Title: Application of the Lifecycle Approach for designing an integrated system for sustainable waste management[1]

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Abstract

Waste management is a critical issue in urban areas due to increases in its daily generation and the shortage of natural resources. The conventional approach of 'collection and disposal' is no longer acceptable in terms of sustainable socio-economic development and environmental conservation. Under these high pressures, an integrated approach that considers the lifecycle impacts of waste management such as the 3Rs (reduce, reuse, recycle) is an alternative for cities in both developed and developing countries. This paper introduces success stories where the implementation of the 3Rs has been successful, in terms of sustainable waste management, in Japan (as a developed country) and Thailand (as a developing country). The two cases used different technologies but shared the common aims of enhancing resource utilization, saving landfill space, reducing environmental impacts, decreasing the budget for waste treatment and so on.

Keywords: LCA, integrated waste management, 3Rs, Japan, Thailand

Waste generation is increasing

Waste generation is increasing continuously due to economic growth, particularly in developing Asia. As income has improved, due to economic development, higher living standards and increased buying power have resulted in more waste generation. A World Bank report estimated that, at present, almost 1.3 billion tonnes of municipal solid waste are generated globally every year with the generation rate of 1.2 kg/capita/day, which is double that reported ten years ago. Furthermore, this report predicted that the quantity of waste will increase to 2.2 billion tonnes with a generation rate of 1.42 kg/capita/day by 2025. The waste generation rate will more than double in lower income countries (Hoornweg and Bhada-Tata, 2012).

The conventional waste management practice of 'collection and disposal' is unsustainable

The conventional practice of 'collection and disposal' is common in developing countries. Due to budget constraints, the collection rate in developing countries such as Mali, Uganda, and Tanzania are often lower than 50% of the waste generated, but there are high collection rates in developed countries such as Japan, Singapore, the United States of America, and the United Kingdom (Hoornweg and Bhada-Tata, 2012).

As the collection rate is very low, it is hard to expect there to be proper management of waste at the disposal site. Often, the collected waste is disposed of by means of open dumping and sometimes open burning is practiced in order to reduce the volume of waste. These practices cause serious impacts not only to the environment but also to human health. Land that could be used for residential or economic development is used for burial of waste, this is a threat to natural resources and a cause

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of land scarcity. In some cities, where land scarcity is crucial, open burning or incineration is used in order to quickly reduce the volume of waste and prevent the outbreak of diseases.

Why is an integrated approach important?

Integrated solid waste management is an approach that provides intervention in order to minimize the quantity of waste that is generated, reduce waste discarded by the collection system, increase resource circulation, avoid the disposal of reusable and recyclable waste and eventually minimize environmental impacts (Fig. 1). The elements of an integrated waste management program should be designed for each city only after careful selection of technologies that best suit the local conditions (Menikpura et al., 2013).

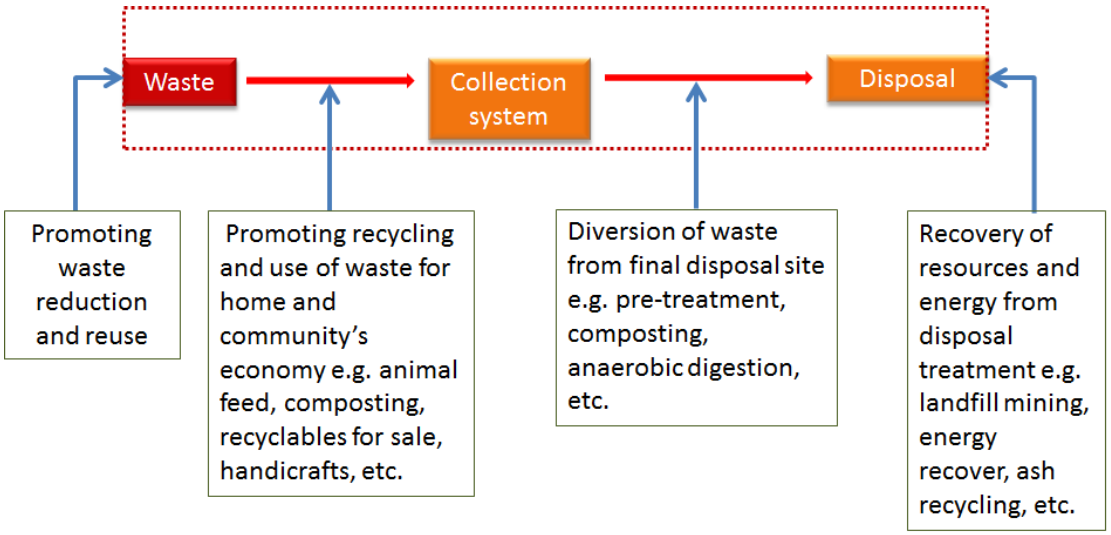

Fig. 1 Intervention of the integrated approach for sustainable solid waste management

