

REVIEW ARTICLE

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Management of hazardous waste in Thailand: present situation and future prospects

Received: February 26, 2001 / Accepted: October 11, 2002

Abstract This paper deals with the present scenario of hazardous waste management practices in Thailand, and gives some insights into future prospects. Industrialization in Thailand has systematically increased the generation of hazardous waste. The total hazardous waste generated in 2001 was 1.65 million tons. It is estimated that over 300 million kg/year of hazardous waste is generated from nonindustrial, community sources (e.g., batteries, fluorescent lamps, cleansing chemicals, pesticides). No special facilities are available for handling these wastes. There are neither well-established systems for separation, storage, collection, and transportation, nor the effective enforcement of regulations related to hazardous wastes management generated from industrial or nonindustrial sectors. Therefore, because of a lack of treatment and disposal facilities, these wastes find their way into municipal wastewaters, public landfills, nearby dump sites, or waterways, raising serious environmental concern. Furthermore, Thailand does not have an integrated regulatory framework regarding the monitoring and management of hazardous materials and wastes. In addition to the absence of a national definition of hazardous wastes, limited funding has caused significant impediments to the effective management of hazardous waste. Thus, current waste management practices in Thailand present significant potential hazards to humans and the environment. The challenging issues of hazardous waste management in Thailand are not only related to a scarcity of financial resources (required for treatment and disposal

facilities), but also to the fact that there has been no development of appropriate technology following the principles of waste minimization and sustainable development. A holistic approach to achieving effective hazardous waste management that integrates the efforts of all sectors, government, private, and community, is needed for the betterment of human health and the environment.

Key words Industrial hazardous waste · Nonindustrial hazardous waste · Generation · Treatment · Disposal

Introduction

During the past decade, the production of solid waste and hazardous waste has increased alarmingly in Thailand, and is now a major environmental problem. With the shift in Thailand's economy towards industrialization, the number of industries that produce hazardous wastes, in particular, has increased dramatically and at a faster rate. From the statistical records of the Department of Industrial Works (DIW), the number of factories in the country increased rapidly from 86000 to 104996 during 1989–1996. It is estimated that the quantity of total waste (industrial, municipal, and hazardous) in the country in 1997–2017 will be between 41792 and 75481 ton/day.¹ The Pollution Control Department (PCD) under the Ministry of Science, Technology, and Environment (MOSTE) reported that the total volume of hazardous waste generated in Thailand in 2001 was 1.65 million tons (PCD, personal communication, 2001).

Treatment and disposal facilities are not adequate to meet the increasing volumes of toxic waste generated. The demand for storage, transport, treatment, and disposal of continuously increasing waste generation has created an urgent need for environmental regulations and standards to ensure public safety. The present regulations and standards are either unavailable and/or insufficient to regulate and manage hazardous wastes which induce critical environmental problems. However, the problems and challenges of hazardous waste management in Thailand can be overcome

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Table 1. Estimates of the volume of hazardous wastes generated in Thailand, by type

Waste type	Hazardous waste volume (tons/year)							
	1986		1991		1996		2001	
	1	2	1	2	1	2	1	2
Oils	124190	106372	219470	188254	387890	332779	686360	589508
Liquid organic residues	190	187	310	311	520	522	880	876
Organic sludge and solids	3740	3737	6670	6674	11950	11951	21530	21533
Inorganic sludge and solids	11700	11655	19250	19163	32040	31858	54080	53696
Heavy metal sludge and solids	832870	302316	1447590	536322	2536030	946565	4418030	1658192
Solvents	19780	19760	36160	36163	66530	66532	124310	124306
Acid wastes	81050	18505	125430	31432	196510	53793	311710	46105
Alkaline wastes	21950	5769	34230	9839	54020	16846	86200	29019
Off spec. products	10	12	20	25	50	52	110	107
PCB	2460	0	0	0	0	0	0	0
Aqueous organic residues	120	116	240	242	500	499	1040	1037
Photochemical wastes	8820	8820	16350	16348	30400	30398	57810	57809
Municipal wastes	7230	7231	11790	11787	19090	19090	31090	31093
Infectious wastes	46670	46674	76080	76078	123500	123219	200070	200699
Total	1160780	531154	1993590	932638	3459030	1634104	5993220	2813980

Sources: 1, ref. 2; 2, PCD (1992)
PCB, polychlorinated biphenyl

with an integrated and coordinated effort by the government, the private sector, and the community. A strategy for the future must be formulated to incorporate technologies that are developed on the principles of waste minimization and sustainable development, as well as the involvement of the private and public sectors.

