

Solid waste management in Asian countries: a review of solid waste minimisation (3'r) towards low carbon

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Abstract. The amount of solid-waste generated in Asian countries has increased tremendously, mainly due to the improvement in living standards, rapid developments in technology, growth in economy and population in the cities. Solid waste management is a global issue and major challenge facing Asian countries and neglecting its management may have negative consequences on the environment. Waste composition data proves the developed countries to have generated more recyclable materials while developing countries produce more organic and less recyclable waste such as paper, plastic and aluminium. In this regard, increase in number of landfills and disposal sites, will have an impact on GHG (greenhouse gas) emissions and pollutants to air and water. Alternative methods should therefore be taken to reduce the volume of waste. Most Asian countries have adopted the 3R (reduce, reuse, recycle) concept in order to reduce solid waste and their governments have implemented laws and regulations in order to support this. Implementation of 3R is the major contributor to the solid waste minimization and it can improve the quality of environmental sustainability and reduction of carbon dioxide emission in to the atmosphere. Based on our review, most of the countries practicing the 3R concept in tandem with laws and regulations perform better than those that just practice the 3R concept without any laws and regulations. The paper suggests that every country must focus on the laws and regulations relating to solid waste minimization so that it could be easily implemented as outlined.

1. Introduction

Solid waste management is one of the major environmental encumbrances in many Asian countries. World population growth, urbanization, rising living standards and rapid technological development as well as modern lifestyles and consumption patterns contribute to the increase in solid waste and the changes in its composition. The objectives of the study (i) to compare the amount of solid waste generated by developed and developing countries in Asia (ii) to assess the applicability of the laws and regulations that ensure the success of solid waste minimisation (iii) to examine the challenges and strategies in minimisation solid waste. The content of this paper aims to help in the achievement of sustainable development or "*A Better Quality of Life*".

2. Solid Waste Management

Solid waste management includes monitoring all elements (collection, transport and transfer site, recycling, processing and disposal) in order to reduce negative impacts on the environment and human health and improved quality of life. Mostly Greenhouse Gas [GHG] emissions in solid waste management are during the process of composting, incineration and landfill. This is where the 3' Rs concept (Reuse, Reduce and Recycle) comes in to minimise solid waste generated.

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2.1. Solid Waste Generated

Solid wastes are generated by many different activities. The largest quantities are produced by the households, followed by commercial, municipal, industrial, agricultural and construction & demolition sectors. Accordingly, Table 1 shows GDPs, populations, waste generation (kg/capita/day) and recycled rates for some of developed and developing Asian countries. It is readily visible that individuals in the developed countries generate the greatest amount of waste (>1 kg/person/day) while those in the developing countries account for roughly half of that amount.

Table 1. Solid Waste Generated In Developed and Developing Countries.

Countries	Population (2007)	Waste generated tons/day	Kg/capita/day	GDP/Cap (USD/2007)	% Recycled
Developed Countries					
Japan	127,568,000	139,726	1.14	33,010	60.00
Singapore	4,553,009	6,849	1.10	31,165	54.00
South Korea	48,607,000	49,000	1.02	23,331	60.10
Developing Countries					
Malaysia	24,821,286	19,100	0.80	12,702	5.00
Vietnam	85,262,356	41,095	0.55	3,502	18.00
Philippines	91,077,287	27,397	0.67	5,409	14.00

Japan has the highest waste generation, followed by South Korea in the list but the percentage of recycled materials also register a higher volume of more than 50%. On a second note, Singapore and Japan enjoy the lowest waste generation rates among the high income countries of the world, (World Bank, 2007). In Japan, South Korea and Singapore, aiming for a conservatively constant per capita waste generation, a number of measures were taken to minimise waste production. With the growing population and economy, solid waste generation is inevitable to increase in developing countries, yet recycling rates remain too low. This will be a hindrance to achieving low-carbon sustainable development.

2.2. Solid Waste Composition

The 3Rs (Reduce, Reuse, Recycle) initiative was introduced by Japan in year 1950's, [2]. Japan has promoted use of the 3Rs domestically and on the international stage. Waste minimization has been placed at the top of solid waste management hierarchy. In line with the goals to increase recycling, a combination of practices has developed incorporating those of both developed and developing countries. The proportion of recyclables (paper, plastics) is high in the developed countries, while degradable organic matter is high in developing countries. The low proportion of recyclables in developing economies can be attributed to the market value of recyclables.