Integrated solid waste management can significantly contribute to a sustainable development approach in terms of social, economic and environmental factors. For instance, in addition to giving maximum protection to the environment, the integrated approach can provide better services to the public, creating jobs and income for the stakeholders, employing a sizable number of people, conserving a significant amount of resources and mitigating a considerable amount of greenhouse gases (Menikpura et al, 2012a).

Why is the lifecycle approach (LCA) a concern?

Every technology has pros and cons. The lifecycle approach considers not only the direct impact of technology implementation but also the indirect impact, this is useful for selecting the most appropriate waste treatment technologies. There are two types of LCA that are suitable for designing sustainable solid waste management. The first one is Cradle-to-Grave which begins with the resource extraction (cradle) through to the use phase and the disposal phase (grave) (EPA, 2006). The second one is Cradle-to-Cradle which is a specific kind of Cradle-to-Grave assessment that is designed to analyse the impacts of recycling or the use of waste as a resource. Fig. 2 is an example of a

Cradle-to-Cradle assessment framework.

The 3Rs (reduce, reuse, recycle) as a strategic approach that is associated with integrated and lifecycle approaches

In many countries, the 3R approach is already exists and has been practiced habitually for many years. However, it has been brought into political and public interest since 2000 by the Japanese Government in order to overcome solid waste management problems in Japan. It has been promoted internationally since 2005. It can enhance resource efficiency by (i) reducing waste generation at the production and consumption stages, (ii) encouraging the reuse of materials and products until they can no longer function properly, and (iii) promoting the recycling of materials for further use and recovering valuable resources such as materials, nutrients and energy prior to final disposal (Fig. 3). The 3Rs approach applies to the entire lifecycle of a product, i.e. all stages of production and consumption including design, manufacture, purchasing, distribution, use and disposal (Sang-Arun et al., 2011). Many actors can thus participate in the 3Rs, including individuals, enterprises, manufacturers, and local and national governments.

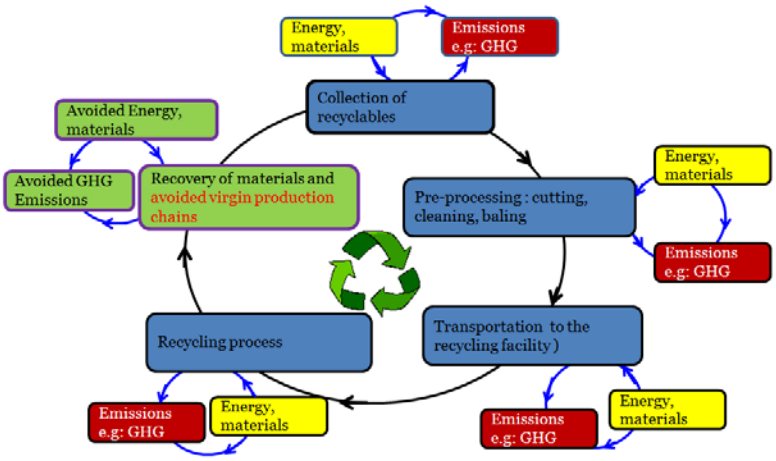

Fig. 2 Example of cradle-to-cradle lifecycle analysis of greenhouse gas emissions from the recycling process (Menikpura et.al., 2012b)

