

Municipal Solid Waste Management in Indonesia

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Abbreviations

ANS	Agency for national standard
FD	Final disposal
ITB	Institut teknologi bandung
JICA	Japan international cooperation agency
MPW	Ministry of public works of Indonesia
MSW	Municipal solid waste
NGO	Non-governmental organization
SNI	Standar nasional Indonesia (Indonesia national standard)
3Rs	Reduce, reuse and recycle
SME	State ministry of environment of Indonesia
TS	Transfer station

1 Introduction

Solid Waste Management Act 18/2008 defines municipal solid waste (MSW) as the residues of human daily activities and/or residues of natural processes in solid forms. Wastes specified under this law are: (a) domestic waste; (b) domestic waste equivalents; and (c) specific wastes:

- Domestic wastes are generated by daily activities performed within households, but does not include feces and specific wastes;

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- Domestic waste equivalents are generated from commercial zones, industrial estates, special zones, social facilities, public facilities and any other facility;
- Specific wastes are wastes that require special management due to their properties, concentrations and/or volumes, in forms of hazardous materials contained wastes, hazardous wastes, wastes generated by disasters, demolition wastes, un-processable wastes due to availability of technology and non-periodical generated wastes.

Indonesia is a country located in South East Asia, which comprises of more than 13,000 big and small islands with a total population of 224,904,900 in 2007. Administratively, the country is divided into 33 Provinces and more than 465 municipalities which consist of 14 metropolitans (one million population or more), 15 big cities (500,000 up to one million population), 56 medium cities (100,000 up to 500,000 populations), and 380 small cities (20,000 up to 100,000 populations).

Municipal solid waste management in Indonesia is the responsibility of the municipality (local government). There is a city/district cleanliness division within the municipality organization. Most of them carry out cleansing service by themselves; while some other big cities contract out part of the services to third parties. In fact, most of the municipalities still give low priority to solid waste services. It can be seen in their low allocation in their annual budget which is mainly used for covering operational costs with a very small allocation for maintenance and investment.

At the national level, the solid waste sector is handled by the Ministry of Public Works (MPW) for its infrastructure planning and implementation, the State Ministry of Environment (SME) for its control and monitoring and some other related Ministry or Board of the Central Government. Although their responsibility is to provide guidance and supervision, they still provide an allocation for the initial investment as well as technical assistance. At the local government level, the Province Government is responsible for coordinating cities/districts in the case of centralized final treatment/disposal in their regions. The Province Government can also provide a 'participatory' budget for the investment of those centralized facilities.

Municipal solid waste problem in Indonesia, particularly in big cities, is one of the most challenging urban problems for city administrators. Population growth and ever increasing activities in major cities entails the increase of waste generation and all of the inherent consequences. It was estimated, that of the entire wastes generated in 2006, at most only around 60–70 % could be transported to final disposal by the institutions responsible in handling wastes and cleanliness, such as City/District Cleanliness Divisions. The rest is handled by the community through their self-effort or unsystematically disposed all over the city.

The general method currently observed in MSW managements all over Indonesia is collect-transport-dispose. The authorities of urban municipalities transport the MSW from designated collection points to a location for its final dumping. Most of the local authorities practice crude open dumping, creating a despondent situation at the landfill sites.

2 Data for MSW Management

The availability of data associated with MSW handling all over Indonesia is currently limited in nature. Generally speaking, municipalities and districts have no adequate data except general data such as number of trucks, number of personnel and the like. There is no systematic data collection on the volume of waste unable to be transported, due to the current practices of measurement based on truck travel frequencies to final disposals. Any waste being handled by the community through self-effort or unsystematically disposed off into improper sites is not systematically calculated.

Although each City/District Cleanliness Division should be responsible for data recording of solid waste measurements in their respective areas, these data are rarely found. Measurement is usually conducted to support certain study activities. Related data are submitted to the Ministry of Public Works or to the State Ministry of Environment as part of Annual Solid Waste Management Performance Questionnaire. Some data are put in Municipal/City Annual Statistics. Many programs and development of solid waste management are mostly based on an estimated quantity of solid waste. Data requiring periodical updates such as wastes generation, wastes composition/characteristics, source composition and the like are generally lacking or incomplete. This would create difficulties in evaluating the conditions or the performances of the existing waste managements, and contribute to further difficulties in setting future development plans. Availability of these data will be necessary to assess factors such as waste quantity and quality projection for the future, specific design of facilities, costs and budgeting, cooperation with third parties.

