

## **Overview of Waste Management Performance of Industrial Sectors by Selected Asian Countries: Current Practices and Issues**

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**Abstract.** Economic development in line with improvement life style is the ultimate purpose in a modern society. Most low-income and developing Asian countries are facing a number of challenges with respect to sustainable waste managing from their industrial activities. On the other hand, these countries aim to be industrialized and consequently, generate huge industrial solid wastes with an increasing trend. Land fill disposal is the most practiced method for handling industrial solid wastes among Asian countries. It was pointed out that illegal industrial waste disposal has increased sharply due to the land scarcity. Meanwhile, there is less attention to practicing waste minimization as a sustainable and effective strategy for controlling industrial solid wastes in developing Asian countries. The lack of significant factor such as strict regulation and strong enforcement, awareness and knowledge, enough funding, technology and skilled manpower are found as the main hindrances to sustainable industrial waste management among Asian countries. This paper is a mini review paper that aimed to compare the current practicing of different waste management options by industries in Asian countries by highlighting challenges and approaches in sustainable solid waste management.

**Keywords:** asian countries, waste minimization, industrial wastes, landfill disposal, sustainable waste management, hindrances

### **1. Introduction**

Many countries are engaged in industrialization producing goods and providing people's needs. This trend also plays an important role in changing lifestyle from rural to urban [1]. However, the negative consequences of huge industrial waste generation wastes on the environment and natural resources cannot be ignored [2]. In order to deal with this increasing trend of industrial waste generation sustainable waste management strategies need to be developed [3]. Improvement of the environmental quality considering the socioeconomic enhancement is the major goal of sustainable development [4]. Sustainable industrial activities should be efficient at using resources, and modify production of goods and services with less negative effects on environment, society and economy [5].

Most Asian countries have been facing rapid population growth in line with social and economic enhancement over the past 50 years [6]. Singapore as a developed and high-income country had a

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remarkable growth of manufacturing industrial activities by approaching of green industries [7]. Similarly, Japan and South Korea have achieved a successful growth in sustainable waste management. Nevertheless, other developing Asian countries such as Malaysia, Thailand, India, China, and Indonesia have not shown considerable improvements in sustainable waste management among industrial sectors [8]-[10]. This paper aimed to assess and compare different options of waste management hierarchy practiced by industries in selected Asian countries. Moreover, barriers of sustainable industrial solid waste management was highlighted by taking into account the current practices and challenges of developing Asian countries for handling their industrial wastes.

## 2. Industrial Solid Waste Generation and Composition

Due to dramatic economic growth and industrialization, many Asian countries are facing an increasing trend of industrial waste generation [11]. There are two categories of industrial wastes, is composed of hazardous industrial wastes with toxic characteristics and hazardous substances and other is comprised of solid wastes that include wastes other than hazardous industrial wastes [12]. Hazardous wastes from industries remain as the main drawbacks of industrialization because of their acute impacts on human' health and environment when they are not managed properly [13].

Hotta estimated that approximately 2000 of industrial wastes were generated in the Southeast Asia which shows a tremendous increase [14]. A huge amount of hazardous industrial wastes are generated in China due to rapid economic growth. It was reported that about 12 million tons of industrial hazardous wastes generated by 2005 come from china representing serious environmental challenges [13]. Taiwan and Thailand as two Asian countries with high load of industrial pollution generate approximately 18 million tons of industrial wastes each year [15]. In Singapore, the waste generation trend was predicted to show considerable decrease due to well-developed sustainable industrial waste management [11]. In Malaysia, about 3500 metric tons of wastes are generated daily from both household and industrial sectors [1]. The classifications of different types of industrial wastes help in to access proper options for developing efficient methods of sustainable industrial waste management. Based on the nature of the raw materials, industrial solid wastes are classified into putrescible and non-putrescible wastes [16]. In India, wastes from industrial activities include paper and cardboard, plastic, metal and other non-hazardous and hazardous wastes [17]. By the year 2007, dominant industrial solid were generally comprised of 31% iron, 24.54% plastic and 25% paper wastes in Thailand [15]. Singapore and Malaysia are two industrialized countries in South East Asia that generate high rates of industrial wastes from basic metal, tobacco, wood and paper products [11]. Inanc predicted that the total solid waste generation will reach to approximately 1 million tons daily by among Asian countries by the year 2025 [18]. Accordingly, Table1 shows the types of industrial solid and non-hazardous wastes generated by some main industrial activities. It includes all types of recyclable wastes such as plastic, paper and glass, scraped metal, boxes, and wood, rubber and textile wastes.

