matter into the ambient.

**Table 6: Toxicity Leaching Procedure Test: Bottom Ash and Fly Ash**

| S.No. | Parameters | Standards |
|---|---|---|
| 1. | *Loss on Ignition (for Bottom ash only) | <5% |
| 2. | Arsenic | 5 mg/l** |
| 3. | Cadmium | 1 mg/l** |
| 4. | Chromium | 5 mg/l** |
| 5. | Manganese | 10 mg/l** |
| 6. | Lead | 5 mg/l** |
| 7. | Selenium | 1 mg/l** |
| 8. | Copper | 25 mg/l** |
| 9. | Nickel | 20 mg/l** |
| 10. | Zinc | 250 mg/l** |
| 11. | Cobalt | 80 mg/l** |
| 12. | Vanadium | 24 mg/l** |
| 13. | Antimony | 15 mg/l** |

**As per Schedule II (Part C of SWM Rules 2016)*

***Concentration Limit to categorize as hazardous waste as per Hazardous and Other Wastes (Management and Trans boundary Movement) Rules, 2016 notified under Environment (Protection) Act, 1986.*

| TABLE 7: ANALYSIS OF BOTTOM ASH & FLYASH AT WTE PLANTS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Parameters** | **Standards** | **Unit 1** | | **Unit 2** | | **Unit 3** | | **Unit 4** | |
| | | **Bottom Ash** | **Fly Ash** | **Bottom Ash** | **Fly Ash** | **Bottom Ash** | **Fly Ash** | **Bottom Ash** | **Fly Ash** |
| *Loss on Ignition (for Bottom ash only) | <5% | 6.20% | NA | 2.4 | NA | 3.4 | NA | 0.983 | NA |
| Arsenic | 5 mg/l** | BQL | BQL | BQL | BQL | BQL | BQL | BDL | BDL |
| Cadmium | 1 mg/l** | 0.45 | **57.4** | 0.31 | **4** | 0.46 | 0.02 | 0.147 | BDL |
| Chromium | 5 mg/l** | 0.69 | 3.06 | 0.45 | 0.28 | 0.2 | 0.05 | 0.036 | BDL |
| Manganese | 10 mg/l** | 7.28 | **11.23** | 3.29 | 0.52 | 5.46 | BQL | 1.578 | BDL |
| Lead | 5 mg/l** | 0.79 | **48** | 0.4 | 0.05 | 0.38 | 0.38 | 0.056 | **5.968** |
| Selenium | 1 mg/l** | BQL | BQL | BQL | BQL | BQL | BQL | BDL | BDL |
| Copper | 25 mg/l** | 2.03 | **87.8** | 3.5 | 0.04 | 1.85 | BQL | 1.006 | 0.145 |
| Nickel | 20 mg/l** | 0.44 | 1.8 | 0.3 | 0.08 | 0.31 | 0.01 | 0.058 | BDL |
| Zinc | 250 mg/l** | 24.05 | 211 | 17.2 | 0.04 | 30.8 | BQL | 8.161 | 0.722 |
| Cobalt | 80 mg/l** | 0.14 | 0.34 | 0.24 | 0.01 | 0.6 | BQL | 0.102 | BDL |
| Vanadium | 24 mg/l** | 0.1 | BQL | 0.04 | 0.02 | 0.01 | 0.21 | 0.007 | BDL |
| Antimony | 15 mg/l** | 0.06 | 0.3 | 0.31 | 1.28 | 0.02 | 0.82 | 0.011 | BDL |

The analysis of flyash and bottom ash in 4 WtE plants is given in **Table 7.** It is observed that bottom ash is meeting the stipulated requirements w.r.t Heavy metal in all the four plants. However, the concentrations are exceeding the stipulated norms for flyash in three out of four plants. In view of above results, it is essential that the flyash and bottom are tested as per provisions of SWM Rules, 2016 before being put to any beneficial use.

### 6.4 Reduction of Odour at the site

To effectively control and minimize odour emissions in waste storage and handling areas, a negative air pressure system is to be maintained in the storage . This can be achieved by operating suction blowers that continuously extracting air from enclosed waste storage zones. The extracted air is subsequently to be directed to the incinerator boilers where it is utilized as combustion air, thereby ensuring that potentially odorous compounds are destroyed at high temperatures during the combustion process. This method not only prevents the escape of foul odours into the surrounding environment but also enhances combustion efficiency.

Herbal-based disinfectants are periodically sprayed within the waste storage and handling areas. These disinfectants are non-toxic, eco-friendly, and chemically stable, ensuring that they do not interfere with or alter any ongoing chemical or biological processes during storage or incineration.