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# Environmental Management of Industrial Hazardous Wastes in India

SHANTANU K DUTTA*, V P UPADHYAY** AND U SRIDHARAN***

Hazardous wastes are considered highly toxic and therefore disposal of such wastes needs proper attention so as to reduce possible environmental hazards. Industrial growth has resulted in generation of huge volume of hazardous wastes in the country. In addition to this, hazardous wastes sometimes get imported mainly from the western countries for re-processing or recycling. Inventorisation of hazardous wastes generating units in the country is not yet completed. Scientific disposal of hazardous wastes has become a major environmental issue in India. Hazardous Wastes (Management and Handling) Rules, 1989 have been framed by the Central Government and amended in 2000 and 2003 to deal with the hazardous wastes related environmental problems that may arise in the near future. This paper gives details about the hazardous wastes management in India. Health effects of the selected hazardous substances are also discussed in the paper.

**Key words :** *Hazardous waste, used oil, E-waste, incineration, secured landfill*

## Introduction

Environmental management of hazardous wastes has become a major concern in India as haphazard dumping of hazardous wastes results in severe environmental impairment. The adverse effects of hazardous wastes as well as the significant potential risks posed by them to the life and its supporting systems are increasingly recognized[1]. Rapid growth of industries in India has resulted in generation of increasing volume of hazardous wastes. Both indigenously generated and imported from other countries for recycling or reprocessing need scientific treatment and disposal. However, only a few secured landfill sites are available in the country for disposal of hazardous wastes in an environmentally sound manner. An illegal dumping of hazardous wastes by the industries may cause severe environmental pollution. The Ministry of Environment and Forests (MoEF) has promulgated Hazardous Wastes (Management & Handling) Rules, 1989 and amended the same in 2000 and 2003 for proper management and handling of hazardous wastes in the country. These rules also deal with the ban for importing a few categories of hazardous wastes. India has also ratified the Basel Convention on transboundary movement of hazardous wastes in 1992, which is a significant tool for controlling and monitoring of import and export of hazardous wastes and its proper management. However, various issues and the regulatory framework for hazardous wastes management in the country should elaborately be understood in proper perspectives by the regulatory agencies and industries to help the Government to develop environmentally sound management system. In this paper, an attempt has been made in this direction to highlight such aspects, which will help policy planners, decision makers, researchers etc. of the country.

## Characteristics of hazardous wastes

Hazardous wastes, which may be in solid, liquid or gaseous form, may cause danger to health or environment, either alone or when in contact with other wastes[2]. Hazardous wastes can be identified by the characteristics that they exhibit *viz.*, ignitability, corrosivity, reactivity, or toxicity[3]. The general characteristics of hazardous wastes are given in **Table 1**. Various agencies have defined hazardous wastes in different ways and as such, there is no uniformly accepted international definition so far. It is presumed that about 10 to 15 percent of wastes produced by industry are hazardous and the generation of hazardous wastes is increasing at the rate of 2 to 5 percent per year[4].

## Process wastes

Hazardous wastes in India can be categorized broadly into two categories, viz., i) hazardous wastes generated in India from various industries, and ii) hazardous wastes imported into or exported to India. Hazardous wastes are being generated in the country by various industries. Inventorisation of hazardous wastes generating units and quantification of wastes generated in India are being done by the respective State

*Central Pollution Control Board, Zonal Office, Shillong
** Ministry of Environment and Forests, Regional Office- North East, Shillong (Author for correspondence: email: vpupadhyay@hotmail.com)
*** Ministry of Environment and Forests, C. G. O Complex, New Delhi – 110 003

**Table 1:** Characteristics of hazardous wastes

| Sr. No | Hazardous characteristics | Potential hazards on living animals / environment |
|---|---|---|
| 1 | Flammable/ explosive | This type of waste may cause damage to the surroundings by producing harmful gases at high temperature and pressure or by causing fire hazards. |
| 2 | Oxidizing | Type of wastes that may yield oxygen and thereby cause or contribute to the combustion of other materials. |
| 3 | Poisonous (Acute) | These wastes have high potential to cause death, serious injury or to harm health if swallowed, inhaled or by skin contact. |
| 4 | Infectious substances | Hazardous wastes containing micro-organisms and their toxins, and responsible for diseases in animals or humans. |
| 5 | Corrosives | These wastes are chemically active and may cause severe damage to the flora and fauna, or to the other materials by direct contact with them. |
| 6 | Eco-toxic | These wastes may present immediate or delayed adverse impacts to the environment by means of bioaccumulation and/or toxic effects upon biotic systems. |
| 7 | Toxic (Delayed or chronic) | These wastes, if inhaled or ingested or if they penetrate the skin, may cause delayed or chronic effects, including carcinogenicity. |
| 8 | Organic peroxides | These are organic waste containing bivalent-O-O- structure and may undergo exothermic self-accelerating decomposition. |

