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Environmental Management of Industrial Hazardous Wastes in North-East India

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ABSTRACT

The Red Category of industries known for its generation of hazardous wastes. Environmental hazards resulting from rapid industrialization mandates developing nations like India to focus on comprehensive hazardous waste management within the country. As per the Annual Report:2020-21 of Central Pollution Control Board, there are 45 common Treatment Storage & Disposal Facilities (TSDF) across 18 states/UTs in India. Among the common facilities (TSDF), 17 units are with integrated facilities having both secured landfills & incinerators. Despite, the establishment of stringent regulations & environmental standards and developing infrastructure within the country, the safe disposal of hazardous waste remains a significant concern in the North-Eastern States of India due to non-availability of TSDF sites within the region. However, hazardous waste management plan is required for effective management of waste at individual industry level in the region. This study was initiated to assess the chemical profile of hazardous waste generated by large chemical industries in north eastern (NE) states; and to improve the current waste management system. Among all industries in NE Region, Refinery contributes more in terms of hazardous chemical waste generation per unit of the product. During FY 2021-22, it was found that Refinery Industries in NE Region re-processed or recycled approx. 41% of the total hazardous waste and the rest 57 % of total waste stored within the units. This trend is more or less similar with all other industries of NE. Sludge samples from pollution control processes were collected from various representative industries for the determination of calorific value of the dried sludge/waste to figure out the suitability of the sludge/waste for co-processing to nearby cement plants in the states of Meghalaya/Assam. Based on the Gross Calorific Value (GCV) (Kcal/Kg) analysis of the Chemical Sludges, it is recommended that Chemical Sludges from ETPs of Petrochemical, Fertilizer & Refinery (GCV 3700-5200 kcal/kg) may be used in mixture with coal as a source of alternative fuel in cement industries (Co-processing).This study helped us in identifying the major Hazardous Chemical Waste Generator industries in NE and help the regulators and policy makers in focusing a better environmental management plan in handling & alternate disposal of the chemical waste within NE India.

Keywords: *Chemical Sludge, Co-processing, Disposal, Gross Calorific Value, Hazardous Waste Management, North-East India, Refinery, TSDF*

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INTRODUCTION

The last decade has witnessed environmental hazards and catastrophes as a result of the fast industrialization of the world. More stringent regulations and the enforcement of environmental standards were established as a result of pressures brought by the crisis in developed nations, Unfortunately, this approach has not yet become mainstream in the majority of developing nations [6] Industrial wastes have been a concern as a result of industrial operations; however comprehensive management should be taken into consideration in order to reduce their hazards. Indian industries have experienced a rapid growth in the past decade, which has led to an increase in the production of hazardous waste. Wastes that are produced locally and those that are imported from other nations for recycling or reprocessing need to be treated and disposed of scientifically. There are, however, very few secure landfill locations in the nation that can properly dispose of hazardous waste. The illegal disposal of hazardous waste by the industries may result in significant degradation of the environment. In India, the safe disposal of these hazardous wastes has emerged as a significant environmental concern. Hazardous waste was first regulated in 1989 through Hazardous Waste (Management &Handling) Rules, 1989, which subsequently were amended in 2008 to incorporate Basel Convention provisions and lastly recently again in 2016 as Hazardous and other Wastes (Management & Transboundary Movement) Rules,2016 (sixth amendment 21.07.2022) to cope with potential hazardous waste-related environmental issues in the foreseeable future within the country.

However, regulatory bodies and enterprises should properly understand various concerns connected to hazardous waste management in different regions of the country in order to assist the government in building an environment friendly management system. As per the Annual Report 2020-21 prepared by Central Pollution Control Board, quantity of Hazardous waste generated during the financial year 2019-20 within India was 7.68 million tonnes. Approximately 50% of the hazardous waste was recycled/utilized (co-processing, captive & non-captive utilization), about 15% of the waste was stored at the premises and rest was disposed via Secured Land Fill & Incineration facilities during that year [2]. There are 45 common Treatment Storage & Disposal Facilities (TSDF) across 18 states/UTs in India. Among the common facilities (TSDF), 17 units are with integrated facilities having both secured landfills & incinerators. However, no such common facility (TSDF) exists within the North-Eastern (NE) Region of India. Hence, a proper environmental management plan for handling, treatment & disposal of industrial hazardous waste within this remote area is required for effective Hazardous Waste Management (HWM). But, No data is readily available regarding the chemical profile of the industries and the characteristics of generate Hazardous wastes by such industries. Thus, this study investigates the characterization of chemical hazardous waste generated by large chemical industries in North Eastern States especially in the States of Assam, Meghalaya and Tripura. Moreover, this paper also tried to portray on the current management system of the generated industrial waste in North-East India before providing recommendations to the concerned authorities for regulation purpose, which will help policy planners & decision makers of the country for effective hazardous waste management.

