

Municipal solid waste generation and treatment in developed and developing countries

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Abstracts: Municipal solid waste (MSW) is a valuable resource for developed countries but is a challenge, problem for developing countries especially low-income ones. This paper presents a comparison on MSW generation and treatment in developed and developing countries. This was done by reviewing recent researches and documentation on MSW, combining with questionnaire, interview and field observations. It came to a conclusion that waste reduction and prevention was well done in many developed countries like the European Union and Japan which resulted in a reduction in waste emission per capita over the last ten years. MSW in developed countries had high content of recycle material which accounts for around 50 % of total waste amount. Incineration with energy recovery and waste recycling were priority in developed countries. Meanwhile, 50% to 60% of MSW in developed countries were organic matter which was a precious source for composing or anaerobic digestion to get biogas for cooking or creating electricity. However, most of the MSW in developing countries was dumped on land in a more or less uncontrolled manner. Developing countries need to much effort and be provided better finances, legislation, appropriate infrastructure, technology and equipment, public awareness, and trained consultants to create waste-free nations.

Key words: Municipal solid waste, waste generation and treatment, developed countries, developing countries.

1. Introduction

Municipal solid waste (also called trash or garbage) is defined at the national level as wastes consisting of everyday items such as product packaging, grass clippings, furniture, clothing, bottles and cans, food scraps, newspapers, appliances, consumer electronics, and batteries (U.S. EPA, 2016). These wastes come from homes, institutions such as schools and hospitals and commercial sources such as restaurants and small businesses. U.S. EPA's definition of municipal solid waste (MSW) does not include municipal wastewater treatment sludges, industrial process wastes, automobile bodies, combustion ash, or construction and demolition debris. Once generated, the MSW must be collected and managed. At present, there are a number of processing technologies available for the treatment of MSW, such as composting, bio-methanation, recycling, refuse derived fuel (RDF), gasification, incineration, pyrolysis, landfills..., (Shyamala, 2016). The method of choice depends on the share of organic waste in the refuse. Many wastes that are disposed of in landfills represent a loss of materials that could be reused, recycled, or converted to energy to displace the use of virgin materials (U.S. EPA, 2016). Zaman et al. (2016) stated that only 15% of the waste was recycled and most of the global waste was still managed by landfills.

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Municipal solid wastes (MSW) constitute a growing problem and have gained increased political awareness over recent years. The amount of solid waste generated in the world is steadily increasing and every government in this world is currently focusing on methods to approach the challenge. Zaman et. al. (2016) indicated that we generated around 1.47 billion tons (436 kg/cap/year) of MSW each year and waste generation is increasing over time. The UK's Institution of Mechanical Engineers (IME) estimated in its report "Global Food – Waste Not, Want Not" (2013) that between 30% to 50% (or 1.2 to 2 billion tons) of all food produced on the planet was lost before reaching a human stomach (Tim Fox, 2013). In Europe, up to 179 kg of edible food was wasted annually per EU citizen and according to the Commission, food waste may reach 126 million tons per year by 2020 if nothing is done (Cécile Barbière et. al., 2015). There is a positive correlation between per capita income gross domestic product (GDP/capita/year) and per capita waste generation (kg/capita/year) and a similar correlation is also observed between per capita income (GDP/year) and per capita resource recovery (kg/year) (Zaman et. al., 2016). Generally speaking, as a society creates and consumes more materials, it demands more resources (e.g., water, energy, minerals, land) and generates greater quantities of pollutants and waste (U.S. EPA, 2016). Basically, lower levels of waste intensity imply that society is using materials more efficiently and more sparingly. By consuming fewer materials, households, businesses, and society at large can achieve cost savings and reduce effects on the environment (U.S. EPA, 2016).

Municipal solid waste management (MSWM) is the collection, treatment and disposal of solid materials that are discarded by purpose or no longer useful. Improper disposal of solid waste results in unsanitary conditions which lead to pollution and spreads various infections and diseases. Solid waste management is a challenge for the cities' authorities in developing countries mainly due to the increasing generation of waste, the burden posed on the municipal budget as a result of the high costs associated to its management, the lack of understanding over a diversity of factors that affect the different stages of waste management and linkages necessary to enable the entire handling system functioning (Lilliana et al., 2013). Solid waste management (SWM) of which there is MSWM has become an issue of increasing global concern as urban populations continue to rise and consumption patterns change. The health and environmental implications associated with SWM are mounting in urgency, particularly in the context of developing countries (Rachael et. al., 2013). In industrialized countries, public health, environment, resource scarcity, climate change, public awareness and participation have acted as SWM drivers towards the current paradigm of integrated SWM. However, the science and engineering of MSWM is relatively new in developing countries. Urbanization, inequality, economic growth, cultural and socio-economic aspects, policy, governance and institutional issues have complicated SWM in developing countries (Rachael et. al., 2013).