Pollution Control Boards (SPCBs) or Pollution Control Committees (PCCs). Depending on the physical and chemical characteristics of hazardous wastes, these may be categorized into three categories, *viz.*, recyclable, incinerable and landfill. The hazardous wastes may be categorized as recyclable when resource recovery is possible by reprocessing the waste, as incinerable when it is possible to incinerate the wastes for destruction and energy recovery, and as landfill waste when this is not suitable either for resource or energy recovery, but suitable for dumping with or without any treatment[1]. Reliable data on quantity of various categories of hazardous wastes generated is not available as yet. The processes of inventorisation of hazardous wastes generating industries and quantification of hazardous wastes in India are in progress. In many cases, it is difficult to procure reliable data on quantification of hazardous wastes and the SPCBs have to rely on the figures produced by the industries, which may not have adopted scientific methods for quantification of different categories of hazardous wastes. While observing data from various sources, the rate of generation of hazardous wastes in India could be above 6.7 MT/ year[5]. Apart from the above *in-situ* hazardous wastes generation in the country, import of hazardous wastes is a matter of concern for India.Various types of hazardous wastes are being imported, mainly from the developed countries. Proper record of the same is still difficult to maintain in spite of due attention drawn by the Supreme Court Monitoring Committee (SCMC) on Hazardous Wastes. These wastes are being imported for recycling. Therefore, there is need to keep an authentic record of whether the hazardous wastes are recycled or dumped elsewhere, as such types of imported recycled wastes are highly concentrated with hazardous constituents. Recycling of hazardous wastes regenerates hazardous wastes, which are often more toxic in concentration than the material recycled. Such wastes have a detrimental impact on public health and the natural environment, including wildlife, if disposed of unscientifically.

**Recycling of hazardous wastes**

Hazardous wastes having the resource values are recycled or reprocessed for value recovery. Used oil, battery wastes and other non ferrous wastes like zinc, lead are commonly recycled in India. Used oil is generated in the industrial sectors and from the automobiles, transformer or capacitor oil etc. Used oil contains high levels of various heavy metals like lead, cadmium, arsenic and chromium etc. It also contains contaminants such as chlorinated solvents, polychlorinated bi-phenyls and other carcinogens. It is estimated that one gallon of used oil is sufficient to contaminate one million gallons of ground water. Import of used oil/waste oil is banned in India due to its potential pollution hazard. However used oil is a precious and non-renewable resource and can be recycled back to pure lube oil again and again. USA generates 1.4 billion gallons of used oil every year, of that only 12 percent is recycled back into high quality products and rest is either burnt (56 percent) or disposed illegally (32 percent).[20]

The Hazardous Wastes (Management & Handling) Amendment Rules, 2003 recommend Environmentally Sound Technologies (EST) for recycling of used oil in our country. These technologies include : i) Vacuum distillation with clay treatment, ii) Vacuum distillation with hydro-treating and

iii) Thin film evaporation process. The Ministry of Environment and Forests can approve any other suitable technology for used oil re-refining. The major concern over recycling or reprocessing of hazardous wastes is that these processes again generate toxic waste, in which the concentration of toxic substances may be more than its pre-processing stage.

