© 2017 IJSRST | Volume 3 | Issue 8 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section: Science and Technology

Hazardous Waste Management in India : Current Scenario and Future Opportunities

[1]D. Vasudevan, [2]Dr. A. G. Murugesan

[1]Research Scholar, Manonmaniam Sundaranar University, Alwarkurichi, Tirunelveli District, Tamil Nadu, India & Environmental Engineer, Tamil Nadu Pollution Control Board, Chennai, India

[2]Professor and Head, Sri Paramakalyani Centre of Excellence in Environmental Sciences, Manonmaniam Sundaranar University, Alwarkurichi, Tirunelveli District, Tamil Nadu, India

ABSTRACT

Proper treatment and disposal of Hazardous waste (HW) is the need of the hour as industrial development is happening at a rapid phase. Improper disposal of waste poses a serious threat to the environment. Until 1997 there was hardly any scientific landfill facility in the country for disposal Hazardous Waste (HW). At present, almost all the states in India have their own waste disposal facilities. Presently there are about 41 well-established treatment, storage and disposal facilities (TSDF) located in 17 States/ Union territories in the country. Necessary regulatory mechanisms are formulated by Ministry of Environment, Forest and Climate Change, Government of India and implemented by State Pollution Control Boards. The Central Pollution Control Board (CPCB) has formulated guidelines and standards for facilitating better site selection for TSDF and operation of its facilities. The Hazardous Waste Management (HWM) comprises several aspects including identification, quantification, treatment, and disposal of hazardous waste. As disposal of Hazardous Waste is the last option, both regulators and industries are supporting its utilisation in co-processing. Co-processing in cement industries has been identified as a better option to convert hazardous waste as it offers dual benefits of utilizing the waste as a supplementary fuel as well as an alternative raw material. About 7.81 million tonnes of hazardous waste are generated annually from 47,103 units in India. Out of 36 states and Union territories, the top 5 waste generating states are Gujarat, Maharashtra and Rajasthan, Tamilnadu and Andhra Pradesh contributing to about 23%, 21 %, 10 %, 8% and 7 % respectively. This paper aims to analyse the current status, problems and challenges in HW Management and future strategies for improvement. The paper also focuses on impact of hazardous waste landfill site to explore environmental impacts relating to disposal facility.

Keywords : Hazardous Waste, TSDF Facility, Waste Management, Co-Processing, Environmental Impacts.

I. INTRODUCTION

Growing human needs and the complementing industrial development bring both desirable development as well as undesirable environmental consequences. Amongst the various environmental impacts caused by industrialisation, disposal of solid wastes including the toxic and hazardous waste is of concern because of its deleterious effect on health and environment[1]. The major incidents, such as those in Minamata Bay-Japan, Love Canal - USA and Bhopal gas tragedy- India have been a curtain raiser exposing the dangers of improper disposal and exposure to hazardous wastes. These incidents have evoked global attention and has led to strengthening regulations on hazardous waste management worldwide[2][3][4].

India, the second most populous country in the world, has witnessed rapid urbanisation and industrialisation in the last few decades. Despite its developmental concerns, the country aims to tread the path of sustainable development in order to the restore its fragile eco-system, while ensuring equitable rights for its citizens over the limited natural resources[5]. Evidently, India is the first country to make constitutional provisions for the improvement and protection of the environment. Indian Parliament inserted two Articles, i.e., 48A and 51A in the Constitution of India in 1976. Article 48A of the

Constitution rightly directs that the State shall endeavour to protect and improve the environment and safeguard forests and wildlife of the country. Similarly, clause (g) of Article 51A imposes a duty on every citizen of India, to protect and improve the natural environment including forests, lakes, river, and wildlife and to have compassion for living creatures. The cumulative effect of Articles 48A and 51A (g) seems to be that the 'State' as well as the 'citizens' both are now under constitutional obligation to conserve, perceive, protect and improve the environment[6].

Recognizing the adverse impacts on the environment and health of the people, the Ministry of Environment, Forest and Climate Change (MoEFCC) in 1989, framed rules for effective management and safe disposal of Hazardous Wastes. The rules were entitled as Hazardous Wastes (Management and Handling) Rules under the Environment Protection Act 1986. These rules were amended from time to time. In April 2016, the Hazardous Wastes rules were revamped as, ‘Hazardous and Other Wastes (Management, Handling and Trans-boundary Movement) Rules. The revamped rules lay stress on the waste management hierarchy in the sequence of priority of prevention, minimization, reuse, recycling, recovery, co-processing and safe disposal. The revamped rules advocate safe disposal as a last option in the waste management hierarchy, only when the other mentioned options are unsuitable [7].

