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Solid Waste Management in Asian Developing Countries: Challenges and Opportunities

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ABSTRACT

In developing countries the rapid population, industrialization, urbanization and growth of economic contribute to increasing solid waste (SW) generation. This paper reviews the existing management of SW and the current problem of collection, transportation and disposal processes in Asian developing countries. We provide alternative solutions. SW generation is between 0.4-1.62 kg/capita/day; the composition of biodegradable organic waste in is range of 42 to 80.2%. The trend of plastic waste continues to increase. The common problems are: no separation at source, complicated collection processes, open dumped landfill, and no control of gas emissions and leachate in landfill. Classification of developing countries was based on World Bank criteria. This paper were reviewing the existing condition and current problems of solid waste management (SWM) in Asian developing countries, and finding out the alternative solutions to reduce the waste generation. Solid waste management (SWM) was assessed by mean of technical and social approaches. It was found that SWM was country specific, and decentralization is the most appropriate management approach.
Key words: solid waste management; Asian developing countries; technical and social approaches

INTRODUCTION

Asian developing countries have increased their population, urbanization and industrialization which contribute to solid waste (SW) generation. For example, in India it was between 0.2 kg/capita/day and 0.5 kg/capita/day with 217 million people [1]. Most of SW composition in the cities of developing countries is biodegradable organics. For examples, it was 65% in Jakarta [2] and 72.41% in Surabaya [3]. Whereas, in the Asian developed countries, such as in Japan, Singapore, Taiwan, and South Korea, these values were generally less than 45% [4]. The World Bank [5] classified countries in the world based on Gross National Income (GNI) per capita. The classification of countries were low income (GNI of $1,005 or less); lower middle income (GNI of $1,006 - $3,975); upper middle income (GNI of $3,976 - $12,275); and high income country (GNI of $12,276 or more). Some developing countries in Asia, such as Sri Lanka, India, Bangladesh, Pakistan, Afghanistan, Thailand, Malaysia, Indonesia, Vietnam, Iran, and Nepal, were commonly in the range of low-income to lower middle income.

Developing countries in Asia have the same existing conditions. The SW generation was high, because of the population and the main component of SW is decomposable organic. For examples, the decomposable organic was 61.5% in Malaysia [6], and in Indonesia of 68.12% [7] to 72.41% [3]. On the other hand, the common problems are lack of collection coverage [8], and open dumped landfill as the final disposal method. This disposal method gave the environmental pollution, such as the pollution of soil, surface and groundwater caused by leachate [9] and GHGs emission caused by the waste decomposition process [10]. The main objective of this paper is to review the condition and current problems of solid waste management (SWM) in Asian developing countries, and to find out alternative solutions to reduce the waste generation.

EXISTING SWM

SW generation and composition

Asian developing countries are experiencing in increasing population, income and urban growth. This situation contributes to the increase of SW volume and type. Most of municipal solid waste comes from residential areas, commerce and other sources [4]. Description of sources and types of SW in Southeast Asian countries is shown in Table 1.

SW generation rate in cities of developing countries is complex. In some cities of India, the SW generation rate in Delhi was about 7000 tonnes/day in 2007 and approximately 17000-25000 tons/day by the year 2011 [11]. In Puducherry, it rose from 265 tons/day in 2003 to 370 tons/day in 2008 [12], Hazra and Goel [13] mentioned that Kolkata generated SW of about 2920 tons/day. These problems also occur in Indonesia,

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such as in Surabaya, of which total SW generation was 2160 tons/day [3]. In Makassar, Indonesia, SW was generated about 830 tons/day with a population of 1.13 million, or 0.73 kg/capita/day [14].

Table 1: Sources and Types of Municipal Solid Waste in Southeast Asia

Sources	Typical waste generators	Types of solid waste
Domestics	Single houses and apartments	Food scraps, paper, corrugated boxes, plastics, clothing, glass, metals, ashes, and domestic hazardous wastes
Shopping and commercial areas	Shopping centers, hotels, restaurants, markets, offices	Paper, corrugated boxes, plastics, wood, food scraps, glass, metals, special wastes, hazardous wastes
Institutional	Schools, government offices, medical-care center, prisons	As mentioned above in shopping and commercial areas
Public facilities	Street cleaning, landscaping, parks, beaches, recreational areas	Street cleanings, landscape and yard trimmings, general wastes from recreational areas

Source: adapted from UNEP [15] and Tchobanoglous et al., [16]

SW generation and its composition in some Asian developing countries are shown in Table 2. The main component of SW is decomposable organic waste which has a range of 42% to 80.2%. Other SW components, which appear in less portion, are paper, plastic, cloth, metals, glass, ash and others. In Puducherry, India [12], Kuala Lumpur, Malaysia [17] and Dhaka, Bangladesh [18], the second component of waste is paper, followed by plastic. The remains are textile, glass, metal, rubber and leather, and others.