MATERIAL AND METHODS

Preliminary data have been collected based on a survey from the representative chemical industries of North East (NE) India. Three (3) Units of Oil Refinery (Assam), One (1) Unit of Petrochemical Industry (Assam), One (1) unit of Oil & Gas Upstream (Drilling), One (1) unit of Fertilizer Industry (Assam), Two (2) units of Distillery (Assam & Meghalaya) & One (1) industrial growth center of Rubber processing industries (Tripura) operating in the states of North-East India have been chosen for this study. The survey form is divided into four sections: first section contains basic information like the name, address, type of industry, nature and quantity of industrial products. Second Section intends to capture the data about Raw material Consumption in the industry, Penultimate section focuses on the Chemical Profiles, quantity & nature of the chemical waste of the industry. The final section includes data on source separation, storage status, frequency of waste discharge, organization responsible for transport and disposal, and techniques for the final disposal of industrial solid hazardous waste (Chemical Waste Management). Sludge samples from pollution control processes (ETP) from Refinery, Petrochemicals, Oil& Gas Upstream (Drilling), Fertilizer & CETP of Rubber Processing Industry were collected for determination of Gross Calorific Value (GCV) of the waste. Following parameters like total Organic Carbon (wt.%), & various metals (Ca, Cd,Cr,Cu, Mg,Mn, Ni, Pb, Zn, Fe &Co) were also analyzed for the oily sludges collected from refinery & petrochemicals industry. The management of the chemical waste by the industries was recommended based on the characteristics of the chemical wastes.

RESULTS AND DISCUSSION

Comparison, Inventorization & Categorization of Hazardous Chemical Waste from Chemical Industries of NE

Data have been collected for Hazardous Chemical Waste Inventories, Generation & Disposal for the representative Industries during FY 2021-22. A ratio (R) has been defined in this purpose to compare the hazardous waste generated per unit of product across different representative industries.

R = Quantity (MT) of Product /Total Quantity Hazardous Waste (Generated) (MT)

Physical significance of this defined ratio R is quite evident. It represents a quantitative figure on how much Quantity of Waste is generated per unit of the Product. More the value of R of a particular industry, i.e., better it is in terms of less generation of Hazardous Chemical Waste. Table 1 gives an idea about a comparison of hazardous waste generation per unit of the product across different industries in NE India.

Table 1: Comparison of Production quantity per unit of hazardous waste generation across Industries of North-East India

Industry Type	Avg. R Value
Refinery (MT/MT)	52.19
Fertilizer (MT/MT)	8,094.05
Petrochemicals (MT/MT)	205.08
Rubber Processing Industry (MT/MT)	3,222.62

It is evident from the above table that among all industries, Refinery Industries contributes more in terms of hazardous chemical waste generation per unit of the product. However, sources and chemical composition of Hazardous Chemical Waste varies for different industries. Various category wastes in a particular industry can be seen from Table 2.

Table 2: Chemical Waste categorization from different industries of NE India

Chemical Industry	Category of Hazardous Waste as per Schedule- I, II, III of HWM Rules	Type of Chemical Waste
Refinery	Schedule-1 & Category 4.1	Chemical & Oily Sludge (ETP)
	Schedule-1 & Category 4.4	Bio-Sludge (ETP)
	Schedule-1 & Category 4.1	Tank Bottom Sludge
	Schedule-1 & Category 4.2	Spent Catalyst
	Schedule-1 & Category 4.3	Slop Oil
	Schedule-1 & Category 5.1	Spent Lube Oil
Petrochemicals	Schedule-1 & Category 1.6	Spent Catalyst & Molecular Sieves
	Schedule-1 & Category 1.3	Oily Sludge
	Schedule-1 & Category 1.1	Coke, reactor residue & debris
	Schedule-1 & Category 5.1	Waste oil & Used Oil
Fertilizer	Schedule-1 & Category 18.1	Spent Catalyst
	Schedule-1 & Category 5.1	Used Oil & Waste Oil
Crude Oil Production	Schedule-1 & Category 2.1	Drill Cutting excluding those fromwater-based mud
	Schedule-1 & Category 2.2	Sludge containing oil
	Schedule-1 & Category 2.3	Drilling Mud
Distillery		Distillery Spent Wash
		Sludge of Waste Water Treatment Plants
	Schedule-1 & Category 5.1	Waste oil & Used Oil
Rubber Processing Industry & CETP		Chemical Sludge from wastewater treatment
		Low-grade rubber sludge from Primary Treatment Tank
	Schedule-1 & Category 5.1	Spent Lube oil