Table 1: Industrial solid and Non-hazardous wastes composition generated by industries in Malaysia

NO	Industrial types	Waste composition
1	Electrical and Electronic	Plastic, Paper, steel, glass, scrap metal, box and wood
2	Non-metallic and Mineral	Glass, wood, paper, metal, box
3	Basic Metal	Metal(iron, copper, aluminum),box, glass, paper and plastic
4	Food and Beverage	Paper, box and plastic
5	Medical device	Box, glass and plastic
6	Textile and apparel	Textile, paper
7	Chemical	Metal, glass, wood, paper, plastic and box
8	Wood	Wood, paper
9	Labeling and packaging	Plastic, paper
10	Rubber	Paper, box, plastic and rubber wastes
11	Machinery and equipment	Paper, metal

Source: [19]

### 2.1. Sustainable Industrial Waste Management

Based on the Brundtland commission report in 1987, sustainable development was described as “the development which meets the needs of the present without compromising the ability of the future generation to meet their own needs” [20].

Among Asian countries; Japan, Taiwan and Singapore have improved their waste management systems toward more sustainable approaches with less landfill disposal and more minimization [6]. In 2005, waste minimization strategy as 3R policies was launched in Japan. The purpose of 3R initiative was to promote 3R activities which include Reduction, reuse and recycling [21]. The concept of 3R has been introduced as the most appropriate strategy that adopted for managing industrial wastes. It consists of Reduction, Reuse and Recycle of wastes located at the highest level of waste management hierarchy. Waste minimization has higher preferences with more embedded energy conservations followed by reuse and recycling. Landfill disposal is located at the lower level of the waste management hierarchy followed by energy recovery, recycle, reuse and waste minimization. Currently, landfill disposal as a method with the lowest desirability is practiced by most Asian developing countries. Fig. 1 illustrates the common practices of waste management in developing countries [8], [22]. As shown in Fig. 1 waste minimizations have higher desirability compared to reuse, recycle and disposal [8].