This study looked at the current situation of MSW and MSWM in some developed and developing countries with more emphasizing the differences on waste composition and treatment methods. Based on that, the paper pointed out some main issues on MSWM in developing countries and suggested the improvements for these issues.

2. Materials and methods

All required data for this study were collected both from primary and secondary sources. The secondary sources of the data was conducted through the review of all available published and unpublished documents of relevant organizations, researchers and from the websites of U.S. Environmental Protection Agency and of the statistical office of the European Union. The primary data were collected from researchers'

observation and key informants. Due to the lack of updated information on the characterization of waste that was generated and MSWM in developing countries, structured questionnaire, checklist, interview guideline and field observations were used to obtain data and information for the study.

Both open and closed - ended questions were incorporated to identify and extract information. A group of 25 researchers, experts and officers on MSW in Ethiopia, Tanzania, Zambia, Tanzania, Rwanda, Mozambique, India and China were chosen for the questionnaire.

Physical surveys were carried out by visiting various existing waste collection and treatment sites in Beijing – China (in May, 2016), Nairobi – Kenya (in August, 2016), Delhi, Agra, Mumbai, Pune – India (in April and June 2017). The surveys were intended to capture the overall key issues on MSWM in the visited countries.

3. Results and discussions

3.1. Municipal solid waste generated and treatment in some developed countries

Municipal solid waste in the United State:

Figure 1 shows trends in the generation and management of MSW in the U.S. from 1960 to 2014. The total quantity of MSW generated in the U.S. grew steadily from 88 million tons (MT) in 1960 to a peak of 259 MT in 2014, equivalent to 0.81 kg/c/day. In the MSW composition, recycle material (paper, paperboard, plastics, metals and glass) accounted for 54%, yard trimmings and food comprised another 28%, rubber, leather, and textiles accounted for 9%. Wood followed at around 6 % and other miscellaneous wastes made up approximately 3% of the MSW generated in 2014 (Figure 2).

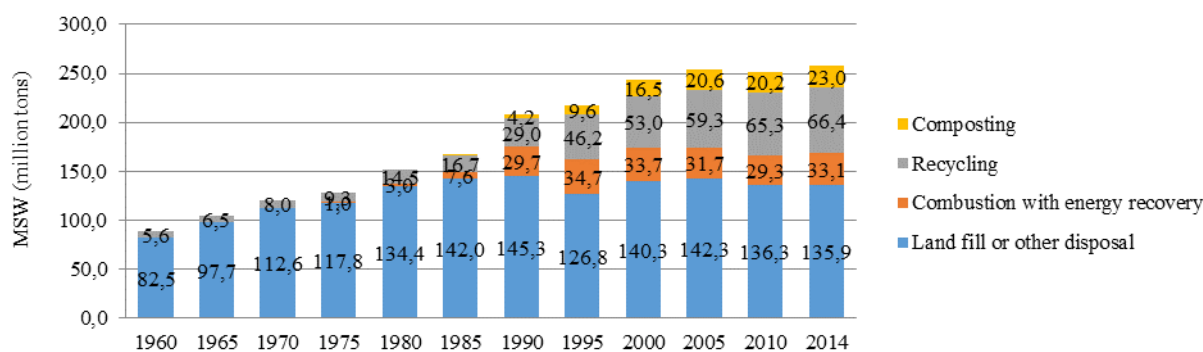


Figure 1: Municipal solid waste generated and managed in the U.S., 1960 – 2014

(Note: No composting data available prior to 1988. “Landfill or other disposal” includes combustion without energy recovery)

Data source: <https://archive.epa.gov/epawaste/nonhaz/municipal/web/html/index.html>

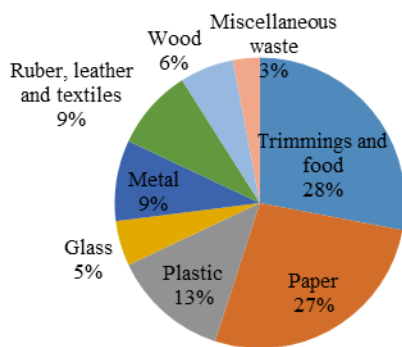


Figure 2. Total MSW generation (by material) in the U.S., 2014

Data source: <https://archive.epa.gov/epawaste/nonhaz/municipal/web/html/index.html>