The CPCB has identified various treatment and disposal options for different hazardous waste streams that include physical/chemical treatment, landfilling, biological, treatment, incineration etc[8]. The secured landfill and incineration though being the most commonly used options for disposal of wastes are not completely exempt from potential environmental risks. While the secured landfills poses risk of possible contamination of land and water sources, the hazardous waste incinerators are known for emitting toxic pollutants, a possible source of health impacts and environmental damage[9] [10].

This paper intends to present a detailed review on the current status, problems and challenges, and future strategies for improvement in HW management system in India. The paper focuses on impact of hazardous waste landfill site on the surrounding environment, particularly on contamination of water sources in the vicinity of a disposal facility.

II. Current Status of Hazardous Waste Management in India

A. Legislation on Hazardous Waste Management

Indian waste management rules are founded on the precautionary principles of “sustainable development” (measures should be taken to avoid environmental degradation and hazards) and "polluter pays" (polluter must bear costs for damages and harm caused to environment by his own acts). These principles form an integral part of Indian environmental law jurisprudence. It mandates companies and industrial units to act in an environmentally accountable and responsible manner and for restoring the balance, if the same has been disrupted by their activities.

The Ministry of Environment Forest and Climate Change (MoEFCC), Government of India is the nodal agency at the central level for planning, promoting and co-ordinating environmental programmes, besides policy formulation. Considering the increasing industrialisation, thereby waste generation, various sub-ordinate legislations for regulating proper disposal of solid waste have been made by MoEFCC under the Environment (Protection) Act, 1986 ("EPA").The executive responsibilities for industrial pollution prevention, and control, are primarily vested with the Central Pollution Control Board (CPCB), a statutory authority, attached to the MoEFCC at the central level. The State Departments of Environment and State Pollution Control Boards (SPCBs) and Pollution Control Committees (PCCs) are the agencies designated to perform these functions at the State and Union territory level[3]. The MoEFCC in conjunct with the CPCB and SPCBs of different states thus administer the gamut of waste management regulations.

The MoEFCC in 1989 notified the Hazardous waste (Management and Handling) Rules, under the aegis of the above referred EPA, 1986. Subsequently, the rules were amended for a better and holistic management of hazardous waste in 2003, 2008, 2009, 2010 and 2016. The Hazardous and Other Waste (Management Handling and Transboundary Movement) Rule, (H&OW(M&TBM) Rules) were revamped in 2016. The rules define Hazardous Wastes as, "any waste, which by reason of characteristics, such as physical, chemical, biological, reactive, toxic, flammable, explosive or corrosive, causes danger to health, or environment".

The salient features of the revamped rules include but are not limited to, a) distinguishing between 'Hazardous Waste' and 'Other wastes' where the latter include: Waste tyre, paper waste, metal scrap, used electronic items, etc. and are recognized as a resource for recycling and reuse, b) the incorporation of a waste management hierarchy in the sequence of priority of prevention, minimization, reuse, recycling, recovery, co-processing and safe disposal, c) mandating the basic necessity of infrastructure to safeguard the health and environment from waste processing industry as Standard Operating Procedure (SOPs), d) prescription of co-processing as preferential mechanism over disposal of waste for use as supplementary resource, or for recovery of energy, e) These rules also deal with the ban for importing and exporting a few categories of hazardous wastes.

The Honorable Supreme Court of India, through its order of October 2003 had constituted a High Power Monitoring Committee on HW, to advise MoEFCC on issues pertaining to HW and other related areas. The High Power Monitoring Committee was to oversee implementation of the directions of this Hon'ble court in timely fashion and also to ensure that the aspects to which the ministry has agreed are implemented without any laxity or delay in the matter [11].

B. Current Status of Hazardous Waste Generation and Management

The industries generate hazardous waste in their operation and the major hazardous waste-generating industrial sectors include petrochemicals, pharmaceuticals, pesticides, paint and dye, petroleum, fertilisers, asbestos, caustic soda, inorganic chemicals and general engineering industries[3]. The rapid industrialisation over the past few decades in the country, has shown an evidently increasing trend in hazardous waste generation (Fig.1). As per the available information obtained from SPCBs/PCCs, it is estimated that there are about 47103 number of hazardous waste generating industries in the country, generating about 7.81 million tonnes per annum. Out of 36 states and Union territories, the top 5 waste generating states are Gujarat, Maharashtra and Rajasthan, Tamilnadu and Andhra Pradesh contributing to about 23%, 21 %, 10 %, 8% and 7 % respectively of the total waste generation [12].