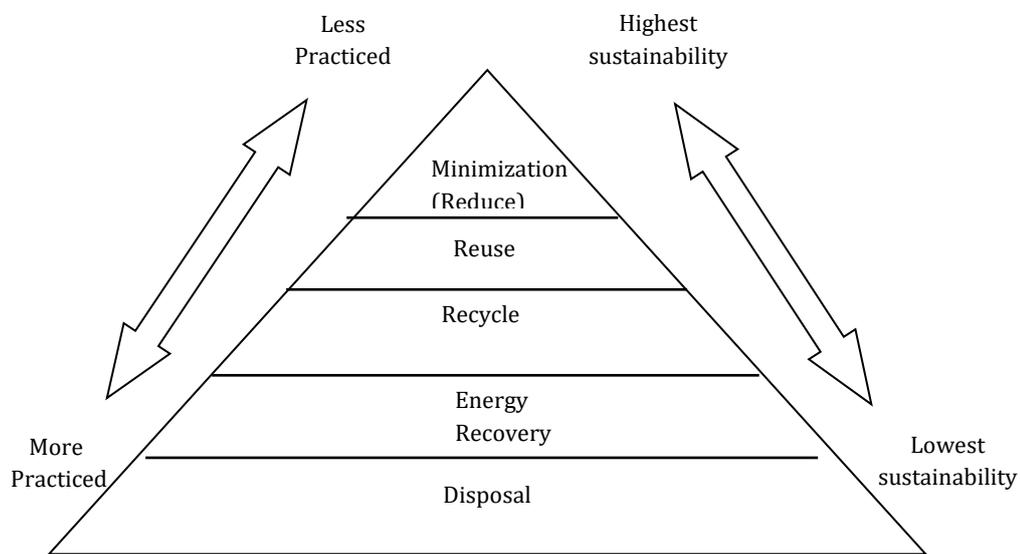


Fig. 1: Waste Management Hierarchy

### 3. Waste Minimization (Source Reduction and Reuse) by Industries

Waste minimization can be defined as any environmental exercises to remove the waste at the point of generation. Waste minimization has been placed at the top level of waste management hierarchy [23]. Since 1992, waste minimization has been recognized as a fundamental component of industries and business entities in the U.K, leading to a considerable decrease in wastes among industrial sectors through the establishment of waste minimization clubs [24], [25]. Waste minimization enhances the sustainability of waste management by manufacturing industries [26]. According to many conducted studies, cost reductions, improvement of the company image and profitability have been achieved by the industries that applied source reduction [27]-[29]. Source reduction and recycling techniques are two main techniques of waste minimization that applied by widely industries. Waste minimization methods can be achieved by equipment or technology modification, process modification, feed stock substitution, housekeeping practice, redesign products and recycling within process [30], [31].

Yang argued that source reduction by manufacturing firms can be carried out through production modification and changing the production system to minimize non-value added activities and wastes [29]. Similarly, Predue stated that source reduction includes the equipment or technology modification, process modification, reformulation or redesign of products, substitution of raw materials and improvement to housekeeping, maintenance, training and inventory control [32]. Previous studies have proven that waste reduction strategies applied by some Asian countries such as Malaysia, Bangladesh, Indonesia, Thailand and

Vietnam were not as successful as those applied by Japan, Singapore and Korea [8]. Industrial waste minimization and elimination of wastes generated by manufacturing activities have been aggressively improving through process innovation in Singapore [7]. Taiwan targeted 86% industrial waste minimization by the year 2020 [33]. Hu and Hsu argued that sustainable waste management has been implemented among the majority of Electrical and Electronic manufacturing industries in Taiwan [34].

#### 4. Recycling Practiced by Industrial Activities

Waste recycling is a well-known sustainable option of waste managing followed by source reduction. This method has both economic and environmental benefits by cutting down on the costs of disposal and mitigating the destructive effects of landfill sites [35]. In contrast to developing Asian countries, developed countries have conducted many researches regarding industrial waste recycling and its applications [36]. Singapore achieved great results by controlling wastes via increasing the recycling rate up to 54 % in 2000. In 2007, approximately 14000 tons of scraped metal was recovered into steel products in Singapore [37]. It was estimated that from 2.63 million tonnes of industrial wastes disposed in Singapore in the year 2008, about 60 % was recycled [38]. Taiwan has promoted recycling of both hazardous and non-hazardous industrial wastes. Approximately 75% of industrial wastes were recycled by the end of year 2006 in Taiwan [33]. China has aimed to increase the recycling rate of discarded automobile products up to 95 % by the year 2020. However it was reported that recycling of solid wastes in China was performed by informal sectors due to minor government initiatives [7].

In Malaysia, an overall 22% recycling rate was targeted for the year 2020. Despite apparent attempts, the current recycling rate has not shown any successful improvements in Malaysia [39]. Recently the recycling rate in Thailand was recorded at 24%, while the remaining 76% of wastes were sent for disposal [10]. Duan reported that approximately 44% of industrial hazardous wastes have been recycled by 2005 in Thailand and only 23% of industrial wastes were sent for sanitary disposal [40]. Figure 2 compares the rate of recycling of total solid wastes among Asian developing and developed countries in 2012. As shown in Figure 2, Honk Kong, Singapore and South Korea had the highest recycling rate (50%), while Malaysia had the lowest ( 5 -7 %) [41].

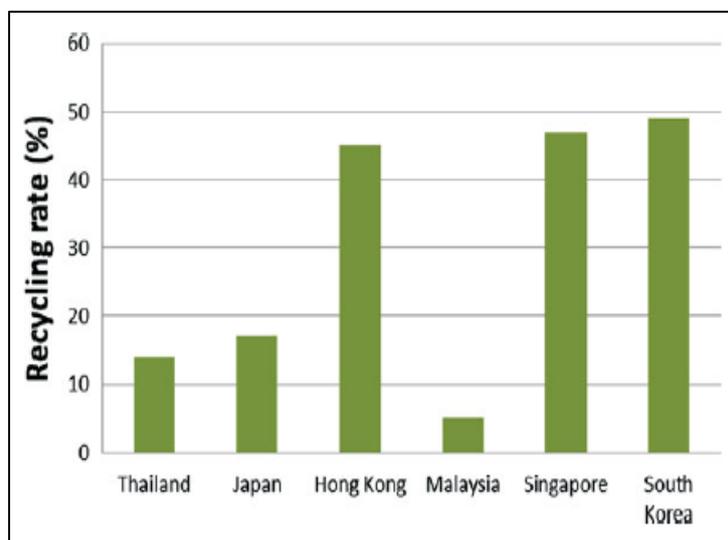


Fig. 2: Recycling rate in some Asian countries in 2012 Source: [8]

