TOOLKIT ON INVENTORISATION OF NON-HAZARDOUS INDUSTRIAL WASTE

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1. Introduction

In India, industrialisation has played a significant role in shaping the country's economic landscape—accounting for 25–30 per cent of the national GDP. Given this pivotal role, it is also imperative to ensure that industrial growth remains environmentally sustainable.

CSE's report, *Good practices in industrial waste circularity: A compendium,* highlights case studies on how different high-volume, non-hazardous industrial wastes are managed across different industries. Non-hazardous refers to waste generated from industrial processes that does not pose a direct threat to human health or the environment under normal conditions. While not inherently dangerous, it still needs proper disposal due to potential environmental impacts. It typically consists of solid waste. Common examples include slag, paper, plastics, glass, metals, etc.

Industrial sectors produce large quantity of diverse products; there is variation both in terms of production scale as well as with the processes, leading to the generation of different types of wastes. While hazardous waste generated by the industries is regulated under the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016, non-hazardous waste falls outside its purview. Globally, even though there is an international treaty known as the Basel Convention, which regulates the transboundary movement of hazardous and other wastes, there is no regulation or framework looking into the non-hazardous wastes across the world, barring some extended producer responsibility rules and a few waste-specific guidelines. For example, there are EPR rules on paper, plastic etc. Recently introduced standards on refuse derived fuel (RDF) usage in cement sector in the draft notification for the Solid Waste Management Rules, 2024.

Unlike hazardous industrial waste—which is managed through clearly defined rules and regulations, industrial non-hazardous waste is outside the domain of the Hazardous Waste Management Rules, 2016. The absence of regulatory enforcements on non-hazardous industrial waste has resulted in poor management practices, such as open dumping and burning of non-hazardous waste.

At present, there is no provision of inventorisation and quantification of the non-hazardous industrial waste due to an absence of legislation. Thus, there is no data available in the public domain on the types and quantities of waste generated by various industrial sectors. Additionally, there are no common facilities for non-hazardous industrial waste management. It is important to highlight here that non-hazardous industrial waste is not always a liability, but can also act as a resource for the same industry or other industrial processes.

Annual inventorisation of hazardous waste

Unlike non-hazardous industrial waste, hazardous waste is comprehensively tracked in India. Central Pollution Control Board (CPCB) releases the *National Inventory on Generation and Management of Hazardous and Other Wastes* every year. This National Inventory Report covers the status of hazardous and other waste generation and its management across India, based on the annual inventories submitted by the State Pollution Control Boards (SPCBs) and Pollution Control Committees (PCCs). The national report, provides the total number of hazardous waste generating units across the country. The total hazardous waste generation in the country is categorised into recyclable, landfillable, or incinerable hazardous waste—and outlines how this waste is managed in terms of recycling, incineration, and landfilling. The report also collates the data on import and export of the hazardous waste and its interstate movement within the country. CPCB further provides a breakdown of the quantity of waste transported across the states, based on the intended mode of application for which it is received or sent from one state to another. The details of disposal or utilisation quantity is divided into different avenues:

- For disposal at secured landfills
- For disposal at common incinerators
- For recycling by Schedule IV recyclers
- For utilisation in co-processing
- For utilisation under Rule 9 provisions

The inventory also highlights major states generating hazardous waste. For instance, Gujarat, Maharashtra, Tamil Nadu, Andhra Pradesh, and Odisha together account for about 76 per cent of total hazardous waste generation in the country—with Gujarat alone contributing nearly 47 per cent.

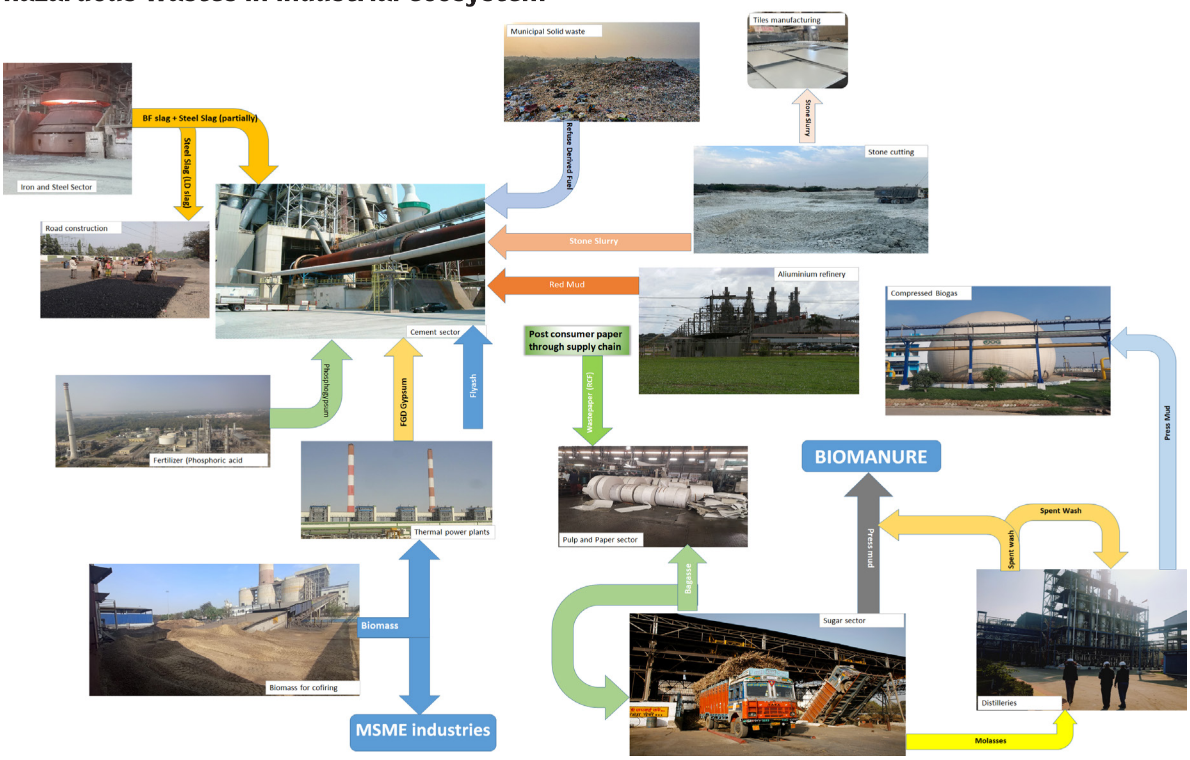
It is, thus, clear that while accounting on hazardous waste is extensively conducted in the country, there is no data available on the type and quantity of non-hazardous waste.