Sector Specific Hazardous Waste Management

Information about Hazardous Waste source separation, storage status, waste discharge frequency, transport and disposal of waste, and techniques adopted for final disposal of solid hazardous waste were collected from each representative chemical industry. Following Table 3 summarizes Waste Management across various industries of NE India.

Table 3: Hazardous Waste Management Practices from different chemical industries in NE

Chemical Industry	Type of Chemical Waste	Method of Disposal
Refinery	Chemical & Oily Sludge (ETP)	Captive Secured Land Fill
	Bio-Sludge (ETP)	Captive Secured Land Fill
	Tank Bottom Sludge	Bioremediation facility
	Spent Catalyst	E-Auctioning to Authorized Recycler
Refinery	Slop Oil	Reprocessing in CDU/VDU & Sold to recyclers
	Spent Lube Oil	Stored in Designated Area
Petrochemicals	Spent Catalyst & Molecular Sieves	Co-processing/E-Auctioning to Authorized Recycler
	Oily Sludge	Bioremediation facility
	Coke, reactor residue & debris	Co-processing in Cement Plants
	Waste oil & Used Oil	Sold to recyclers
Fertilizer	Spent Catalyst	Sold to recyclers
	Silica	Entire waste is reused as filler in Single Super Phosphate production
	Zinc Mud	Entire waste is reused as filler in Single Super Phosphate production
	Used Oil & Waste Oil	Sold to recyclers
Distillery	Sludge of Waste Water Treatment Plants	Used as a Fertilizer
	Waste oil & Used Oil	Sold to recyclers
Rubber Processing Industry & CETP	Chemical Sludge from waste water treatment	TSDF Sites
	Low-grade rubber sludge from Primary Treatment Tank	Resold to recyclers
	Spent Lube oil	Sold to recyclers

It is quite evident that majority of the chemical industries dispose liquid hazardous waste i.e., Slop oil, waste oil & used oil through authorized recyclers. In refinery & petrochemical industries some of oily & chemical

sludge may be treated in bioremediation facility. After bio-remediation treatment, the same is being used in horticulture and land filling. In absence of any treatment facility, a major shared of produced hazardous waste is stored at the premises of the facility. During FY 2021-22, it was found that Refinery Industries in NE India re-processed or recycled approx. 41% of the total hazardous waste in that FY and the rest 57 % of total waste remains with the unit. This trend is more or less similar with all the industries of NE. Some chemical industries of NE dispatch high calorific value solid hazardous waste to nearby cement industries for co processing. The transportation of the waste is majorly done through Pollution Control Board authorized agencies. However, proper characterization, calorific value determination & monitoring of generated chemical hazardous waste from the process of chemical industries are necessary for planning effective Source Separation, Storage, treatment & disposal of the wastes.

Characterization of Chemical Wastes

Sludge samples from pollution control processes & other chemical wastes were collected from various representative industries for the determination of calorific value of the dried sludge/waste and figure out the suitability of the sludge/waste for co-processing to nearby cement plants. Table 4 depicts calorific values of different dried chemical wastes/sludges collected from the industries. Chemical Sludges from ETPs of Petrochemical, Fertilizer & Refinery has sufficient GCV (Kcal/Kg) that can be sent for co-processing in cement industries.

Chemical characterization of ETP sludge (Chemical &oily) collected from Refinery & Petrochemical Industries has also performed to analyze the metal content (wt.%) in the waste. Chemical Characterization of the different chemical wastes collected from the refinery & petrochemical industries can be observed from the table 5 (A) & 5(B). Iron is found to be higher among heavy metals in both oily sludge samples of refinery & petrochemical units. Considering the heavy metal contents, these sludges should be handled & disposed off carefully to avoid any contamination in the surrounding environment.