Definition and classification of hazardous waste in Thailand

The management of hazardous waste is complicated by the fact that “hazardous waste” is still not a well-defined term in Thailand. According to the Hazardous Substance Act 1992, the term “hazardous waste” is applied to any waste which exhibits, or which is contaminated with, hazardous material, including explosive substances, flammable substances, oxidizing agents and peroxides, toxic substances, substances causing disease, radioactive substances, mutant-causing substances, corrosive substances, irritating substances, and other substances, chemicals or otherwise, which might cause injury to persons, animals, plants, properties, or environments. The types of hazardous waste generated by industrial and nonindustrial (community generated) sectors are classified by their identification under the same Act.

Generation of hazardous waste in Thailand

From the statistical records of the DIW, the number of factories registered in the DIW nation-wide increased rapidly from 86000 to 104996 during 1989–1996. It is estimated that the quantity of total waste (industrial, municipal, and hazardous) over all the country in 1997–2017 will be between 41 792 and 75 481 ton/day. The wastes which will be

generated in the urban areas are estimated at about 20 542–46 848 ton/day, while the wastes in the rural areas will be approximately 21 250–28 633 ton/day.¹

The PCD reported that the total volume of hazardous waste generated in Thailand in 2001 was 1.65 million tons, of which 1.29 million tons (78%) were generated by the industrial sector, and 0.36 million tons were generated by the nonindustrial (community) sector (PCD, personal communication, 2001). As well as the industrial and nonindustrial sectors, a main source of hazardous waste generation is the transport of hazardous wastes from foreign countries into Thailand.

Industrial hazardous wastes

The first comprehensive estimate of nation-wide hazardous waste generation was reported in 1989 by two engineering companies.² In 1992, the PCD, in collaboration with the Ministry of Industry, revised this inventory and down-scaled the estimates. Estimates of the nation-wide generation of hazardous wastes, published in 1989 and 1992, listed 14 main types. Table 1 shows the estimates for each type in 1986, 1991, 1996, and 2001. The quantity of hazardous waste generation reported in 2001 (1.65 million tons/year) is lower than the estimated projection (2.81 million tons/year), due mainly to the Asian economic crisis. However, these estimates indicate that more than 70% of the hazardous waste generated in Thailand is in the form of heavy metal sludge and solids. Other important groups of hazardous waste are oils, acid wastes, infectious wastes, solvents, and alkaline wastes. It has also been reported that petroleum refineries, and the electroplating, textile, paper, and pharmaceutical industries are the primary producers of hazardous wastes in Thailand.

Table 2. Projected industrial hazardous wastes quantities in Eastern Seaboard provinces

Province	1995	2000	2005	2010
Rayong	54671	82966	125907	191072
Chachoengsao	247104	374997	569083	863662
Chonburi	59253	89920	136550	207087
Total	361028	547884	831540	1261780

Source: TDRI estimates

The industries generating hazardous wastes are mainly located in the Bangkok area, Samut Prakan province, and Eastern Seaboard provinces. The electroplating and textile industries are the largest contributors to hazardous waste production in the Bangkok area, while the tanning and chemical industries are major generators of hazardous waste in Samut Prakan province. In the Eastern Seaboard provinces, heavy metal sludge and solids are the largest contributors to the hazardous waste generated. These provinces (Chachoengsao, Chonburi, and Rayong) have an economic growth rate of 10%–11%, and out of a total of 2904 registered factories, 979 are potential generators of hazardous waste. These factories include a heavy industrial complex making use of natural gas to house large numbers of petrochemical, chemical, and nonferrous industries. The total hazardous waste generated in the region in 1993 was about 282639 tons, of which 209132 tons, or 74%, came from Chachoengsao province alone. Table 2 shows a conservative projection of the industrial hazardous waste quantities generated by industries in the three provinces.

Nonindustrial hazardous waste

A significant amount of hazardous waste in Thailand is generated from everyday activities in nonindustrial or community sources, such as automotive repair shops, gas stations, hospitals, farms, and households. Hazardous waste from community sources consists primarily of used oils, lead-acid and dry-cell batteries, cleaning chemicals, pesticides, medical wastes, solvents, and fuels.

