DOMESTIC HAZARDOUS WASTE

An approach towards scientific collection, treatment and disposal in India

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BMC	Bhopal Municipal Corporation
CFL	Compact Fluorescent Light
CHW-TSDF	Common Hazardous Waste – Treatment, Storage and Disposal Facility
CPCB	Central Pollution Control Board
CSWAP	City Solid Waste Action Plan
DHW	Domestic Hazardous Waste
FCO	Fertilizer Control Order
IARC	International Agency for Research on Cancer
IMC	Indore Municipal Corporation
MSW	Municipal Solid Waste
NEERI	National Environmental Engineering Research Institute
PPM	Parts Per Million
PIBO	Producer, Manufacturer and Brand Owner
PVC	Poly Vinyl Chloride
RCRA	Resource Conservation and Recovery Act
SBM	Swachh Bharat Mission
ULB	Urban Local Body
USEPA	United Nations Environment Protection Agency
VOC	Volatile Organic Compounds

1. Introduction

What is hazardous waste?

Simply defined, hazardous waste is that category of waste the properties of which make it potentially dangerous or harmful to human health or the environment. It can be the by-product of manufacturing processes, discarded used materials or discarded unused commercial products such as cleaning fluids (solvents) and pesticides.

Although the exact definition of hazardous waste varies across regulatory jurisdictions, hazardous waste generally includes any discarded material that is potentially harmful due to its ignitability, corrosivity, reactivity or toxicity. As per USA's Resource Conservation and Recovery Act (RCRA), hazardous waste is a solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical and infectious characteristics may:

a) cause, or significantly contribute to, an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or
b) pose a substantial threat or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of, or otherwise managed.

The United States Environmental Protection Agency (USEPA) considers end-of-life materials that can catch fire, react, explode under certain circumstances, or that are corrosive or toxic as 'hazardous waste'. These may include paints, cleaners, oils, batteries and pesticides which contain hazardous ingredients and require special care when we dispose of them. For its scientific management, Subtitle C of RCRA creates a cradle-to-grave management system for hazardous waste to ensure proper treatment, storage and disposal in a manner protective of human health and the environment.

In India, the Hazardous Waste (Management Handling and Transboundary) Rules were promulgated in 1989 by the Ministry of Environment and Forests (MoEF) under the aegis of the Environment Protection Act, 1986. The Rules were notified to ensure safe handling, generation, processing, treatment, packaging, storage, transportation, use reprocessing, collection, conversion, offering for sale, and destruction and disposal of hazardous waste. These Rules were amended in 2000 and 2003. In 2016, the final notification of the Hazardous Waste (Management,

Handling and Transboundary Movement) Rules was promulgated in supersession of the former notification. The Rules lay down corresponding duties of various authorities such as MoEF&CC, Central Pollution Control Board (CPCB), State/UT governments, SPCBs/PCCs, Directorate General of Foreign Trade (DGFT), Port Authority and Custom Authority. State Pollution Control Boards (SPCBs) and Pollution Control Committees (PCCs) have been designated with wider responsibilities touching across almost every aspect of hazardous waste generation, handling and disposal.

Under the said Rules, hazardous waste is defined as any waste that because of any of its physical, chemical, reactive, toxic, flammable, explosive or corrosive characteristics causes danger or is likely to cause danger to health or the environment, whether alone or when in contact with other wastes or substances.

WHAT IS NOT DOMESTIC HAZARDOUS WASTE AS PER SOLID WASTE MANAGEMENT RULES, 2016?

SANITARY WASTE

In many cases, sanitary waste such as soiled sanitary pads, liners, tampons, syringes, diapers, cotton and bandages, and other materials contaminated with bodily fluids are categorized under domestic hazardous waste. However, it is essential to note that sanitary waste has infectious properties, and it should be stored and collected separately. It is not chemically reactive but biologically reactive in nature. As per the Solid Waste Management Rules, 2016, sanitary waste should be wrapped securely in the pouches provided by the manufacturers or brand owners of these products or in a suitable wrapping material as instructed by the local authorities and placed in the bin meant for dry waste or non-biodegradable waste. However, SBM 2.0 mandates the cities to practice four-way segregation (dry, wet, domestic hazardous and sanitary waste).

E-WASTE

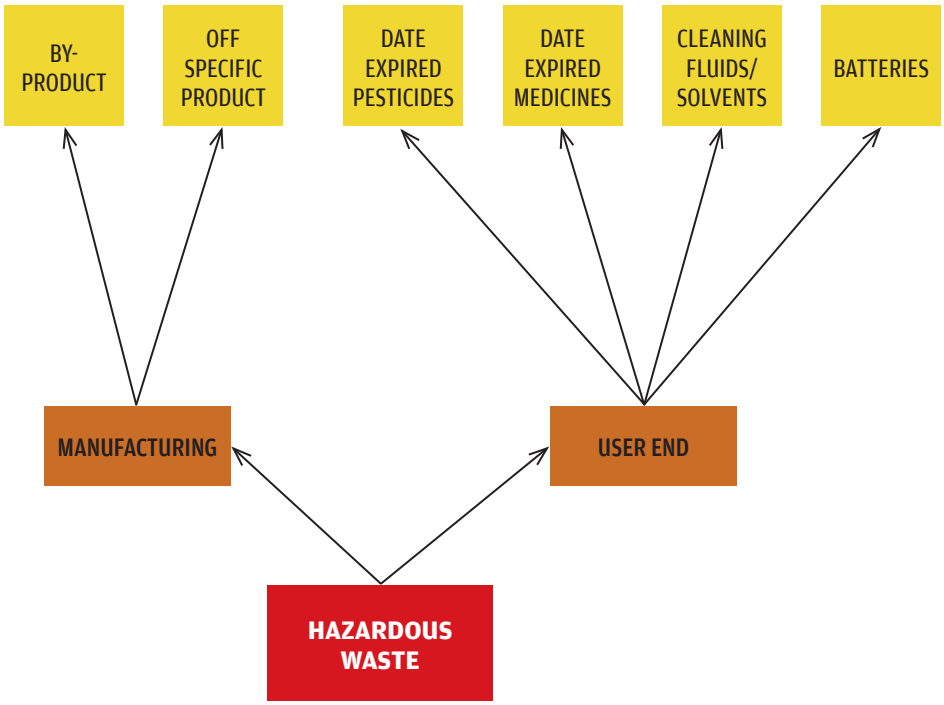
Another fraction of waste that sometimes makes its way to domestic hazardous waste is electronic waste or e-waste. According to CPCB, nearly 1 million tonne of e-waste was generated in the country in 2018. Due to its complexity and its composition, end-of-life management of e-waste is particularly challenging. Due to the presence of high amounts of valuable materials such as precious metals and rare earth elements, e-waste is an essential source for secondary raw materials. However, hazardous substances such as lead, mercury or brominated flame-retardants pose high environmental and health risks and require proper management at end-of-life. E-waste is not hazardous if stored safely or recycled by scientific methods. However, e-waste can be considered hazardous if thrown in municipal garbage. It is interesting to note that the informal sector is recycling a significant portion of e-waste generated in the country. The remaining 5 per cent is handled in the formal units. As a result, most of the end-of-life electronic and electrical components are not thrown in garbage bins. Instead, they are sold under the buy-back scheme or to the kabadiwala. In most cases, it does not reach landfills or the formal waste management chain meant for municipal solid waste. Hence, this should also not be categorized as municipal solid waste.

Sources of hazardous waste

Hazardous waste could be generated from two sources: (1) from manufacturing industries as by-product and off specific products; and (2) from the user-end (it could be date expired pesticides and medicines, or cleaning fluids and solvents, or post-consumer batteries).

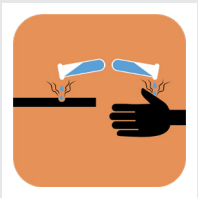
It is important to note that hazardous waste generated from manufacturing industries is regulated at the industry level in larger amounts; however, it is relatively unregulated in the smaller, discrete amounts found in consumer items (user-end). The parts of end-of-life household products which are labeled as flammable, toxic, corrosive or reactive and contain substances like lead, mercury, arsenic, cadmium, PVC and acids are often disposed of along with the general municipal solid waste. This has the potential to cause irreversible damage to the environment and public health. Over the last few decades, the need to find environmentally sustainable and economically viable methods for managing hazardous waste generated from households has emerged as one of the biggest challenges for urban local bodies (ULBs) in India.

Figure 1: Sources of hazardous waste



Source: D.D. Basu, CSE

Table 1: Properties of hazardous waste as per the Hazardous and Other Wastes (M&T) Rules, 2016



CORROSIVITY

- pH < 4 or >12
- Corrosion of steel at 6.35 mm/year at 55 o C

Causes deterioration, or eating away of body tissue and other surfaces that it touches.

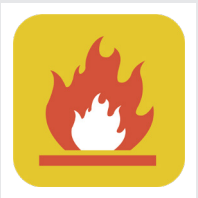
Examples: Bleach, laundry stain removers, oven cleaners, drain cleaners and lead acid batteries.

REACTIVITY

- Unstable and readily undergoes violent change without detonation

Unstable waste which may cause explosions or release toxic fumes, gases, or vapors when heated, compressed or mixed with other materials.

Examples: Batteries, windshield washer fluid, antifreeze and laundry detergent.



IGNITABILITY

- Liquid other than an aqueous solution containing >20% organic content by volume & flash point <60 ºC

Oxidizing substance when in contact with moisture, or other materials/wastes, results in spontaneous fire or combustion. Flammable waste, easily catches on fire.

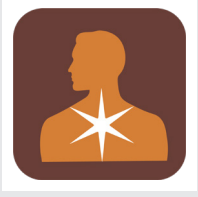
Examples: Petroleum products, pesticides, insecticides and deodorants.

TOXICITY

- Poisonous and may cause injury or death if swallowed, inhaled, or absorbed through the skin.

A solid waste exhibits the characteristics of toxicity if the leachate from the representative sample by TCLP test method contains any of the contaminants in excess of the prescribed concentration limits.

Examples: Insecticides, paints, paint thinners and disinfectants.

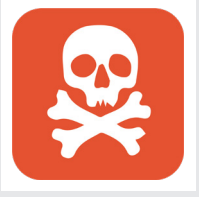


CARCINOGENIC

- Carcinogenic substances and preparations that if inhaled or ingested or penetrate the skin may induce cancer or increase its incidence.

Certain chemicals, including benzene, beryllium, asbestos, vinyl chloride, and arsenic are known human carcinogens.

Examples: Cleaning agents

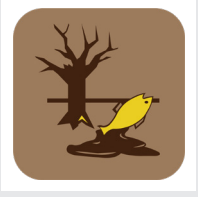


POISON

- Substances or wastes liable either to cause death or serious injury or harm to human health if swallowed or inhaled or by skin contact.

Certain chemicals including Benzyl benzoate, chlorine and alkyl ammonium chlorides, abarmectin, propoxur, trichlorfon, sulfluramid, chlorpyrifos and boric acid.

Examples: Pesticides, insecticides, fungicides and rodenticides.



ECO-TOXIC

- Substances or wastes which, if released, present or may present immediate or delayed adverse impacts to the environment by means of bioaccumulation or toxic effects upon biotic systems or both.

Many household products contain chemicals which are not biodegradable in nature and bioaccumulate in the food chain.

For example: Cleaning products, detergents and drain cleaners.