Existing technologies for used oil refining use a combination of heat and pressure to remove contaminants. A solvent extraction system eliminates the need of thin film evaporators as well as very expensive hydro treating step, and water, additives and contaminants are removed at ambient conditions, which then allow the resulting oil to be handled with traditional distillation equipment. Interline Resources Corporation, USA has a patent for claim that this solvent extraction system operates without extensive heat and pressure and used oil refineries can be built with an approximate cost 30 to 40 percent less than traditional technologies, which do not require larger capital costs and higher collection volumes. This technology is suitable to bigger as well as smaller scale facilities depending on the local circumstances. The technology mixes the used oil with a solvent, which has capacity of rejecting heavy metals and other contaminants from the used oil and has high selectivity for hydrocarbons. The rejected metals and contaminants are retained in an asphalt medium.[20] Interline extraction process eliminates coking and corrosion problems of transitional used oil distillation processes and works at ambient conditions. With the help of a solvent stripper, solvent is removed from the oil and then condensed and reused. After removing light hydrocarbons at atmospheric pressure, the remaining oil is distilled in a vacuum column to produce high quality base oil lube stock, diesel and bottom products. The residue is transferred to an asphalt blending vessel to get mixed with tower bottoms of vacuum distillation column. The resulting mixture is good material for roofing or as an asphalt modifier for paving asphalt.

Recycling of used oil is an environmentally responsible way to recover the resource value of used oil as well as to decrease its pollution potential. Companies generating such wastes can recycle used oil back to the pure lube oil again and again, and help saving a precious as well as non-renewable resources.

Lead wastes are generally available as lead ash and battery scrap. Lead is a potent toxin. Lead wastes recycling process is also known to yield cadmium and other metals as significant pollutants[6]. Zinc wastes are highly recycled in India. Zinc ash/residue generally contains toxic heavy metals like lead, arsenic, cadmium and chromium, and may also contain chlorinated contaminants.

**Electronic wastes**

Over the years, our dependence on the electronic products has grown manifold, both for domestic and for office uses, and this has resulted in generation of electronic wastes (E-waste) all over the world. E-wastes are a fast growing waste stream. On an average, E-waste makes up approximately 1 percent of municipal solid waste (MSW) stream as per the study report of EPA, USA[7]. Many municipalities are facing problems with huge amounts of E-waste because rapid changes in computer technology attract the people to throw the gadgets of old technology. Obsolete computers, color cathode ray tubes (CRTs) and other electronic appliances form the electronic waste or E-waste. These E-wastes contain hazardous substances, such as lead, mercury, chromium, etc. A television and CRT monitor contains about four pounds of lead on an average[8]. E-waste may contribute high level of Hg contamination in muncipal solid waste. Flame retardants containing bromines are used in plastic materials of various electronic appliances. Toxics abundant in E-waste are released into the environment through leachates in land fill sites or through incinerator ash. Toxic air pollutants are also released into the environment through incinerators. Therefore, management of E-waste has become a priority in many countries.

India is now experiencing the environmental problems of E-waste[9]. However, presently there is not any legislation enacted for disposal of E-waste in India. Central Pollution Control Board is working for formulation of the E-waste rule in India under the provisions of Environment (Protection) Act, 1986.

European legislation has brought Waste Electrical and Electronic Equipment (WEEE) Directive 2002/96/EC, governing the disposal of electric and electronic equipment for disposal of obsolete hardware. The British Environmental Agency (BEA) found that developing countries not covered under the Basel Convention, preventing the export for disposal of hazardous waste, were receiving E-waste without the means for proper tracking or disposal. Toxic Link, India found that E-wastes containing heavy metals like lead, brominated flame-retardants, beryllium, hexavalent chromium, PVC plastics, cadmium, and antimony, and plastics are imported as scrap metals to deceive customs authorities. E-wastes, originating in US or Western Europe, are reaching in the developing nations like India, Pakistan, China and other pacific countries. It has been reported that 23,000 tons of E-waste material was exported to developing nations from the UK in 2004[5, 10].

**Recycling of E-waste**

Recycling of E-waste is a need of the day to reduce/ avoid pollution, and to extract valuable and limited virgin resources. Recycling reduces the energy used in new product

manufacturing. In developed countries, municipalities, public and private organizations accept used / waste computers and other electronics for recycling. Now electronics manufacturers like Dell and HP are offering recycling services in some countries. The retailers and dealers of electronic items may be made responsible to ensure proper end-of-life disposition of E-wastes.