3 Waste Generation and Composition

Indonesia is located at the equator, and it has two seasons every year (dry and rainy seasons) and because of the monsoon rains, each season lasts 6 months. The rainy season is also the fruit season and fruits like the durian produce an enormous amount of waste in the city.

The principal generation source of MSW in Indonesia is households. They generate about 50–60 % (wet-weight) of the total quantity of MSW per day. This waste consists mainly of food scraps, yard waste, and wrapping materials. It is a mixture of all kinds of waste, organic and non-organic, recyclable and non-recyclable waste, even hazardous and non-hazardous materials. The other sources are traditional markets, commercial activities/areas, industries (non-hazardous categories), public gardens and streets.

Some cities provide their generation data by conducting surveys and sampling but many other cities usually estimate their waste volume by using the estimated generation rate as 2.5–3.0 l/capita/day based on standard national of MSW

generation (SNI S 04-1993-03) established in 1993 (ANS, 1994). Therefore, the accuracy of solid waste generation figures is questionable. Table 1 shows the MSW generation from some main cities in Indonesia based on those approaches. Based on questionnaire survey conducted by JICA and ITB in 2007, it was estimated that MSW generation of all municipalities in Indonesia in 2006 was 38.5 million tonne as presented in Table 2.

Some big cities in Indonesia, such as Jakarta and Bandung, are one step ahead of other cities in Indonesia in terms of MSW quantity measurements. Some studies conducted in Jakarta indicate the waste quantity (Table 3) and the waste composition (Table 4).

The amount of MSW is normally dominated by the organic compositions (more than 55 %-by weight) that mainly come from food scraps type of waste. This amount contributes to about 65 % of the water content of MSW. Plastic and paper forms are the two next major items. They are mainly composed of packaging/wrapping materials and food, beverage etc. Wood and textiles are the next two important components. Based on a survey in 2007 in Bandung metropolitan areas, the average amount of organic MSW taken at Transfer Stations was around 60 % (by weight) as presented in Table 5.

The amount of inorganic wastes was around 40 % (by weight), while about 6 % (by weight) was classified as recyclable inorganic components. Table 5 and 6 present the characteristics of MSW at Bandung Metropolitan areas in 2007.

Table 1 MSW generated in main cities, 2005

Cities	Population (inhabitant)	Waste generation (M ³ /day)	Generation rate (L/cap/day)
Surabaya	2,599,796	6,700.0	2.58
East Jakarta	2,385,121	5,442.0	2.28
Bandung	2,141,837	6,473.7	3.02
Medan	2,068,400	4,382.0	2.12
South Jakarta	1,708,269	5,223.0	3.06
Tangerang	1,700,000	4,225.0	2.49
West Jakarta	1,565,406	5,500.0	3.51
Palembang	1,500,872	4,698.0	3.13
Semarang	1,424,000	4,274.0	3.00
North Jakarta	1,176,307	4,180.0	3.55
Makassar	1,160,011	3,580.2	3.09
Central Jakarta	897,789	4,651.0	5.18
Bogor	820,707	1,996.0	2.43
Denpasar	585,150	2,320.0	3.96
Yogyakarta	512,464	1,571.0	3.07

Source Handoko and Sulistysdi (2008)

Table 2 MSW generated in main cities, 2006

Islands	MSW generation (thousands tonnes)
Sumatera	8.7
Java	21.2
Bali and Nusa Tenggara Islands	1.3
Kalimantan	2.3
Sulawesi, Maluku and Papua	5.0
Total	38.5

Source SME 2008

Table 3 MSW generation in Jakarta

Sources	1997 ^a	2000 ^b	2005 ^c		
	(%)	(Tonne/day)	(%)	(Tonne/day)	(%)
Households	65	4,169	65	3,067	51
Markets	–	–	–	280	5
Schools	–	–	–	308	5
Commercial	15	963	15	1,583	26
Industry/institution	10	641	10	516	9
Others/roads, drainage	10	640	10	246	4
Total	100	6,413	100	6,000	100

Sources Handoko and Sulistysdi (2008) quoted from:

^a Jakarta cleansing bureau, 1997

^b Feasibility study of SWM improvement, 2000

^c SWM for jakarta master plan review, 2005

Table 4 Solid waste composition in Jakarta

Components	1981 ^a	1986/1987 ^b	1987 ^c	1996/1997 ^d	2001 ^e	2005 ^f
Garbage, leaves	79.7	74.7	72.0	65.1	52.7	55.4
Paper	7.8	8.3	8.3	10.1	20.1	20.6
Plastics/Styrofoam	3.7	5.4	5.4	11.1	14.5	13.3
Wood	3.7	3.8	3.2	3.1	2.6	0.1
Textiles	2.4	3.2	3.2	2.5	2.6	0.6
Rubber/leather	0.5	0.6	3.2	0.6	0.9	0.2
Metals	1.4	1.4	2.1	1.9	1.1	1.1
Glass	0.5	1.8	1.8	1.6	1.2	1.9
Construction waste	-	-	-	-	-	0.8
Hazardous waste	-	-	-	-	-	1.5
Others	0.5	1.0	1.0	4.1	4.4	4.7