Trend of solid waste generation shows an increase in the composition of plastics waste. Plastic is polymer from the synthetic or semi-synthetic organic that can be molded. Plastic solid waste (PSW) is categorized into seven groups, namely: (1) polyethylene terephtahalate (PETE), (2) high-density polyethylene (HDPE), (3) polyvinyl chloride (PVC), (4) low-density polyethylene (LDPE), (5) polypropylene (PP), (6) polystyrene (PS), and (7) others [16]. Trihadiningrum et al. [19] found that the average percentage of PSW rose to 14.72%. As stated by Mutha et al. [20], plastic waste in India has risen from 0.7% in 1971 to 4% in 1995. In Malaysia, PSW multiplied from 5.27% in 1995 to 11.45% in 2000 [17]. Moghadam et al. [21] also mentioned that plastic had significant increased from 3.2% in 1998 to 9% in 2007. The significant rising growth of PSW came from the changing of life-style. Recently, all food packaging, bottles, glasses and other wrapping are from plastics, which PSW gives other consequences in SWM.

Table 2 SW generation and composition in cities of Asian developing countries

City (Country)	Waste generation		Composition (in percentage)									
	Tons/ day	Kg/cap. day	Decomposable organic	Paper	Plastics	Textile	Glass	Metals	Rubber/ leather	Wood	Ash	Others
Surabaya (Indonesia)[3]	2160	0.8	72.41	7.26	10.09	2.68	1.7	1.41	0.46	2.39	1.48	0.12
Jakarta (Indonesia)[7]	6000[22]	0.65	68.12	10.11	11.08	2.45	1.63	1.90	0.55	NA	NA	4.12
Allahabad (India)[23]	500[a]	0.4	45.3	3.6	2.86	2.22	0.73	2.54	41.66[b]	-	-	-
Puducherry (India)[12]	370	0.59	42	30	10.4	4.5	5	4.1	2.5	1.5	NA	NA
Kathmandu (Nepal)[24]	523.8	0.66	71	7.5	12	0.9	1.3	0.5	0.3	NA	NA	6.7[c]
Bangkok (Thailand)[25]	8778	1.54	42.68	12.09	10.88	4.68	6.63	3.54	2.57	6.9	NA	10.04
Phuket (Thailand)[26]	364	2.17	49.39	14.74	15.08	2.07	9.67	3.44	2.28	NA	NA	3.33
Yala (Thailand)[27]	80	1.049	49.3	14.5[e]	19.9[f]	-	10.08	0.4	-	5.1	NA	NA
K. Lumpur (Malaysia)[17]	3798.9	1.62	61.5	16.5	15.3	1.3	1.2	0.25	0.6	0.4	0.7	NA
Rasht (Iran)[21]	420[f]	0.8[g]	80.2	8.7	9[h]	0.4	0.2	0.7	-	0.4	NA	0.4
Dhaka (Bangladesh)[18]	5340	0.485	68.3	10.7	4.3	2.2[i]	0.7	2.0	1.4	-	NA	10.4

Note: NA = not available, the author did not mention the quantity
Decomposable organic includes food waste
[a] Allahabad Municipal Corporation (2003) cited in [22]
[b] includes plastic and rubber
[c] others contains of construction and demolition (C&D) waste, hazardous waste, and other waste
[d] includes ceramic and other
[e] includes paper and textile
[f] includes plastics and rubber
[g] Technical report, OWRCMR (2007) and Recycling organization of Rasht Municipality (2007) cited in [14]
[h] includes textile and wood
[i] includes wood, rubber, leather, ash and others

Collection and transportation of SW

In Asian developing countries, SW cycles through collection, transport and final disposal. In Jakarta only 70% waste was collected [2]. The SW collection process is a complicated task in many places. For example, in Rasht City, Iran, the odor and leachate were emitted from decomposition of decomposable organic in SW. On the other side, mechanical equipment is inadequate and manual collection is more implemented for picking up the SW [21]. The problems of SW collection can be caused by no transfer station facility in Tibet [28]. The collection service in developing countries was conducted door-to door, such as in Jakarta [2], in metro cities in India [29], and in Bangalore [30].