Of the MSW generated in 1960, 6% was recovered through recycling and 94% was landfilled or disposed of using other methods (including burning). In 2014, 26% of MSW was recycled, 9% was composted, 13% was combusted with energy recovery, and 53% was landfilled or disposed of using other methods. The last several decades have seen steady growth in recycling and composting, while the total amounts landfilled peaked in 1990 (145 MT) and have generally declined since then (136 MT in 2014). The total amounts combusted have remained fairly steady. Disposal practices have also been influenced by the development of large waste-to-energy facilities, particularly during the 1980s. Overall, from 1960 to 2014, total MSW generation in the U.S. increased by 193%. During this time, the U.S. population increased by 76%, and the size of the U.S. economy as measured by real GDP grew by 414% (U.S. EPA, 2016).

Municipal solid waste in Japan:

In Japan, the total waste emissions and waste emissions per person per day slightly declined from 2000 to 2015, resulting the reduction in amount of MSW treatment (Figure 3). For example, the total of treated MSW decreased from 52,900,000 tons in 2000 to 44,870,000 tons in 2013 (-19.85%). Per person, it represented a daily waste emission of 958 grams in 2013 (-0.6% from 964 grams in previous year). This revealed that Japan has been well carried out the waste reduction and prevention policies. Packaging represented approximately 54% of MSW waste in term of volume and 25% in terms of weight (Christine et. al., 2015). Combustion was the most popular waste treatment method in Japan and accounted for about 80% of waste treated amount recently (Figure 3). Historically, incineration has been the main waste treatment method due to a lack of space for landfills and the obligations to treat waste locally. The primary objectives were therefore volume reduction and easy disposal process rather than energy recovery. It resulted in many small-scale plants for the use of individual municipalities, which made the generation of electricity or recovery of heat uneconomic. However, with the promotion of thermal recycling, modern waste-to-energy plants were then incentivized to recover energy. Most of them now use the electricity generated by waste incineration to run the plant and sell the surplus to power supply companies. 28.0% of all plants were equipped with power generation facilities, and the total power generating capacity increased (Christine et. al., 2015). The quantity of waste disposed of by landfill was very little and has been decreasing.

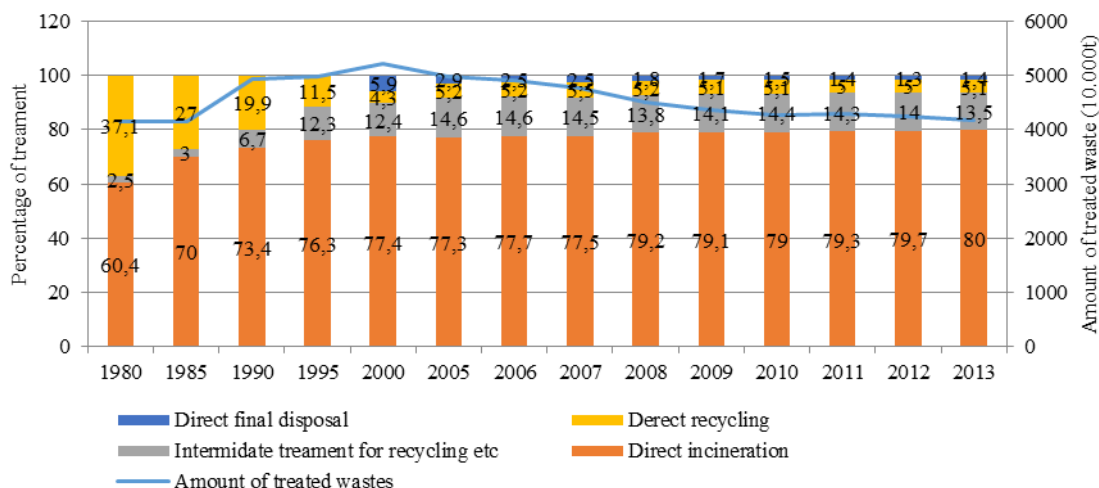


Figure 3: Municipal waste treatment amount and methods in Japan

Source: METI, 2014 and Christine, 2015

Municipal solid waste in the European Union:

In the European Union, the amount of municipal waste generated has been reducing recently (Figure 4 and 5). From 2005 to 2015, the amount of MSW per capital had been declined from 1.41 kg in 2005 to 1.3 kg in 2015 (- 8.8%). Countries showing large reduction were Bulgaria (- 27.4%), Spain (- 26.4%), Hungary (19.4%), United Kingdom (- 16.8%), Belgium (- 13.8 %), Slovenia (13%), Netherlands (12.4%) ... In 16 of the 31 countries (EU-Member States and EFTA), the amount of municipal waste generated per capita increased between 1995 and 2015. The highest average annual growth rates were recorded for Latvia based on 1995 and 2015 figures (26.2 %), Slovakia (15.8 %), Serbia (11.2%), and Denmark (10.8%). During the period from 2005 to 2015, Slovakia, Czech Republic and Poland had the lowest amount of waste generated with around 0.82 kg per person (Figure 5). At the opposite site, Denmark (2.16 kg/c/day) had the highest amount of the waste generated, well ahead of Luxembourg, Cyprus and Germany with lower amounts but about 1.97 kg/c/day. Recently 80% of the municipal solid waste in Europe is recyclable or compostable.

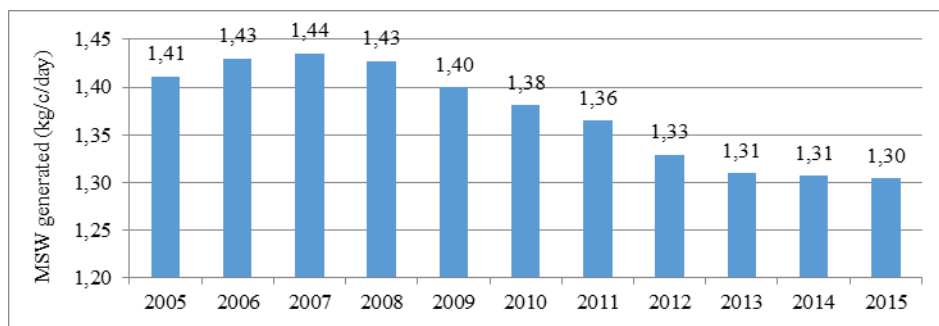


Figure 4: Waste generated in European Union (28 countries) from 2005 to 2015

Data source: Eurostat, 2017

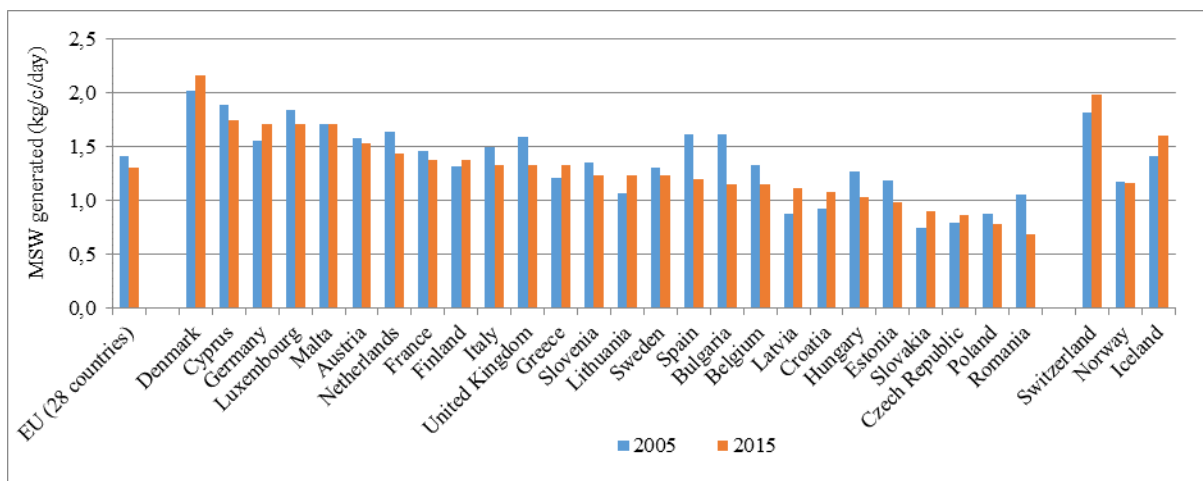


Figure 5: Municipal waste generated by country in 2005 and 2015 in EU and Switzerland, Norway and Iceland