In 1996, the PCD carried out a feasibility study on the collection and disposal systems for hazardous waste generated from communities in the Kingdom of Thailand.³ The estimated volume of nonindustrial (community-generated) hazardous wastes in 1996 and future projections are given in Table 3. It was further estimated that over 300 million kg/year were generated from communities, an amount which equals approximately 5.07 kg per person per year in the Kingdom (Table 4).

Transborder sources of hazardous waste

In the period 1990–1993, an estimated 4446 tons of hazardous waste entered Thailand in the form of raw waste (i.e., solids, sludge, slag) and spent consumer products (e.g., batteries) from Australia, the UK, and the USA. According

Table 3. Volume of community (nonindustrial) generated hazardous waste (CGHW) in Thailand, by category

Waste category	Total hazardous waste generated (tons/year)				
	1996	2002	2007	2012	2017
Toxic	147332	183581	213667	244042	274672
Ignitable	143221	185241	220419	255836	291462
Infectious	11191	14814	17858	20916	23997
Reactive	1347	1795	2170	2547	2928
Corrosive	259	345	418	491	564
Radioactive	31	41	50	58	66
Others	750	998	1206	1416	1627
Total	304131	386816	455787	525306	595316

Source: PCD, MOSTE

Table 4. Estimated community-generated hazardous waste (CGHW) quantity in 1996

Region	Estimated CGHW quantity, 1996 (million kg)	CGHW quantity per capital	
		Kg/capita-year	Kg/capita-day
Bangkok	94	13.28	0.036
Vicinity of Bangkok	18	5.43	0.015
Central	48	4.77	0.013
Northeast	66	3.25	0.009
North	43	3.88	0.011
South	35	4.35	0.012

Source: PCD, MOSTE

to the US Port Import–Export Research Service, Thailand received roughly 17.2 metric tons of plastic wastes from the United States.

The PCD documented steady increases in imports of asbestos throughout the 1980s. This is a building material which is banned in most industrialized countries. Between 1978 and 1992, imports of asbestos increased from 50690 tons to 128126 tons per year.

In 1989, Engineering Science et al.² put the volume of hazardous wastes stored at the Klong Toey port to be roughly 161937 kg, and estimated that approximately 0.27 million baht (US\$ 1.08 million) would be necessary properly to dispose of the waste dumped at the port. Unfortunately, no action was taken, and in 1991, an explosion ripped through the port, killing at least 21 people and causing chronic health problems for hundreds of people living in the vicinity.

Existing hazardous management practices in Thailand

Industrial hazardous management practices

The bulk of hazardous waste that is generated from small-scale factories is currently dumped into waterways and land-disposal sites, or stored with little or no previous treatment. Medium- and large-sized factories are usually equipped with treatment facilities, but most of these are inefficient and incapable of treating hazardous waste.

Industrial estates provide waste treatment facilities for their member factories, but none is known to have complete hazardous waste treatment facilities.¹

Because of the lack of hazardous waste treatment facilities in Thailand, in the early 1990s, the Ministry of Industry (MOI) strongly encouraged all factories classified as hazardous waste generators, according to the Ministry of Industry Announcement No. 25 (1988), to have on-site storage facilities where hazardous waste could be stored until treatment facilities were constructed. Many national and multinational firms in Thailand responded by storing waste at on-site landfills and in storage facilities. Unfortunately, however, reports of hazardous waste dumping on public land (i.e., in municipal landfills, or close to public parks) are not uncommon.

Treatment and disposal system

Owing to the severely limited hazardous waste treatment facilities, just one-tenth to one-twentieth of the waste generated in Thailand is treated.⁴ The DIW, Ministry of Industry, which is the government agency directly responsible for the management of hazardous wastes generated from industries, has established two industrial waste treatment service centers.

1. *Samae Dam, Bangkhuntian District, Bangkok*

This plant was established in 1988, as Thailand's first industrial hazardous waste treatment center, to provide a treatment service primarily for electroplating and textile industries located in Bangkok and the vicinity. The treatment methods include:

- physical-chemical treatment (primary wastewater);
- stabilization and landfill.