Properties of hazardous waste

The properties of hazardous waste are based on the physical and chemical nature of comprising materials. These properties classify waste as toxic, reactive, ignitable and corrosive (see *Table 1: Properties of hazardous waste as per the Hazardous and Other Wastes (M&T) Rules, 2016*). For example, toxic wastes are typically products with poisonous properties, even in very small or trace amounts. They may cause acute health impacts, causing death or illness, or they may have chronic effects, slowly causing irreparable harm. Reactive wastes contain chemically unstable chemicals and react violently with air or water. Ignitable wastes burn at relatively low temperatures and may cause an immediate fire hazard such as the flammable liquids present in air fresheners. Corrosive wastes include strong acidic or alkaline substances.

2. Concept of domestic hazardous waste

Why a separate class?

In India, and the rest of the developing world, there has been a significant increase in solid waste generation rates over the last three decades due to accelerated urbanization and concurrent population growth. As a result, urban local bodies (ULBs) are under increasing pressure to scientifically treat and utilize all fractions of solid waste—wet, dry, sanitary, domestic hazardous, etc. It has also become imperative for pollution control authorities to minimize the environmental and health hazards posed by non-scientific dumping of mixed municipal solid waste (MSW).

Domestic hazardous waste (DHW) is typically generated in lesser quantities than other waste fractions but the potential risks to the environment and human health are disproportionate to its quantum. Internationally, most DHW is co-disposed with MSW in municipal waste dumpsites or landfills. Such co-disposal of potentially hazardous waste can lead to latent risk; not only are DHW substances potentially dangerous to the environment and health but they can also induce alterations in the properties of other waste streams by reacting directly with the waste or changing the redox environment (acids, alkalis, and solvents).

The unsegregated waste that ends up in landfills contains many toxic substances such as paints, varnishes, expired medicines, needles, empty bottles of mosquito repellents, rodenticides and pesticides. These substances are recalcitrant in nature and pose various hazards to human health and the environment when improperly disposed of along with the regular municipal solid waste. In addition, dumping of unsegregated waste also leads to the generation of toxic leachate. The highly contaminated and hazardous leachate is formed due to rainwater infiltration through landfill space and inherent water present in waste by physicochemical and biological transformations.

It is important to note that e-waste and household waste with infectious and radioactive properties can also be termed as domestic hazardous waste in many countries. However, in India, the infectious waste generated from households (typically diapers, menstrual products, etc.) comes under the category of sanitary

waste, while radioactive and e-waste are regulated under separate regulations. Under Section 3 (17) of Solid Waste Management Rules, 2016, 'domestic hazardous waste includes discarded paint drums, pesticide cans, CFL bulbs, tube lights, expired medicines, broken mercury thermometers, used batteries, used needles and syringes and contaminated gauze generated at household levels.'

List of domestic hazardous waste

HOUSEHOLD CLEANERS
Oven cleaners, drain cleaners, wood and metal cleaners and polishes, toilet cleaners, tile and shower cleaners, bleach (laundry)

AUTOMOTIVE PRODUCTS
Motor oil, fuel additives, air conditioning refrigerants, starter fluids, automotive batteries, transmission and brake fluid antifreeze

HOUSEHOLD INSECTICIDES
Herbicides, insecticides, fungicides/wood preservatives

MISCELLANEOUS
Mercury thermostats or thermometers, fluorescent light bulbs, discarded PVC toys, batteries, computer components and end-of-life electronics items

PAINTING SUPPLIES
Adhesives and glues, furniture strippers, oil or enamel-based paint, latex or water-based paint, stains and finishes, paint thinners and turpentine, paint strippers and removers, fixatives and other solvents

INDOOR PESTICIDES
Ant sprays and baits, cockroach sprays and baits, flea repellents and shampoos, bug sprays, houseplant insecticides, mosquito coils, moth repellents, pet care products, pet food items

OTHER FLAMMABLE PRODUCTS
Compressed gas cylinders, kerosene diesel fuel gas/oil mix, lighter fluids, shoe polish, cigarette butts

NOTE: The list may also contain anything that comes under the category of corrosive, ignitable, reactive, toxic, carcinogenic, or causes any short-term or long-term harm to the human health and environment.

Environmental and health hazards of domestic hazardous waste

The extent of risk posed to human health and environment by unscientific disposal of DHW is directly related to the quantity of waste produced and the disposal method adopted (probability that exposure pathways lead to a pollution event). Landfilling or dumping of mixed waste is the most commonly practiced disposal method across the country. Leachate in dumpsites or landfills can extract heavy

metals and volatile organic compounds (VOCs), thereby causing groundwater and surface water contamination. Leachate is inherently variable due to the heterogeneity of waste composition, water infiltration rate and amount, residual refuse moisture content plus factors relating to the landfill: design, operation, management and age. Leachate components result from the types of waste disposed and the processes occurring within the landfill. The presence of inorganic compounds including heavy metals and hazardous organic contaminants, such as halogenated aliphatic compounds, aromatic hydrocarbons, phenolic compounds, and pesticides in MSW landfill leachate is a direct indicator of the disposal of domestic hazardous waste with MSW.

Several studies reported the presence of toxic metals and organic contaminants in the fine fraction (soil-like material recovered from dumpsite of size less than 5 mm) of waste recovered from old dumpsites (see *Table 2: Concentration of toxic metals in the dumpsites*). One of the toxic substances that is frequently detected in the landfills is mercury, which is released from fluorescent light bulbs. Even a small amount of mercury vapor poses a significant risk to human kidneys and lungs. Eventually, these substances leach into groundwater and soil, causing both ecological and health hazards.

Table 2: Concentration of toxic metals in the dumpsites

Heavy metals (mg/kg)	Okhla Dumpsite, Delhi	Bhalswa Dumpsite, Delhi	Noida Dumpsite	Hyderabad Dumpsite	Kadapa, Chennai	Mulund, Mumbai	Indian soil limits
Chromium (Cr)	188–201	168–199	273–395	169–189	179–198	149.3–615	
Nickel (Ni)	110.79–130	94–146	221–268	104–120	105–124	36.3–197	
Copper (Cu)	121–156	75–216	50–164	227–249.25	116.19-120	146.8–988.2	135–270
Zinc (Zn)	118–242	147–229	157–428	209–375	128–158	271.3–1984.3	300–600
Arsenic (As)	13-34.5	8.8–30	68–322	36–122	52–64	NA	
Selenium (Se)	1.3–1.6	1.18–2	4–6	1.9–2.6	1.9–2.4	NA	
Cadmium (Cd)	6.9–7	6.9–7.5	11–16	6.6–7.0	6.9–7.1	1.3–6.7	3–6
Lead (Pb)	27–34	23–33	33–39	26–30.5	31–34.5	34.1–525.6	

These metals could be from a wide range of domestic hazardous waste generated from households and disposed of along with the rest of the municipal solid waste leading to contamination of the entire dump with organic and inorganic contaminants. Because of their high degree of toxicity, arsenic, cadmium, chromium, lead and mercury rank among the priority metals for public health significance. They are all systemic toxicants known to induce multiple organ damage, even at lower levels of exposure. According to the United States Environmental Protection

Agency (USEPA) and the International Agency for Research on Cancer (IARC), these metals are also classified as "known" or "probable" human carcinogens based on epidemiological and experimental studies showing an association between exposure and cancer incidence in humans and animals.

Apart from toxic metals, waste in the dumpsites was found to be contaminated with traces of pharmaceutical chemicals and emerging pollutants. A study by AIIMS, New Delhi reported high concentration of diclofenac (136 µg per litre) and ibuprofen (898 µg per litre) in landfill leachate collected from Delhi. This is attributed to co-disposal of waste medicines along with the regular municipal solid waste. Ibuprofen is a moderately toxic compound. The degradation of this compound in surface water is limited and its degradation by biological means is slow. Additionally, the metabolites generated as a product of Ibuprofen degradation, like 4-isobutylacetophenone have been reported to be highly hazardous. Thus, it is necessary to regulate these compounds before they are discharged into waterbodies and landfills.

MSW containing domestic hazardous waste can also contaminate all other waste components. The quality of recycled products, such as recycled plastics (might contain hazardous entities) and compost can be affected if hazardous components are mixed with other waste streams. NEERI carried out a study to analyse municipal solid waste compost produced in Delhi in order to assess its marketability and use in different areas with respect to physio-chemical properties and heavy metal polluting potential. The study reported high concentrations of Cu, Pb and Cr in the compost sample which exceeded the Fertilizer Control Order (FCO) standard by 66.7 per cent. The presence of Cu, Pb and Cr can be attributed to the contamination of toxic materials and residues in wet waste. Another study by Anna University reported that heavy metal content in municipal solid waste sampled from Perungudi dumpsite in Chennai exceeded the Indian standards. In some samples, metal content was beyond the limits prescribed for compost by CPCB. For example, the concentration of Hg was 0.78 mg/kg while the Indian compost standard for Hg is 0.15 mg/kg, Pb was 112.0 mg/kg while the standard is 100 mg/kg and Cr was 261.0 mg/kg while the standard is 50 mg/kg.

Pollutants of concern in household products

Lead in household products

Lead in DHW is mostly contributed by lead-containing paints (residual paints, empty containers). Lead (in the form of lead naphthenate and lead oxide) imparts colour in some cases, makes the paint more durable and corrosion-resistant, and

speeds up drying. The prescribed concentration of lead in paints as per CPCB is 90 ppm. Whereas, as per the study conducted by Toxic Links (a Delhi based-NGO) 20 samples procured from states like Andhra Pradesh, Delhi, Rajasthan, Punjab and Odisha have lead levels above 90 ppm. The lead content was observed in the range of 189 ppm to 109,289 ppm, which is much higher than the standards prescribed by CPCB. Even the samples collected from Delhi clearly mentioned 'no added lead' but they had 49,321 ppm (golden yellow) and 473 ppm (cherry red) of lead. Besides, many organometallic lead compounds such as lead arsenate ($AsHO_4Pb$) are still used in pesticides. Decorated coloured glasses including tumblers, beer and wine glasses, and jars could be another source of lead where lead (II) oxide is used to reinforce the colour and brightness of glass. Besides, lead-antimony and lead-acid batteries contain a high amount of lead. Lead is sometimes added to the zinc anode of household batteries to reduce corrosion.

Cadmium in household products

Cadmium pigments are used to create bright yellow, orange, red and maroon dyes, paints, plastics and ceramics. The metal is used to produce nickel–cadmium batteries and in galvanizing and electroplating. It may be found in electrical conductors, polyvinyl chloride (PVC) products, photocells, tires, automobile radiators, electronic components, and heating elements. Due to its high technical performance, cadmium is widely used in accumulators and accounts for about 75 per cent of all cadmium found in household waste. Accumulators are used in various devices: electric toothbrushes and razors, electrical tools, medical devices and mobile phones. Nickel-cadmium batteries contain cadmium or cadmium hydroxide as anode material. NiCad batteries in power tools, cameras, cell phones and computers are recyclable and are generally not disposed of with regular waste. There are many products coated with cadmium to provide a gloss or for corrosion resistance: radio and television equipment, commonly used household appliances and metal products. One of the main sources of cadmium is waste fertilizer. Cadmium is also widely used in packaging (except for food). Cadmium sulfides and cadmium sulfoselenides are used as dyes (orange-yellow, pink-red and chestnut colours) in plastics, ceramics and paints.

PVC plastic stabilizers include cadmium stearates (except PVC-based plastic for food packaging to prevent contamination). Cadmium is found in various electrical and electronic devices. While many cadmium compounds are insoluble in water, some are soluble in acids and organic compounds, thus still presenting a risk of environmental contamination when disposed of with regular waste.