Data source: Eurostat, 2017

Figure 6 and 7 show the municipal waste treatment in EU from 1995 to 2015. As can be seen in those figures, the percentage of treated MSW was increased from 67% in 1995 to above 97% in 2015. There were 11 countries reaching 100% of treatment. Most of them are the leading industrial countries like Denmark, Spain, France, Netherlands, Poland ... The lowest treatment rates were 75% (Serbia) and 84.5% (Latvia). The treatment followed different methods, including landfill, recycling, incineration, composting. The treatment methods varied strongly from 1995 to 2015, in which incineration and recycling increased 90% and 162% correspondingly while landfill and other treatment decreased 60% and 41%. The EU's 2008 Waste Framework Directive called for recycling of at least 50% of household waste by 2020. In 24th May 2012, the European Parliament (EP) passed a resolution on a Resource Efficient Europe which, if implemented, could put the EU on the road for Zero Waste for 2020. In this resolution, the EP joined the European Commission in expressing the need to bring residual waste closing to zero and consequently called on the European Commission to make proposals by 2014 with a view to gradually introducing a ban on landfill in Europe and for the phasing-out by 2020 of incineration of recyclable and compostable waste. This practically meant the end of waste disposal in Europe by 2020. In 2015, 25% of the MSW in EU were landfilled, 27% incinerated and 46% recycled or composted, 2% other. Waste incineration has also grown steadily in the reference period, though not as much as recycling and composting.

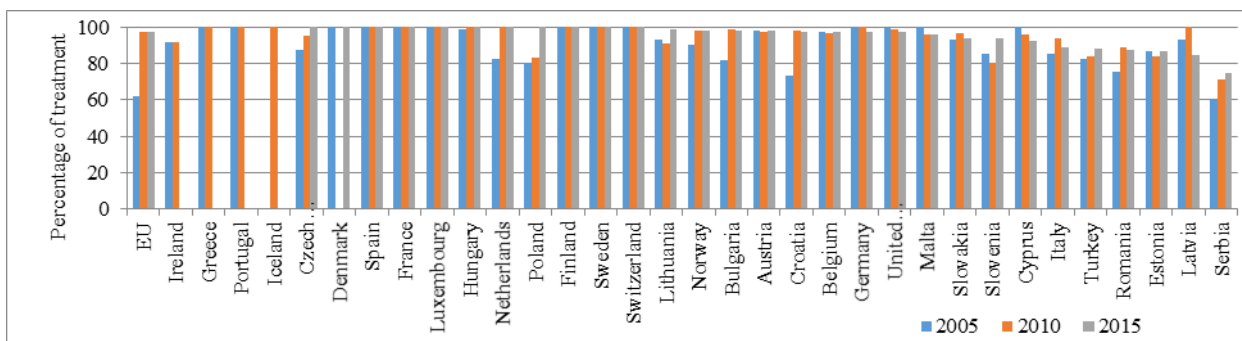


Figure 6: Percentages of municipal waste treatment compared to generation, EU-27, 1995 - 2015

Data source: Eurostat, 2017

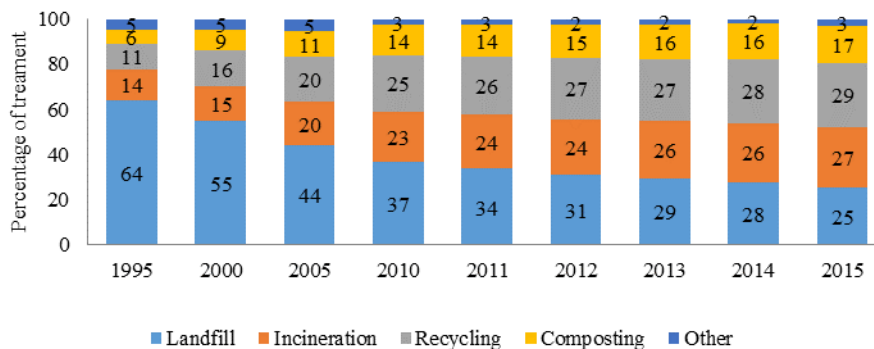


Figure 7: Municipal waste treatment by type of treatment, EU-27, (kg per capita), 1995 - 2015 Data source: Eurostat, 2017