The interconnection between circularity and non-hazardous waste management

As circular economy is becoming a focus at the national level, it is essential to assess the utilisation potential and quantity of utilisation of different non-hazardous wastes as raw material or fuel across industries. Management of non-hazardous industrial waste can pave the pathway to upscale industrial waste circularity. CSE, in its earlier studies, has observed that non-hazardous industrial wastes have a lot of potential of getting utilised within or outside the industries, where it is getting generated. It is important that non-hazardous waste managed and utilised in applications within or outside the industries. A model of industrial waste circularity depicting the utilisation potential of different non-hazardous industrial waste is shown in the figure below (see *Figure 1*).

With this background, CSE has compiled this toolkit as a guidance document for stakeholders—such as SPCBs, consultants, and waste management organisations—to inventorise and quantify the non-hazardous industrial waste. It aims to identify reuse and recycling opportunities and foster the development of a circular economy in the industrial sector.

Figure 1: Circularity and waste management: The interconnection of different non-hazardous wastes in industrial ecosystem



1.1 Status of non-hazardous industrial waste management in industrial areas in Delhi-NCR

CSE's studies conducted between 2020–2024—*Assessment of industrial air pollution in Delhi-NCR* and *Status of industrial infrastructure in Delhi-NCR*—have highlighted that improper management and open burning of non-hazardous industrial waste in industrial areas is one of the major causes for air pollution in the region. Waste is often dumped in open dumping yards and subsequently burnt, leading to hazardous emissions.

To assess the existing scenario of non-hazardous waste management scenario, CSE did an extensive on-ground survey in 23 industrial areas across different regions of

Waste dumping in industrial areas of Delhi-NCR

Waste dumping in Neemrana industrial area, Alwar

Waste burning in Khushkhera industrial area, Bhiwadi

RAI industrial area, Sonipat

Loni industrial area, Ghaziabad

Waste dumping at Mundka industrial area, Delhi

Waste burning at Mundka industrial area, Delhi

Image credits: CSE survey team

Delhi-NCR. The findings revealed that none these industrial areas have a system in place for managing non-hazardous industrial waste. Also, due to the lack of waste management facility in industrial areas, waste dumping and waste burning incidences were observed in many industrial areas, shown in the images below (see *Waste dumping in industrial areas of Delhi-NCR*).

Moreover, since there is no regulatory requirement mandating the accounting of non-hazardous industrial, there is no inventory or quantification of such waste available. Regulatory bodies and relevant government organisations lack comprehensive databases on this category of waste, which makes it important to quantify it and establish a methodology to estimate the total generation of certain non-hazardous industrial wastes, based on corresponding production of goods.

Due to the lack of waste management facilities, issues of waste dumping and waste burning are often seen in industrial areas, which subsequently impact the air quality of the industrial area. An efficient waste management system would enhance the overall health and safety of the community, and foster a responsible and environmentally-conscious industrial sector.

RIICO Bhiwadi, HSIIDC Barhi, HSIIDC RAI and HSIIDC Kundli have allotted plots in industrial areas for waste dumping. However, during CSE's visit, it was discovered that a lot of industrial waste is being dumped on roadside and vacant plots, even after the availability of a waste dumping site in their industrial areas. Waste-burning incidents have also been seen at the waste dumping site in Bhiwadi

Waste burning at waste dumping site in industrial areas of Delhi-NCR


Bhiwadi industrial area

RAI industrial area, Sonipat

Image credits: CSE survey team

and RAI industrial area, depicted in the images below. (see *Waste burning at waste dumping site in industrial areas of Delhi-NCR*).

1.2 Challenges in non-hazardous industrial waste management

The challenges observed in the management of non-hazardous industrial waste are as follows:

- **Lack of regulatory framework**: As there is an absence of a dedicated rule or guideline for non-hazardous waste, there is a need for regulatory scrutiny to streamline the management process.

- **Lack of operational focus:** Management of non-hazardous waste is not adequately focused upon, mostly ignored in Indian governmental frameworks.
- **Ambiguity in roles and responsibilities**: The responsibility for management of non-hazardous waste remains unclear among the stakeholders.
- **Underutilised circularity potential**: There is significant unutilised potential for non-hazardous waste to be reused and recycled—as an input to circular economy.

In light of the above challenges, there is an urgent need for comprehensive information on non-hazardous waste generation, potential for its reuse and recycling, and its disposal in a sustainable manner. Such information is critical for framing required strategy and legislation. CSE has collated the data based on its past studies and developed this toolkit for the assessment of non-hazardous industrial waste generated by industrial sectors.

2. Methodology for developing the toolkit

This toolkit aims to provide a methodology for assessing the type and quantity of non-hazardous waste generated in different manufacturing sectors and outline the steps to be followed.

In order to develop the toolkit, data generation is imperative prerequisite, with the overall objective of establishing specific solid waste generation factors (SWGF) for different wastes generated in industrial areas covered under this toolkit.

Specific solid waste generation factor is defined as a ratio of solid waste generation per unit of production, within a specific period of time (day, month, or year).

$$\textbf{Specific (Sp.) SWGF} = \frac{\textbf{Quantity of waste generation unit*/time}}{\textbf{Quantity of production unit*/time}}$$

*Quantity of production (in kilogram, tonne or number)

In order to maintain consistency, monthly (kg/month) or yearly (tonne/year) data is preferable. Daily values come with variation, but monthly or yearly figures will be more stable and reliable.