Nickel in household products

In waste, nickel occurs in compounds of low solubility such as steel alloys and galvanized coating of various products like car parts and tools. Some nickel compounds in waste are mobile and dangerous to the environment. Along with lithium-ion batteries, nickel is released into the environment in the form of $LiNiO_2$. Nickel hydroxide ($Ni(OH)_3$) is known to be used in alkaline iron nickel accumulators, while nickel oxide is used in zinc-nickel and nickel-metal hydride accumulators. Nickel (III) oxide is used as an additive to the special glass in optical devices.

Mercury in household products

A significant amount of mercury is found in thermometers and fluorescent lamps. On average, one compact fluorescent lamp contains 3–6 mg of mercury, while one linear lamp contains 50–120 mg. Approximately 500–600 mg of mercury is used in one household thermometer. However, some countries have banned mercury thermometers. Until recently, some mercury was used in silver-oxide and zinc-air batteries. Now-a-days, mercury use is prohibited in all batteries except button type. Mercury-based dyes may be found in coloured plastic. Some pesticides with mercury include phenyl mercuric chloride (C_6H_5ClHg).

Table 3: Estimated consumption and uses of mercury in India

Household product containing Hg	Mercury use per unit	Production	Calculated mercury use (tonnes)
Thermometers	0.6–1 gm	8,957,000	7.2
Alkaline Batteries	Approx. 25 mg	NA	NA
Fluorescent lamps	0.0252–0.080 gm	150,000,000	7.89
Thermostat switches	3–6 gm	4,051,000	18.23
Alarm clocks	0.6–0.7 gm	1,481,000	0.96

Source: CPCB, 2009

Arsenic and zinc in household products

Arsenic is widely used in herbicides, insecticides, fungicides and desiccant pesticides in the form of calcium, sodium and lead arsenates, or copper acetoarsenite. Other major sources of arsenic compounds in household waste are medicines, enamels, nutritional supplements and washing agents.

Compounds of zinc such as zinc sulphate and zinc phosphide are used in cosmetic products, medicines and pesticides. High water-solubility of these zinc compounds results in their easy release into the environment.

Copper in household products

Being a good conductor, copper is heavily used in electrical cables and printed circuit boards. It is in the highest average concentration compared to other metals in electronic waste (41 g/kg). Also, about 14 per cent of total copper in household waste is contained in fluorescent lamps.

Other hazardous constituents in DHW

There are a wide range of household products which contain chemicals apart from heavy metals which are hazardous to human health (see *Table 4: Chemical constituents in domestic hazardous waste*).

Table 4: Chemical constituents in domestic hazardous waste

Type of DHW	Hazardous chemical constituents
Oven and stove cleaners	Sodium hydroxide and/or ammonium hydroxide (ammonia), and possibly methylene chloride
Drain cleaners	Concentrated sodium hydroxide (can be solid or in aqueous solution of 50 per cent m/m), or hydrochloric acid or sulphuric acid (up to 70 per cent m/m)
Household bleach	Sodium or calcium hyper chlorite in concentrations up to 10 per cent m/m, or hydrogen peroxide
Toilet bowl cleaners	Hydrochloric acid or sodium hyper chlorite and if coloured blue can contain chromium compounds
Mould and mildew cleaners	Sodium hyper chlorite and formaldehyde
Other cleaning products	Ammonium hydroxide (ammonia) and ethanol, chlorinated phenols and complex phosphates
Air fresheners	Formaldehyde or phenol
Pesticides	Organophosphates and chlorinated compounds such as chlorinated pyrethrums
Pharmaceuticals	Cytotoxic/cytostatic, antibiotics
Paints and related products	Alcohol, glycols, ethers, ketones, toluene, xylene, acetone, esters, petroleum distillates and solvents
Anti-freeze	Ethylene glycol
Pool chemicals	HCl and NaOCl

Source: Chemicals in Waste: Household Hazardous Waste, 2011

Figure 2: Domestic hazardous waste and health impacts

Swallowing antifreeze (ethylene glycol) may cause damage to the heart, brain, kidney and other internal organs. Inhaling antifreeze is not as dangerous but may cause dizziness.

Being a strong corrosive substance, bleach can affect the respiratory system if inhaled. Bleach can also irritate or burn the skin and eyes. Ingesting bleach can cause pulmonary edema or vomiting and coma. Wearing rubber gloves and a dust mask when using bleach is strongly recommended.

Drain cleaners are dangerous substances which contain lye and other chemicals known to cause burns to the skin and eyes, and even blindness in severe cases. Swallowing a small amount of drain cleaner can severely affect the throat, stomach and may even cause death.

Carpet cleaners contain naphthalene, which is known to cause cataract formation and liver damage over a long exposure. The perchloroethylene in carpet cleaners is carcinogenic, and it may cause dizziness, headaches, kidney dysfunction, neurological damage and other problems from short-term exposure.

Air fresheners are known to contain formaldehyde, a strong (possibly carcinogenic) substance that irritates the skin, eyes or throat. They contain other dangerous chemicals which may cause nervous system damage or pulmonary edema in sensitive individuals.

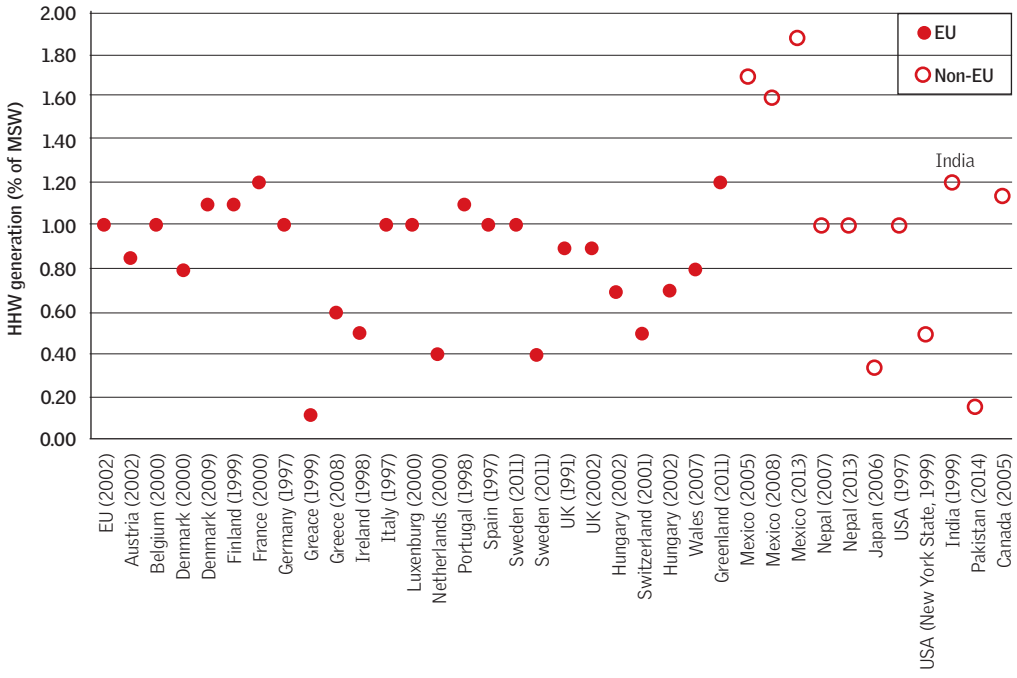
Broken CFLs and thermometers contain mercury which is extremely toxic. Elemental and methylmercury are toxic to the central and peripheral nervous systems; nervous, digestive and immune systems; lungs and kidneys; and may be fatal. The inorganic salts of mercury are corrosive to the skin, eyes and gastrointestinal tract, and may induce kidney toxicity if ingested.

Exposing the environment to lead and strong corrosive acids found in batteries can cause hazards. Toxic metals like nickel and cadmium found in batteries are known human carcinogens. Another toxic metal that can be found in batteries is lead, which has been linked to severe medical issues like developmental and neurological damage and congenital disabilities.

Quantity of domestic hazardous waste in India

When a household product containing potentially hazardous chemicals or entities is discarded, it becomes domestic hazardous waste. In developing countries, one of the problems with daily household products is that their chemical formulation is largely unknown, both quantitatively and qualitatively. Considering the low level of segregation and collection efficiency in the country, attempts to quantify and characterize domestic hazardous waste have proved to be challenging. The complexity of identifying each hazardous material from the general waste stream has restricted quantification to calculating cumulative domestic hazardous waste in total MSW.

Graph 1: Domestic hazardous waste generation as a percentage of municipal solid waste



Source: Inglezakis and Moustakas, 2015

The quantity of domestic hazardous waste generated from households represents 1 per cent (w/w) of municipal waste. In India, it is reportedly 1.2 per cent of the total waste generated. This is also reported by a study conducted by the Karnataka State Pollution Control Board for Bangalore city in 2007. The estimates made by a study for domestic hazardous waste generation in EU and non-EU countries is presented in Graph 1. It is important to note that these figures are rough

approximations and are not based on actual measurements, with exceptions, as in the cases of Canada and Greece, where the percentage of DHW has been estimated based on sampling in a municipal landfill. A study conducted by CSE and NITI Aayog in 2021 reported that domestic hazardous waste percentage in the total waste can range between 0.2 to 4 per cent by weight. However, many cities have cumulatively reported DHW quantities along with sanitary waste and e-waste.

Regulatory framework for managing domestic hazardous waste in India

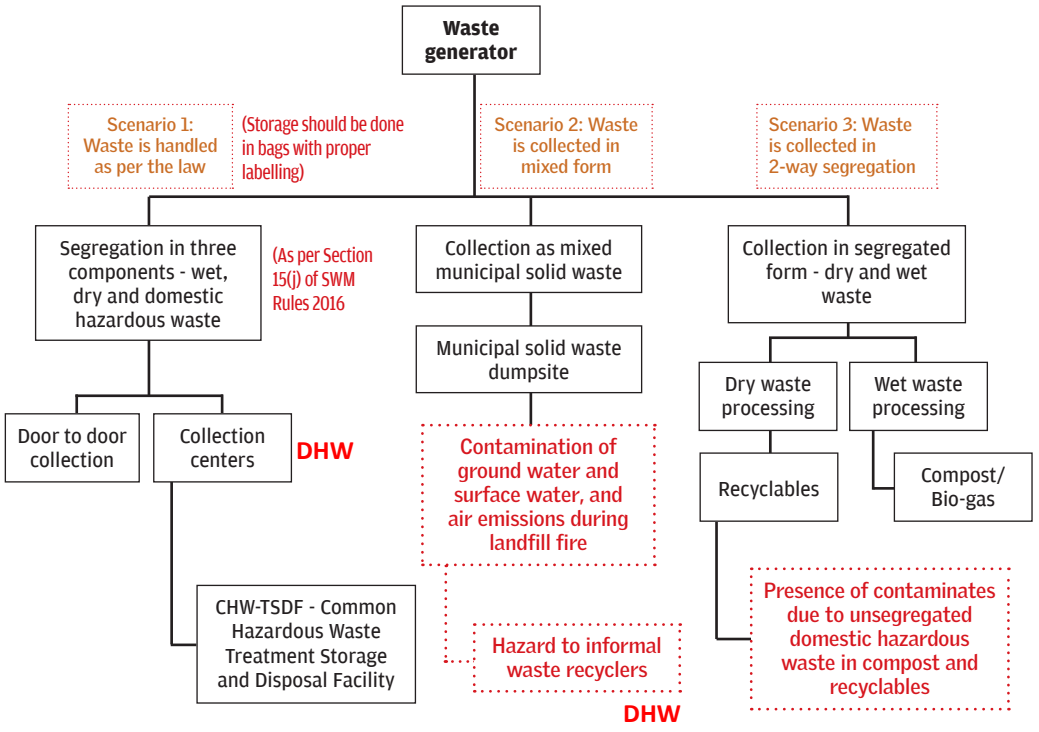
In order to manage hazardous waste in a scientific manner, so as to minimize adverse environmental impacts, the regulatory framework plays a very significant role. The management of domestic hazardous waste is governed under the Solid Waste Management Rules, 2016.