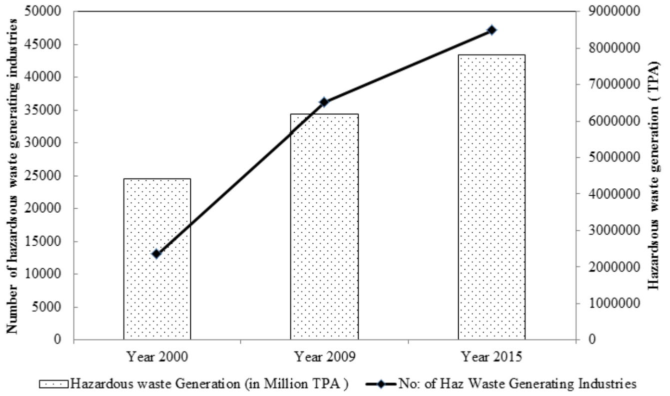


Figure 1. Graph showing increasing trend of hazardous waste generation

i. Prevention/ Avoidance of waste by change of process or technology

Many large scale industries particularly in sectors such as Iron and steel, hosiery, paint manufacturing, pulp and paper industries etc., have adopted the prevention and avoidance of waste as a measure of resource conservation and sustainable development[13][14]. Waste minimisations in these industries are usually achieved through resource reduction, recycling and product modification techniques. But the informal sectors or small scale industries lack the technical financial capabilities for upgradation. Suitable incentives and technical support for investments, machinery, R&D activities and training through government aids can enable such industries to adopt cleaner production in their units.

ii. Reuse, Recycle, Reprocess of waste

The concept of '3 Rs' i.e, Reduce, Recycle and Recover is being strongly promoted by MoEFCC for better and efficient waste management in the country. While embracing the 3R concept and to form basis for planning of TSDFs, the hazardous waste generation is categorised into three basic types vis-à-vis its composition in terms of recyclable, incinerable and suitable for landfill with or without treatment. Such categorisation of wastes require scientific criteria based on techno-economic feasibility considerations as prescribed in the CPCB publication[15].

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 waste for energy recovery, and suitable for landfill when it cannot be either used for or is not suitable either for resource or for energy recovery, but for dumping only with or without any treatment.

Of the total hazardous waste generation of 7.813 million metric ton per annum, the quantities and percentage contribution of different kinds of hazardous waste is presented in Fig.1.

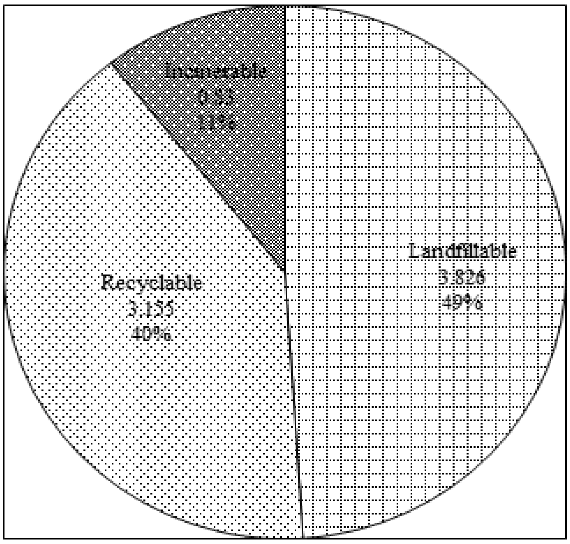


Figure 1. Categories of Hazardous Generation (Million MTA, %)

Recyclability of wastes is often decided based on economic feasibility (availability of end user, technological ease, price of recovery, transportation, and legal requirements etc.,). It has to be explored as the first option since many wastes contain valuable resource or can be used as supplementary source of energy in certain industries as such or after some pre-processing. The Schedule IV of Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 lists the wastes that can be recycled or used for recovery. The wastes enlisted can be broadly grouped as used and waste oil, non-ferrous metal wastes, electronic wastes, paint and ink sludge/ residues. Guidelines for, 'Environmentally sound recycling of hazardous wastes' was published by CPCB in 2010. These guidelines illustrate the available and practicable technologies for environmentally sound recycling of hazardous wastes. Accordingly, those recyclers demonstrating the use of environmentally sound technologies for waste processing are granted authorisation from the Central/ State Pollution Control Board to operate a recycling/ recovery facility[16].