#### 5. Disposal of Industrial Solid Wastes as the Least Desirable Method

Landfill disposal still remains as the main option for handling industrial wastes in both developing and developed countries [42]. However, landfill disposal has been used as the least priority among many developed countries. For instance, Hong Kong as an Asian developed country has utilized new strategies to minimize the quantity of wastes sent to landfill sites through thermal treatment since 2005 [43]. In the early 1990, landfill disposal was a common method in Taiwan. However, applying landfill disposal of solid wastes has shown a significant decline in Taiwan since 2003[33].

In Thailand, landfill disposal is the main option for handling industrial wastes. However landfill sites are not well engineered up to the standard levels leading to acute impacts on human' health [10]. In India most types of industrial wastes were sent for landfill disposal without any source segregation [44]. Currently in Malaysia 95% of wastes from industrial activities are sent to landfill disposal, while the remaining 5% of wastes are minimized [39], [45]. This contradicts the target of 22 % recycling by the year 2020 in line with industrial growth [46]. Landfill disposal as the most common method for handling industrial wastes is not established according to the standards due to high cost of implementation giving rise to the illegal disposal activity. It has been reported that approximately 33% of industrial wastes are dumped illegally in Malaysia [47]. Based on the Department of Environment' report (DOE); sanitary landfill is the most common methods for handling of hazardous wastes generated from industrial activities in Malaysia [48]. Table 2 shows disposal method of some types of hazardous wastes from industrial activities. As represented in the table sanitary landfill is the most practical method.

Table 2: Generating scheduled hazardous wastes managed under special management in Malaysia

Waste types	Waste code	Source	Quantity (Metric Tons)	Methods of disposal
Heavy metal sludge	SW204	Industry	107,958	Sanitary landfill
Fly Ash and Bottom Ash	SW104	Industry	17,496	Reuse as raw material for product
Gypsum	SW205	Industry	81,382	Sanitary landfill
Discarded pharmaceutical wastes , discarded products	SW405, 429	industry	60.757	Sanitary landfill
Ash of paper sludge	SW406	industry	3,277	Sanitary landfill

Source: [48].

## 6. Challenges and Barriers in Managing Industrial Wastes

In the high-income Asian countries such as Singapore, most issues in handling of solid waste generation were solved by utilizing new waste management strategies. However, waste management remained as one of the biggest challenges among low-income Asian countries [11]. There have not been many studies focused on the specific barriers to sustainable waste management among manufacturing industries in developing Asian countries [49]. In general, all developing Asian countries face certain multiple challenges for managing their industrial solid wastes according to the sustainability principals [50].The followings are the main and common hindrances to industrial solid waste management among Asian countries.

### 6.1. Lack of Clear Policy and Institutional Factors

In many Asian countries, there are rarely specific regulations focused on industrial solid waste management such as Malaysia, Thailand and Indonesia [8]. Chung reported that local authorities responsible for solid waste management in developing countries have been facing lack of organizational capacities and expert knowledge [51]. It was further noted by Jiayuan that without strict regulations and enforcements, source segregation of wastes cannot be operated [52]. Simpson argued that policy instruments played a fundamental role in encouraging waste reduction among industries in India [53]. Both India and China faced serious deficiency of specific waste minimization policy for handling electrical wastes in 2006 [54], [55]. However, some developments have been led within the recent years with respect to the regulatory frame works of E-wastes [8]. Zhue revealed that there are no strict regulations and enforcement to force industries to implement environmentally friendly policies in India [56]. Luken and Van Rompaey have found that high production cost and ineffective environmental regulations are the main barriers to implementing cleaner production technologies among some manufacturing industries in China and Thailand [57].