Table 4: GCV of Chemical Sludges from different chemical industries in NE

Industry Type	Source of Chemical Waste	Gross Calorific Value (**Kcal/Kg**)
Petrochemical	ETP Sludge	**4307.57**
Oil & Gas Upstream (Drilling)	ETP Sludge	**2011.60**
Refinery	ETP Sludge	**5243.60**
Fertilizer	ETP Sludge	**4108.51**
Rubber Processing	ETP Sludge	**3765.00**

Table 5 (A, B): Chemical Characterization of the different chemical wastes from different chemical industries in North-East India

Table 5 (A)

Sample Source of Chemical Waste	Parameters	Compositions (wt.%)
ETP Chemical & Oily Sludge (Refinery)	Moisture Content	84.620
	Oil Content	3.700
	Organic & Volatile Matter	9.200
	Iron	0.480
	Sodium	0.120
	Sulphide	0.120
	Phenol	0.003
	SiO_2 & Trace Metals	0.045
	Chloride	0.960
	Calcium	0.220
	Magnesium	0.100
	Manganese	0.008
	Nickel	0.000
	Sulphate	0.420
	Zinc	0.001
	Lead	0.000
	Copper	0.001
	Cobalt	0.001

Table 5 (B)

Sample Source of Chemical Waste	Parameters	Compositions (wt.%)
Oily Sludge (Petrochemicals)	Alumina (Al_2O_3)	15.030
	Sulphide	0.860
	Calcium Oxide	0.740
	Magnesium Oxide	0.145
	Chloride	0.135
	Oil & Grease	11.450
	Organic & Volatile Matter	42.280
	Silica (as SiO2)	22.600
	Iron	3.170
	Nickel	0.006
	Zinc	0.032
	Manganese	0.001
	Sulphate	0.420
	Copper	0.006
	Chromium	0.001

RECOMMENDATIONS & CONCLUSION

After conducting an in-depth study of chemical profile of wastes in various industrial sector of NE India, following points have been recommended for efficient management of the Hazardous Chemical waste in North East India:

- The Ministry of Environment, Forest & Climate Change- Government of India has notified a number of solutions for the treatment and disposal of diverse hazardous waste streams, including **recycling, land-filling, biological treatment, incineration, and physical and chemical treatment.**

- **Secured landfills** should be used for disposal of non-biodegradable and non-treatable hazardous waste. **Bio-remediation techniques** may also be adopted for biologically degradable waste to avoid land-filling.
- Based on the GCV (Kcal/Kg) analysis of the Chemical Sludges, it is recommended that **Chemical Sludges from ETPs of Petrochemical, Fertilizer & Refinery may be used in mixture with coal as a source of alternative fuel in cement industries (Co-processing)**. Oil- Drill Mud may also be used in Brick-Kiln industry due to having less calorific value (~2000 Kcal/Kg). This practice will also boost the policy of **circular economy** in the country.
- Facility in NE region may be established to collect & recover the **precious metals from Spent catalysts** & other chemical wastes through authorized dealers.
- A **common facility (TSDF) for treatment & disposal** of hazardous waste may be established in North-Eastern region for effective HWM.
- Waste collection, treatment, and disposal programmes provide a great opportunity for entrepreneurs to profit from this sector of development, comparable to other sectors of development where private entities are actively participating. Not only will this help a facility provider maintain a profitable business, but these development efforts will also benefit society as a whole by creating jobs and a cleaner environment.

The development of alternative technology to completely stop the production of hazardous wastes is challenging. In developing nations, the emphasis on economic development frequently places a higher value on production costs than the finest possible technology, which increases the output of trash. Such wastes incur expenses for treatment and disposal, which burdens society. Many studies [3,7] outline selection criteria for such sites that consider hydro- geological aspects, land use/cover, ecological values, and human values. Prior to choosing a landfill, the other choices, such as resource recovery through reuse and recycling of such wastes, should be given equal weight. Environmental Impact Assessment (EIA) is used all over the world to choose a location for a secure landfill to ensure that such a facility has a minimal negative impact on social and natural systems [4]. Despite the country's availability of the aforementioned technological expertise, the creation of such facilities has not progressed at the necessary rate. Secured

landfill and incinerator projects have a lot of potential to develop into a formal industry under the nation's environmental management Programme. A regional hazardous waste facility will be more cost-effective, profitable, and able to meet regional needs, reducing the breadth of the scattered effects of several smaller-scale plants. This study regarding chemical waste from various industrial sectors in NE India would help us in identifying the major Hazardous Chemical Waste Generator industries in NE and help us in focusing a better environmental management plan in handling & alternate disposal of the chemical waste in NE India.

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CONFLICTS OF INTERESTS

The authors declare no conflicts of Interest.

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