It is reported that 1.6 million kg of material each month are recovered in recovery centres of HP in the US and Europe, which is 98% by weight of all material received from customers and from within HP[10]. The waste and the constituent parts must be sent to specialists, who can deal with the components to recover reusable materials and then safely dispose of the rest. CRTs, LCDs, printed circuit boards, power supplies and batteries must all be processed individually to ensure that the respective materials are handled safely. The recycling programmes of Dell and HP have encouraged the Irish people to take advantage of E-recycling. Through Dell, Irish customers recycled over 22 tons of computer equipments in 2004. Looking at this Irish trend, continued and concerted effort on behalf of government, producers and environmental groups is needed in each state level and country as a whole to ensure proper management of increasing volume of E-waste in India.

Reusing and recycling the raw materials from obsolete E-products help in conserving natural resources and reducing the air and water pollution as well as reducing greenhouse gas emissions, which are caused during manufacture of such products. As being followed in many countries, donating electronics for reuse extends the life of the electronics as well as keeps the valuable products out of the waste management system. By donating used electronics to the schools, NGOs, and lower income families, which can not afford the new-purchase, the society can be benefited. USA provides tax incentives for computer donations.

**Universal waste**

This is a new term, generally applied for the hazardous wastes generated in the households. E-waste may be considered as part of the universal waste. Batteries, lamps, aerosol cans, mercury thermometer, rubber floorings, electronic devices, etc. categorize under the universal waste. Although most of the hazardous management rules do not apply on these items, yet these are required to be segregated and disposed of at waste facilities. Many of the universal wastes can be recycled. These wastes may pose serious health hazards, if accumulated for longer duration in houses. California Environmental Protection Agency (CEPA) has framed rules for managing universal wastes, which prohibit disposal at an unauthorized sites like roadside or ditches, which is termed as an illegal and a serious crime and environmental threat[11].

**Issues of concern**

*Management and disposal*

The major issues of concern for hazardous wastes in India are import, illegal dumping sites and in-complete data on generation and disposal of hazardous wastes in the country. Industrial incinerators in use are generally not efficient and are merely a combustion chamber and source of emission of dioxins and furans. Environmentally sound management of hazardous wastes would require Common Hazardous Waste Management Facility (CHWMF) for industrial clusters spread all over the country, as it is not possible to have hazardous waste management facility for each unit, particularly in the case of small and medium scale units.

*Health effects of hazardous wastes / substances*

Hazardous wastes are considered very harmful to man and environment. These wastes pose a severe environmental hazard to the human health and to various components of environment, viz. soil, air or water[12]. Various possible effects of hazardous wastes on human health are given in **Table 2**. Health impacts of hazardous pollutants have been studied in great detail by many organizations and individuals including the Government Organizations in India and other countries. In addition to research on health impacts, there are impact-related guidelines advocating for a full-fledged Health Impact Assessment (HIA) developed by several organizations[13, 14].

**Legislations and regulations for hazardous wastes**

*Hazardous Wastes (Management and Handling) Rules, 1989*

Hazardous Wastes (Management and Handling) Rules, 1989, as amended to date, were notified in the country under the provisions of the Environment (Protection) Act, 1986, for management and handling, and import of hazardous wastes into the country. These rules were amended in 2000 and 2003, to bring the Rules in line with the requirements of the Basel Convention and also to improve the applicability and implementation aspects with regard to imports of hazardous waste. Apart from Ministry of Environment and Forests (MoEF), Central Pollution Control Board (CPCB), State Pollution Control Boards (SPCBs) / Pollution Control Committees (PCCs) have been delegated certain powers for control and regulation of hazardous wastes.

There are 36 types of industrial processes listed in Schedule-I of Hazardous Wastes (Management & Handling) Amendments Rule, 2003. These industrial processes generate various categories of hazardous wastes and main rules applicable for such wastes and related activities are described hereunder. As per Rule 11 of the Hazardous Wastes Rules, 1989, import of hazardous wastes from any country to India shall not be permitted for dumping. Import of hazardous wastes