Section 1 (a) of SWM Rules, 2016 mandates that all waste generators segregate waste in three separate streams—bio-degradable, non-biodegradable and domestic hazardous. Waste should be stored in suitable bins and handed over to authorized waste collectors as per the directions provided by local authorities. Implementing source segregation of domestic hazardous waste is not only essential for proper disposal but also to minimize occupational health hazards to waste-workers directly handling mixed waste from households, community bin areas and dumpsites.

Section 15 (i) of SWM Rules, 2016 mandates local authorities to establish waste deposition centre/s for domestic hazardous waste. Section 15 (j) mandates local authorities to ensure safe storage and transportation of domestic hazardous waste to suitable disposal facilities or as may be directed by the state pollution control board or pollution control committee. The scientific treatment and disposal of domestic hazardous waste should be done as per the provisions of Hazardous and Other Wastes (M&T) Rules, 2016. CPCB guidelines are available for land disposal, thermal disposal by incineration and co-processing plants.

Presently, domestic hazardous waste is collected from households either in mixed form or in two-way segregated form. Both methods pose several health and environmental hazards. For example, dumping of mixed waste (wet, dry and domestic hazardous) can severely affect the quality of ground water and surface water bodies. Improper collection and recovery of empty bottles of pesticides and insecticides by the informal sector can cause various occupational health hazards.

Figure 3: Mechanism of collection, treatment and disposal of domestic hazardous waste



Scientific management of domestic hazardous waste

Some DHW can be recycled for a different purpose or may contain material, which can be extracted for use in manufacturing other products. For example, fluorescent bulbs and tubes can be utilized following the norms of E-waste Management Rules, 2016. Reportedly, all the components of fluorescent tubes aside from the fluorescent powder have been reported to be reused.

Most of the components of DHW are disposed of scientifically in common hazardous waste treatment storage and disposal facilities (CHW-TSDF). These are dedicated facilities equipped with state-of-art technologies for environmentally sound disposal of hazardous waste. These facilities comprise of secured (engineered) landfills or incinerators (equipped with air pollution control devices) or a combination of both (integrated CHW-TSDF).

Secured landfills for DHW disposal

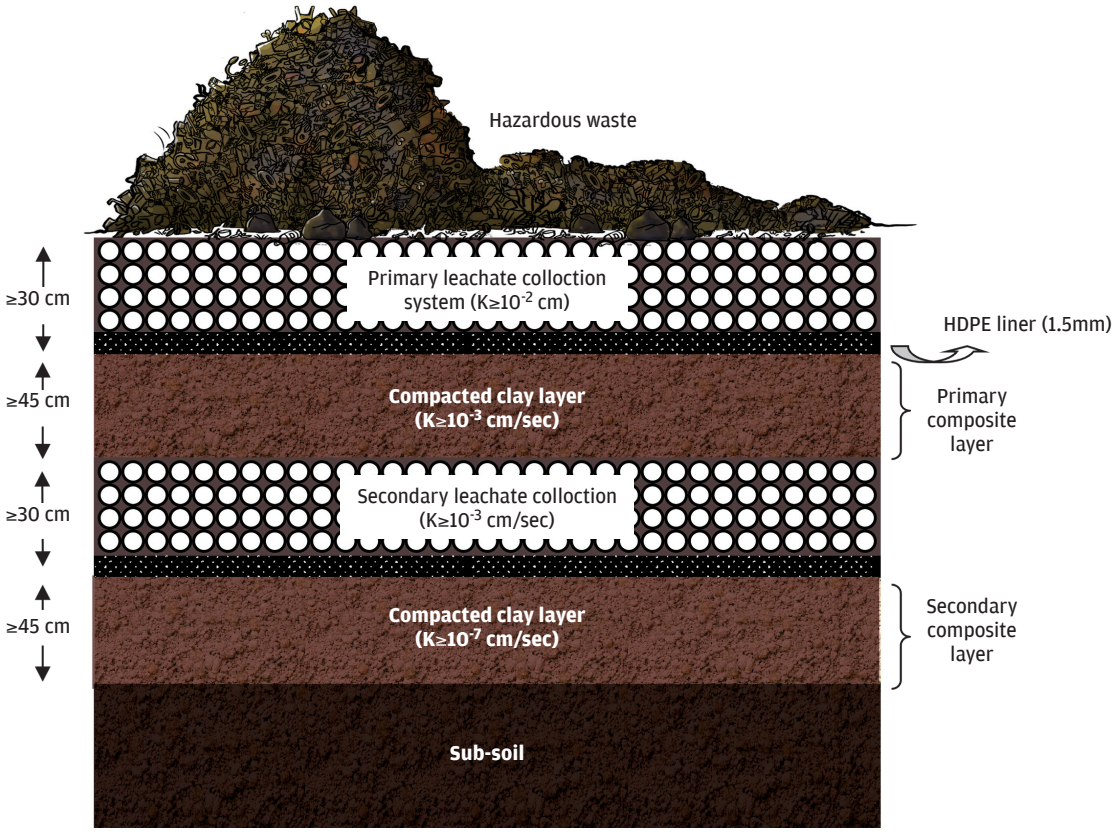
Hazardous waste landfills are defined as waste disposal units, which are designed and constructed in such a way that they cause minimum possible impact to the environment. These landfills have to be designed and constructed as per the

guidelines of pollution control authorities. Components of secured engineered landfill are liner system, leachate collection and removal system, leak detection system, daily/intermittent cover, gas removal system, capping and closure system, storm water drainage system and redundant liner at bottom.

It is important to understand that the design of secured landfills is similar to that of sanitary landfills (for municipal solid waste rejects). However, there are double protective layers in case of secured landfills such as primary and secondary leachate collection system and double liner system. Waste with no leachable toxic metals is directly disposed into the secured landfills at the CHW-TSDFs.

Waste with leachable contaminants is first treated by certain methods to render it harmless prior to disposal in secured landfills. Un-stabilized waste may potentially contribute to the generation of hazardous leachate, which can contaminate the ground water system. The hazardous contaminants in waste must be physically and chemically bound by some material so that there would be no risk of consolidated stress and leaching.

Figure 4: Cross-section of double liner composite system in a secured landfill



Source: CPCB-HAZWAMS/17/2000-01

Diagrammatic representation of double liner composite secured landfills as suggested by regulatory authority is given in Figure 4. The specifications are as follows:

1) A primary leachate collection layer of thickness 30 cm or more and coefficient of permeability in excess of 10^{-7} cm/sec.
2) A single composite liner or HDPE (high density polyethylene) geomembrane of thickness 1.5 mm or more.
3) Compacted clay (or compacted amended soil) layer of thickness 150 cm or more having a coefficient of permeability of 10^{-7} cm/sec or less.
4) A secondary leachate collection layer (also called leak detection layer) of thickness 30 cm or more and co-efficient of permeability in excess of 10^{-3} cm/sec.
5) A secondary composite liner comprising of HDPE geomembrane of thickness 1.5 mm or more.
6) A compacted clay layer of thickness 45 cm or more having a co-efficient of permeability of 10^{-7} cm/second or less.

Most commonly used pre-treatment techniques include decanting of empty bottles containing hazardous liquids, solidification, stabilization, chemical fixation and encapsulation. Pre-processing techniques such as solidification and stabilization can be used for immobilization of contaminants like heavy metals, but they can also be used for different waste streams including glass pieces and asbestos waste. Various methods for treating waste before final disposal in secured landfills are as follows:

- **Solidification**: Solidification is a process that involves mixing of additive material in waste in order to convert the waste mix into a solid monolith like structure. It includes physical dewatering of waste and the improvement of physical properties such as strength, compressibility and permeability. It is generally applied to waste in which there is high moisture content but low heavy metal concentration.
- **Stabilization**: Stabilization includes dewatering/solidification as well as chemical bonding of the additive material/particles with the contaminants. The contaminants are thus made chemically more stable. It is usually done for waste containing toxic metals such as lead, chromium, mercury and nickel.
- **Encapsulation**: Encapsulation is defined as the enclosure or entrapment of waste by some material—such as packing it into a plastic bag.

Thermal processes

Thermal oxidation through incineration is one of the proven technologies for destruction of hazardous waste in all its forms—solid, semi-solid, liquid and

gaseous based on the feeding system—so as to render it innocuous in the form of non-toxic and non-hazardous residue. This method is suitable for waste such as expired medicines, pesticides, insecticides and paints.

Destruction of complex hazardous waste requires the knowhow to judge the compatibility of various types of waste for the purpose of homogenization before it is fed into the incinerator. Operation and maintenance of thermal processes and pollution control devices in the incinerator demand skill and experience with respect to compliance with prescribed environmental regulations.

Regulatory requirements for parties involved in hazardous waste management

1) **Manifesting procedures**: The uniform "hazardous waste manifest" is the tracking tool used to ensure hazardous waste sent to a treatment, storage, and disposal facility actually reaches its destination. It is the control and transport document that goes with the waste from its generation site to its final destination. Each party—including the ULB, CHW-TSDF, transporter (if third party is involved) and pollution control board—has a record of the waste flow. This greatly reduces the potential for illegal dumping. Domestic hazardous waste is not to be accepted for transport without a uniform hazardous waste manifest (Form no. 7 of Hazardous and Other Wastes (M&T) Rules, 2016) that has been properly completed and signed by the generator and transporter. A person transporting hazardous waste in a vehicle is to have a manifest in his or her possession while transporting the hazardous waste.

2) **Valid authorization**: The generator (ULB), transporter and CHW-TSDF shall have valid authorization for generating, storing, transporting and disposing of hazardous waste as per Hazardous and Other Wastes (M&T) Rules, 2016. All hazardous waste transporters and permitted treatment, storage and disposal facilities must have ID numbers, which are used to identify the hazardous waste handler and to track the waste from its point of origin to its final disposal (From Cradle to Grave).

3) **Containers**: To be made up of appropriate leak proof material with mechanical stability in order to avoid any leakage of contaminants into the surroundings.

4) **Labelling**: The bins, bags and containers should be properly labelled with all the necessary information written on them, in order to understand the potential hazards and remedial measures or first aid required at the time of emergency or spillage. They should also contain the information of a contact

person in case of emergency [Form 8 of Hazardous and Other Wastes (M&T) Rules, 2016].