Sources Handoko and Sulistysdi (2008) quoted from:

^a Board for assessment and application of technology, 1981

^b Jakarta cleansing bureau, 1986/1987

^c JICA, jakarta solid waste management master plan, 1987

^d Jakarta cleansing bureau, 1996/1997

^e JCI survey, 2001

^f SWM for jakarta master plan review, 2005

Table 5 Composition of MSW at 2 transfer station (TS) at Bandung (July 2007)

Item		% Wet-weight	
		TS-1	TS-2
Recyclable components	Hard-papers	0.92	0.95
	Archives (white) Papers	0.14	0.34
	Bottle-glass	1.77	0.50
	Drinking bottle-plastic	0.29	0.19
	Drinking glass-plastic	0.17	0.34
	Can	0.22	0.32
	PE-plastic	0.03	0.42
	Divers-plastic	1.63	0.47
	Aluminum	0.06	0.05
	Cartoon/cardboard	0.33	0.31
	Newspapers	0.13	0.16
	Metals		0.03
Total of recyclable components		5.69	4.08
Organic Component	Food waste	33.90	58.04
	Leaves etc.	12.32	2.21
	Tissue-papers	11.02	1.78
	Textile	0.89	0.90
	Wood	1.98	0.70
Total of organic components		60.10	63.62
Others: an-organic non-recyclable		34.21	32.30

Source Damanhuri and Padmi (2009)

Table 6 Some characteristics of MSW at transfer points in Bandung, 2007

Components	Water contents (% wet-weight)	Volatile matters (% dry-weight)	Ash contents (% dry-weight)
Food waste	88.33	88.09	11.91
Tissue-papers	5.03	99.69	0.31
Leaf etc.	34.62	96.92	3.08
Bottle-glass	1.30	0.52	99.48
Plastic bottles, cups	2.57	88.48	11.52
Hard paper (board)	6.57	94.45	5.55
White papers	50.65	80.00	20.00
Textiles	3.41	86.32	13.68
Divers plastics	68.45	98.21	1.79
Cans	0.13	2.62	97.38

Source Damanhuri and Padmi (2009)

4 Reduce, Reuse and Recycle (3Rs) Approach

A positive impact derived from the current SWM systems in developing countries and economies in transition is the high level of recycling of the inorganic component of MSW. Although the methods employed for sorting and separation of MSW in these countries are considered inappropriate for solid waste management

systems as defined by developed countries, these existing methods not only provide an income stream to the hundreds of thousand of people involved in this informal sector but also ensure a far greater amount of MSW generated is recycled.

Most Indonesian people of all economic levels have a different terminology in perceiving the end-of-life of goods, including consumer goods. In developed countries, some goods like used newspapers, old magazines/books, old clothes, old electronic–electrical equipments etc. are considered to be waste and tend to generate problems. In Indonesia, plastics, glass, paper, and metals are well collected by either the informal sector or municipalities, and these materials are recycled. These wastes would be perceived as used objects that still have an economic value, to the extent that they rarely would be found in municipal waste management chains, for the very reason that these items are actually saleable, or could be donated to others of lower income.

Like other major cities in developing countries, the informal sector plays an important role in any recovery effort over the usable materials of waste. The recycling activity engages this sector, to include housewives, waste workers (from the cleansing division), vendors of used articles, and waste pickers. Middlemen or intermediary traders are found in all corners of Indonesian cities to buy used articles directly door-to-door. Dry waste (inorganic waste) is the most easily found for waste recycling in large cities in Indonesia.

Some of the recyclable wastes are collected by wastes pickers who sell these wastes to the collectors. The latter separate and classify the wastes into several groups of items depending on the types, then sell them to the wholesalers. These wholesalers will then trade these wastes with recycling factories. Some parts of these wastes are recycled within the cities that produce them, or they sell these wastes to other cities, or even export them abroad.

It is known that the recyclable-material is reduced en route to the transfer points and to the final disposal. Many stakeholders are involved in the reduction process, e.g. sorting at the solid waste sources, scavenging. It is not only done by the scavengers but also the waste handling crew. These waste recovery activities that have been practiced in many cities in Indonesia are mostly done by the informal sectors, consists of handcarts crews, mobile scavengers, transfer depot scavengers, final disposal scavengers, waste traders, recycling business people, and composing units at several points over a city. In so far, the role of informal sectors in wastes recovering activities is not well organized.