The treatment methods differ substantially between Member States (Figure 7). In 2015, a third or more of the municipal waste was recycled in Slovenia (50%), Germany (49%), Belgium (35%) and Sweden and Switzerland (both 32%). Composting and digestion were most common in Austria (32%), followed by the Netherlands (27%), Switzerland (21%), Belgium (20%), Italy (20%) and Luxembourg (20%). At least half of the municipal waste treated in 2015 was incinerated in Estonia (59%), Denmark and Norway (both 53%) and Sweden (51%), while the highest shares of the waste landfilled were recorded in Malta (93%), Romania and Croatia (both 82%), and Greece (84%). Estonia, Finland, Norway, Denmark, Sweden and the Netherlands have been the leaders in using the energy generated from incineration in localized combined heat and power facilities supporting district heating schemes. By 2012, the Netherlands established 12 incineration plants that helped 50,000 households in Amsterdam to attain 25% heat requirements from waste incineration (EEA, 2013). Direct landfill did not exist or occupied a very small proportion in Germany, Sweden, Belgium, Denmark, the Netherlands, Austria, Switzerland, Norway.

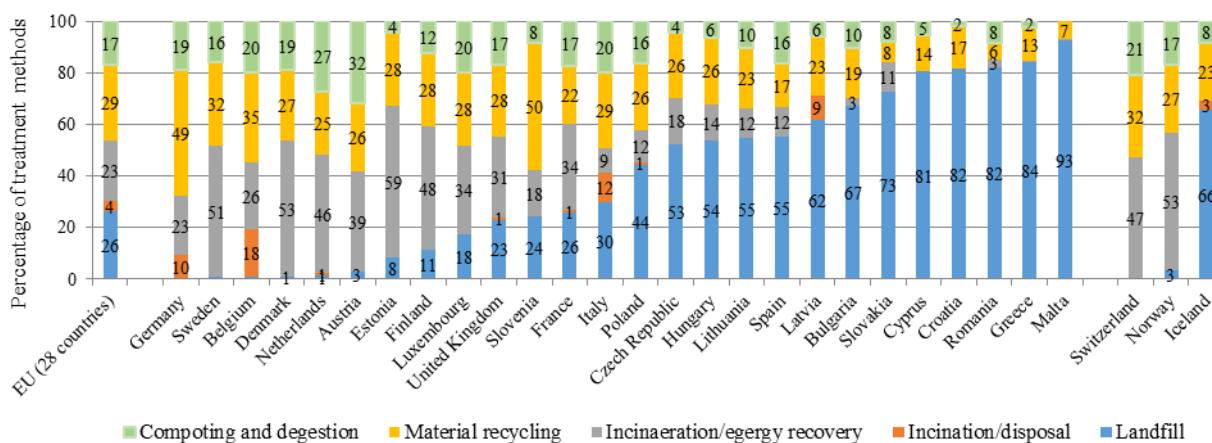


Figure 7: Municipal waste treatment in 2015, EU28 + Switzerland, Norway and Iceland

Data source: Eurostat, 2015.

3.2. *Municipal solid waste generated and treatment in some developing countries*

Municipal solid waste generated and treatment in India:

India is a developing country. It is developing not only economically but also demography. India is the world's second most populous country after China with a population of 1.31 billion and an annual growth rate of 1.2% (Neha et. al., 2017). According to the Central Pollution Control Board (2015), India generated 1,43,449 tons per day of MSW during 2014 - 2015 (Shyamala et. al., 2016). The yearly increase is estimated to be about 5%. It was estimated that solid waste generated in small, medium and large cities and towns in India was about 0.2 - 0.3 kg, 0.3 – 0.4 kg and 0.5 kg per capita per day respectively (Shyamala et. al., 2016). MSW constitutes 51% of organic waste, 18% of waste which are classified as recyclable wastes (plastics, paper, and glass ...) and 31% of the inert and non-organic waste (Neha et. al., 2017). Of the total waste generated, approximately 68% MSW was collected.

MSWM is one of the major environmental problems of Indian cities. About 80% of the MSW was disposed of unscientifically in open dumps and landfills, creating problems to public health and the environment (CPCB, 2016). Recently, 95 landfill facilities have been reported as constructed in the country. The field observations in Delhi and Agra (April, 2017), Mumbai and Pune (June, 2017) showed that the effort made in waste segregation was not successful due to a lack of waste processing and disposal facilities. India have been using aerobic composting (organic compost as fertilizers), anaerobic composting (biogas as fuel or electricity) or refuse derived fuel (secondary fuel for solid fuel industry) to manage their municipal solid waste (Rishabh et. al., 2014). Composting/vermin - composting technology is preferred in small towns as it is easy to operate by local bodies rather than going for other options like thermal processing (incineration, pyrolysis, gasification, etc.). In many states, local bodies have so far not preferred waste-to-energy projects due to lacks of experiences, capital investment and demands. However, metro-cities have no other option but go for waste-to-energy projects for managing large quantity of MSW.