The capacity of this plant is 500m³ of liquid and solid hazardous waste per 8-h shift, or 100000 tons of liquid and 25000 tons of solids per year. The treated waste is disposed of at an 80-ha landfill site in Ratchaburi Province, 100km southwest of Bangkok.

2. *Map Ta Phut Plant, Rayong Province*

Genco is a joint venture company between the DIW and private companies. Genco was formed in 1994 to establish an integrated hazardous waste treatment facility to service the entire Kingdom. Essential treatment methodologies have three phases.

- Phase I: chemical stabilization, secure landfill, fuel blending for cement kilns.
- Phase II: physical-chemical treatment.
- Phase III: incinerator or thermal treatment.

The capacity is 500 tons/day, 125000 tons/year, and this will be expanded to 1000 tons/day in the near future.

However, the capacities of these treatment centers are still insufficient to process all existing hazardous wastes, and the DIW plans to establish three additional plants, to be located in the Chonburi, Saraburi, and Rayong Provinces, in the near future.

Waste recycling

At present, most of the waste recycling activities are on a small scale involving scavenging and low technology in the form of manual techniques for the physical separation and purification of recyclable materials (e.g., glass, metals, and other items in the municipal solid waste stream). Used lubrication oil and lead from waste batteries are also recycled. Recycling facilities for spent cleaning solvents using a distillation process are being developed. New initiatives are focused on developing an information exchange center in order to facilitate and promote the recycling of industrial hazardous wastes.

Disposal at sea

Thailand has not ratified MARPOL 73/78 owing to its lack of legislation and environmental pollution control measures. The disposal of wastes at sea is prohibited. It is suspected that the illegal dumping of wastes at sea in the Gulf of Thailand, both by unidentified vessels and by local ships, is taking place occasionally, but this has not been confirmed.

Waste minimization/pollution prevention

There are currently no waste minimization initiatives for hazardous waste. However, under the National Hazardous Waste Management Plan, the following measures have been implemented and encouraged:

- tax exemptions for the import or provision of facilities for the collection of recyclable waste;
- a progressive tax on the amount of waste to be disposed of;
- supporting finance and privileges for the establishment of waste recycling facilities;
- programs to improve understanding and awareness among waste producers.

Nonindustrial (community-generated) hazardous waste management practices

The PCD reports that at present there is little regulatory control of the movement of community-generated hazardous waste throughout the country. Community-generated hazardous waste (CGHW) management practices are broken down by waste category and waste generator type. The research data indicate that more than 70% of the hazardous waste generated by communities is reported as being separated from other wastes. The data also indicate that

Table 5. Distribution of disposal and reuse practices by waste category, nationally (kg/year)

Waste category	Estimated total quantity	Reuse	Co-disposal with MSW	Burning/medical waste incinerator	To environment	To sewer	Other
Ignitable organic wastes	20703846	7341080	6697026	4194	2323018	1714638	2623890
Recyclable waste oils	98974338	61083844	6841624	1594882	14490316	1517447	13446223
Nonrecyclable waste oils	23543151	11554177	5596881	12651	1454708	152286	4772447
Solid, acids, alkalis	110766	989	25510	15	35666	36117	12469
Liquid, acids, alkalis	148518	10616	40018	12136	6280	75691	3776
Reactive chemicals	1347075	11637	139858	44886	86061	1040037	24597
Explosive wastes	–	–	–	–	–	–	–
Solid, heavy metals	1954472	787582	986445	634	47127	13525	119160
Liquid, heavy metals	3881118	2886277	67828	2310	52986	506202	365514
PCBs	2105755	38869	1924237	1412	59227	849	81161
Misc. aqueous photochemical waste	1547977	148822	39430	592	324516	1015393	19225
Misc. toxic chemicals	30179123	958434	1769162	18916	4554466	21822927	1055217
Chlorinated organics from dry cleaning	319685	7165	233813	4925	20361	15665	37756
Coolants, engine coolants	2936416	184150	571560	–	227310	1568628	384768
Cooling tower sludges	8612	212	2516	–	1933	810	3142
Lead acid batteries	79575087	68772354	6370407	–	1129143	398251	2904931
Dry cell batteries	20717848	3555	19242749	1319	671421	208	798596
Fluorescent light bulbs	4106111	2367	2903423	3813	115601	13820	1067088
Infectious medical wastes	11190566	–	4097283	5246274	299639	854053	693316
Mixed wastes	31065	2068	9264	7601	4483	2657	4992
Refrigerants	100535	23679	8110	–	24263	26705	17777
Partially unreached chemicals	638795	360	134256	176250	34242	269525	24162
Returnable anesthetic gases	10362	355	7182	790	8	–	2026
Total	304131221	153818590	57708583	7133602	25962775	31045436	28462235