Waste pickers often throw the contents of garbage bags or bins to take anything of value. In many cases, they take the plastic bag as part of waste recovered for being sold, so will be increasing the difficulty of waste crew collector to collect waste. Waste recovery by waste pickers often is considered as a problem. Unorganized waste picking can have an adverse impact on neighborhoods and cities. However, municipal authorities do not ban their activity but do not also support them.

Surabaya Best Practice: Empowerment of Citizen in Waste Handling

To enhance the community participation in waste reduction efforts at the source through the 3R program, the Ministry for Environment and the Ministry of Public Works, especially after the enactment of the Solid Waste Management Act 18/2008, created similar programs annually in cities in Indonesia, including pilot programs involving NGOs and local communities. The main problem faced is how to maintain the sustainability of this system, and how to keep the community for continually willing to involve in the program.

Government of Surabaya City in cooperation with Unilever Care Foundation Indonesia since 2001 introduced a yearly program namely *Surabaya Green and Clean* (SGC program). The primary aim is to make settlements in Surabaya green and free from garbage by educating people to manage their waste with the 3Rs concept (<http://rileksmedia.com>).

Surabaya is the second largest metropolitan city in Indonesia after Jakarta. The population of Surabaya in 2006 was 3,221,119 in the night and up to twice during the day, and generated MSW approximately 8,700 m³/day waste (<http://www.silaban.net>). Surabaya is also working with city of Kitakyushu (Japan) since 2001 in the sister city program. One result from this cooperation was the introduction of composting model for household scale, known as Takakura composter (invented by Mr. Koji Takakura), which is widely used in Indonesia.

The SGC program is consistent with the main program of waste management in the city of Surabaya, namely (a) empowerment of citizens to handle their waste, (b) street sweeping and transportation of waste, (c) proper waste handling at transfers station and landfill site, and (d) planning and construction of new landfill. The targets are not only segregating the organic and inorganic waste, processing the organic waste into compost, recovering the valuable inorganic component, but also is empowering the communities to reduce waste at its source (www.silaban.net).

The SGC program in Surabaya (and other cities in Indonesia) is similar to that conducted by the Ministry for Environment through the Adipura Program (Damanhuri and Padmi 2009). The approach is to develop citizen participation in handling their waste by way of empowering them, to provide them with the environmental knowledge, particularly in waste handling. The second approach is the selection of cadres, which are selected among the citizens in each neighborhood level. These cadres serve continuously in each neighborhood to persuade and to invite the respective community to participate in the program.

The assessment criteria for the neighborhood winner include the innovation on waste management, greening the settlement, local leader participation, citizen enthusiasm in participating in this program. The local leaders from the neighborhood which win this competition will be awarded as '*environmental cadre*'. They are considered successful in getting citizens to participate in this program. When an environmental cadre in the next year re-elected, then the corresponding

status is upgraded to become ‘*environmental facilitator*’, and when the next year he/she wins again as the best facilitator, then the corresponding status will be upgraded again to become an ‘*environmental motivator*’, who shall serve to motivate citizens more broadly not only in his/her respective neighbourhood.

Each year, the neighbourhood that followed the program increases. For example in 2006, there were 968 neighbourhoods from 163 villages (kampong) which were participating, and 20 neighborhoods were elected as the winner. At the same time, about 350 environmental cadres have been selected which won in this competition. The rewards are performed by the Mayor of the city in the event such a citizen party. In 2006 the program was enhanced, by involving more private companies that wish to participate, with the theme *Let's Independence from the Garbage* (<http://www.silaban.net>). In 2008, the number of the environmental cadres has reached 5,684 people who came from some 1,200 neighbourhoods (<http://www.unilever.co.id>).

Another important activities undertaken by the Surabaya city is to coordinate the activities of scavengers in the area, by forming a kind of association between them. The first step is to record the scavengers in the city of Surabaya.

The positive outcome of this program among others is the increasing of motivation and desire of citizens to participate in waste segregation, while creating opportunities for income from the sale of valuable waste. One of the waste recovery mechanism is the formation of garbage-savings-selling mechanism, that is widely known in Indonesia as “banks of garbage”, which is managed by residents in the form of cooperative. This institution will accept valuable dry waste deposited from citizens, then it will be sold to the waste collector coming to the cooperative. This kind of business form (banks of garbage) is widely found in Indonesia, mostly in the form of cooperative (a business that is owned and run jointly by its members, who share the profits). Money from the sale of such material will be recorded in the ‘account’ of citizens who deposit their waste in the cooperative. Some profits from this transaction will be an additional cash income for the neighborhood.