Transportation of SW is the other problem in SWM. Kardono [7] stated that the environmental issue of SWM in Jakarta also involved limited application of appropriate method. There was scarcity of SW transfer facility and low collection-transportation service. The other difficulty in transportation of SW are the aging of waste transport vehicles and the condition of streets in Sri Lanka [31], and weakness in organization structures, and collection method in Yangon, Myanmar [32].

Final disposal and treatment

UNEP [15] stated that methods for final SW treatment and disposal in developing Southeast Asian countries were commonly open dumping, landfill and others. These proportions were open dumping (more than 50%), landfill (10-30%), incineration (2-5%), and composting (less than 15%). The final disposal method is generally open dumped landfill. In Malaysia the amount of SW collected for final disposal, was about 70%, whereas 20-30% was dumped or thrown into river [9]. In Bandung, the collected municipal SW was 60%, and the rest was dumped on the roadside, drainage and river [8]. Almost similar conditions were found in Malaysia, landfill was the only method for disposal [6]. In Indonesia, the transported SW to landfill was 69%, buried 9.6%, composted 7.15%, burnt 4.8%, disposed to river 2.9% and others 6.55% [33]. The Southern Province of Sri Lanka also conducted the final disposal in open dump 22 sites, and composting only 1 site of the 57 sites [31].

Composting is one of the treatments for solid waste, which more suitable than other treatment in Asian developing countries such as incinerator [34]. The most composition of SW in those countries is decomposable organic, which has high moisture content. The constraints of composting in Asian developing countries included high cost in operation and maintenance, and weak in maintenance and operation of facilities, incomplete separation of non-compostable materials. Besides, as well as higher cost of compost compare to commercial fertilizers, also affect the implementation of composting [15]. On the contrary, SWM in Asian developing countries is less financial resource, and low enforcement of environmental regulation [35]. As the problem of composting, composting is applied in India only 10-12%, and other countries like Nepal, Pakistan, Bangladesh and Sri Lanka less than 10% [36].

The Informal Sectors in SWM

The informal sector, which involved scavengers or waste pickers, waste collectors and waste agents play the main role in SW recycling in low-income countries, such as in Bangladesh [37], and in Indonesia [22]. For example, used paper is collected by garbage collectors and recycled by the pulp industry. It contributes to waste reduction from 1% to 10% of total waste in Indonesia [22]. The scavengers also had role in reducing SW in Iran [21], In lower middle-income countries like Thailand, the poor communities contributed to reducing solid waste by exchanging the recyclable material for egg. This was not only the activities of exchanging for egg, but also empowering the poor community in decreasing the trash. Egg was as an exchanger mean because it has economical, nutrition and social value [27]. Figure 1 shows the informal sector role in SW recycling in Surabaya City, Indonesia.

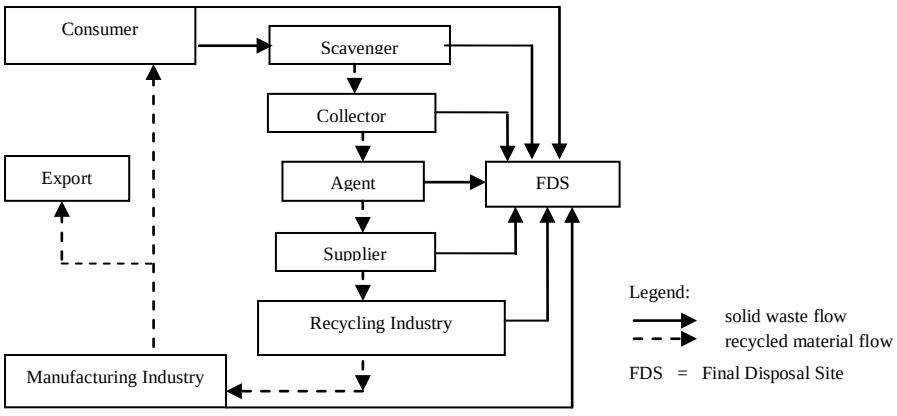

Figure 1. Informal sector role in municipal SW reduction [19]

ALTERNATIVE SOLUTIONS IN SWM

SW generation in Asian developing countries shows an increase in plastic components. Another problem is the dominance of biodegradable organic waste (more than 40% of total weight), which is potential to emit greenhouse gases (GHGs). Therefore, appropriate strategies should be determined for solving these problems.