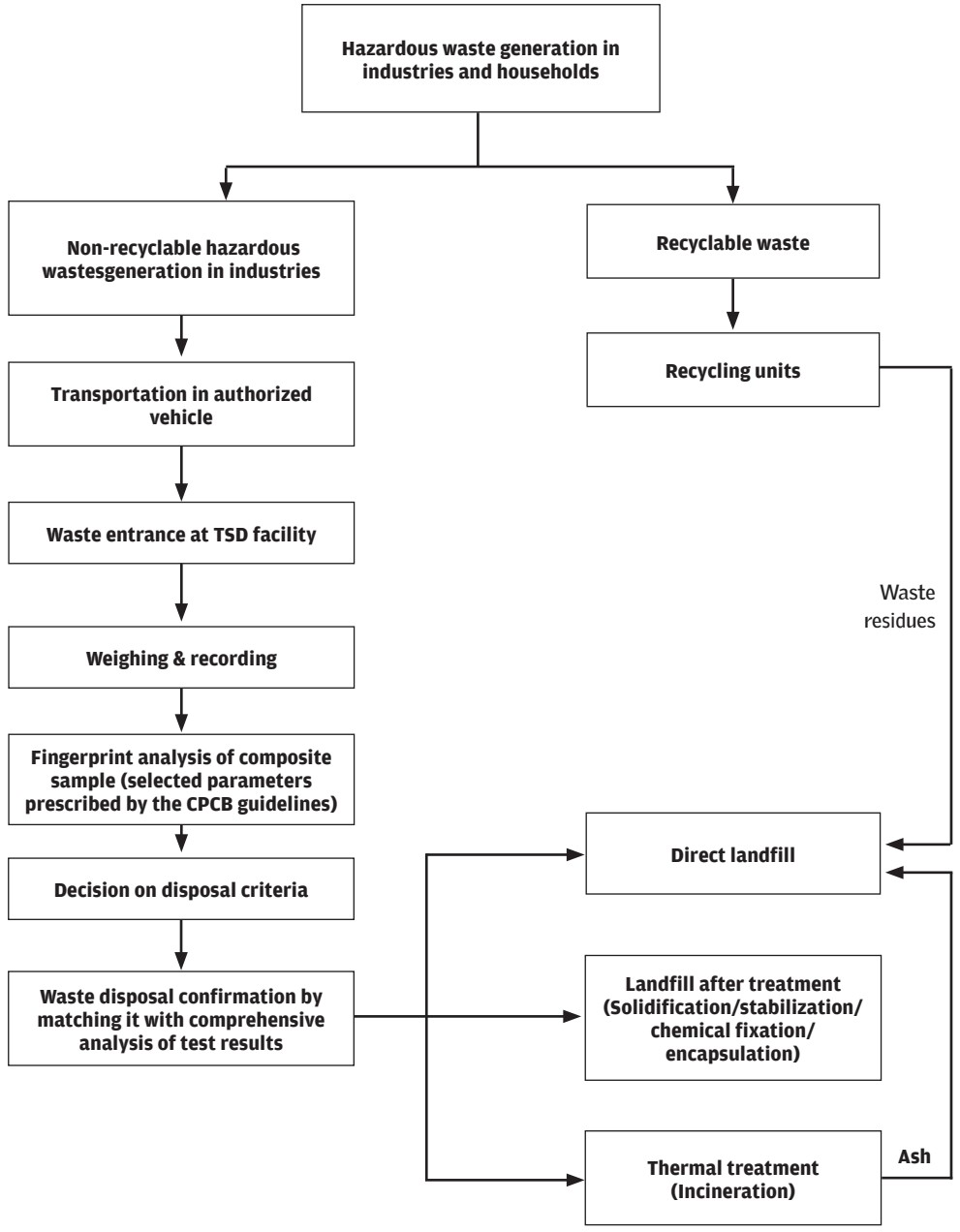
5) **Transportation vehicle**: Transportation vehicles shall be designed suitably (with proper colour coding) to handle and transport corrosive, toxic, flammable and reactive hazardous waste. Authorized dedicated vehicles should be used for transportation of the waste. Vehicles should have compliance (permits, licences and insurance) with all statutory requirements applicable in the state (Motor Vehicles Act, 1988). Vehicles should be equipped with first aid kits, spill control equipment and fire extinguishers, and drivers shall be properly trained to deal with emergencies [Hazardous and Other Wastes (M&T) Rules, 2016].

6) **Emergency reporting**: The generator (ULB) shall provide the transporter with relevant information regarding the hazardous wastes—the hazardous nature of the wastes and measures to be taken in case of emergency [Transport emergency (TREM card): Form 10 of Hazardous and Other Wastes (M&T) Rules, 2016]. If a spill or discharge of hazardous waste occurs at a transfer facility, the transporter must take appropriate immediate actions to prevent further release and to protect human health and the environment. The transporter must clean up any hazardous waste discharge in a timely manner so that the spill no longer presents a hazard. They must also immediately identify the character, source, amount and areal extent of the spill. Within 15 days of a reportable incident, the transporter must send a written incident report to the SPCB/PCC.

7) **Packaging**: Containers must be able to withstand normal handling and retain integrity for a minimum period of six months. Regulatory requirements for packaging, labelling and transportation of hazardous waste are provided in rule 7 of Hazardous and Other Wastes (M&T) Rules, 2016.

8) **Waste storage**: Hazardous waste is commonly stored prior to treatment or disposal in containers and tanks maintained as per the guidelines of pollution control authorities. Storage sheds are typically of two types: Temporary and Intractable. Intractable storage sheds are provided for complex wastes (if there is any discrepancy observed in the waste or disposal criteria).

Figure 5: Storage and movement of hazardous waste consignment within TSDF based on waste disposal criteria



3. Status of Indian Cities

Current status in the cities

India, which has close to 8,000 towns and cities as per Census 2011, has never officially estimated the domestic hazardous waste it generates. Traces of this toxic waste, though, can be found in most landfills. It has been recognized that very few ULBs in India are collecting, storing and disposing of their domestic hazardous waste in an appropriate manner. For example, Indore Municipal Corporation has taken membership with a TSDF in Indore for transporting and disposing of their domestic hazardous waste. Reportedly, the authorization granted to the Indore Municipal Corporation by the MPPCB is for 1000 tonnes per year (2.7 tonnes per day).

if Indore, with a population of nearly 3 million, is generating around 3 tonne of domestic hazardous waste every day, bigger cities like Delhi (30 million), Mumbai (20 million), Chennai (10 million) and Hyderabad (10 million) would be generating much higher quantities of domestic hazardous waste. Yet, there is no mechanism for its collection, transportation and disposal in these cities. The waste is getting collected, transported and dumped/treated along with the regular municipal solid waste.

Case studies in India

Indore Municipal Corporation

Indore Municipal Corporation introduced three-way source segregation in 2018–19 for wet, dry and hazardous domestic waste. A year later, it urged its residents to follow five-way source segregation (biodegradable, non-biodegradable, hazardous, electronic and sanitary waste) to improve the purity levels of waste for recycling.

In January 2021, the municipal corporation added plastic waste as the sixth category. Today, biodegradable waste in the city that is used for composting is 99 per cent pure, while the recyclable non-biodegradable waste is 95 per cent pure (by contamination level). The municipal corporation has taken an authorization to send 1,000 tonne of domestic hazardous waste to a CHW-TSDF every year.

Door-to-door collection is done in compartmentalized vehicles. The compartment for storing and collecting domestic hazardous waste is specially designed in

such a way that it can carry waste tube lights. There are six separate spaces for biodegradable, non-biodegradable, plastic, sanitary, domestic hazardous and electronic waste in each tipper. These tippers carry waste from households to transfer stations. GPS has been installed in all waste collection and transportation vehicles. A special cell monitors the GPS. Penalties are imposed on drivers for route deviations and multiple deviations can result in the termination of their contracts.

For achieving six-way segregation and bringing behavioural change at a mass level, IMC took multiple steps to spread awareness among people and motivate them to embrace segregation. Social media was used extensively, along with *nukkad nataks*, wall paintings and radio jingles. Schools were engaged to promote segregation among students through competitions focused on cleanliness, and through oath taking ceremonies in the morning assembly. IMC has engaged more than 800 self-help groups (SHGs), comprising more than 8,000 women, to spread awareness about source segregation in the nooks and crannies of the city.

IMC deploys one resource person with each garbage collection vehicle in order to spread awareness and to ensure that everyone is giving segregated waste. If a resource person fails to convince any household, then they can bring in the assistant health officer and ward daroga to penalize the offender. This is cost intensive but IMC knows that it is necessary to ensure 100 per cent segregation of waste and so it is willing to bear the cost.

Image 1: Customized vehicles to collect and transport different fractions of waste in Indore

Source: Richa Singh, CSE

Image 2: Workers segregating domestic hazardous waste at a transfer station in Indore

Source: Richa Singh, CSE

Image 3: Segregated domestic hazardous waste at a transfer station in Indore

Source: Richa Singh, CSE

Image 4: Domestic hazardous waste storage at a transfer station in Indore

Source: Richa Singh, CSE

Image 5: Decentralized material recovery facility in Indore

Source: Richa Singh, CSE

Bhopal Municipal Corporation (BMC)

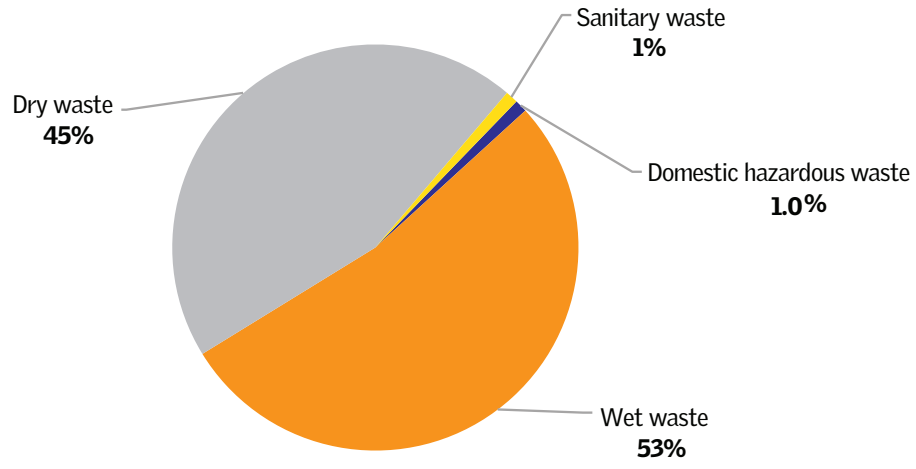
Bhopal completely overhauled its solid waste management practices based on a comprehensive strategy directed towards achieving 100 per cent source segregation, efficient treatment of recyclable waste and scientific disposal of non-recyclable fractions of waste (especially sanitary and domestic hazardous waste). Residents segregate their waste into four categories: biodegradable, non-biodegradable, hazardous and sanitary. By assuring citizen participation, BMC has been able to extend door-to-door collection to all the wards. Vehicles are designed to carry the four fractions of waste separately. BMC has also set up two collection centres which are instructed to accept only segregated waste.

The storage area for domestic hazardous waste has been constructed as per the instructions of the state pollution control board. BMC has been granted the "Consent to Operate" (Segregation & Safe Storage of Domestic Hazardous Waste and its safe transportation for disposal in the Hazardous Waste Disposal Facility) under Section 25 of the Water (Prevention & Control of Pollution) Act 1974 and under Section 21 of the Air (Prevention & Control of Pollution) Act 1981. It has been granted authorization under Hazardous and Other Wastes (M&T) Rules 2016 and under Solid Waste Management Rules 2016 for both Danapani and Arif Nagar garbage transfer stations. As per the authorization, 547.5 MT per annum of domestic hazardous waste can be segregated and safely stored (up to 90 days). Authorization has been granted for collection, reception, storage, transport, reuse, recycling, recovery, pre-processing, co-processing, utilization, treatment and safe disposal of hazardous and other wastes.

Hazardous waste as per Schedules I, II and III of these rules is: Empty barrels/containers/liners contaminated with hazardous chemicals/waste. Domestic hazardous waste is disposed of at the CTSDF in Pithampur or sold to authorized recyclers registered with the state pollution control board.

BMC stores the domestic hazardous waste and has applied for authorization to send 600–700 tonnes of it to the treatment facility in Indore per year. Essentially, the Bhopal model has proved to be suitable, efficient, sustainable and cost-effective for the city. Source segregation is the mandatory component for waste processing in this model, with garbage being segregated into four categories.