5 Waste Collection and Transportation

The handling of the MSW is the responsibility of the local government. Usually the cleanliness division is in charge to carry out this task, particularly for transporting the waste from transfer point to final disposal. The waste collection from house-to-house to transfer point is organized and handled by the neighborhood community, which is consist of sub-neighbourhoods and neighbourhoods. The structure of neighborhood community in Indonesia is as follows:

- Sub-neighbourhoods (*RT = rukun tetangga*) are the smallest social units within the community structures, led by the community leader who is elected by the

members of each sub-neighbourhood; one sub-neighbourhood comprises of 30–35 households;

- Neighbourhood (*RW = rukun warga*) comprises of 10–15 sub-neighbourhoods, led by neighbourhood leader who is elected by neighbourhood members;
- Villages or kampong (*kelurahan/desa*) are the lowest formal governmental units within the governmental structures of Indonesia, comprise of several neighbourhoods and led by *Lurah*;
- Sub-district (*kecamatan*) is the next hierarchy of formal governmental unit, led by *Camat*. *Lurachs* and *Camats* are civil servants of the local government on municipal or city level; and
- City, municipality or district comprises of several sub-districts, led by *Walikota* (Mayor) or district leader, called *Bupati*. Several cities and districts form provincial territory or provinces, led by Governor. *Walikota*, *Bupati* and Governor are political positions elected by their respective peoples through direct general elections.

As generally practiced in urban areas all over Indonesia, there are two different services in MSW handling:

- The collection-transportation of waste from households to a transfer-point, mostly done by manual handcart carriages, is normally organized by the respective neighborhoods. The system is being handled and funded by the *RT/RW* communities, who could afford the expenses associated with the activities. This community employs a person who is known his residence address, which usually live near the settlement. Generally these people are those who do not have a permanent job. They are not scavengers and this activity is considered legal, however the waste crew is categorized as an informal sector. Almost all these waste crews perform valuable waste segregation. In many cases, the waste collected is already sorted by the generator and given to these waste crews.
- All of wastes in the transfer-depot, along with non-residential wastes, would be subsequently transported by trucks to landfills by city cleansing division crews.

Like any other collection system in developing countries, where the municipal waste from household sources is commonly collected through labor-intensive (Cointreau 1982; Joseph 2010), in urban area in Indonesia their waste is collected mostly using handcarts drawn by 1–2 crews. Typically, waste generated at households is generally accumulated in small containers, and then is placed on the ground directly, thus requiring being shoveled by hand; or it is left in plastic bag, open carton or basket to be picked up by hand. These waste crew collection workers have significantly direct contact with solid waste, so they are more likely to encounter potentially toxic and hazardous materials. Containers used for household storage of solid wastes are of many shapes and sizes, fabricated from a variety of materials depending on the economic status of the waste generator. The wide variety of types and shapes commonly encountered within a community creates difficulty in establishing and operating an efficient solid waste collection system (Joseph 2010).

In 2001, it was estimated that the existing city waste management could only serve around 32 % of the population in 384 cities all over Indonesia (Table 7). Of this percentage, only 40 % of the entire wastes generated by the city population could be transported to processing sites (Table 8). The transportation of MSW in most cities are conducted by the city cleanliness division of the municipalities. Some big and medium cities have been contracting out part of the collection and transportation to private firms.

Collection of waste is conducted in several methods, namely:

- Communal collection: where the community bring their waste by themselves to the transfer collection point located in certain places from where the transportation is carried out by using trucks. In certain places, the community brings their waste to vehicles which move along their routes while playing a traditional song.
- Individual indirect collection: where collection of waste is conducted by small vehicles or carts' from door-to-door, and brought to the transfer depot from where the waste is transferred onto trucks and transported to disposal/treatment sites.
- Individual direct collection: where garbage is collected door-to-door by using trucks and directly transported to disposal/treatment sites. This type of

Table 7 Population served by city waste management in 2001

Region	Total city		Population		% Population Served
	City	(%)	Population	(%)	
Sumatera	100	6.04	17,884,336	16.35	46.0
Java and Bali	148	8.54	75,049,732	68.59	28.4
Kalimantan	45	1.72	5,259,688	4.81	34.4
Sulawesi	62	6.15	6,103,336	5.58	36.5
Others	29	0.55	5,115,469	4.68	30.9
Total Indonesia	384	00.00	109,412,561	100.00	32.1
West Indonesia	248	4.58	92,934,068	84.94	31.8
East Indonesia	136	5.42	16,478,493	15.06	34.1