At present, there is no listing available of the non-hazardous industrial wastes which are produced in the industries across the country. The only source of data on non-hazardous industrial waste are the consent to operate (CTO) forms. This too is not uniform across the country and varies widely between states; not all states include information on non-hazardous waste in the consent forms. Apart from this, CSE also observed that environmental clearance reports of the industries also include details on expected non-hazardous waste to be generated from the concerned units. However, there is no provision of reporting on non-hazardous waste management by the industries under any regulatory obligation.

Since, data on waste generation figures is not available, it is important to have a baseline for the estimation of the non-hazardous industrial waste. Accordingly, CSE has identified two ways to do the inventorisation and estimation of the non-hazardous industrial waste:

i. Forecasting method based on historical data
ii. Reconnaissance survey

The methodology of both the approaches is given in this toolkit, which will help the regulatory bodies and other stakeholders in preparing inventory of non-hazardous industrial waste. When applied together, both of these estimation methods can provide representative data—useful for any industrial or environmental policy on non-hazardous industrial waste.

A well-structured data collection questionnaire is essential for both methods. A sample format has been given in the *Annexure*.

Methodology adopted to develop the toolkit for assessment and management of non-hazardous solid waste, expanded below:

i. Forecasting method based on historical data

This method allows findings from the past to be translated to the present by a relevant scaling factor. Key steps are as follows:

- Identification of target industrial areas or sectoral clusters.

- Location of selected industrial area, which includes:
  - o Address
  - o State-wise location on map
  - o Layout plan of the area (a hand-drawing may also serve the purpose)

- Database of the industries of a specific region, can be sourced from either the district industries centre (DIC), industrial development corporation, or SPCB.

- Identification of the major non-hazardous wastes getting generated in different manufacturing sectors in the area.

- Preparation of the inventory of different types of non-hazardous waste generated in each sector using the different sources available in public domain, like CTO documents issued by SPCB regional office, online through the Online Consent Management and Monitoring System (OCMMS), environmental clearance reports, etc.

- Collection of the baseline data on production capacity of the industry and subsequent waste generation for each identified waste, within a specific time period.

- Calculation of the specific solid waste generation factor (SWGF) for each waste of different industrial sectors, using the production capacity and non-hazardous waste generation (as mentioned above).

- Specific SWGF can be used to derive the actual non-hazardous waste generation in an industry and the potential of its utilisation in different applications.

ii. Reconnaissance survey method

It is a more exhaustive and representative method to compliment and validate the findings of baseline method.

- Data collection:
  - **Questionnaire preparation**: A sample questionnaire is developed to collect the data related to production and waste generation from the industries (see *Annexure*).

  - **Reconnaissance survey**: A survey is to be conducted for collecting the information from different industrial units based on the questionnaire developed. An onsite survey is important to understand the actual generation and management of waste by the industries. In this stage, industry to industry survey may be carried out with selected industries of each type. The sample of industry for selection of survey should be in relation to total number of industries and type of industrial sectors.

  - **Documentation of production processes**: Industry-specific production process in a block diagram showing unit operations generating waste can be helpful in identifying the different waste streams from an industry.

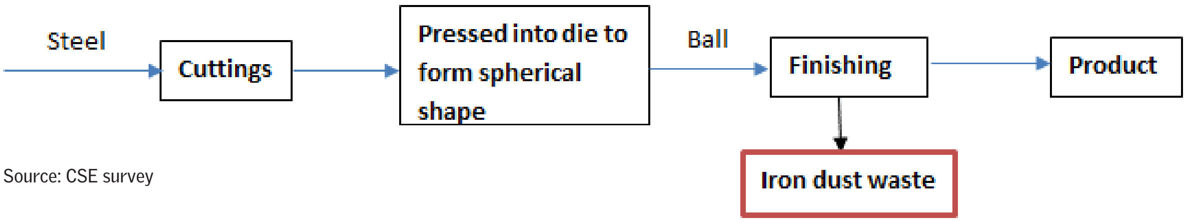
Example of reconnaissance survey method

Bearing industry are of two types: (1) Ball bearing and (2) Forged bearing.

Ball bearing

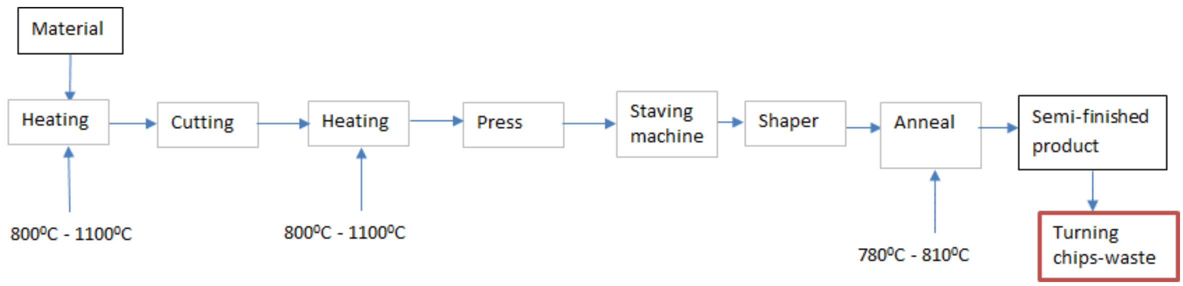
Ball bearings are made from a steel wire rod. The wire rod is cut into fixed lengths and force is applied to press the rod into a die to form a spherical shape. Balls formed from the process have uneven and rough surfaces. To make their surfaces smooth, the hashing process is carried out. This process generates iron dust which is cleaned by water, producing iron slurry. The slurry is dried to form iron dust again which is often used for land filling (see *Figure 2*).