India generates about 3.155 MT of recyclable hazardous wastes per annum. This constitutes about nearly 40 % of the total hazardous waste generated, offering more opportunities and challenges for recycling of wastes, thereby reducing the quantity of waste to be disposed in landfill. Presently there are nearly 800 authorised units for recycling/reprocessing of hazardous wastes as listed in Schedule- IV of the said rules, which includes lead acid battery scrap, lead and non-ferrous metal (Cu, Ni, Zn, Co, V etc.) scrap, process residues, waste oils and used lubricating oils etc., [17]. Further in case of high volume and low effect industrial wastes such as utilisation of fly ash in cement plants, slags in cement plants, phosphor-gypsum in cement plants and panel boards various recycling options are being adopted.

Besides the conventional environmental recycling methods, co-processing of hazardous wastes in cement kilns is gaining attention in India in view of the economic and environmental benefits it offers. The cement production in India is over 300 Million Tons per annum, for which estimated 50 Million Tons per annum of coal and 450 Million Tons per annum of raw material (lime stone, iron ore, clay, bauxite etc.) are required. There is a huge potential for utilization of large quantum of wastes such as non-recyclable hazardous and other wastes, segregated combustible fractions from municipal solid wastes (MSW), MSW based Refuse Derived Fuel (RDF), non-hazardous industrial wastes, plastics wastes, tyre wastes, non-usable bio-mass etc. as an alternative fuel and raw material (AFR) in cement kilns. Such utilization does not only help in recovering energy and material value present in them but also help reduce the consumption of primary fossil fuels and raw materials [18][19].

Co-processing is being practiced sustainably in many countries including in India. Substitution of raw materials and clinker with industrial inorganic wastes such as fly ash from coal-fired thermal power plants and blast furnace slag (BFS) from the production of pig iron is being increasingly adopted. Indian cement standards allow up to 35 per cent clinker substitution by fly ash or 70 per cent by BFS. So far around 54 number of cement plants have been granted permission for co-processing and around 1.76 lakh tonnes of hazardous waste was co-processed in cement industry during 2014-15[20]. Thus it can be noticed that the recycling of hazardous and other waste has made considerable progress in India

iii. Waste disposal through engineered landfill or incineration at Common Hazardous Waste Treatment, Storage and Disposal Facilities (CHWTSDF)

The last option for waste disposal to be considered based on the waste quality is disposal through incineration or landfill. Incinerable waste is often classified based on calorific value of the waste and reference in this regard is the acceptable criteria for secured landfill. Incineration is a controlled process which involves oxidative conversion of combustible solid material to a less bulky, less toxic, or less noxious material [10]. Waste material not suitable for other disposal options is disposed into the secured landfill. Sometimes, the criteria set for acceptable characteristics of hazardous waste for disposal into secured landfill may warrant prior treatment i.e., stabilization, etc.

The hazardous waste may be disposed at captive treatment facility installed by individual waste generator or at Common Hazardous Waste Treatment, Storage and Disposal Facilities (CHWTSDFs). Disposal at TSDFs is advantageous as compared to the captive facility because of the reasons such as reduced capital investment, reduced cost of treatment, checks mushrooming of treatment equipment in an area, easy implementation by the regulatory bodies etc.

Out of the total hazardous waste generation in the country 11 % is incinerable and about 49 % is disposable in secured landfills respectively. Currently there are about 17 Integrated TSDFs (with both SLF and Incinerator), 9 TSDFs with only Common Incinerators and about 15 TSDFs with only common secured landfills in the country spread over 16 and 12 States/UTs respectively. These States /UTs contribute to about 96% of total landfillable and 86 % of total incinerable hazardous wastes generation. The wastes generated in remaining states have limited or inadequate options for disposal due to hindrances in interstate movement and permissions. The annual operating capacities of the TSDFs range from 10,000 T/annum to 1.2 lakhs T/annum with an operating life span of 15-30 years[21][22].