Source Sujono (2003)

Table 8 Population served by municipalities in Indonesia, 2006

Islands	Population (million inhabit)	Population served (million inhabit)	% Population served
Sumatera	49.3	23.5	48
Java	137.2	80.8	59
Bali and Nusa Tenggara Islands	12.6	6.0	47
Kalimantan	12.9	6.0	46
Sulawesi, Maluku and Papua	20.8	14.2	68
Total	232.7	130.3	56

Source SME (2008)

collection is conducted in the high income area or commercial areas where a large amount of waste is generated.

Transportation of waste is carried out via several other methods in conjunction with the earlier mentioned collection methods:

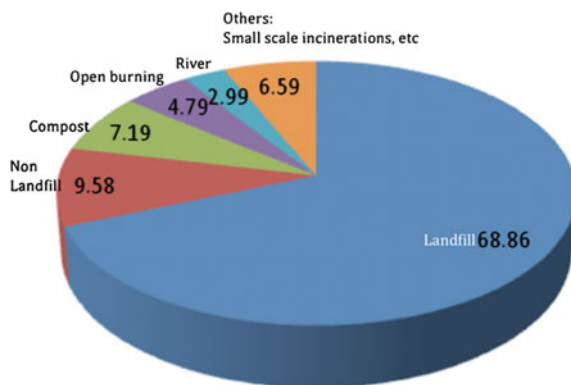
- Temporary collection or load haul method: it is applied in conjunction with communal and/or individual indirect collection. Dump trucks and/or arm roll trucks are used to carry out this transportation work;
- Direct transportation: it is applied in conjunction with individual direct collection by using dump trucks or compactor trucks to collect and transport the waste from each source in the serviced area;
- Transfer station: to bring big amount of waste by using about 20 tonne container/trailer trucks especially when the distance to disposal site is more than 25 km. This method is used in Jakarta City, where the disposal site is located more than 40 km from the city center.

6 Treatment and Disposal of Waste

So far, most of the existing MSW management systems in Indonesian municipalities rely on the existence of landfills. The excess has been handled by the community through various ways, such as burning, burying, composting, and other ways such as recycling or disposing at improper sites, including ducts or drainage channels. Based on a questionnaire survey conducted by JICA and ITB in 2007 in 154 cities in Indonesia, the mode of handling of MSW in Indonesia in 2006 is shown in Fig. 1.

Most wastes transported to final disposal sites left in open dumps, and it is estimated that only about 10 % of it was handled through better systems such as using controlled landfills. In many sites, these facilities are nothing more than uncontrolled open dumping sites. Lack of serious attention over these final

Fig. 1 Percentage of MSW handling in Indonesia in 2006
(Source SME, 2008)



disposals tends to be a general practice on the part of city administrators in Indonesia. In many cases, it was found that waste from industry and also pathogenic waste from hospitals were brought to the same dumpsites as the non-hazardous municipal waste, although since 1995 the government of Indonesia has regulated hazardous waste landfill criteria.

Another method of treating MSW in some cities in Indonesia is incineration. There are several small-scale incinerators in operation in different cities, each with a capacity of about 100–200 kg/h operating 8 h per-day. Therefore, the system is only able to handle a small percentage of the total MSW generated. Composting of organic waste has also been introduced as part of waste treatment. They are located, mostly, in final disposal sites. In principle, the composting system comprises a centralized sorting and shredding system, and thereafter composting of the organic matter is by a simple composting method.

Most municipal authorities have no other alternative if their existing landfill are in a troubled state, and have no experience in other better and more efficient way of handling waste. In so far as the existing landfills are not adequately prepared and are not professionally operated the troubled landfill cases would always appear. On the other hand, the consciousness on the part of the surrounding communities of their right to enjoy better environmental quality in their lives is ever increasing.

Landsliding of Leuwigajah Landfill

Since 2000, failures of landfill operations all over Indonesia began to show themselves, the most interesting of them are Bantar Gebang landfill in Jakarta, Keputih landfill in Surabaya and the latest Leuwigajah landfill in Bandung. The most remarkable failure of a landfill is the case of the landslide at Leuwigajah landfill in 2005. The Leuwigajah landfill landslide caused the termination of the landfill service to receive more wastes from three local governments, namely, City of Bandung, City of Cimahi and the District of Bandung. Wastes that could be transported to landfills were very limited in volumes, resulting in stacks of garbage on the sides of streets and roads. The City of Bandung turned to the Jelekong landfill, 20 km to the south of Bandung, to handle its waste problems. The Jelekong landfill was facing similar conditions of exposed to environmental factors and also protects from its surrounding communities.