Figure 2: Production process and waste generation in ball bearing industry



Source: CSE survey

Figure 3: Production process and waste generation in forged bearing process



Source: CSE survey

Forged bearing

Forged bearing is a process of making bearing rings to manufacture bearing. Steel bars are first heated, cut, and then pressed by machines and moulded into inner and outer ring shapes—formed by a hot forging process. These forged shapes are then subjected to a turning process to get the finished product. The turning process involves removing excess material through turning operations to achieve the desired dimensions and concentricity of the bearing rings. The waste produced from turning process is turning chips (see *Figure 3*).

Data formatting from in-depth survey—from bearing industry

Based on the above processes, the different types of waste generated from several industries surveyed is given in the table (see *Table 1*).

- Data processing
  - o Collection and retrieval: Collected data from on-site survey or using online consent forms to be compiled and analysed for developing sectoral non-hazardous industrial waste generation scenarios.

Table 1: Type and quantity of waste generated from bearing industry

Number of bearing industries surveyed	Total production capacity	Waste generation percentage or per piece production	Waste production (TPA)	Present management practice
11	5,299 TPA	a. Metal scrap: 12–14 per cent of production	742	Sent to recycling plants
		b. Iron dust: 1 per cent of production	53	Iron dust for land filling
13	778,445, 200 units per annum	Metal scrap: 0.057 kilogram/unit	44,371	Unit, land-filling, or dump

Source: CSE survey

Table 2: Major stakeholder agencies

Government offices	Industry	Civil society
State industrial corporation	Individual industry	Non-government organisation
Pollution control board	Industry association	Representative of municipal bodies
Municipal authorities	Recycler	
District authority		

- Stakeholder consultation and validity of factors
  - o Identify the relevant stakeholders including industries, industrial associations, and sector experts to validate the specific SWGF for each sector and different wastes.
  - o Composition of stakeholders who should be invited for the consultation. The agencies need to be identified (see *Table 2*)).
  - o Key issues to be discussed in the consultation

- Validation of the quantity of waste generated per tonne of product— with respect to industries, specifically quantity and calculation.

- Proportion of waste that is recyclable, and status as well as existing practices of waste utilisation.

- Volume of waste being dumped—whether at designated sites or randomly in non-designated places.

3. Factors for estimation of non-hazardous industrial waste

Based on the surveys conducted in industries, consultations with industry association, sector experts and secondary sources, CSE has tried to establish the specific solid waste generation factors (SWGFs) for waste generated in different industrial sectors, as part of this toolkit. The industrial sectors have been included in the table considering the homogeneity of generated waste. Sectors where there are a significant number of different waste-types have not been included in this study, one example being FMCG.

Furthermore, CSE identified different types of waste generated in each sector, and estimated the specific SWGFs for quantification of waste generation in different industrial processes. CSE also compiled the specific SWGFs for large sectors and non-hazardous industrial waste, based on previous CSE studies and industrial standards. The table below provides the specific SWGFs for different industrial sectors (see *Table 3*).

Table 3: Template for specific solid waste generation factor/SWGF (range) for various non-hazardous industrial waste and estimation of waste generation

Serial number	Name of the sector	Type of waste generated	Typical range for specific solid waste generation factor (per unit of production)	Typical production (tonnes/ annum), specify units	Average estimated waste generation (tonnes/ annum)	Present practices of recycle / disposal waste to waste dump	Potential applications
	1	2	3	4	5=3X4	6	7
1.	Engineering fabrication						
	a. Bearing industry (Forged)	Metal scrap	5–7 per cent of production			Recycling	Melted in furnaces (EAF/IF/BOF), sold to scrap dealers[1]
		Iron dust	1–2 per cent of production			Land fillings	Briquetting—reused in sinter plants or blast furnace in steel industries[2]
		Waste cloth	1–2 per cent per tonne of production			Burned or dumped in nearby area	
	b. Metal fabrication	Metal scrap	15–20 per cent of total production			Recycling	Melted in furnaces (EAF/IF/BOF), sold to scrap dealers
2.	Plastic manufacturing industries (PTE bottles, plastic granules, HDFE and PVC pipes, polypropylene, bags, and HDPE products)	Plastic scrap	4–6 per cent of the total production capacity			Recycle/ dumping	Shredded and recycled into packaging/ fibers[3]
3.	Sponge iron	Iron oxide fines	0.03–0.05 tonnes/tonne of DRI			Landfilled if unrecoverable	Used in pigments or cement
		Char	0.2–0.4 tonnes/tonnes of sponge iron[4]				Used as fuel, adsorbing agent[5]

Serial number	Name of the sector	Type of waste generated	Typical range for specific solid waste generation factor (per unit of production)	Typical production (tonnes/ annum), specify units	Average estimated waste generation (tonnes/ annum)	Present practices of recycle / disposal waste to waste dump	Potential applications
	1	2	3	4	5=3X4	6	7
4.	Foundry	Slag	3–4 per cent total of production (in tonnes)			Very few industries are sending slag to cement plant and most industries are dumping their waste	Potential to use as road base or in concrete
	a. Induction furnace	Silica sand generation	5–6 per cent total production			Very few industries are sending slag to cement plant; most industries are dumping their waste	Reused in foundries/ construction
	b. Cupola furnace	Slag	5–6 per cent of total production			Dumping	Potential use in building industry
5.	Wire and cable						
	a. Copper and aluminium wire units	Metal scrap	2–3 per cent of total production			Scrap is recycling at authorised recycler shop	Melted in furnaces (EAF/IF/BOF), sold to scrap dealers
	b. MS wire/GI wire/barbed wire	Metal scrap	2–3 per cent of total production			Scrap is recycling at authorised recycler shop	Melted in furnaces (EAF/IF/BOF), sold to scrap dealers
	c. PVC and XPLE (cross-linked polyethylene) cable and conductor units	Metal scrap	0.2–0.5 metric tonne/ kilometre			Metal industry is recycling; PVC is reused in the process	Melted in furnaces (EAF/IF/BOF), sold to scrap dealers
6.	Rolling mill	Mill scale	2–4 per cent of production			Reuse at cement plant and dumping it in an area nearby	Recycled in sinter plants or palletisation; high iron content