Changing of the public behavior

The improvement in living standards has changed life style and SW composition. In high-income residential areas in some developing countries recyclable material (i.e. plastics, metal, glass and others) tend to increase, because of the consumption of more packaged products.

Following are some alternative solutions which have been successfully implemented in Surabaya and Medan, Indonesia. In these cities public awareness was improved after receiving guidance concerning environmental issues. The trainers were from local leaders and facilitators with the assistance of Non-Government Organizations (NGOs). This program was performed as community based SWM [38]. The program successfully applied 3R (reduce, reuse, recycling), which included waste separation at the source and composting. A Refuse Bank, which received domestic recyclable waste from the community, had also been initiated and operated in these cities. The gender role was dominant in 3R implementation. Most of the 3R cadres were women. In Yala, Thailand, the poor communities in reducing SW was triggered by exchanged the trash for nutrition food. They empower themselves in environmental awareness [27].

Reducing biodegradable SW at source

Composting is one of the preferred methods for reducing biodegradable organic material. Composting can reduce more than 50% of biodegradable organic components of SW on-site. Composting decreased the residential SW between 38 and 55% in Dar es Salaam City, Tanzania [39]. Composting can also extend the life-time of landfills [40]. Even this process can cut landfill space exhaustion rate of more than 50% [39].

Composting in most developing countries occurs at household level rather than that at the municipal level [41]. For example, in Dhaka, Bangladesh, composting was more successful in small-scale plants than in large-scale. The main reasons were effectiveness in operation and maintenance cost, well separation of SW, and effectiveness in marketing [42]. Zurbrugg et al. [43] found that composting in decentralized system could recover costs and yield a profit. Narayana [44] also stated that the people contribution in composting increase themselves awareness and reduced the operating cost.

Waste to Energy (WTE)

Some developing countries in Asia are trying to change SW into energy. India, Philippines, and Thailand have converted waste to energy. In Western Paques, India, anaerobic digestion process was applied to produce methane gas from SW. A pilot plant of 150 ton/day capacity of municipal SW produced 14,000 m^3 of biogas, with 55-65% methane product, which was equivalent to 1.2 MW [45]. In the Philippines the Clean Development Mechanism (CDM) was implemented with a WTE project in Payatas. This plant generated electricity of 60 kW to 70 kW, which was supplied to 20 residents [46]. Almost similar in Thailand, the anaerobic digestion tanks have been operated in three areas. The anaerobic digestion tanks have capacity from 10 tons/day to 300 tons/day MSW which generate electricity from 625 kW to 2,5 MW [25].

Landfill as final disposal site has the potential to emit greenhouse gases (GHGs). GHG emissions, which contribute to climate change, are another environment issue which has to be coped with. Asuwei landfill site, located in Beijing City was the earliest and the biggest landfill site to capture GHGs. It had a capacity of 2000 tons/day. The landfill gas has captured after 2001. It is currently used to generate electricity [47].

Partnership in SWM

In all activities of SWM especially in municipalities, partnership involves residents, institutions or local government and the private sector, such as micro companies. In Yala, Thailand, a program of recycling and garbage reducing was established through a relationship between poor communities and the municipal administration [27]. Similar to in India, the government had the cooperation with private sector and citizen in recycling SW [48]. On the other hand, initiatives of the private sector (citizen and enterprises) such as public-private-community partnership also help to increase the efficiency of waste management system [43], [49], [50], [51]. Cooperation is built between governments, research institute, NGOs, stakeholder, and people participation to solve the problem in SWM [52].

CONCLUSION

Most of Asian developing countries face SW generation problems. The main constraints are weak organization and limited budget allocation for SWM. Therefore, in most Asian developing countries SW reduction is conducted from the source up to the landfill sites. The activities involve community development and the informal sector. Alternative solutions of SWM in Asian developing countries use social and technical approaches. Social approaches are changing the public behavior by improving community through training, and encouraging partnerships with decentralized SWM. The technical approaches are reducing biodegradable SW at source, converting waste to energy, and using simple technology. These approaches are expected to improve the sustainability of SWM in Asian developing countries.

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