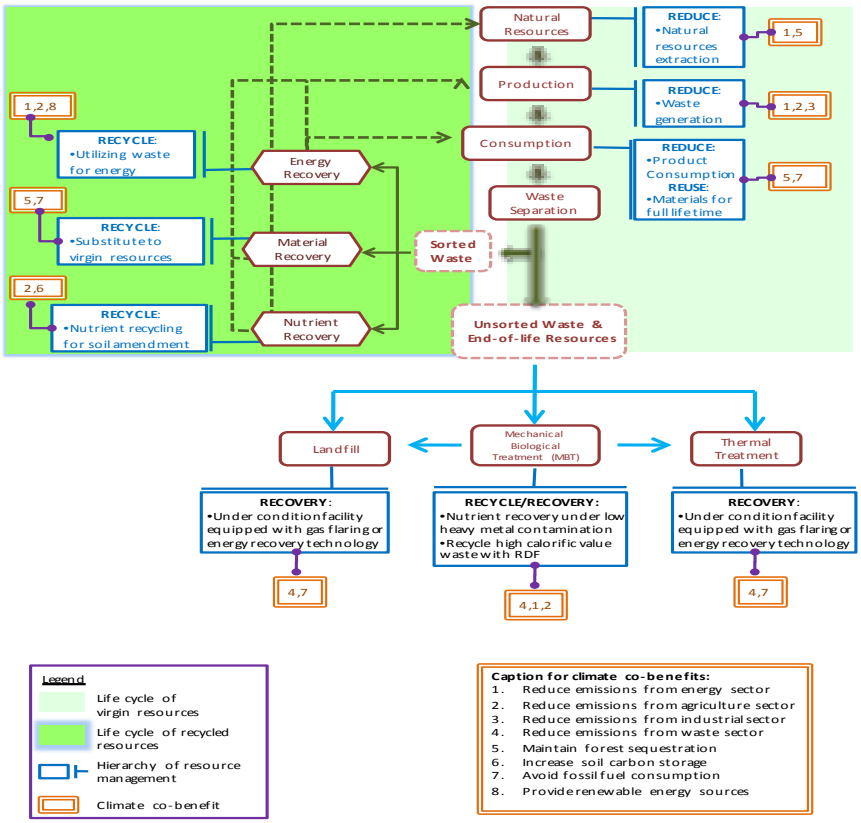

Fig. 3 The 3Rs (reduce, reuse, recycle) contributions to sustainable waste management and climate change mitigation (Sang-Arun et al., 2011)

Case studies

Integrated solid waste management under the 3R approach at the national level

Japan has successfully introduced the 3Rs and integrated solid waste management for reducing waste generation, increasing the rate of recycling as well as reducing waste for incineration and landfill. As a result, the waste generation rate has decreased from 1.19 kg/person/day in 2000 to 0.98 kg/person/day in 2011. The recycling rate has increased from 15.9% in 2002 to 20.4% in 2011. The remaining lifetime of landfill sites has increased from 12.8 years in 2000 to 19.4 years in 2011. The cost for municipal solid waste management in 2011 was 25% lower than that of 2002 (MOEJ, 2013).

Due to the great achievement of Japan, some developing Asian countries have thus followed the same 3R strategy in their national waste management program. For instance, China has announced that they will be applying the 3Rs for economic development, resource utilization, and environmental conservation and rehabilitation through enacting the Circular Economy Law in 2009. India has also mentioned the 3Rs as a possible solution for solid waste management in the National Environment Policy.

Bangladesh, Cambodia, Indonesia, Malaysia, the Philippines, and Thailand have drafted specific national 3Rs strategic plans. The Philippines will focus its national 3Rs strategic plan on improving the working conditions and livelihoods of the informal sector, which makes an important contribution to

waste recovery (Hotta, 2009). Viet Nam has announced a national 3Rs strategy. In addition, Thailand has drafted the Master Law for the Promotion of Waste Reduction, Reuse and Recycling in order to mainstream the implementation of the 3Rs strategy.

Integrated solid waste management under the 3R approach at the local level

There are many success stories regarding the introduction of the 3Rs for integrated solid waste management both in developed and developing countries. In this report, a success story in Yokohama (Japan) and Phitsanulok (Thailand) will be introduced as representatives of a city from a developed and a developing country.

Yokohama, Japan

Yokohama covers an area of 437.4 km² and is the capital city of Kanagawa Prefecture. It is the second largest city in Japan by population after Tokyo and the most populous municipality of Japan (3.7 million people and 1.6 million households as of 2011). The conventional practice of this city, regarding waste management, was collection and disposal on landfill. This is similar to most cities in the world. Due to the pressure of increased waste generation and land scarcity, the city has gradually introduced incineration since the 1950s. Yokohama introduced the reuse and recycle policy and started avoiding the use of landfill sites for fresh waste in the 1970s and has fully promoted the 3Rs under the G30 Plan since 2003 (City of Yokohama, 2012).