Serial number	Name of the sector	Type of waste generated	Typical range for specific solid waste generation factor (per unit of production)	Typical production (tonnes/ annum), specify units	Average estimated waste generation (tonnes/ annum)	Present practices of recycle / disposal waste to waste dump	Potential applications
	1	2	3	4	5=3X4	6	7
		Metal scrap	4–5 per cent of production			Metal scrap is being sent to foundries for recycling	Melted in furnaces (EAF/ IF/BOF)
7.	Footwear	Polyurethane	1–2 per cent			Dumped nearby	Crushed and used as carpet underlay, for soundproofing
		Rubber	10–12 per cent production			Recycling dumping nearby	For co-processing in cement plants
		PVC	8–10 per cent production			Recycle in machinery recycling. Secured landfill (hazardous if burned)	Reprocessed into pipes/ flooring
8.	Ghee	ETP sludge	0.9–1 tonnes per tonne of production			Landfill	Can be co-processed in cement kilns
9.	Rice mills	Rice husk	220 kilogram per tonne of paddy processed			Used as fuel in biomass-based boilers	Silica extraction and biochar production[6]
10.	Sugar and distillery (molasses based)	Bagasse	0.25–0.3 tonnes per tonne of sugarcane crushed			Used as fuel for boiler	Boiler fuel, raw material for paper industry, and moulded products like plates
		Molasses	4–5 per cent per tonne of sugarcane crushed			Sold for alcohol production	
		Press mud	3–5 per cent of sugarcane crushed			Used as soil nutrient	Raw material for compressed biogas production

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	1	2	3	4	5=3X4	6	7
		Spent wash	8–12 litres/ litre of alcohol produced			Treated in ETP, some used for boiler fuel	Used in boilers in distillery as fuel
11.	Iron and steel industry	Blast furnace slag	300–540 kilogram per tonne of iron			Cement substitute and road construction	Cement substitute and road construction
		Steel slag	150–200 kilogram per tonne of crude steel			Major quantity landfilled	Cement and road construction
		Electric arc furnace slag/ induction furnace slag	200–220 kilogram per tonne of steel			Hardstand or landfilling	
		Desulphurisation slag	14–16 kilogram per tonne of hot metal			Hardstand or landfilling	
12.	Thermal power plants	FGD gypsum	1.6 tonne per tonne of limestone used in limestone-based FGD systems			Sold to cement/ gypsum board industries	Cement making and gypsum boards are two major application
13.	Aluminium	Red mud	1–1.5 tonnes per tonne of alumina production			Stored in ponds, some attempts at reuse	As a raw material for cement sector
14.	Rubber industry	Cured rubber waste	2–5 per cent of production			Often landfilled or sent to incineration	Used as a filler or component in new rubber products
15.	Copper	Ferro sand (copper slag, CS)	1.6–1.9 tonnes of ferro sand per tonne of copper produced			Landfilled	Abrasive blasting and sand replacement in concrete

Serial number	Name of the sector	Type of waste generated	Typical range for specific solid waste generation factor (per unit of production)	Typical production (tonnes/ annum), specify units	Average estimated waste generation (tonnes/ annum)	Present practices of recycle / disposal waste to waste dump	Potential applications
	1	2	3	4	5=3X4	6	7
16.	Zinc smelting (pyrometa-llurgical)	Zinc slag	0.8–1 tonne per tonne of zinc produced			Secured landfill (heavy metals)	Zinc recovery and construction filler, road construction etc
17.	Textile sector	Yarn and fabric trimmings	2–5 per cent of fabric/yarn production			Sent to landfill or informal units	Can be used for cellulose extraction
18.	Leather manufacturing (finished leather)[7]	Unusable WB splits, WB shavings and WB trimmings	171–180 tonnes/tonne of finished leather (for heavy bovine leather) 180–513 tonnes/million m^2 finished leather (for sheep and goat leather and light bovine leather)				Shredded for filler/composite boards
		Dry leather wastes (trimmings and dust)	28–30 tonnes/ tonnes of finished leather (for heavy bovine leather) 83–151 t / million m^2 finished leather (for sheep and goat leather and light bovine leather)				Recycled into bonded leather
19.	Ceramic industries	Fired rejects/ broken tiles/ crockery	5–10 per cent of production			Dumped in open yards or sent to landfills	Can be used in the construction industry as aggregates in concrete

Serial number	Name of the sector	Type of waste generated	Typical range for specific solid waste generation factor (per unit of production)	Typical production (tonnes/ annum), specify units	Average estimated waste generation (tonnes/ annum)	Present practices of recycle / disposal waste to waste dump	Potential applications
	1	2	3	4	5=3X4	6	7
20.	Automobile and auto parts	Metal scrap (steel, aluminium)	3–6 per cent of production			Rarely dumped; typically recycled	Scrap can be recycled by melting in furnaces
		Plastic and rubber parts (rejected)	1–2 per cent of plastic and rubber components			Sometimes landfilled or sold to informal recyclers	Can be used as an alternative fuel in cement plants in processed form
21.	Ferro alloys (35–50 TPD ferrosilicon and ferrochrome)	Silica fines	0.1–0.2 tonnes/tonne of product			Reused or dumped	
		Fe-Cr slag	0.8–1.2 tonnes/ tonne of product			Slag yards if inert	Metal recovery (Cr/Fe), cement/road construction
		Charcoal and coke fines	0.1–0.2 tonnes/ tonne of product			Reused as fuel	
22.	Chlor-alkali						
	a. Caustic soda	Brine sludge[8]	20–30 kilogram/ tonne of caustic soda			Landfilled or TSDF	Can be utilised for manufacturing of bricks
	b. Soda ash[9]	Fines of raw limestone from screening	30–300 kilogram/tonne soda ash			Dumped or used in construction	
		Grits from slaker containing inert material	10–120 kilogram/tonne soda ash			Landfilled	Can be used as construction material[10]
23.	Pharmaceuticals	Process waste/ API residues	2–5 per cent of batch size (depends on yield and process)			Mostly disposed via TSDF	Co-processing in cement plants
		Packaging waste (blister packs, bottles)	~2–4 per cent of total raw material and product handling			Sometimes co-disposed with general waste	Converting waste medical blister packs into aluminium powder and PVC powder[11]

Note: The range of solid waste generation factors derived in the table are based on survey of industries, inputs of sectoral experts, and discussions with industrial bodies. These are indicative in nature and tend to change with production capacity, as well as with efficiency of the manufacturing process.