**Table 2:** Health effects of hazardous wastes[3,17,18,19]

| Hazardous waste | Source | Health effects |
|---|---|---|
| **Heavy metals** | | |
| Arsenic | Mining, non anthropogenic geo-chemical formation | Carcinogenic, cardiac disorders, anemia, |
| Cadmium | Mining, fertilizer industry, battery waste | Carcinogenic, damage to livers and kidneys, chronic obstructive pulmonary diseases, cardiovascular and skeletal disorders. |
| Chromium | Mining areas, Tanneries | Kidney damage, skin disease, acute tubular damage. |
| Lead | Lead acid battery smelters | Lead poisoning, neurotoxic, mental impairment in children, damage to brain, kidney and liver |
| Manganese | Mining areas | Respiratory disease, neuropsychiatric disorder |
| Mercury | Chlor-alkali industries, health care institutes | Hg poisoning affects human brain, central nervous system, kidneys and liver. High Hg exposure causes vision, speech and hearing impairment. May lead to death |
| Nickel | Mining, metal refining | Lung and nasal cancer, damage to gastrointestinal system, cerebral edema, respiratory failure |
| **Hydrocarbons** | | |
| Benzene | Petrochemical industries, solvents | Headaches, nausea, leukemia, damage to bone marrow |
| Vinyl chloride | Plastics | Carcinogenic (liver and lung cancer), depression of central nervous system, embryotoxic |
| **Pesticides** | Insecticides | Cancers, genetic damage, stillbirths, immune system disturbances, embryo damage |
| **Organic chemicals** | | |
| Dioxins | Waste incineration, herbicides | Cancer, birth defects, skin disease |
| PCBs | Fluorescent lights, E-waste, Hydraulic fluid | Skin damage, possibly carcinogenic, gastro-intestinal damage |

may be allowed for processing or re-use as raw material, after examining each case on merit by the Ministry of Environment & Forests. In Schedule 8 of Hazardous Wastes Amendment Rules, 2003, 29 categories of hazardous wastes, prohibited for import and export are tabulated. Wastes containing Hg, As, Waste Asbestos (Dust or Fibres), waste oil etc., are in the list of banned wastes for import and export. Both Basel Number and OECD Numbers as applicable are mentioned for each of these 29 categories of hazardous wastes. After import or export permission is granted by the Central Government or the SPCB/ PCC, as the case may be, the same is intimated to the concerned Port Authority to take appropriate steps regarding the safe handling of the hazardous wastes at the time of off-loading the same. Any person importing hazardous wastes shall maintain the records of the hazardous wastes imported as specified in Form 6A, and the records so maintained shall be open for inspection by the MoEF / CPCB / SPCB / PCC, or an officer designated by these regulatory bodies.

The Ministry of Environment and Forests (MoEF) is the nodal agency for environmental matters in India. It exercises control over imports of hazardous wastes under the Hazardous Wastes Rules. The MoEF is also a nodal authority in India for the purposes of implementing the legal provisions of the Basel Convention. Hazardous Substances Management Division (HSMD) of the MoEF deals with the management of hazardous wastes (both indigenous and imported), hazardous chemicals and major chemical accidents.

Under Rules 11 (2) and (3) of Hazardous Wastes Rules, a country which wants to export hazardous waste to India must apply to the MoEF to get permission for the proposed trans-boundary movement of hazardous wastes. After examining the communication received and being satisfied that the import of such hazardous wastes is for processing or reuse as raw materials, the Central Government grants permission for the import of such wastes. The Central Government may specify various conditions to the exporter of hazardous wastes, as and if required. The MoEF is also responsible to oversee safe-handling of hazardous wastes at the time of off-loading through appropriate communications to the port authorities under Rule 11(6) of the said HW Rule. The Central Government may refuse permission to import such hazardous wastes, if the government does not satisfy with the communication.

Rule 13 (3) of the Hazardous Wastes Rules regulates the import of hazardous wastes. According to this rule, an importer has to take permission from the MoEF for importing hazardous wastes. The MoEF ensures before granting

permission for import that the importer has environmentally sound / safe technology for reprocessing and that the importer has the capability to handle and reprocess hazardous wastes in an environmentally sound manner, and has adequate facilities for treatment and disposal of wastes generated. An importer of hazardous wastes has to provide necessary information regarding the type of hazardous wastes proposed to be imported, in Form 6, to the concerned SPCBs / PCCs, which will examine the information and issue necessary instructions to the importers. The SPCBs / PCCs examine the applications for import and forward with recommendation and requisite stipulations to the MoEF for safe transport, storage and processing / disposal. Both the importer and the exporter have to take permission from the MoEF. Like MoEF, SPCB/ PCC is also responsible to oversee safe handling at the time of off-loading of hazardous wastes through appropriate communications to the port authorities under Rule 11(6) of the Hazardous Wastes Rules. The SPCBs or PCCs accord authorization to the actual user for handling, transport, treatment, storage or disposal of hazardous wastes in India under the Hazardous Wastes (Management & Handling) Rules. The CPCB is responsible to compile the report on inventorisation of hazardous wastes after collecting the information from various SPCBs / PCCs. The CPCB is also responsible for ensuring implementation of the conditions of imports and for monitoring compliance with the conditions of import.