The G30 plan aims to reduce waste (both household and industrial waste) that ends up at final treatment (incineration) facilities by 30% compared to 2001. This target can be achieved by reducing waste generation and increasing recyclable waste separation at the source. In 2010, as of a result of this ambitious target, the city achieved a 43% reduction in this target area (915 ton/day) as compared to 2001 (1,609 ton/day). Two incineration plants (2,400 ton/day in total) were shut down and an incineration plant with capacity of 1,200 ton/day was suspended (City of Yokohama, 2012). As of 2011, the city of Yokohama has announced the Yokohama 3R Dream Plan (2010-2025). This plan aims to reduce more waste generation by the producers, encourage residents to reuse any goods as long as possible, and promote the separation of recyclables for recycling. The city aims to reduce the total amount of waste to final treatment and disposal by more than 10% by 2025 in comparison with the generation rate in 2009. It also aims to reduce the greenhouse gas emissions from garbage processing by more than 50% as compared to the emissions in 2009 (based on a lifecycle approach) (City of Yokohama, 2012).

Phitsanulok Municipality, Thailand

Phitsanulok Municipality is a medium sized city located in Northern Thailand. The Municipality covers an area of 18.26 km². Its permanent, official population is approximately 90,000. The Municipality has been confronted with a rapid increase in the volume of waste for disposal since 1993. The Municipality could not handle the waste properly. The local residents forced the Municipality to close several dumpsites due to the serious impacts on the environment and public health.

From 1997, the Municipality introduced various activities to promote the 3Rs in both midstream (consumption stage - waste generation) and downstream (final disposal site). At the consumption stage, the Municipality aimed to avoid waste generation by introducing community based solid waste management for promoting the use of biodegradable and reusable materials, encouraging waste

separation for sale, establishing a drop-box system for hazardous waste separation, and supporting composting at household and community levels. Waste buyers and waste pickers were trained under a public-private partnership strategy and they were upgraded to “volunteers for the environment”. Educational institutions were involved in awareness raising programs. Furthermore, the Municipality aimed to improve final disposal through the pre-treatment of waste using mechanical biological treatment (MBT; composting of mixed waste and separation of valuable waste) prior to landfill (Sang-Arun and Bengtsson, 2012).

As shown in Fig. 4, the quantity of waste transported to the disposal site decreased sharply from 142 ton/day in 1997 to 82 ton/day in 2000, a level that has been subsequently maintained. The number of waste buyer shops and mobile waste buyers has increased 2-3 fold while the numbers of waste pickers have decreased by 50-75%. Therefore the municipality can significantly reduce the budget for waste collection and transportation.

The MBT plant further reduces the quantity of waste by 64%. Of the remaining waste, 13.5% is compost-like products that are used as biofilter for the MBT process, 59.9% is recovered plastic that will be used as alternative energy, and the rest is inert waste that needs to be disposed of in the landfill which is equivalent to 5% of the total waste generated before the implementation of the project (Sang-Arun, 2012).

Conclusion

The integrated solid waste management program designed under a lifecycle approach is applicable for both developed and developing countries. Each city can design the elements of an integrated solid waste management system that is based on capacity and local conditions. As shown in the two cases, they used different technologies but shared the common aims of enhancing resource utilization, saving landfill space, reducing environmental impacts, decreasing the budget for waste treatment and so on.

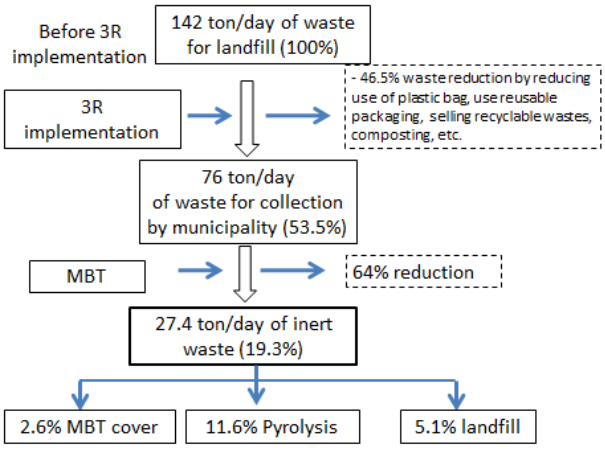

Fig. 5 Waste reduction through 3R practices in Phitsanulok Municipality (Sang-Arun, 2012)

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