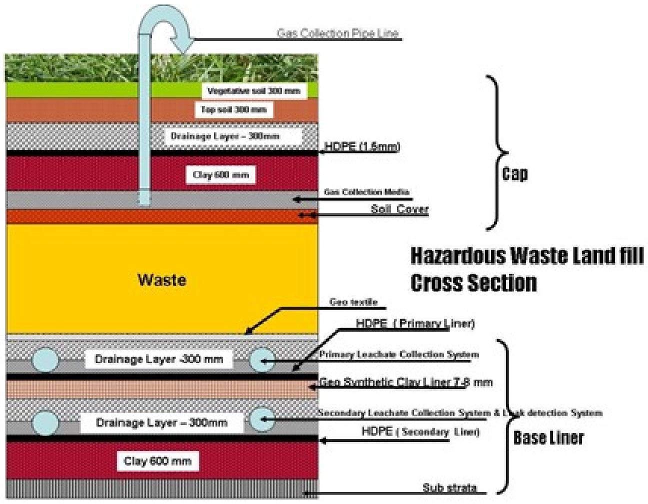
III. Disposal of hazardous waste in engineered landfill

Hazardous wastes landfill refers to a waste disposal unit, which is designed and constructed with the objective of minimum impact to the environment. The site selection for such facilities involves defined criteria covering the hydrogeological factors, land use-cover, ecological and human values followed by the EIA process for obtaining environmental clearance as prescribed in CPCB publications, “Criteria for Hazardous Waste Landfills and the “Guidelines for conducting Environmental Impact Assessment: Site Selection for Common Hazardous Waste Management Facility”. These guidelines provide criteria for location, site selection, site investigation, planning & design, requirements of landfill liner & cover, construction & operation, inspection, monitoring and record keeping, apart from requirement of post-closure plan as financial assurance as well as contingency plans for emergencies.

Acceptance of extremely dangerous waste such as radioactive wastes are prohibited in the Common Hazardous wastes Landfills and such wastes are disposed off in specially designed waste disposal units and in a manner approved by Atomic Energy Regulatory Board of India (AERB). The hazardous waste handled at the CHWTSDF site are subjected to neutralization, chemical fixation, encapsulation and other pre-treatment techniques, based on the characteristics of waste prior to disposal. Due to volatility and for other reasons, hazardous materials may require immediate cover. Due to these reasons, land disposal of hazardous wastes normally requires a greater degree of sophistication in design and operation at a given site [23].

A. Components of a hazardous waste engineered landfill

The hazardous wastes landfill 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. The layout of geo-liners as per CPCB criteria for Hazardous Waste Landfills (*HAZWAMS/17/2000- 2001*) is shown in Fig.3.



As per the guidelines, HDPE lining is used to make the landfill impervious for preventing water entering and leaving the landfill. A leachate collection drainage system is constructed in the base of the landfill, immediately above the liner to ensure that the head of leachate does not exceed 300 mm during any season of the year. For the treatment of leachate, the operator of the facility is directed to use spray evaporative drier only to vaporise the leachate from the landfill activity and scrubber blow down from incinerator. Besides the volume of the generated leachate, assessment of the quality of the associated properties of leachate, components of the leachate is essential to treat or remove toxic pollutants such as degradable organic compounds, non-degradable organic compounds, heavy metals etc. After 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 vegetation cover is provided. However, continuous monitoring of reclaimed site is necessary for longer period.

IV. Monitoring of impact of landfill on the water resources

Migration of leachate containing hazardous substances into groundwater is often an important environmental concern in relation to landfill sites and can cause soil and groundwater contamination. Monitoring of environmental impacts is necessary either to detect a functional failure of a landfill and correct it or to confirm that the controlled seepage is behaving as predicted[24]. Moreover, such studies are helpful for those responsible for compliance regulation at sites, their siting and remediation[1]. Several studies have been reported earlier on assessment methods of groundwater contamination in and around landfill sites. A recent study conducted in China reported development of a risk assessment method to delineate the groundwater pollution in an HWL site by choosing 38 indices based on source term, underground media, leachate properties, risk receptors and landfill management quality. Another study was also reported by Mulvey and Brisbane, 1996 to assess groundwater contamination based on the initial chemical interaction of the soil/rock leachate[24]. It was reported that the initial breakthrough of leachate can be seen through an alteration in ratio of cations in the leachate to native ones and through the evaluation of indicative parameters for movement of the leachate plume. Further, methods using simulation and prediction with mathematical models [25][26][27][28], leachate degradation and transport characterization by means of isotopic tracing[29][30][31], analysis and laboratory experiment testing[32][33] were also reported for evaluating the contamination of groundwater.

Contamination of groundwater by landfill leachate has been evidenced by several researchers during their previous studies, even for the well designed and constructed landfills [34][35][36]. Kubal *et al*, 2003 reported contamination of groundwater caused by concentrated and acidic leachate released from a HWL in Pozdatsky, Czech Republic. The landfill had stored about 12000 tons of waste ferrous sulphate[33]. The hydrogeological tests suggested that the probability of liner perforation caused by heavy machinery during waste loading could have permitted the groundwater to come into contact with the landfill body. As isolation of ferrous sulphate by upper coverage HDPE liner was not complete, the rain water penetrated through the landfill causing solubilisation of highly acidic ferrous sulphate and leachate generation.