Bandung is the capital of the West Java Province in Indonesia. The population of the Bandung Metropolitan area in 2005 accounts for approximately six million. The landfill site was operated by three different authorities, the City and the District of Bandung, as well as the City of Cimahi.

The Leuwigajah landfill, about 12 km from the center of Bandung City and located at City of Cimahi, was one of principal facilities in waste handling at the Bandung Metropolitan area, particularly for Bandung City and Cimahi City. From ± 23.5 Ha of the site, 17Ha (72.3 %) of it is owned by Bandung City. The contribution of Bandung City to the inflow of waste to Leuwigajah

was $\pm 3.000 \text{ m}^3/\text{day}$, while Cimahi City contributed up to $400 \text{ m}^3/\text{day}$, and residential areas of Bandung District on the vicinity contributed about $750 \text{ m}^3/\text{day}$.

The dumpsite was established in a narrow valley on the outskirts of Leuwigaja. From a hydrogeological point of view, the valley is a suitable site. The subsoil consists of rock covered by a thin layer of 1 m of silt or clay material, performing as a natural barrier. Before the waste disposal started, small water streams were running through the valley in the wet season carrying the surface runoff. Precipitation in the region is high (between 1,500 and 2,000 mm per year) while rain distribution is significantly non-uniform. Heavy rainfall and thunderstorms are common during the wet season.

Officially, sanitary landfills had already been adopted for final disposal since the middle 1990s. However, due to financial constraints, the cleansing agency could not afford it, so open dumping became a general procedure for waste disposal for nearly all landfill sites in Indonesia. Dumping activities started from the top of the valley by just dropping the waste over the edge. The natural landscape of the valley showed a gentle slope of approximately 5–10 % at the bottom of the valley and a slightly higher slope at the upper end. Before the failure happened, the maximum height of the dumpsite rose to 60–70 m. The front slope facing the open valley showed a slope angle between 30° and 45° .

The landslide happened on February 21st, 2005 at 2.00 a.m. After 3 days of heavy rain, about 2.04 million cubic meters of waste started sliding down the valley. The waste covered a 200–250 m wide stripe on a length of 900 m. Witnesses reported a roll of thunder similar to an explosion. Regarding the speed, observations indicate that the waste came like an avalanche. Rescue teams' uncovered 147 dead bodies out of the waste. Rescue activities were carried out only in the area close to the two settlements.

Observations and researches done, particularly in 2003/2004 by ITB, concluded that the condition of the Leuwigajah site was very unhygienic and had a very high exposure to environmental problem, due mainly to open dump filling which could result in landslides. The operation of the dump itself had created environmental problems. Uncontrollable leachate polluted the water body over its downstream. The smoke, bad smell and flies continuously affected the environment around the landfill. Before the last landslide, which resulted in death and casualties, there were at least two slides of waste stacks which occurred during the preceding.

After the closing of the Leuwigajah site, the only dumping site available was Jelekong, located in the district of Bandung, 20 km South of Bandung, which had a limited capacity. The Cicabe dumping site that closed in 1985 and the Babakan dumping site owned by the District of Bandung, operated as emergency sites until April 2005. After that, Jelekong became the only site that operated, but it was closed because of objections from the community in December 2005. Cicabe was re-opened and this time the surrounding community only consented to its operation until April 15, 2006.

The state of solid waste management one year after the Leuwigajah site landslide disaster was the worst in Bandung history. By April 15, 2006 the city of Bandung did not have a dumping site to dispose their waste. The heaped waste in

Bandung city since April 15, 2006 to June 21, 2006 reached 105.000 m³. This situation drew the attention of the President of Indonesia who through the Minister of Environment obligated the Governor of West Java to overcome the problem.

The termination of the Leuwigajah landfill operation has direct impacts on the Bandung metropolitan area until now. The currently available alternative for Bandung is temporary Sarimukti dumping site, 45 km west of Bandung. Being in an emergency state, the local governments of Bandung area were forced to find alternative landfills, including re-opening long-terminated landfills. After the disaster, the West Java Government took the lead in appointing emergency dumping sites so as to be able to handle administrative “cross-border” issues (Damanhuri 2006).