Graph 2: Composition of municipal solid waste in Bhopal

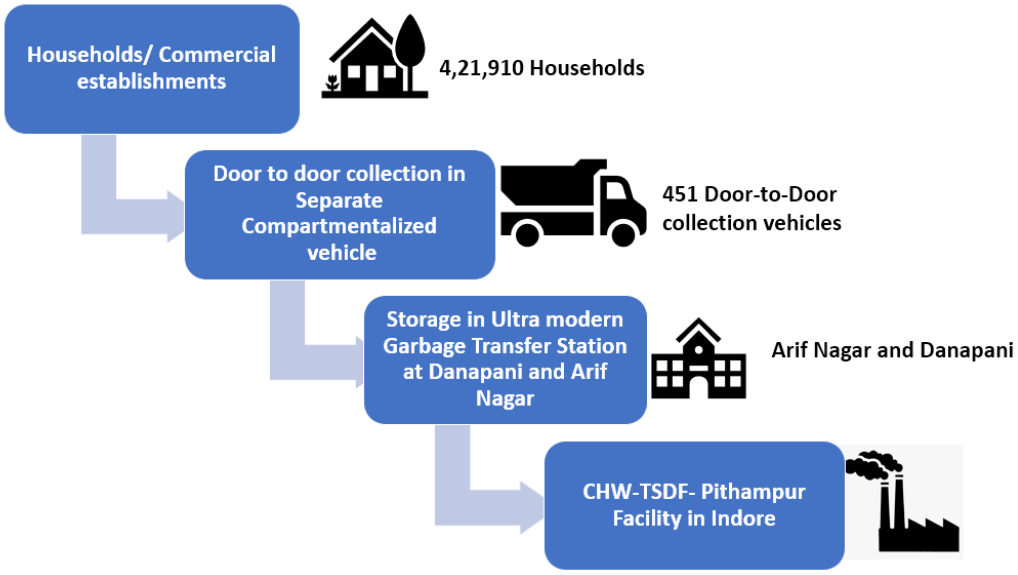


Source: Bhopal Municipal Corporation

Type of domestic hazardous waste generated:

- Aerosol cans
- Batteries, car batteries, oil filters and car care products and consumables
- Bleaches, household kitchen and drain cleaning agents
- Oils, chemicals and solvents and their empty containers
- Cosmetic items, chemical-based insecticides and their empty containers
- Medicines including expired medicines, pesticides and herbicides and their empty containers
- Paints, oils, lubricants, glues, thinners and their empty containers
- Photographic chemicals
- Soft foam packaging from new equipment
- Thermometers and mercury-containing products

Figure 6: Processual flow of domestic hazardous waste in Bhopal



Graph 3: Quantity of domestic hazardous waste processed by different transfer stations

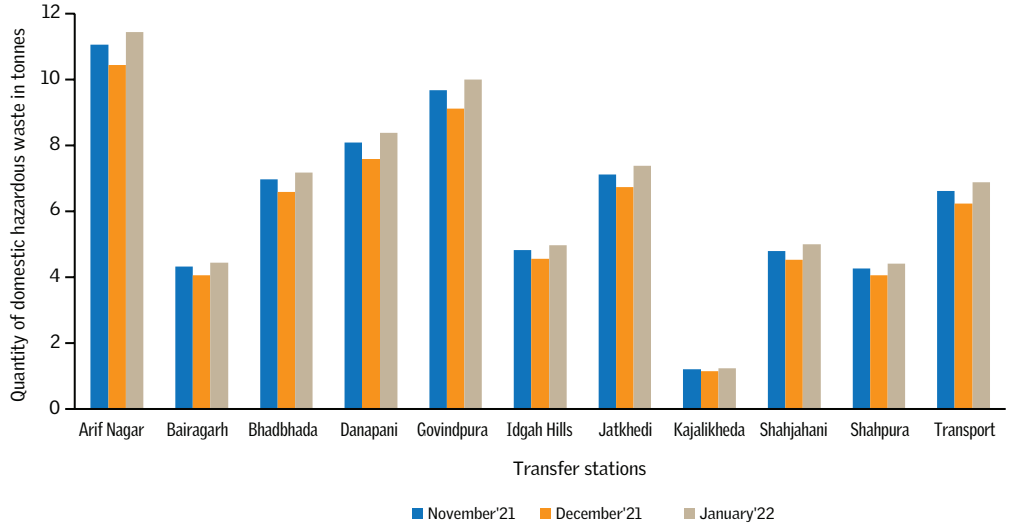


Image 6: Customized vehicles for collecting different fractions of waste in Bhopal

Source: Richa Singh, CSE

Image 7: Transfer station for collecting and storing different fractions of waste in Bhopal

Source: Richa Singh, CSE

Image 8: Bins for collecting and storing the sanitary and domestic hazardous waste at transfer stations

Source: Richa Singh, CSE

Karad Municipal Council (KMC)

Karad is a small city in the Satara district of Maharashtra with an estimated population of 86,000 in 2022. It is spread over 10.51 sq. km and divided into two zones consisting of 14 wards each. Karad has achieved 100 per cent source segregation and disposal of all the waste streams including domestic hazardous waste.

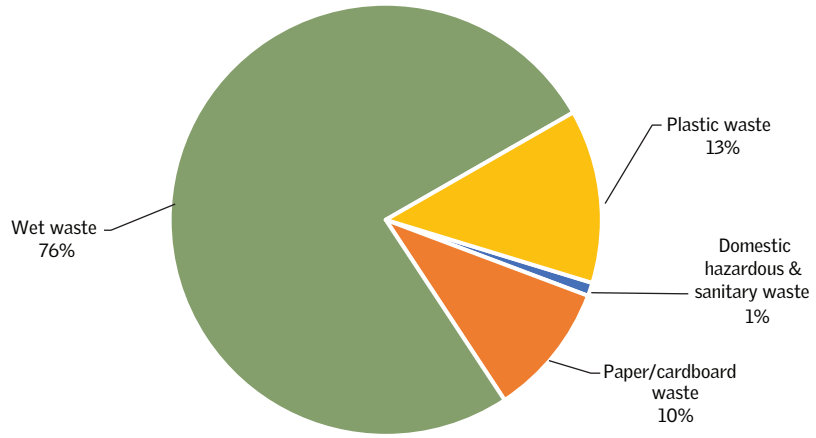
Karad started with three-way segregation (biodegradable, non-biodegradable and hazardous) in 2015 with the help of a team of 7 people from a SHG called the Greeny team (IEC team), 16 foremen and 200 volunteers across the city. The volunteers followed a five-round protocol, which is a five-round survey done in the below-mentioned manner:

- 1st round – theoretical (volunteers reach out to the households and made them aware about the importance of following source segregation)
- 2nd round – practical (volunteers demonstrate how to do source segregation to the households)
- 3rd round – monitoring (volunteers monitor the progress in selected wards)
- 4th round – correction (for the households not practicing source segregation, rounds 1 and 2 are repeated)

- 5th round – penalize (households not practicing source segregation are penalized Rs 500)

Initially, sanitary waste was collected along with domestic hazardous waste. Collected hazardous waste was transported daily to the material recovery facility. At the facility, sanitary waste was processed in the incinerator while domestic hazardous waste was stored separately.

Graph 4: Composition of municipal solid waste in Karad



Source: Karad Municipal Council

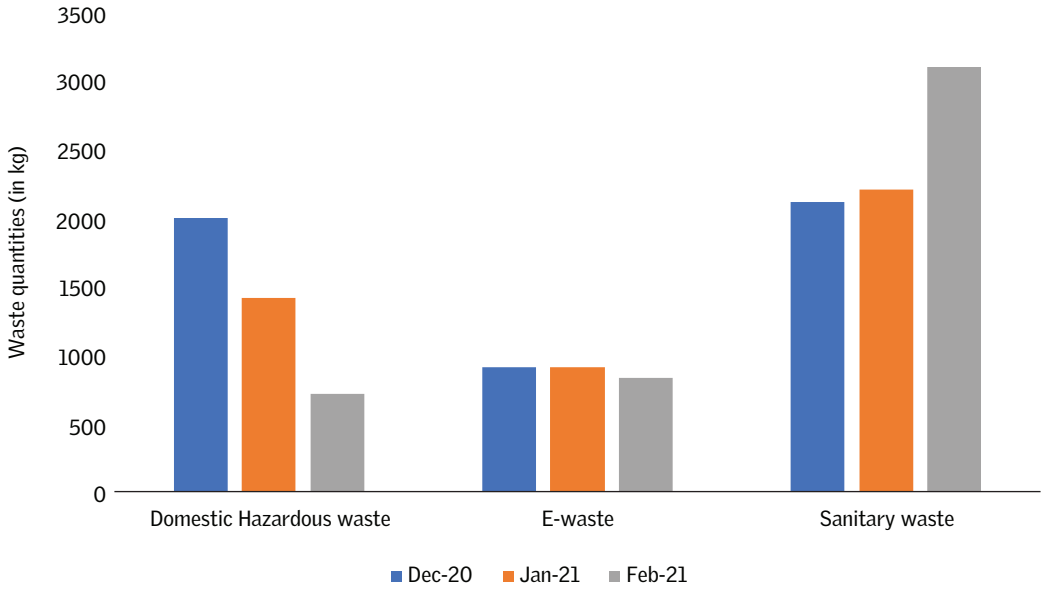
In 2020, KMC moved to six-way source segregation—1) Biodegradable waste 2) Plastic waste 3) Paper/cardboard waste 4) Domestic hazardous waste 5) E- waste 6) Sanitary waste. With the help of Greeny Team and waste collection team, various capacity building and awareness programmes were conducted. Vehicles have been customized to collect all six streams separately.

It is important to note that despite several efforts, efficient source segregation still needs to be strengthened in Indore, Bhopal and Karad, especially the segregation of domestic hazardous waste which is still being disposed of with dry waste by waste generators. This can be avoided by conducting extensive IEC and BCC programmes in these cities.

Image 9: Customized vehicles to collect segregated waste streams in Karad

Source: Karad Municipal Council

Graph 5: Monthly quantities of domestic hazardous waste, e-waste and sanitary waste collected in Karad



Source: Karad Municipal Council

4. Challenges

Lack of data

Since domestic hazardous waste is not segregated from other household waste, it becomes very difficult to determine the quantity and composition of this waste stream. Further, hazardous waste is commonly overlooked in waste statistics because the amount generated is relatively small. Considering that hazardous waste can directly react with non-hazardous waste and cause disproportional damage to the environment, it is critical to estimate the quantity of hazardous waste generated at a national level in order to understand the magnitude of the problem and plan a disposal strategy accordingly.

Under the Swaccha Bharat Mission (SBM) urban guidelines, the quantity of domestic hazardous waste should be disclosed by the urban local body in the daily management information software (MIS). Urban local bodies also have to provide information on a monthly basis about how they are disposing of hazardous waste. However, most cities are not providing the required information. Besides, details on processing and disposal of domestic hazardous waste should be provided in the MIS as and when required.

The city solid waste action plan (CSWAP), SBM 2.0 guidelines, has estimates of percentage of dry waste, wet waste, inerts and C&D waste. Domestic hazardous waste is mentioned but no thumb rule for estimating its quantity is provided by SBM 2.0 guidelines.

Lack of information about its generation and composition hinders the creation of special programmes for its collection and treatment, making domestic hazardous waste a potential threat to human health and the environment.