Municipal solid waste generated and treatment in China:

Rapid urbanization and economic growth are the main factors of increasing MSW generation in China. China produced about 30% of the world's municipal solid waste (Xiao et. al., 2007). The generating MSW has 55.86 % food waste with high moisture contain due to unavailable source separation. Chinese MSWM was dominated by 60.16 % landfilling, whereas incineration, untreated discharge, and other treatments are 29.84, 8.21, and 1.79 %, respectively (Mian et. al., 2017). The site survey in Beijing in May, 2016 showed that even if separate bins were available for recyclable and non-recyclable waste, waste did not remain sorted in the collection process and government waste services did not have the capacity to operate a recycling system. The separated waste was bundled together into one truck. Chinese urban waste management services generally collected unsorted MSW to be disposed of in landfills or waste incinerators around the periphery of the city or further out into the countryside. The results from the questionnaire and the field surveys in May, 2016 in China revealed that Chinese landfills were similar to other landfills around the world in that organic matter did not decompose properly in the landfill's anaerobic conditions. The central government was recently interested in using anaerobic digesters to decompose organic waste and capture the methane as a fuel source. There are now many large-scale anaerobic digester pilot projects in China.

Municipal solid waste generated and treatment in Vietnam:

In 2015, Vietnam generated around 42.000 tons MSW per day and the yearly increasing rate was 10%. It was estimated that the MSW would be 61.600 tons and 83.200 tons by 2020 and 2025 correspondingly. The average MSW was about 0.65 kg/c/day (Vietnam DONRE, 2016). The MSW had an organic proportion of about 54 %, and recyclable waste (plastic, glass and metal) accounted for 24 % (Figure 8). The average collection rate in big cities, suburban areas and rural areas for the period 2013 - 2014 was 90% - 100%, 60% and 40-55% respectively. Most MSW was not segregated at source but was directly collected and transported to landfills. The main treatment method of MSW was disposal of in open dumpsites or sanitary landfills which accounts for 80% amount of MSW.

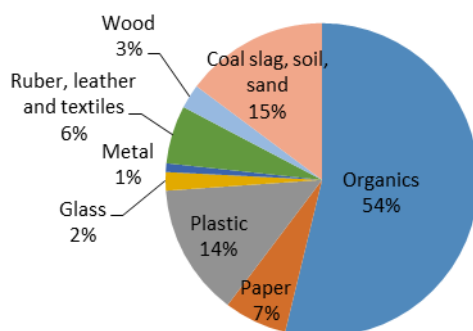


Figure 8: Composition of MSW in Hanoi, Vietnam

Source: MONRE, 2016

Municipal solid waste generated and treatment in the Southeast Africa (Ethiopia, Tanzania, Zambia, Tanzania, Rwanda and Mozambique):

Updated information published recently on the characterization of MSW and MSWM in the Southeast Africa was scarce. The results of questionnaires and field surveys showed that the major composition of wastes generated in most part of the Southeast Africa was biodegradable organic materials which accounted for over 60%. The share of recyclable material was about 20%. On average, each capital produced about 0.2 - 0.5 kg per day. In 2014, the daily solid waste generation in the city of Addis Ababa (Ethiopia) was estimated to be 0.5 kg/c/day (Hayal et. al., 2014). From the questionnaires, about 40 - 65% of generated wastes were collected in big cities and transported to the disposal sites. The remaining amount were left uncollected thereby disposed in drainage channels, rivers, open spaces, street sides among other improper places (see figure 9). Adriaan and Antoine (2014) indicated that in Mozambique, the collection ranged from 40-65% of the total solid waste. The waste disposal was not performed as provided by the national laws but according to costumes and habits deeply embedded in the population. The wastes were usually abandoned and accumulated on city streets. Many cities like Bahir dar, Addis Ababa city in Ethiopia, Nairobi in Kenya, Dar es Salaam in Tanzania, Kigali in Rwanda ... were lacking appropriate collection/segregation of solid waste, even some cities (Nairobi in Kenya, Kigali in Rwanda ...) had provision of different kinds of bins for different kinds of solid wastes.