Source: PCD, MOSTE

MSW, municipal solid waste

more than 85% of the waste is reported to be stored in some type of container prior to discard. Only 2% of the waste is reported as being treated. Table 5 provides a breakdown, on a national basis, of the waste disposal and reuse practices employed, based on estimates made from the survey data, and broken down by waste category. It is encouraging to note that about 51% of community-generated hazardous waste is reused and recycled in Thailand. Approximately 57 million kg of waste per year of infectious, mixed (radioactive), and general hazardous waste is collected and codisposed with municipal solid waste, thereby rendering the nonhazardous waste at the municipal waste sites hazardous. Another 85 million kg of waste per year is discharged to the environment via open dumping, open burning, or dumping in surface water, discharged directly into the sewers, or other unspecified disposal methods. In addition, the 153 million kg of waste that is reused is recycled by parties other than the generators, and is either collected by the recycler at the source, or hauled by the generator to the recycler.

Some of the wastes can be reused, in particular waste oils, ignitable organic wastes, lead-acid batteries, and metals. According to the survey findings, most of the reuse of the wastes entails burning it for energy. Although this method is generally preferable to the disposal practices observed in Thailand, i.e., discharge into the environment or the sewers, it can nevertheless produce toxic emissions depending on the composition of the waste and the com-

bustion methods. Other reported methods of waste reuse include the application of used oil as a dust suppressant or herbicide, which can cause the contamination of soil, groundwater, or surface water, and potential human exposure to carcinogens (e.g., polychlorinated biphenyl (PCB)). In addition, used oil is reformulated illegally/improperly and reused as motor oil. This motor oil typically has high concentrations of heavy metals, which will not only cause the engine of a vehicle or piece of equipment to deteriorate, but also volatilize to the atmosphere and pose the potential inhalation of volatilized toxic heavy metals as a result. There are other methods of reusing wastes which are not considered to be environmentally problematic. Lead-acid batteries are reconditioned for automotive use, and are also salvaged for metal recovery. Used bleach and bleach-fix solutions from photographic processing are processed for metal (silver) recovery.

Problems and challenges to hazardous waste management in Thailand

Countries like Thailand, which are shifting from their traditional economy to a technology-based industrialized economy, are facing problems and challenges in managing both resources and wastes. These are numerous on the way

to achieving effective management of hazardous wastes. The key issues in Thailand for hazardous waste management are the environmental health implications of uncontrolled waste generation, improper waste separation and storage prior to collection, multiple waste handling, the poor standards of disposal practices, and the nonavailability of treatment/disposal facilities. The most influential issue is the scarcity of resources (skilled human as well as budgetary) in the country. The majority of the problems and challenges facing by Thailand in managing hazardous waste are discussed in this paper.

Generation and characteristics of hazardous waste

The availability of comprehensive and reliable data on the generation of hazardous waste in Thailand is still far from ideal. It is intrinsically difficult to obtain accurate data given the heavy reliance on industry for such information, and the fact that industries are not keen to make such information freely available, or are unaware that the waste they are generating is hazardous. In such a situation, one has to rely on estimated and projected data on hazardous waste generation for planning and development purposes. The quantity of hazardous waste generated in Thailand in 2001, as reported by the PCD, was 1.65 million tons, of which community-generated hazardous waste was 0.36 million tons and industrial hazardous waste was 1.29 million tons. Moreover, there is currently a steady increase in the generation of hazardous waste. The absence of a national definition of hazardous wastes has caused significant impediments to its proper management. Environmental quality standards for hazardous wastewater are too general, and the design of these standards has a number of conceptual shortcomings. In the absence of appropriate characterization, the ever-increasing quantity of hazardous waste is a challenge to proper handling and management practice in Thailand. In addition to the need to abate the liquid and solid hazardous waste problems generated by industries, emphasis must be given to dealing with the problem of community-generated hazardous waste. For instance, 22718 tons of waste from the dry-cell battery industry is produced in Thailand each year (PCD 1996).