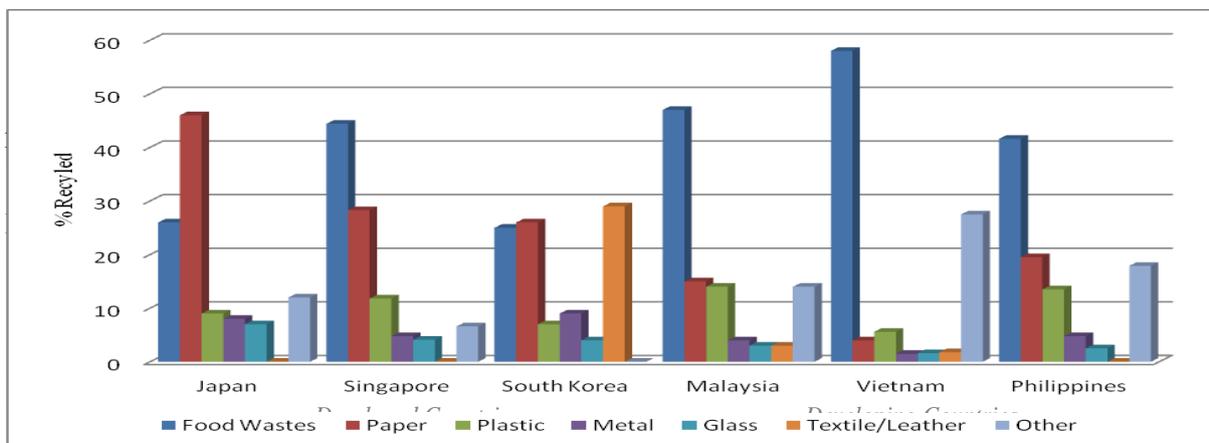


Figure 1. Type of Solid Waste Composition (%).

(Source: Asian Institute of Technology, 2008)

3. Legislation and Regulation on Solid Waste Minimisation

The 3R solid waste minimization strategy is one of the finest and latest ways to decrease solid waste with zero Greenhouse Gas emission (GHG). In order to implement the 3R's for each country, legislations and regulations are needed to place the responsibility on the households and stakeholders involved in the production of waste. Table 2 displays the legislations and regulations passed and implemented by a range of developed and developing countries in Asia for the minimization of solid waste.

Table 2 : Legislations and Regulations on Solid Waste Minimisation.

Country Status	Legislation and Regulations	Date of Enforcement	
Developed Countries			
Japan	i) The National Government Develops the Fundamental Policy for Waste Reduction;		} Adequate
	ii) The Development Plan of Waste Treatment Facilities;		
	iii) Programs of Recycling;		
	iv) Law of Solid Waste Minimisation;		
	Waste Reduction Law	1997	
	Law of Effective Utilization of Resources	2000	
	Laws for Recycling		
	✓ Containers and Packaging Recycling Act	1995	
✓ Home Appliance Recycling Act	1998		
✓ Food Recycling Act	2000		
✓ End-of-Life Vehicles Recycling Act	2002		
✓ Green Purchasing Act	2000		
✓ Treatment of Cyclical Food Resources Act	2000		
Singapore	i) Regulation		} Adequate
	Law of Environmental Public Health (Public Cleansing)	1970	
	ii) Programs of Recycling;		

	iii) Licensing Solid-Waste Collectors; iv) Guidelines and Handbooks for Recycling; v) Educational Materials and Milieu	1989	
Korea	i) Comprehensive Plan for the Resourcification of Food Waste 1998 ii) Programs of Recycling; iii) Laws of Solid Waste Minimisation; ▪ Saving and Reutilization of Resources Act ▪ Green Product Purchase Act	1992 2004	Inadequate
Developing Countries			
Malaysia	i) Strategies - 3rd Outline Perspective Plan ii) National Policy on Solid Waste Management iii) Solid Waste and Public Cleansing Management Act iv) Programs of Recycling;	2001-2010 2007 started 1990's	Inadequate
Vietnam	i) Action Plan - Green Aid Plan ii) Programs of Recycling; iii) Laws of Solid Waste Minimisation ▪ Environmental Protection	1989	Inadequate
Philippines	i) Laws of Solid Waste Minimisation; ▪ Ecological Solid Waste Management Act ▪ The Local Government Code ii) Programs of Recycling;	2000 1991	Inadequate

Japan and Singapore are the two most aggressive nations in the world when it comes to the promotion of recycling and waste reduction. These countries conduct systematic management by focusing laws, policies, education, guidelines and licensing on households and stakeholders as the responsible bodies for Municipal Waste Management. This is to achieve acceptably low carbon levels for the quality of life, while developing countries such as Malaysia, Vietnam and the Philippines have already initiated action in favour of the 3'Rs as on-going strategies that are but nevertheless inadequate in execution.