### 6.2. Financial Constraint

Financial factors are effective in practicing waste minimization by industries [58]. Due to lack of financial factors including incentives and unwillingness to pay, relevant stakeholders have failed to control solid waste management in most developing Asian countries [59]. Zhue and Geng suggested that financial barriers were the main hindrance among manufacturing industry for implementing cleaner production [60]. Financial constraints in China were realized as the main obstacle to manage industrial solid wastes properly

[7]. According to the MHLG report, lacks of financial resources in Malaysia prevent industries from applying new technologies for sustainable waste management [61]. It was reported that there is inadequate funding allocated for industries for adoption cleaner production technologies in Malaysia [62]. In India industries lack well established waste management system and are incapable of employing expertise and manpower due to financial limitations [63]. In Thailand, lack of financial resources is the core issue for implementing environmental management system and green purchasing among firms [64].

### **6.3. Lack of Environmental Awareness and Source of Information**

Accurate data and information plays an effective role in choosing appropriate options for managing industrial wastes [65]. Inadequate information regarding the value of industrial wastes among manufactures, hamper industries to practice waste minimization [66]. Most Asian developing countries are dealing with absence of accurate data and documents on industrial solid waste generation and composition. By contrast, developed Asian countries such as Japan, Hong Kong and Singapore have a reliable database regarding industrial solid waste generation trend and composition [6]. Lack of basic data and information regarding the waste generation and composition are one of main hindrance to sustainable strategies of waste management in Malaysia [39].

Lack of knowledge and concerned attitude toward environmental problems affect the waste minimization behavior among industries [67]. Manaf argued that the awareness toward waste recycling is poor among some Asian countries [39]. Stakeholders' education plays an important role in successful waste management. In Malaysia, environmental awareness is not adequate enough to eliminate the waste management issues [42]. In India, lack of environmental knowledge regarding the legislative frameworks has caused ignorance of negative impacts of manufacturing activities on the environment [68]. Lack of awareness about cost savings opportunities to practice waste minimization by industries has been realized among some managers in India [69]. Krambia have proven that lack of knowledge about environmental management among employees is a preventive factor for sustainable waste management in pulp and paper industries in Thailand [70].

### **6.4. Lack of Technology and Technical Expertise**

One of the main concerns with implementing environmental practices among industries in Asian developing countries is lack of human resource capabilities such as lack of expertise and skillful employees [71]. Sarkis found training of human resources as the most effective factor in improvement of environmental practices by industries [72]. Luken conducted a study among manufacturing industries in Asian developing countries. Based on his finding, lack of expertise is one of the most important hindrances to implement waste minimization [57].

Most developing Asian countries are dealing with technological aspects for managing their industrial wastes [73]. According to other studies, technology barriers can be categorized into lack of technology modification, old production process, and lack of proper inventory management techniques, lack of equipment modification technology, and lack of material and product modification technology [32], [57], [74]. Among Asian developed and developing countries, countries with less financial issues spend more money on industrial waste handling technologies [6]. Due to lack of effective environmental measures and fear of failure at adopting new technologies in India, refraining from use of new technologies have become one of the main obstacles among manufacturers [75], [76]. Junjun revealed that recycling industries in China are required to adopt more supportive technologies for enhancing recycling activities [77]. Similarly in Malaysia, lack of technology is hindrances to practice waste minimization by industries. Lack of information and technical skills hampered manufacturing industries in Thailand to implement environmentally sound technologies [57]. Lack of technology for rock wool recycling was highlighted by Usapein among chemical industries in Thailand [10].

## **7. Conclusions**

This paper attempts to highlight issues on sustainable industrial waste management and compare industrial waste management strategies applied by different Asian countries. Most of studies conducted with respect to 3Rs and sustainable waste management activities focused more on municipal solid wastes. Presumably, there are minor literatures dedicated to sustainable industrial waste management among Asian

countries. Industrial activities have increased drastically in many Asian countries in the past few decades. Despite the fact that environmental issues are a serious matter of concern in the region, there have not been appropriate efforts in order to move toward sustainability, especially within industrial organization in most Asian developing countries. In order to dealing with these issues more effective measures need to be taken by setting objectives and holistic perspective for sustainable industrial waste management among Asian developing and low-income countries.

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