7 Current MSW Policy and Future Development

The MSW management in Indonesia had reached a relatively sound performance level during 1990–1995, where many cities were motivated to improve their cleanliness/sanitation due to, inter alia, the existence of the Adipura Award program which was granted to any city that was successful. Since the multidimensional crises in Indonesia and the reforms entailing such crises in 1998, the turning point in MSW management in Indonesia began. The era was significantly marked by fundamental changes in political and governmental aspects, such as decentralization and local autonomy (Damanhuri 2008).

In line with the implementation of the local autonomy policy, municipal/district governments took over the full authority and responsibility of waste management from the central/province government. Many of these local governments adjusted the related policies, even drastically, especially in its institutional aspects. The MSW management which formerly tended towards independent divisional establishment was contracted to sections or even sub-sections. These have directly affected unfavorably the priority of handling wastes in many cities, especially in budgetary allocations. Another significant impact is the appearance of locality egocentrism which in turn posed difficulties to municipal governments to operate their respective landfills that are generally situated in sites outside their own jurisdiction.

In 2005, the Government Regulation 16/2005 was announced. It regulated the final disposal of MSW in relation to water resources protection for water supply. In 2006, the Ministry of Public Works through Ministry Regulation 21/PRT/2006 outlined the policy and national strategy for MSW management. This regulation defined the target of MSW recycling for the subsequent 10 years (MPW 2007). The last formal regulation issued by the Indonesian Government was the Solid Waste Management Act 18/2008. This act is expected to bring major changes and new challenges in waste management, which will serve as the umbrella for sound MSW managements in Indonesia.

The basic approach of this new law is waste reduction through 3Rs as the first priority, and the next priority is waste handling. This concept is considered as a new paradigm to replace the collect-transport-dispose concept, which is usually adopted in most Indonesian cities. All of the involved parties agreed that the concept is the best available measure to reduce wastes, and active involvement on the part of the community and other waste generators to reduce waste volumes are the key to the success of any waste management systems.

According to this law, waste processing and dumping technologies that are safe and healthy, and conform to Indonesian circumstances would serve as Indonesia's principal method of MSW processing in the years ahead. There needs to be, however, a common intention among the parties concerned, that the volume of waste to be transported and dumped should be progressively decreased, particularly through reduction and recycling-based waste management, or any other processes such as composting and so on. In the long run, the existence of landfill as a facility should be seen as one component of the more fundamental strategy of reduction and recycling waste management, which would require determination and commitment on the part of city managers to carry out the process consistently.

One of the most strategic governmental programs, through the Ministry of Environment associated with wastes issue is the Adipura Program, which has been revived since June, 2002. The program of award granting reached its highest position as the most important program during the era prior to multidimensional crises as discussed earlier in this paper. The main objective of this program is to motivate local governments to apply good environmental principles in managing the urban environment, so as to realize a clean and green city (SME 2004).

The development of a better final disposal such as the sanitary landfill, based on a regional approach in some metropolitan areas is in progress. The government is committed to close open dumping sites and rehabilitate them to sanitary landfills or controlled landfills. A target has been set to develop 240 new landfills site by the year 2014. This program has been conducted since 2006 in 187 landfill locations across Indonesia in 2012. Some of this development is connected to the CDM project. Indonesia has promising potential for development of landfill gas facilities. With many large urban areas including 18 cities with a population over 500,000 and 10 cities with a population over 1,000,000, Indonesia produces large quantities of MSW. It is estimated that the major urban centers in Indonesia generate enough waste to provide just less than 80 MW of electricity through landfill gas (Damanhuri 2008).

The first CDM project in Indonesia is proposed by the landfill of Suwung (Metropolitan of Denpasar, Bali). Other big city, Pontianak, Bekasi, Palembang, Makassar, Semarang, Bandung and Jakarta are currently interested in undertaking a landfill gas project under the CDM project. This project aims to improve environment both at global and local scales through the capture and treatment of landfill gases, which would not only make significant impacts on global warming but also great negative effects on neighborhoods around the waste disposal sites. In addition, the project aims to contribute to sustainable development of the

respective municipalities as economic profits will be achieved and waste management will be improved.

An integrated and a centralized (regional) landfill would significantly reduce potential problems. The landfill would serve wastes from the surrounding areas regardless of their administrative boundaries or local governments transporting them. The local government where the landfill lies could serve only as a monitoring agent to the extent that the functioning of the landfill creates no harm to the population and environment within its administrative authority. The prerequisite is the existence of a single institution to operate it (MPW 2008). The regional landfills that are currently being reviewed extensively are landfills in the metropolitan area of Denpasar (Bali Province), metropolitan area of Yogyakarta, metropolitan area of Bandung (West Java Province), and metropolitan area of Makassar (South Sulawesi Province), and metropolitan of Banda Aceh (Aceh Province).

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