Gaps in the existing regulation

Domestic hazardous waste is defined in the Solid Waste Management Rules, 2016 as 'discarded paint drums, pesticide cans, compact fluorescent lightbulbs, tube lights, expired medicines, broken mercury thermometers, used batteries, used needles and syringes and contaminated gauge, etc. generated at household levels.' The definition is not exhaustive, and so leaves a lot to the imagination of individual households and local government bodies such as panchayats and municipalities. For example, the rules leave out cigarette butts even though they contain traces of

heavy metals and other chemicals. The definition of domestic hazardous waste is not adequate.

Inefficient source segregation

Many urban local bodies in India are still struggling to attain three-way segregation. Domestic hazardous waste has not been the priority of urban local bodies because it is generated in relatively lesser quantities. As a result, its segregation is not being practiced by households. In many cases, communities are not well informed to segregate this special waste stream.

Inadequate collection

A majority of collection vehicles are not designed appropriately to collect hazardous waste from the households. They usually only have two or three separate compartments.

No disposal mechanism

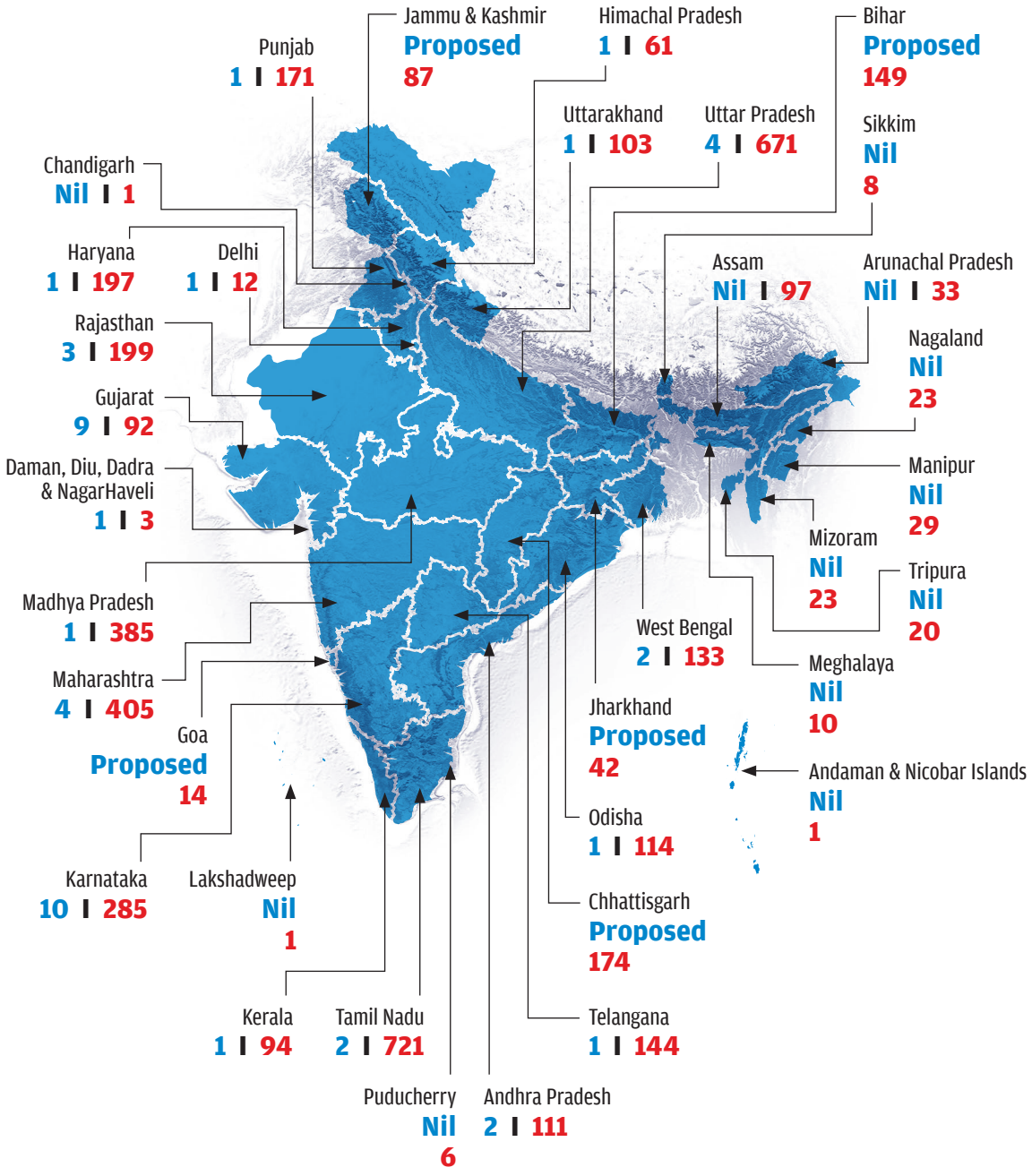
Even if the waste is collected, the country does not have enough disposal facilities to safely treat them. Currently, there are only 45 of these facilities, as per the Handbook on Chemicals and Hazardous Waste Management and Handling in India released in 2019 by the Union Ministry of Environment, Forest and Climate Change.

Their distribution remains skewed. At least 18 states and Union Territories, including Delhi, Bihar and Assam, do not have safe disposal facilities. Twelve others, such as Punjab and Haryana, have one facility for the entire state.

There is an urgent need to have a proper mechanism for source segregation, collection, storage and environmentally sound disposal of domestic hazardous waste in the cities. Urban local bodies should collaborate with the nearest CHW-TSDFs for its disposal. The frequency of transportation should be decided based on the quantity of domestic hazardous waste generated in a city and the distance between the city and CHW-TSDF. Map 1 depicts the state-wise availability of CHW-TSDFs and the number of urban local bodies in each state. Cities should first get authorization from the concerned pollution control boards to declare the quantity of DHW they are generating per day. Afterward, they should send the hazardous waste to the nearest CHW-TSDFs.

Map 1: State-wise list of CHW-TSDFs and total number of urban local bodies in each state

00 Number of common TSDFs in operation **00** Total number of ULBs



Source: CPCB

Cost of disposal and transportation

The cost of transportation and scientific disposal of domestic hazardous waste is typically much higher than other waste fractions. Considering the low number of CHW-TSDFs in the country, incentives should be provided to those urban local bodies which are taking initiatives for segregation, collection and scientific disposal of domestic hazardous waste.

5. Recommendations

Hazard and risk identification at consumer level

Labelling of household products containing hazardous constituents is the primary communication tool for classifying hazardous substances and combinations. The hazard label should be consistent in communicating information about hazards for a given product or combination to the consumer. This enables consumers to protect themselves while using the product and to dispose of the end-of-life product appropriately after usage. While the responsibility for labelling lies with the manufacturer of the product, consumers should carefully read product labels before buying and while disposing of products look for signal words such as danger, warning and caution. Danger means the product is extremely hazardous because it is poisonous, extremely flammable or corrosive. Warning or caution indicates a product that is somewhat less hazardous but still poses dangers.

Image 10: A bug spray with composition of the insecticide written on the container

Image 11: Hazard warning mentioned in the container

The pictographic hazard-warning diamonds made on all household products containing hazardous constituents may also bear information regarding the hazard and associated handling risks. However, the basic principle is that the shape, colour, and pictogram convey a clear message of danger. Pictograms overcome language difficulties and provide a warning to the general public to keep away. Further, in an accidental situation, emergency services are provided information about the primary hazard likely to be encountered. Pictograms and list of ingredients can potentially help consumers identify domestic hazardous waste. After usage, the obsolete products can be segregated in a separate bin or bag and handed over to the waste collector.

Consumers should reduce generation of domestic hazardous waste by switching to potential alternatives (organic) of household products containing hazardous constituents. Domestic hazardous waste should be stored separately at the household level and carefully handed over to the waste collector.

Legal intervention

Domestic hazardous waste should be appropriately defined in the Solid Waste Management Rules 2016 to help local bodies identify it and plan its segregation, collection, transportation and disposal accordingly.

CPCB has drafted separate guidelines for the management of high-volume low-effect industrial waste such as fly ash, phosphogypsum, red mud, jarosite, slags from pyrometallurgical operations, mine tailings and ore beneficiation rejects which are excluded from the category of hazardous waste. Separate guidelines should also be drafted for the management of low-volume high effect waste such as hazardous waste generated from households.

Introduction to municipal bye-laws with penal provisions

Urban local bodies can introduce bye-laws which specifically ensure source segregation and environmentally sound management of domestic hazardous waste. As per Section 15 of SWM Rules 2016, local authorities are required to frame bye-laws incorporating the provisions of SWM Rules within one year from the date of notification of these rules and ensure their timely implementation. They are to also prescribe criteria for levying spot fines for littering or failing to comply with the bye-laws.

Identification and inventory of domestic hazardous waste by urban local bodies

Unlike the waste streams originating from industrial sources, hazardous substances in household waste are not strictly regulated and controlled under the hazardous waste regulations in India. Domestic hazardous waste is disposed of in landfills along with regular municipal solid waste. The quantities of generation and, most importantly, the significance of adequately collecting and disposing it of are poorly understood. Typically, it is assumed that quantities are small and therefore risks of disposal are negligible. Information about disposal is lacking or unreliable and ambiguous.

As a result, it is extremely important to create a comprehensive list of all the possible varieties of domestic hazardous waste and classify them in different categories as per the hazardous waste regulation. A nation-wide survey on the quantities and characteristics of domestic hazardous waste is critical to understand the current scale of the problem and identify the gaps and challenges.

Under the SBM (Urban) guidelines, urban local bodies should disclose the quantity of domestic hazardous waste in the daily MIS. They should also provide information about how they are disposing it off on a monthly basis. However, most cities are not providing the required information. Besides, details on processing and disposal of domestic hazardous waste should be provided in the MIS as and when required.

The city solid waste action plan (CSWAP), SBM 2.0 guidelines, has estimates of percentage of dry waste, wet waste, inerts and C&D waste. There is mention of domestic hazardous waste but no thumb rule for estimating the quantity is provided by the SBM 2.0 guidelines.
It is critical for urban local bodies to provide the details of domestic hazardous waste generated in their cities. For the same, they should conduct a survey on the composition and quantification of domestic hazardous waste.

Capacity building programmes for local officials and waste workers

In order to ensure proper collection and disposal of domestic hazardous waste, it is critical that local officials are well trained to do the same. Additionally, workers, drivers and operators involved in collection, transportation and segregation of hazardous waste at transfer stations and material recovery facilities should be trained to ensure safe handling.

Extensive IEC activities to train households to segregate domestic hazardous waste

To avoid potential risks associated with household hazardous waste, it is important that consumers avoid using products with hazardous components as much as possible, and when they have to use them, it is essential that they monitor the usage, storage and final disposal of end-of-life products. Improper disposal of such products can include pouring them down the drain, on the ground, into storm sewers, or in some cases putting them out with dry and wet waste.

As discussed earlier, the impacts of irresponsible disposal might not be immediately obvious, but can pollute the environment and pose a threat to human health. Certain types of domestic hazardous waste have the potential to cause physical injury to sanitation workers and contaminate septic tanks and wastewater treatment systems if poured down drains or toilets. They can also be dangerous to children and pets if left around the house.

Once the waste is generated at the household level, it should not be mixed with regular wet and dry waste. It should be kept in separate bins, bags or containers and handed over to the waste collector.