Traffic in hazardous wastes, particularly from developed countries to Thailand where controls and standards are less strict, is a serious problem. The main factor driving this process is the economic gradient, which leads firms to search for the cheapest and easiest dumping grounds, and ship their waste to those developing countries, including Thailand, which have less strict environmental laws or inadequate enforcement of such laws. The major problems encountered in preventing the trafficking of hazardous waste are (a) the absence or inadequacy of facilities for wastes disposal, (b) legislative weaknesses, (c) ineffective institutional arrangements, and (d) lack of monitoring capabilities.

Treatment, processing, and disposal facilities

Although there are large numbers of industries generating hazardous waste, housed in a number of industrial estates, which are located in many provinces of Thailand, few industrial and hazardous waste treatment facilities have been established. These few are located in the areas surrounding Bangkok and the Eastern Seaboard provinces. The issue of waste treatment is complex, and needs comprehensive study. The selection of treatment technologies requires a great deal of waste characterization, and depends on affordability and the need for environmentally sound technology. Treatment facilities for textile and electroplating wastes have been constructed in the Bangkok area, where about 80% of the industrial waste being generated is from these two industrial sectors. Physicochemical treatments, chemical stabilization, and incineration techniques have been adopted for the industrial and hazardous waste produced in the Eastern Seaboard provinces, since those wastes frequently contain petrochemical ingredients and metal sludge. Incineration or the physicochemical treatment of industrial and hazardous waste is a more environmentally acceptable, but more costly, disposal system.

There are no established separation, storage, collection, and transportation systems, and no separate regulations for hazardous wastes generated from industrial or nonindustrial sectors. Therefore, these wastes find their way to public landfills, nearby dumpsites, or waterways, raising serious environmental concerns. In addition, there are insufficient hazardous waste collection, treatment, and disposal services for small-scale waste producers who do not have their own treatment facilities. Hazardous wastes from these sources are collected and disposed of with municipal wastes. Following the regulations brought in by the DIW to contain hazardous waste in secure sites, large stocks of hazardous or partially treated hazardous waste are stockpiled in the vicinity of industrial sites. These wastes must be disposed of appropriately. Failing to manage such wastes leads to groundwater pollution, resulting in a health hazard to the public, who use groundwater as the source of their domestic water supply and for irrigation.

Institutions and legislation

National-level institutions and legislation provide the basic infrastructure for the implementation of policies and actions for waste management. The PCD in MOSTE and the DIW are two national-level institutions which handle waste management. These institutions develop regulations for the efficient management of hazardous waste generated from the industrial and nonindustrial sectors. The enforcement of current regulations on hazardous waste in Thailand is very weak, for reasons including poor cooperation among government agencies, and the overlapping, and sometimes duplication, of legal authority and responsibility. Although many regulations have been developed for waste management in Thailand, the current legislation lacks adequate provisions for ensuring compliance and implementation.

The most effective way of controlling hazardous waste pollution in the nonindustrial or community sector is to strengthen local institutions. However, owing to various constraints, such as lack of skilled manpower, technical know-how, and funds, local institutions are not capable of taking the lead in waste management. Hazardous waste management is not achievable without proactive political commitment.

Resources, funding and public participation

In Thailand, a particular problem in establishing an environmentally sound system for the management of hazardous wastes is how to find the resources (personnel, technologies, etc.), and how to finance the development and operation of treatment and disposal facilities. There is a shortage of suitable resources (trained personnel, technical know-how, and funding) in hazardous waste management to effectively monitor and manage proper waste treatment and disposal. The lack of funds impedes implementation and enforcement. Although limited public funds are available, these are insufficient for the establishment of central treatment facilities. There is a need to attract private sector or international lending agencies to finance these facilities.

The almost complete lack of public participation in the development of projects creates huge problems during implementation. The basic problem lies in information dissemination and public awareness campaigns. As an example, the siting of central treatment facilities is usually opposed by local people who fear potentially adverse environmental and health effects. This reaction has caused delay or abandonment in the planning of waste treatment facilities.