4. Findings, Challenges and Strategies to Management Solid Waste Minimisation (3'Rs)

Japan, South Korea and Singapore have been aggressively improving their management on solid waste minimization with a view to eliminating landfills towards low carbon targets. In many developing countries in Asia, there are no specific regulations for solid waste minimization. Table 3 shows the challenges and strategies of regulation as adopted by developed and developing countries.

Table 3. Challenges and Strategies in Practice the Solid Waste Minimisation.

Country	Challenges	Strategies
Developed Countries		
Japan	▪ Recycling cost upon households increases with the complexity of recycling programs.	▪ Start from Local government under their own specific circumstances; ▪ Education/advertisement with several channels; ▪ Participation on source separation and 3'Rs;

Singapore	<ul style="list-style-type: none">▪ Government has started turning towards recycling, worried about limited landmass. Even the regulations are revised and solid waste is to be charged base on "Pay-As-You-Throw", yet difficult to implement, since 80% of Singaporeans live in high-rise apartments, and solid waste generated from each household is discharged directly at home through a common discharge chute. The quantity of solid waste from each individual household is therefore hard to detect.	<ul style="list-style-type: none">▪ Economic incentives,▪ Penalties and disciplinary action.▪ Singapore Green Plan 2012. Targets;<ul style="list-style-type: none">✓ Recycling rate from 44% to 60% by 2012;✓ Extend the lifespan of the landfill site to 50 years, and strive "towards zero landfill"; and✓ Reduce the need for new incineration plants.
Korea	<ul style="list-style-type: none">▪ Lack of policy to promote 3Rs.▪ Lack of empirical studies on household waste management policies and recycling and waste disposal behaviour.▪ Increasing separation of recyclables does not necessarily mean that the environmental attitude has improved. It may simply mean that faster people have learn to segregate faster.	<ul style="list-style-type: none">▪ Mandatory law can play critical role to control the waste management behaviour.▪ Educational programs and continuous policies for enhancing sustainable pro-environmental attitudes.
Developing Countries		
Malaysia	<ul style="list-style-type: none">▪ Local Authority is no longer responsible for SWMPC once Act comes into force;▪ Low awareness on 3Rs and source segregation;▪ Delivery systems on recycled materials are still scarce.	<ul style="list-style-type: none">▪ Improved delivery system – inventories and databases, clear guidelines and regulations▪ Need a campaign/promotion of public awareness and information dissemination – dialogues, seminars, mass media.▪ Corporate Social Responsibility (CSR) compost campaign.
Vietnam	<ul style="list-style-type: none">▪ Low awareness on 3Rs and source segregation;▪ The existing regulations are no more effective;▪ Overlap and gap in agency responsibilities; and▪ No criteria for environmentally sustainable cities.	<ul style="list-style-type: none">▪ Promote 3'R activities;▪ Clear responsibilities/tasks among government agencies;▪ Develop and promote a standard/guideline for environmentally sustainable cities; and▪ Mechanism to increase private sector participation;
Philippines	<ul style="list-style-type: none">▪ Government shortcoming in implementation of the law on national and local levels;▪ Lack of public information; and▪ Lack of environmental education.	<ul style="list-style-type: none">▪ Development of procedures, standards and strategies for promoting the use of recyclable materials and local markets for recycled goods.

5. Conclusion

The management of Municipal Solid Waste Minimization (MSM) in the Asian cities still faces many problems. The current regulation system is not perfect and the existing management system does not fit the present requirements. The elements of solid waste minimization involve government institutions, product manufacturers, private businesses, communities/households and other stakeholders to reduce the amount of waste in the waste stream. The main strategies to overcome a number of challenges related to policies and legal frameworks include: i) Formulation of national policies quantifying the achievable targets with pertinent time frames, ii) Review and updating of the policies; iii) Identification of responsibilities and roles of the different formal and informal stakeholders in the delivery system; iv) Promoting the formulation of stakeholders in different sectors of the society covering professionals, academicians, political groups etc; v) National policy-based legal structures for different streams e.g. municipal, healthcare, hazardous etc; vi) Simple and transparent enforcement mechanisms; and vii) Time review and amendments to the legal framework in keeping with the feedback. Further, strategies will be needed to be structured as institutional arrangements, appropriate technology, operational and financial management and public participation and awareness [3].

References

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- [3] Ashok V and Shektar 2008 *Waste Management* **29** 1438-48