A similar study conducted around a HWL in Hyderabad, India showed presence of increased amount of heavy metals in soil environment which indicated contamination either due to leachate from landfill or due to the indiscriminate disposal of industrial wastes in the surrounding area. The study showed evidence of increased concentrations of As, Cr, Pb exceeding the threshold and natural background values, whereas the upmost concentrations of Cu, Ni and Zn were beyond the prescribed threshold limit [37]. Studies conducted by Takashi Yamamoto *et al*, 2001[38] on the leachate characteristics of a secured hazardous waste landfill in Japan revealed that the levels of bisphenol A ranged from 1.3 to 17,200 μg/l with a median concentration of 269 μg/l. The source of bisphenol A in landfill leachates was attributed to the waste plastics in waste landfill proving that the leachates may be a significant source of bisphenol a found in the environment.

Absence of negative environmental impacts due to the HWL has also been evidenced by researchers who reported that the environmental quality remained unaffected due to the landfill. Peter Montague, 1982[39] studied the impact of four HWL on the surrounding groundwater quality in

New Jersey, USA and reported that no evidence of contaminated groundwater was found. The results of impact assessment studies conducted in and around a secured HWL in Gummidipoondi, India showed that the environmental quality in the area with respect to noise air, soil and water quality were within the prescribed limits of the International standards[40]. Similar observations were also reported in case of a study around the HWL site in Indore, India where the environment remained unaffected due to the presence of landfill operations[41].

The above studies demonstrate the importance of impact analysis of HWL on the environment. It can be understood that regular monitoring of groundwater is essential to detect migration of contaminants or leachate from a landfill. The presence of chemicals in groundwater is an important factor in determining the risk posed by landfill sites. Moreover regular monitoring and analysis of landfill leachate is vital to ensure that the landfill operations are carried out properly and no abnormal deviation in the leachate characteristics is observed. To evaluate the impact of landfill and the magnitude of contaminants leaching out of wastes, regular monitoring of water and soil environment for toxic metals in the landfill areas are required.

V. Challenges & Issues in HWM in India

Though there has been a considerable improvement in the management of hazardous waste over the past two decades, there are issues that still need to be addressed, few of which are discussed here. Despite the major reforms and rules with regard to HWM Rules being enforced, illegal dumping of HW is still a persisting issue affecting the environment. Alleged disposal of HW need to be strictly curbed at the earliest through effective enforcement of regulations.

The most common and a major restraint to the establishment of TSDFs are the 'NIMBY'(Not in my back yard) syndrome, exhibited by the local population. Their opposition stalls the establishment of scientific disposal through secured landfills and CHWTSDFs. Non availability of CHWTSDF in the close proximity, lead to higher transportation cost for waste disposal, which in turn motivates industries for illegal dumping. Awareness on the co-benefits of secured landfill and CHWTSDF needs to be created for the industries as well as the public for effective management of hazardous wastes.

The recycling of hazardous wastes has large potential still to be tapped, establishments of R&D centres need to be encouraged to convert waste to wealth. Though co-processing of hazardous wastes has shown significant growth, there exists a wide scope in terms of pre-processing wastes and establishment of adequate pre-processing facilities in India.

Though mandatory environmental compliance monitoring for CHWTSDFs are in practice, there are only few reported studies available on their environmental impacts. Therefore, more R&D activities on environmental impact assessment need to be encouraged, to facilitate identification and mitigation of adverse impacts, if any.

VI. Conclusion

India has been continuously upgrading its approach for management and handling of hazardous waste in the country. The legal enforcements aim towards waste prevention and waste minimisation options through encouraging recycling and co-processing activities. The waste management hierarchy prescribed in the latest Hazardous and Other Wastes Rules, 2016 stands as a witness to this fact. Consequently, there are also increasing numbers of recycling and co-processing units, paving way for alternative disposal options for wastes that were earlier disposed through landfill and incineration methods. As waste minimisation and recycling has potential for further development, research in this field should be encouraged to bring in new technologies and novel methods for application. For supporting co-processing activities, TSDF operators should come forward by providing facility to blend different wastes to have a consistent quality commitment for use as fuel. The ultimate objective should focus on waste minimisation and recovery so that wastes coming up for incinerator or landfill disposal are minimised.