*Basel Convention*

Basel Convention deals with the trans-boundary movement and disposal of hazardous wastes as well as other chemical wastes by regulating and controlling the movement of scheduled hazardous wastes from OECD countries to non-OECD countries. India ratified the convention in 1992 showing India's commitment to solve the problem of transboundary movement and disposal (or dumping) of hazardous wastes through international cooperation. Restrictions imposed by the Convention aim at encouraging the signatory countries to reduce generation with proper treatment and disposal in an environmentally safe manner. The Rotterdam and Stockholm Conventions also aim at reducing or eliminating various types of hazardous emissions.

Though the Basel Convention banned the export of hazardous wastes, it is not putting an import ban of such wastes. After ratification of this Convention, if India desires to import hazardous wastes, it will be unable to source these wastes from OECD countries because of the ban. However, the Convention is unable to prevent the inflow of hazardous wastes into India from countries that have not ratified the agreement. USA is a major exporter of hazardous wastes into India. USA not being party to the Basel Convention can still export hazardous wastes to India. The same is true for many other developed countries in the north, which are not a party to the Convention and can send huge volume of hazardous wastes to India. Industrialized countries want to dump their wastes in developing countries such as India due to strict regulations of disposal and management of such wastes in their own country.

*Role of judiciary*

The Hon'ble Supreme Court of India has been playing a significant role for proper environmental safeguards in the country. A Public Interest Litigation (PIL) was filed in the Supreme Court of India by an NGO objecting to the import of hazardous wastes into the country in violation of the provisions of the Basel Convention. The court constituted a High Powered Committee (HPC) in 1997 to look into the allegations and to submit the report to the Apex court. In its report, which was submitted to the Supreme Court of India in 2001, the committee noted that "*situation in regard to hazardous wastes in the country is grim. It particularly affects the groundwater system in the country and remediation is very difficult and expensive. It affects a large number of innocent people, workers as well as community, who have to pay for the sin of the others".* The HPC also recorded that the approximate number of hazardous wastes generating units is 13,011, out of which 11,138 are authorized by the SPCBs. However, the inventorisation of hazardous wastes generating units in the country is not completed. Considering the grim scenario in the country in the field of hazardous wastes management, the Apex court banned import of all hazardous wastes listed under Annexure VIII of the Basel Convention vide its order dated 5.5.1997.

*World Initiatives*

After the Bhopal Gas Tragedy in 1984, USA enacted the 'Emergency Planning and Community Right to Know Act, 1986', which may be considered as a pioneering legislation regarding 'Community Right to Know'. Industries must prepare emergency response plans with discussion and due representation of the local community. As in USA, in our country also *Toxic Release Inventory* (TRI) should be made available to the public by way of printed reports, computer disks and on-line telephone support services and such a database should be in the public domain. Agenda 21 of United Nations Conference on Environment and Development (UNCED) in 1992 focused on pollutant release and transfer register. It prompted the Organization for Economic Cooperation and Development (OECD) to host a series of workshops to design such a register. The HPC has strongly recommended that the information on such areas where hazardous chemicals / materials are being used should be made available, and suitable legal steps should be taken to enact an Emergency Planning and Community Right to Know Act or a similar law for use in India. One of the achievements in the above aspects, as India's initiative, is that all industrial facilities

shall put up two signboards of 6 x 4 ft each at a publicly visible place at the main gate. The first signboard shall provide information regarding the facility-specific Consent to Establish and Consent for Operate conditions. The second signboard shall provide information on releases to the environment, including air emissions, water discharges and solid wastes. If the facility handles hazardous materials, display information to the public would also include the maximum range of the vulnerable zone, if a catastrophic accident occurs in a worst case scenario.

**Management options**

*Use of hazardous wastes as fuel*

There are 250 cement works located in the European Union (EU), which, altogether are using around 3 million tons of hazardous waste as alternate fuels. This is over 10 percent of the fuels used and the figure is rising steadily across the European Union with countries such as Germany leading the way[1,15].