Source: CSE survey

4. Benefits of non-hazardous industrial waste circularity: Case studies

CSE in its report, *Good Practices in Industrial waste circularity: A compendium*, has documented several examples where non-hazardous industrial wastes have been successfully utilised within the industries as a fuel or raw material. Therefore, highlighting the importance of managing non-hazardous industrial waste, below are a few active case studies from the industries which depict the environmental and economic benefits of non-hazardous waste management, and subsequently its impact on pollution reduction and conservation of natural resources.

Case study 1: Use of non-hazardous Linz-Donawitz (LD) slag in tile making and road construction

Steel slag is generated during steel manufacturing. About 12 million tonnes of steel slag is generated per year in India.[12] About 150–200 kilogram per tonne of steel slag is generated per tonne of steel produced. Traditionally, steel slag was considered waste and often disposed of in landfills. However, with the growing focus on sustainable practices and resource efficiency, there has been increasing interest in harnessing the circularity potential of steel slag.

SAIL Bhilai steel plant (BSP)

SAIL BSP is doing an in-house pilot project on manufacturing of paver blocks using steel slag. The stone chips (5–12 milimetres), which are natural aggregates, are replaced by steel slag and the paver blocks are used for internal use at present. One paver block weigh about 6.5 kilograms and consumes around 1.8 kilograms of steel slag. The pilot scale project is capable of producing about 1,000 blocks per day. Thus, about 1.8 tonnes per day of steel slag is utilised in paver block manufacturing.

Apart from saving on natural aggregate, use of slag in place of stone chips is also an economically viable option as the cost of stone chips may range between Rs 1,000–2,500 per tonne or even higher, while the cost of processing of steel slag is about Rs 100–150 per tonne.

The cost economics of replacing stone chips with steel slag (at one plant) is estimated as follows:

Weight of one paver block = 6.5 kilograms
Steel slag share in one paver block = 1.8 kilograms
Steel slag consumption in 1000 paver block manufacturing = 1.8 tonnes per day
Cost of stone chips at Rs 1,750 (average cost) = Rs 3,150 per day
Cost of transportation at Rs 500/tonnes = Rs 900 per day
Total cost of using stone chips = Rs 4050 per day
Cost of using steel slag (may vary as per location of utilisation) = Rs 270 per day

Total cost saving by replacing stone chips with steel slag in paver block manufacturing
= Rs 3,780 per day
Annual cost saving = Rs 1.25 million

Note: The above-mentioned cost economics is indicative and will vary on a case-to-case basis for paver block manufacturing units.

Process of tile making at SAIL Bhilai steel plant

Proportioning and mixing

Vibrating table

Curing

Finished product

Image credits: CSE survey team

TATA Steel, Jamshedpur

Steel slag generated at the Jamshedpur steel plant is used for various applications. It is divided into two forms—metallic and non-metallic slag. Metallic slag is either used for internal applications or sold externally for metal recovery.

In the case of non-metallic slag, slag of more than 6 millimetres in size is matured through steam-induced system or steam ageing, resulting in making the slag lime free. This reduces the expanding properties of the slag to less than two per cent, which makes it usable in construction activities.

About 50 per cent of the LD slag is utilised as 0–6 millimetres, out of which about 30–35 per cent is used in cement making and slag of more than 6 millimetres in size is all utilised in road construction. Tata Steel has launched the branded LD slag products, Tata Aggreto and Tata Nirman, in January 2018.

Tata Aggreto conserves about 16,500 metric tonnes (MT) of natural aggregates for every kilometre of National Highway constructed. It is thus an ideal green raw material for construction, as it reduces our dependency on heavy mining.

Case study 2: Use of marble slurry in tile making

Slurry consists of marble fines suspended in water, generated during processing, cutting, and polishing of marble. The slurry generated during marble processing is diverted to sedimentation tanks, where the marble dust settles by gravity. The settled semi-solid slurry is pumped in tankers and transported for disposal. Every year, nearly five to six million tonnes marble slurry waste is generated through established processing units.

In India, Morbi is the hub for tile production, hosting around 750 tile manufacturing units. Among these, a significant portion—roughly 40–50 per cent units—utilise marble slurry in their production. It is estimated that marble slurry consumption in Morbi, Gujarat is between 5,000–6,000 tonnes per day. The extent of marble slurry utilisation by tile manufacturing units depends upon the type of tiles they produce, like vitrified (floor) tiles, wall, and porcelain tiles. In Morbi, mainly three types of tiles are manufactured (see *Table 4: Types of tiles manufactured in Morbi*).

Table 4: Types of tiles manufactured in Morbi

Type of tiles	Water absorption	Temperature required for firing
Vitrified (floor)	0.05–0.1 per cent	1,200–1,250
Wall	1–5 per cent	1,150–1,160
Porcelain	More than 5 per cent	1,050

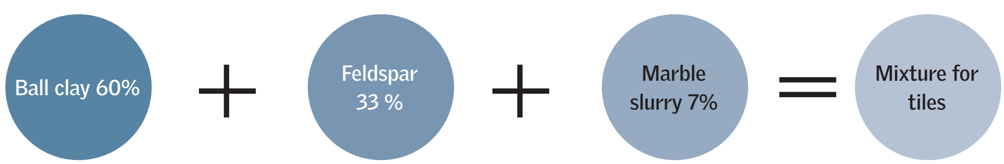
Source: CSE survey

Claystone Granito Private Limited, Morbi

The Claystone Granito Pvt. Ltd. is a vitrified (floor tile) tile manufacturing plant located in Morbi, Gujarat. The essential raw materials for tile production include ball clay, natural feldspar, and marble slurry.