For wastes that end up in incinerator or landfill for disposal, regular environmental monitoring is necessary to assess negative impacts to the environment, if any. As presence of large quantities of mixtures of potentially hazardous chemicals in landfill poses a major environmental threat associated with leachate and groundwater contamination, more importance should be given for periodical environmental assessments around hazardous waste landfills to ensure public health and environmental safety.

VII. REFERENCES

[1]. M. Vrijheid, "Health effects of residence near hazardous waste landfill sites: A review of epidemiologic literature," Environ. Health Perspect., vol. 108, no. SUPPL. 1, pp. 101-112, 2000.

[2]. Fortunato Mary Beth, "A Hazardous Inquiry : The Ranshom Effect at Love Canal," vol. 1, no. 12, pp. 12-14, 2000.

[3]. Y. Joshi and K. P. Ishwar, "India: State of Environment, 2001," pp. 133-149, 2001.

[4]. S. K. Dutta, V. P. Upadhyay, and U. Sridharan, "Environmental management of industrial hazardous wastes in India.," J. Environ. Sci. Eng., vol. 48, no. 2, pp. 143-150, 2006.

[5]. U. E. M. India, "India’s Intended Nationally Determined Contribution," Unfccc/Indc, no. October, pp. 1-38, 2015.

[6]. V. K. Agarwal, "Environmental Laws in India: Challenges for Enforcement," Bull. Natl. Inst. Ecol., vol. 15, pp. 227-238, 2005.

[7]. CPCB BULLETIN, "CENTRAL POLLUTION CONTROL BOARD," vol. I, no. July, pp. 15-17, 2016.

[8]. "CPCB Ready Reckoner: Hazardous Wastes Management (HAZWAMS/12/1998-99)."

[9]. T. H. Christensen, P. Kjeldsen, H. Albrechtsen, G. Heron, P. H. Nielsen, P. L. Bjerg, and P. E. Holm, "Attenuation of landfill leachate pollutants in aquifers," Crit. Rev. Environ. Sci. Technol., vol. 24, no. 2, pp. 119-202, Jun. 1994.

[10]. A. Rabl, J. V Spadaro, and P. D. McGavran, "Health risks of air pollution from incinerators: a perspective," Waste Manag. Res., vol. 16, no. 4, pp. 365-388, Aug. 1998.

[11]. S. Kumar, S. Mukherjee, T. Chakrabarti, and S. Devotta, Hazardous Waste Management System in India: An Overview, vol. 38, no. 1. 2007.

[12]. CPCB, "Updated Inventory of Hazardous Waste generation-2015."

[13]. P. V Viswanathan and T. K. Gangadharan, "Environmental and waste management in iron and steel industry," pp. 199-207, 1996.

[14]. S. S. Kumar and K. Joseph, "Waste minimisation in hosiery textile dyeing - A case study," J. Ind. Pollut. Control, vol. 22, no. 2, pp. 345-352, 2006.

[15]. CPCB BULLETIN, "Criteria for Hazardous waste Landfills." p. 35, 2001.

[16]. "Guidelines for Environmentally Sound Recycling of Hazardous Wastes (As per schedule IV of Hazardous waste (M,H& TM) Rules,2008) (2010)."

[17]. "National Hazardous Waste Management Strategy; Executive Summary."

[18]. "Hazardous And Other Wastes (Management and Transboundary Movement) Rules, 2016, PUBLISHED IN THE GAZETTE OF INDIA, EXTRAORDINARY, PART II, SECTION 3, SUB-SECTION (i)] GOVERNMENT OF INDIA MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE, April 2016."

[19]. "Guidelines for Pre-processing and Co-processing of Hazardous and Other Wastes in Cement Plants as per H&OW(M&TBM) Rules 2016, Published by Central Pollution Control Board (Ministry of Environment, Forest & Climate Change, Government of India) ."

[20]. "CPCB Annual Report 2014-15," 2015. .