Future strategies for hazardous waste handling and management in Thailand

Although there are problems with hazardous waste management in Thailand, these problems could be minimized by analyzing the present situation and management practices and changing direction in the future (if necessary), thus enhancing pollution abatement and ensuring a healthy and sustainable society. Some appropriate strategies are outlined below.

Legislation, regulation, and standards

Thailand needs a coordinated approach to the enforcement of laws and standards among regulatory agencies, thus avoiding duplication, overlapping, and inconsistency in government policy regarding waste management. To make hazardous waste management in communities really effective, local-level institutions must be strengthened by building their capacities. The present regulations also need further amendment, including:

- amend and elucidate the regulation of waste management, including the direction, separation, storage, transportation, and disposal of the waste;
- enforce the Manifest regulation to control hazardous waste transformation;
- enforce the separation of hazardous waste from municipal wastes, and push to establish centers of excellence.

Treatment, processing, and disposal

In Thailand, the fundamental hurdle to be overcome in order to achieve effective hazardous waste management is the lack of facilities to separate hazardous waste from municipal waste. Once the hazardous waste stream is separated from municipal or community waste, treatment requirements become focused, since the quantity and type generated, whether liquid or solid, can then be defined.

The future strategy must firmly establish the principle of waste minimization by promoting clean technology. Waste minimization consists of source reduction, reuse, and recycling. Source reduction means any activity that reduces the generation of waste at the source, usually through changes in operational and maintenance practices, process optimization and/or modification, or product redesign. Reuse involves the use of potential waste as raw materials, and recycling means reprocessing and resale.

The practices of reuse and recycle observed in community-generated hazardous waste management must be strengthened and extended to other sectors. Future strategies must emphasize the adoption of “zero discharge” treatment technologies instead of “end of pipe” technologies in the industries generating hazardous waste.

Integrated approach to hazardous waste management

To achieve appropriate and sustainable hazardous waste management, the efforts of all the stakeholders must be integrated. A conceptual model of this approach is shown in Fig. 1. It is proposed that the government sector (national-level authority and local-level authority) should act as a facilitator to speed up the development of hazardous waste management systems and to ensure the proper enforcement of the regulatory framework. The government should also seek sources of funding.

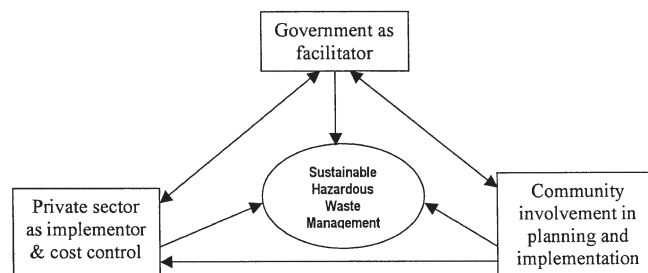


Fig. 1. Conceptual model for an integrated approach to hazardous waste management

A powerful means of improving efficiency is to involve the private sector in the delivery of hazardous waste management services. The main reasons for the involvement of the private sector are to reduce the cost of public services to consumers, to improve the quality of the service, to increase entrepreneurship, to innovate and adopt new technology, to avoid interruptions to the service, and to be responsive to cost control.

The existing practices of CGHW reuse and recycling in Thailand obviously show the importance of public involvement. However, public awareness programs about waste minimization and appropriate waste management must be promoted effectively. Public involvement must be considered as part of the process in all phases of development in future strategies.

Conclusion

In conclusion, in Thailand, the amount of hazardous waste is increasing rapidly due to the expansion and upgrading of its industrial base. At present, there is a relatively weak hazardous waste management system, with inadequate treatment and disposal facilities. The potential hazards arising from the waste problem can be minimized or eliminated through proper management practices. The steps needed toward solving the problems of sustainable waste management should be dealt with in the following order: waste avoidance and waste reduction; recycling; the establishment of environmentally appropriate disposal of residual waste substances; the minimization of pollution and costs pro-

duced by waste management processes. The government should recognize the importance of the public in decision-making, and make efforts to encourage public participation in the early stages of planning for hazardous waste treatment projects. The public will then become allies of government in the monumental task of hazardous waste management and the protection of the environment in Thailand.

Acknowledgments The authors would like to thank the Pollution Control Department, Ministry of Science, Technology and Environment, the Public Cleansing Department, Bangkok Metropolitan Authority, and Genco for their assistance in providing valuable information.

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