This plant integrates marble slurry into its manufacturing process, thereby reducing feldspar contribution. Feldspar, a natural mineral resource, is typically used in tiles to lower the melting point of raw materials. It improves the strength, toughness, and durability of ceramic bodies by decreasing tile porosity.

Caption: Composition of mixture for tile making



Source: CSE survey and inputs shared by industry

The marble slurry utilised by the plant is sourced from Jalore, Rajasthan. The utilisation of marble slurry in the process is around seven per cent. The tiles manufactured with this seven per cent marble slurry exhibit a modulus of rupture (MOR) of 450 kg/cm^2 pressure, surpassing the international standard MOR 350 kg/cm^2.

Slurry utilisation in tile production

Claystone Granito's tile production is 550 tonnes per day. Its marble slurry utilisation is seven per cent of the production, equivalent to approximately 40 tonnes per day, i.e. 14,400 tonnes annually. However, the utilisation of slurry in the manufacturing process cannot increase beyond seven per cent due to higher silica content in slurry.

Utilisation of stone slurry in tile manufacturing unit

Stone slurry

Mixing of raw material in ball mill

Image credits: CSE survey team

Cost economics for the industry

In the production of vitrified (floor) tiles, ball clay (60 per cent), feldspar (33 per cent) and marble slurry (seven per cent) are utilised. Feldspar plays a crucial role, as it enhances strength and reduces porosity in the final product, with its proportion typically maintained at 40 per cent.

Consequently, to uphold 40 per cent feldspar content in the tile mixture, 33 per cent feldspar is mixed with seven per cent marble slurry; seven per cent slurry utilisation reduces the consumption of feldspar by the same percentage.

For example, in Claystone Granito Pvt. Ltd, this results in an approximate annual saving of 14,400 tonnes of feldspar. A-grade feldspar typically costs around Rs

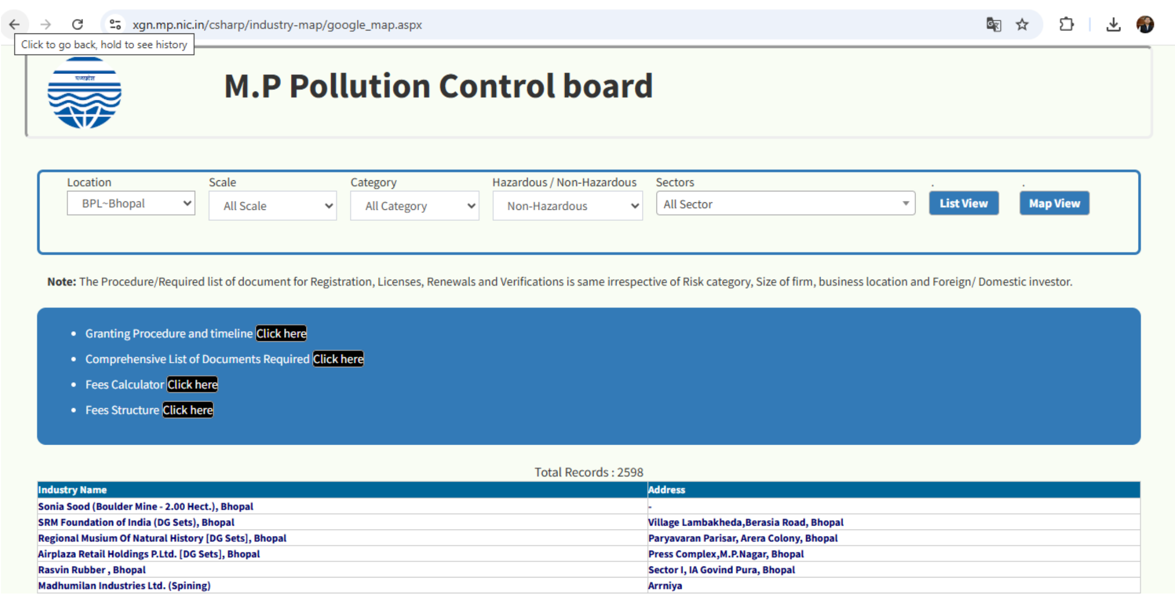
3,000–3,500 per tonne. So, by utilising marble slurry, the plant achieves an annual saving of Rs 2.73 crores (calculated as Rs 4.32 crores, the cost of 14,400 tonnes of feldspar—Rs 1.58 crores, landed cost of 14,400 tonnes of marble slurry at Rs 1,100 per tonne).

4.1 Good practices on accounting of non-hazardous industrial waste

i. Identification of industries generating non-hazardous waste, including details on online consent management portal by Madhya Pradesh Pollution Control Board (MPPCB)

One state which has acted proactively and taken initiative to identify and classify the industries based on non-hazardous or hazardous waste generation is Madhya Pradesh. The online consent management system includes the information of all the industries in the state, based on scale (small, medium, or large) and category (red, orange, or green). MPPCB has also included the provision of hazardous or non-hazardous classification of industries in the consent management system, as well as the different types of sectors generating non-hazardous industrial waste.

Snapshot of MPPCB's dashboard of online consent management



Source: MPPCB

ii. Inclusion of non-hazardous waste details in the consent to operate (CTO) by Maharashtra Pollution Control Board

There are some states which have included the information on non-hazardous waste in consent to operate (CTO) issued to industries. This practice can be replicated by other SPCBs to establish a baseline for non-hazardous industrial waste generation. This data can ultimately feed into the development of waste inventories. The production data of the industries can be used to derive specific waste generation factor, which can be used in the quantification of non-hazardous waste in different industrial sectors. A sample CTO issued by Maharashtra State Pollution Control Board is shown below.

This method uses the historical data, and thus would be an estimation of the waste generated. Moving forward, SPCBs also need to collect data on non-hazardous industrial waste generated by the industries, as it is already done in the case of hazardous waste, and inventory can be updated as per actual data at later stages.