[21]. "Treatment, Storage, and Disposal Facilities (TSDFs) data published by Central Pollution control Board, ENVIS Centre on Control of Pollution Water, Air and Noise, 2016, http://cpcbenvis.nic.in/tsdf.html#."
[22]. D. N. Ratnakar. and Dharmendra., "Hazardous Waste Management System in India: An Overview," Glob. Sustain. Transitions Impacts Innov., Dec. 2014.
[23]. V. Misra and S. D. Pandey, "Hazardous waste, impact on health and environment for development of better waste management strategies in future in India," Environ. Int., vol. 31, no. 3, pp. 417-431, 2005.
[24]. M. P and B. S, "Mulvey Monitoring Landfill Leachate," Aust. water, 1996.
[25]. N. Depountis, G. Koukis, and N. Sabatakakis, "Environmental problems associated with the development and operation of a lined and unlined landfill site: a case study demonstrating two landfill sites in Patra, Greece," Environ. Geol., vol. 56, no. 7, pp. 1251-1258, 2009.
[26]. P. Kjeldsen and T. H. Christensen, "A simple model for the distribution and fate of organic chemicals in a landfill: MOCLA," Waste Manag. Res., vol. 19, no. 3, pp. 201-216, Jun. 2001.
[27]. "Slack, R.J., Gronow, J.R., Hall, D.H., Voulvoulis, N., 2007. Household hazardous waste disposal to landfill: using LandSim to model leachate migration. Environmental Pollution 146 (2), 501 to 509."
[28]. R. J. Slack, J. R. Gronow, and N. Voulvoulis, "Household hazardous waste in municipal landfills: Contaminants in leachate," Sci. Total Environ., vol. 337, no. 1-3, pp. 119-137, 2005.
[29]. J. F. Hogan and J. D. Blum, "Boron and lithium isotopes as groundwater tracers: a study at the Fresh Kills Landfill, Staten Island, New York, USA," Appl. Geochemistry, vol. 18, no. 4, pp. 615-627, 2003.
[30]. D. Hube, L. Gourcy, J.-C. Gourry, and D. Guyonnet, "Investigations of natural attenuation in groundwater near a landfill and implications for landfill post-closure," Waste Manag. Res., vol. 29, no. 1, pp. 77-88, Nov. 2010.
[31]. J. D. Vilomet, A. Veron, J. P. Ambrosi, S. Moustier, J. Y. Bottero, and L. Chatelet-Snidaro, "Isotopic Tracing of Landfill Leachates and Pollutant Lead Mobility in Soil and Groundwater," Environ. Sci. Technol., vol. 37, no. 20, pp. 4586-4591, Oct. 2003.
[32]. C. Oman and H. Rosqvist, "Transport fate of organic compounds with water through landfills," Water Res., vol. 33, no. 10, pp. 2247-2254, 1999.
[33]. W. W. J., J. Yong-Chul, T. T. G., and L. Steven, "Leachate from Land Disposed Residential Construction Waste," J. Environ. Eng., vol. 128, no. 3, pp. 237-245, Mar. 2002.
[34]. M. Kubal, V. Kočí, A. Švagr, M. Kuraš, and M. Kuraš, "Environmental impact of hazardous waste landfill breakdown," in WIT Transactions on Biomedicine and Health, 2003, vol. 7, pp. 93-102.
[35]. S. Karnchanawong, S. Koottatep, and T. Ikeguchi, "Monitoring and evaluation of shallow well water quality near a waste disposal site," Environ. Int., vol. 19, no. 6, pp. 579-587, 1993.
[36]. S. Mor, K. Ravindra, R. P. Dahiya, and A. Chandra, "Leachate Characterization and Assessment of Groundwater Pollution Near Municipal Solid Waste Landfill Site," Environ. Monit. Assess., vol. 118, no. 1, pp. 435-456, 2006.
[37]. V. Parth, N. N. Murthy, and P. R. Saxena, "Assessment of heavy metal contamination in soil around hazardous waste disposal sites in Hyderabad city (India): natural and anthropogenic implications," E3 J. Environ. Res. Manag., vol. 2, no. 2, pp. 27-34, 2011.
[38]. T. Yamamoto, A. Yasuhara, H. Shiraishi, and O. Nakasugi, "Bisphenol A in hazardous waste landfill leachates," Chemosphere, vol. 42, no. 4, pp. 415-418, Feb. 2001.
[39]. P. Montague, "Hazardous Waste Landfill: Some Lessons from New Jersey," Civ. Eng., vol. 52, no. 9, pp. 53-56, 1982.
[40]. N. V Mariappan E & Prathiba Princeton, "Environment assessment of industrial landfill site in tamil nadu," Int. J. Curr. Res., vol. 4, no. 10, pp. 252-256, 2012.
[41]. S. Tomar, R. P. Singh, and R. Chaudhary, "Environmental Monitoring of Hazardous Waste Disposal Site- A case study," Int. J. Sci. Nat., vol. 2, no. 4, pp. 837-843, 2011.