All stakeholders engaged in the management of domestic hazardous waste such as urban local bodies, waste operators and waste collectors should provide clear and detailed instructions for preventing the generation of domestic hazardous waste, and its identification, sorting and disposal (including via improved labelling of hazardous products) once it is generated. The messages should be simple and preferably in local languages to avoid confusion to the waste generator who is generating a wide variety of such waste. It is also important for urban local bodies to prepare a comprehensive list of hazardous wastes along with pictures and provide it to the households. This will help households understand the hazards associated with the products they use and also make them aware of the potential health and environmental hazards due to improper disposal. This can encourage good sorting and disposal behaviour.

The locations and opening hours of transfer station sites (if applicable) and other household waste collection points should also be communicated to the residents. This can be shared via different channels including social media, ensuring the message reaches all segments of the population.

Involving local stakeholders such as NGOs and CBOs and other social groups in the segregation and collection of hazardous waste is very important. This can lead to better awareness and citizen engagement. Awareness among the communities can also be increased by promoting educational programmes particularly targeting children, who are good ambassadors for sound waste management practices. By educating children about the importance of these practices (via classroom teachings, workshops, site visits, etc.), their parents and elders will also be indirectly incentivized to sort waste.

Ensuring proper collection and disposal mechanism

Urban local bodies should ensure that collection vehicles are equipped to collect domestic hazardous waste in separate compartments. The frequency of collection should be decided on the basis of waste generation and population size. While fractions like biodegradable and non-biodegradable waste should be collected daily, domestic hazardous waste can be collected once a month since its generation is low. The location can be flexible (trucks can periodically pick up domestic hazardous waste at central locations). This is mostly organized or facilitated by municipalities, but is sometimes outsourced to private waste management operators.

CASE STUDY OF AGRA

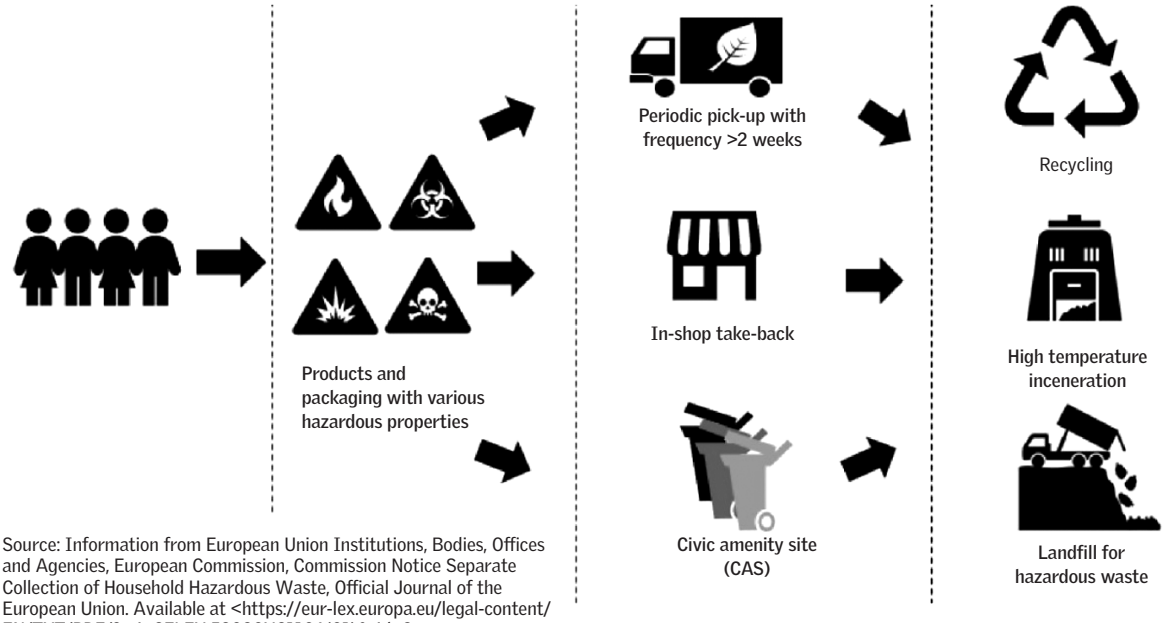
Considering the critical focus points mentioned in *Agra: Roadmap for a Zero Waste City*, Agra Municipal Corporation (AMC) decided to embark on the journey towards a zero-waste goal with the first and most important aspect of solid waste management, i.e., source segregation. Six municipal wards were selected for conducting solid waste management IEC activities within a 2 km periphery of Taj Mahal to make it a garbage-free area. Subsequently, a professional agency called 'Feedback Foundation' was deployed on the ground to engage with communities and institutions to educate them about the benefits of source segregation. A team of 24 mobilizers, two supervisors and one project head started awareness drives in the six wards through a door-to-door campaign. During the campaign, the group of mobilizers visited every household and establishment to teach them how to segregate waste into four different categories: wet, dry, domestic hazardous and sanitary.

Through rigorous door-to-door awareness campaigns, ward meetings and street plays, citizens were made aware of the benefits of source segregation, which also started reflecting on the ground. CSE reinforced the source segregation campaign with IEC material used to instruct waste generators during the awareness campaign activities regarding the importance of following social distancing norms during the pandemic. With efficient use of the IEC material, and other informative tools and techniques, the team of volunteers from Feedback Foundation guided citizens about mapping various types of waste with colour-coded bins. In time, the citizens of these wards started developing a habit of practising segregation of waste at source.

The IEC material developed by CSE has a clear depiction of all types of wastes including domestic hazardous waste and sanitary waste. Such depictions are easy to understand and follow for the citizens.

IEC material developed by CSE for source segregation of wet, dry, sanitary and domestic hazardous waste

Figure 7: Separate collection and treatment schemes for household hazardous waste



Source: Information from European Union Institutions, Bodies, Offices and Agencies, European Commission, Commission Notice Separate Collection of Household Hazardous Waste, Official Journal of the European Union. Available at <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020XC1106(01)&rid=2>

Enforcement

Improper collection and sorting degrade the quality of collected waste for recovery. Domestic hazardous waste, collected as part of mixed household waste or other non-hazardous waste, negatively impacts the potential for high quality recycling of that waste. Although communication helps households know how to sort their waste properly, some level of incentives, or control and enforcement, is required. In practice, competent authorities can carry out the following control actions—

Visual inspection of transparent waste collection bags: Bags should be marked as non-compliant and left at the pickup point if the bag contains materials that are not part of the relevant separate collection system.

Fines: Along with the refusal to pick up bags or bins containing improperly sorted waste, administrative fines are an effective instrument to promote correct separate collection at source. Fines also help to avoid the problem of refused bags remaining uncollected in public spaces. Fines should however supplement adequate economic incentives, persuasion and communication.

EPR policy for domestic hazardous waste

Organizations implementing extended producer responsibility obligations provide in-shop take-back facilities for a range of waste streams like beverage packaging

and waste electrical and electronic equipment (WEEE). Compared to door-to-door collection, take-back facilities offer user-friendly solutions for consumers while optimizing the logistics.

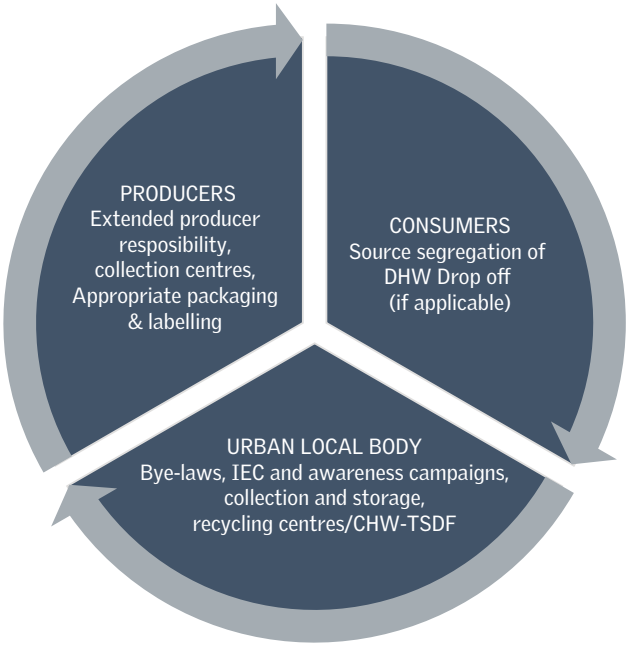
Studies revealed that the cost of collection, transportation and scientific disposal of domestic hazardous waste is prohibitively high for urban local bodies. According to the current waste characterization data, about 1 per cent of the total municipal solid waste generated in the country is hazardous in nature. According to the Swachh Bharat Mission (Urban) dashboard, India generates about 140,000 tonne of municipal solid waste every day. Therefore, the quantity of domestic hazardous waste would be close to 1,400 tonnes per day. A TSDF charges approximately Rs 25–30,000 for processing and disposal of every tonne of domestic hazardous waste, which amounts to roughly Rs 4 crore of financial burden to the municipal governments every day.

Even if cities are able to get domestic hazardous waste segregated at source and stored separately, it is still challenging for them to bear the costs incurred in the long run. In such circumstances, it is important to address the issue of financial sustainability. Going by the principle of "polluter pays", the producer, manufacturer and brand owner (PIBO) of products having hazardous components should be held accountable to bear the cost of collection, transportation and treatment of domestic hazardous waste. This is the way plastic and e-waste are dealt with currently under the EPR policy. In addition, a "deposit refund system" should be introduced through a reverse logistic system so that the packaging of domestic hazardous products can be channelized back to the PIBO for refilling and reuse. Municipal authorities may also institute dedicated collection and storage facilities to effectively implement the reverse logistics mechanism which could be facilitated by the producer responsibility organization (PRO) for the PIBOs. Such provisions need to be introduced under the scope of the current policy for management of domestic hazardous waste to provide a legal instrument to urban local authorities.

The main objective of such policies is to shift the responsibility for managing a product's end-of-life from municipalities to producers, or to at least get the producers to share responsibility with municipalities. In most schemes, however, municipalities remain in charge of some aspects of the organization of waste management. Other actors, such as consumers and waste management operators, are usually also involved.

EPR is an approach under which producers are given a significant responsibility—financial and/or physical—for the treatment or disposal of post-consumer

Figure 8: Collaborations between urban local bodies, manufacturers and consumers for safe handling and disposal of domestic hazardous waste.



products. Assigning such responsibility could in principle provide incentives to prevent waste at the source, promote sustainable product design, and support the concept of resource recovery and recycling. EPR policy has been adopted by many countries worldwide for management of waste such as e-waste, plastic waste, waste tyres as well as domestic hazardous waste. For example, in Japan, the Packaging Recycling Act clearly defines the roles and responsibilities of every stakeholder: consumers have responsibility for sorting their waste including domestic hazardous waste, municipalities take charge of sorted collection and producers handle the recycling. In Germany, the role of municipalities differs for EPR schemes on Waste Electrical and Electronic Equipment recycling (shared responsibility as producers handle the WEEE collected by municipalities) and on packaging, batteries and ELVs (full producer responsibility). In Canada, domestic hazardous waste is completely taken care of by the manufacturer.

Many governments have reviewed available policy options and concluded that shifting/sharing the responsibility for the post-consumer phase of certain goods containing hazardous entities on the producers/manufacturers could be an option to minimize pollution and resource depletion, along with ensuring scientific disposal of end-of-life products. Such mechanisms should be explored for management of domestic hazardous waste in India as well.

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Domestic hazardous waste is typically generated in lesser quantities than other waste fractions but the potential risks to the environment and human health are disproportionate to its quantum. It becomes especially lethal when given a chance to react with other material in common landfills. This is why this report makes a case for addressing this waste stream separately and demands an efficient system of segregation and collection as well as scientific disposal in an environmentally sound manner.

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