Consent to operate (CTO) format issued by Maharashtra Pollution Control Board

MAHARASHTRA POLLUTION CONTROL BOARD

Phone : 4010437/4020781 /4037124/4035273
Fax : 24044532/4024068 /4023516
Email : enquiry@mpcb.gov.in
Visit At : http://mpcb.gov.in

Kalpataru Point, 3rd & 4th floor, Sion- Matunga Scheme Road No. 8, Opp. Cine Planet Cinema, Near Sion Circle, Sion (E), Mumbai - 400 022

Consent order No :- 1.0/BO/CAC-Cell/UAN No:-0000018373-17/CAC-1709000939 *Date-* 26|09|2017

To,
M/s. Kasturi Foundry Pvt. Ltd.,
Plot No. T-6, Kagal Hatkanagale, 05 star MIDC,
Vill. Talandage, Tq. Hatkanagale,
Dist. Kolhapur.

Subject: Consent to establish in RED category.
Ref : 1] Minutes of CAC meeting held on 17.04.2017 & 08.08.2017.

Your application: 0000018373
Dated: 29.12.2016
For Consent to Establish under Section 25 of the Water (Prevention & Control of Pollution) Act, 1974 & under Section 21 of the Air (Prevention & Control of Pollution) Act, 1981 and Authorization under Rule 6 of the Hazardous and Other Wastes (M & T M) Rules 2016 is considered and the consent is hereby granted subject to the following terms and conditions and as detailed in the schedule I, II, III & IV annexed to this order:

1. **The consent is granted for a period a period up to Commission of the unit or 5 years whichever is earlier.**

2. **The proposed capital investment of the industry is Rs. 85.5 Cr (as per C.A. undertaking submitted by industry)**

3. **The Consent is valid for the manufacture of –**

Sr. No.	Product / By-Product Name	Maximum Quantity
1.	C.I. and S.G. Casting	28,000 MT/A

4. **Conditions under Water (P&CP), 1974 Act for discharge of effluent:**

Sr. no.	Description	Permitted quantity of discharge (CMD)	Standards to be achieved	Disposal
1.	Trade effluent	Nil	As per Schedule –I	NA
2.	Domestic effluent	2.4	As per Schedule –I	On land for gardening

5. **Conditions under Air (P& CP) Act, 1981 for air emissions:**

Sr. no.	Description of stack / source	Number of Stack	Standards to be achieved
1.	Induction Furnace (3 Nos.)	1	As per Schedule -II
2.	DG set (1 No)	1	As per Schedule -II

6. **Conditions about Non Hazardous Wastes:**

Sr. no.	Type Of Waste	Quantity & UoM	Treatment	Disposal
1.	Burnt Sand	500 MT/M	NA	Sale to Brick Manufacturer

5. Recommendations

1. Central Pollution Control Board (CPCB) to develop a methodology for inventorisation of non-hazardous industrial wastes from industries

Currently, there is no data on the type and quantity of non-hazardous industrial waste available in India. Most of these wastes can be a resource for different industries. There is an urgent need for CPCB to come up with a methodology for inventorisation of non-hazardous industrial waste.

2. Mandate annual returns on non-hazardous industrial waste for each category of industries to State Pollution Control Board (SPCB)

There is a provision of filing the annual return form for the hazardous wastes generated in the industries, however, the same is not applicable to the non-hazardous industrial waste. CPCB should mandate the filing of non-hazardous waste along with hazardous waste, either by integrating it with the existing *Form 4* (for hazardous waste) or through a separate format.

3. Standardise CTO format to include non-hazardous waste details

In most of the states, the consent to operate (CTO) of the industries does not include information on non-hazardous industrial waste expected to be generated from the manufacturing unit. It is only practiced in few states, like Maharashtra, Andhra Pradesh, and Telangana. Maharashtra and Andhra Pradesh specifically have included the condition about non-hazardous waste wherein, the approved quantity of each non-hazardous waste of the concerned industry is mentioned. A snapshot of CTO issued by Maharashtra Pollution Control Board is provided in the earlier section.

Table 5: Format for including details on non-hazardous industrial waste in CTO forms of industries

Serial number	Type of non-hazardous waste	Quantity generated	Unit	Proposed treatment	Proposed disposal

4. Ensure non-hazardous industrial waste management facilities in industrial areas

CPCB as well as SPCBs, should made it mandatory for the upcoming industrial areas to have dedicated central waste management facility for non-hazardous industrial waste. Such infrastructure will help reduce waste dumping and waste burning incidences in industrial areas, and promote circular economy by exploring the potential of utilisation of different non-hazardous industrial waste in industrial applications. Also, the authority—under whose jurisdiction the area comes—need to ensure that all industries are channelising their waste to the common facility.

6. Annexure

Suggested format for the questionnaire on reconnaissance survey

1. **Name of industry** ________________________________
2. **Type of industry** ________________________________
3. **Address** ________________________________
4. **Type of products and quantity**

Serial number	Name of product	Production (tonnes/year)

5. **Type of Non-hazardous solid waste and quantity of generation**

Serial number	Type of non-hazardous waste	Waste generation (tonnes/year)

6. **Quantity of waste recycle**

Serial number	Name of waste	Waste generation (tonnes per year)	Quantity of waste recycled (tonnes per year)	Applications where recycled

7. **Quantity of waste reused within the industry**

Serial number	Name of waste	Waste generation (tonnes per year)	Quantity of waste recycled (tonnes per year)	Frequency of reuse

7. References

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In India, there is a well-established system for managing hazardous waste across various industrial and other sectors. However, there remains a significant lack of data and quantification regarding the generation of non-hazardous industrial waste. CSE has developed this practical toolkit to help inventorise and estimate the generation of such non-hazardous waste across different industrial sectors.

As the country moves towards a circular economy, greater emphasis must be placed on non-hazardous industrial waste, which holds the potential to serve as a valuable resource for industries. Its effective reuse can reduce dependence on virgin materials—ultimately lowering carbon emissions, conserving natural resources, and improving overall waste management.

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