There are a large number of hazardous wastes generating units located in the Country. 11,138 units have been given authorization by SPCBs under Hazardous Waste (Management and Handling) Rules, 2003, mostly for temporary storage of hazardous wastes within the plant premises. In India, about 4.43 million tons of hazardous wastes are generated annually, out of which 71,833 tons are incinerable (as per the reports of SPCBs submitted to the Hon'ble Supreme Court).There is a need to explore the possibility of using such wastes by other industries.

*Incineration*

Incineration is the process of destruction of all high calorific and highly toxic wastes by burning the waste at high temperature. Incineration at $1200^0$ C mineralises (breaks down into basic non-toxic components) all kinds of organic matter in the waste. However, the process of incineration releases toxic air pollutants like dioxins, furans, etc., if the waste is not incinerated at very high temperature. Therefore, destruction efficiencies of toxic compounds during incineration (effectively 99.99%) with no generation of persistent organic pollutants (POP) should be the prime criteria for design of an incinerator system. Incineration serves the dual purpose of reduction of both the toxicity and the volume of the waste, which is an important consideration when the disposal of wastes is finally destined for landfills. Most of the process wastes from chemical unit operations can very well be treated in properly designed incinerators.

*Hazardous wastes (secured) landfill*

'Hazardous wastes landfill' refers to a waste disposal unit, which is designed and constructed with the objective of minimum impact to the environment[15]. The hazardous wastes landfill site is designed scientifically to have an impervious stratum at bottom to stop leachates percolation, and thus to avoid soil and water pollution/contamination in the vicinity of the landfill site. HDPE lining is used in making the landfill impervious. There are arrangements made for collection and treatment of leachates from the hazardous wastes. Once the landfill is filled up, it is covered with HDPE lining to make the landfill impervious from the top. The top is again covered with thick layer of soil and finally the site is covered with vegetation cover. However, continuous monitoring of reclaimed site is necessary for longer period. Various reports indicate that more than 19 Treatment, Storage & Disposal Facility (TSDF) have been created in Gujarat alone. Many other states are following the similar action to establish such facilities. However, some kind of risk will always be there for the people and ecosystem by these operating and closed TSDFs. Therefore, before deciding hazardous wastes disposal in TSDFs, we must make sure that all other environmental friendly options, like recycle and reuse of such wastes are not possible. Reduction and minimization of hazardous wastes is absolute requirement in today's world. Option of storing of dangerous wastes would not be a long solution and could be considered for bridging period only. There are more than 30,000 chemical and radioactive disposal sites in USA and of these 1200 – 2000 sites are considered threat to human health, as reported by the Environmental Protection Agency (EPA).

**Conclusion**

It is difficult to develop alternative technology for total elimination of hazardous wastes generation. In developing countries, the thrust on economic development is often given priority to production costs than the best available technology and this results in more wastes generation. The cost of treatment and disposal of such wastes becomes a liability on the society. The MoEF has elaborately identified various treatment and disposal options of different hazardous waste streams that include physical / chemical treatment, landfill, biological treatment, incineration, recycle and recovery and solidification etc. As on today, the most often used option for disposal of wastes is secured landfill. Several publications define criteria for selection of such sites keeping in mind hydro-geological factors, land use-cover, ecological and human values[16]. The other options should be given also equal weightage to reuse and recycle of such wastes for resource recovery before deciding for a landfill. Environmental Impact Assessment (EIA) is being practiced all over the world to decide a site of secured landfill to ensure less negative impact of such facility on human and ecological systems.

In spite of the above technical knowledge available in the country, development of such facilities has not taken at desired pace. As in other sectors of development where private ventures are entering in a big way, waste

management, treatment and disposal programmes offer a good scope for private entrepreneurs to benefit with this sector of development. This will not only enable a facility provider to sustain his industry with profit but also the society will be benefited from these developmental activities in terms of getting cleaner environment and employment. Secured landfill and incineration projects have enormous scope to become an organized sector in Environmental Management Programme of the country. Regional Hazardous Waste Facility shall be more economical, profitable and will serve the requirement of a region, thus, eliminating the scope of scattered impact of many such facilities of smaller scale.

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