Figure 9: Nairobi River (Kenya) – a dumpsite of wastes (by E. Kemboi - Kenya)

The main methods of MSW treatment were disposal of in uncontrolled open dumpsites and uncontrolled incineration. Open dumpsites received all kinds of municipal waste. Recovery of recyclable materials took place at the dumpsites and this was done by informal waste pickers. Officers in dumpsite waste separation worked in very poor health and hygiene conditions. They often stood side by side with members of the population, searching useful materials. The dumpsites in Kenya were controlled by cartels. Until now, sanitary landfill sites are almost absent in the Southeast Africa. A small share of MSW was composting.

With the supporting from overseas, a number of projects on MSWM have been conducted in some countries. One example is the project facing the introduction of waste separation and recycling in the Koinonia community in Lusaka. The main objective of the project was the creation of a MSWM model that was effective, lasting and exportable to other African countries. The analysis of the territory and community habits, along with the involvement of the local population, have led to the success of the project, currently under implementation and realization, for the differentiation of product classes of waste generated in the community with a view to recovery and recycling (Mahmood et. al., 2017).

In recently, the legislation of many countries on MSWM is updated and conformed to the international guidelines for health and environment protection. Rwanda did use plastic bags. Kenya had the legislation of no plastic bag packing starting on August 2017. However, MSWM still appears fragmented, characterized by several critical issues. One major challenge of MSW in Africa is the creation of enough capacity not only limited to monetary terms but also in technological and infrastructural advancement. In addition, a lack of transparency, bad governance and prevalence of corruption in most Southeast African countries are major problems militating against MSWM (Belo et. al., 2016).

3.3. Differences in MSW generation and treatment between developed and developing countries

There is much differences in MSW generation and treatment between developed and developing countries due to deep differences exist between them in terms of revenue, consumption patterns, institutional capacity, capital available for urban investment and standard of living. Generally, citizen in developed countries generates much waste than one in developing countries. However, in the last 10 years, the EU and Japan has well carried out the waste reduction and prevention policies. Consequently, the MSW generated per capital

has been steadily decreasing recently in the EU. However, the MSW generated per capita is still very high in comparison with that in developing countries (Table 1). It should be note that, although developed countries generate more MSW than those in developing countries but the wastes are more effectively managed and treated so the impacts on the environment and human being are less.

The table 1 illustrates some of the differences that may exist in refuse composition between developed and developing countries. The most notable differences lie in the percentages of recyclable and organic materials. The major composition of wastes generated in developing countries is biodegradable organic materials which makes up 51% - 60%. While around 50% of MSW in the developed countries are recyclable materials. The content of unidentifiable material such as ashes and dust is also characteristically larger in waste from developing countries (Elizabeth, 1998). The waste composition in developing countries is different from developed countries leading to a completely different approach to manage the waste. With a high content of biodegradable organic compounds in the MSW, composting and anaerobic methods are good options of treatment for developing countries. Meanwhile, developed countries prioritize the waste recycling and incineration with energy recovery due to a high content of packaging made of paper, plastic, glass and metal in the MSW. In developed countries, recyclable waste collection takes place at the sources but in developing countries, it happens at final waste deposit points like dumps or landfills. It is worthwhile to note that the segregation of waste at the door step is absent although door to door waste collection is improving in many developing countries.

Table 1: MSW generation in some developed and developing countries

	U.S	EU	Japan	Vietnam	India	China	Southeast Africa
Waste per capital (kg)	0.81	1.3	0.96	0.65	0.4	-	0.1 – 0.4
Percentage (%)							
Organics	28	31	25	53.8	51	55.86	60
Recyclable	54	48	-	23	18	-	20
Other	18	21	-	23.2	31	-	20

Data sources: U.S. EPA, 2016; Eurostat, 2015, Christine, 2015; Vietnam MONRE, 2016; Mian, 2017; Hayal, 2014; and the results of questionnaires and field surveys.

The other major difference between developed and developing countries lies in the infrastructural power. In developed countries, waste collection and disposal is largely taken care of either by public agents or private companies under the government’s scrutiny. On the other hand, in developing countries, waste picking is a mean for under - privileged populations and newcomers in the city, for example migrant workers in China, low-casts in, Southeast Africa, unlucky woman in Vietnam, India ...

Most of the developed countries are managing the solid waste with the best approach and laws by reducing the wastes and recovering energy from wastes. They are using advanced management techniques that are proving to be very helpful in eluding the waste as well as treating a better probability of recycling and reuse. Use of such techniques has allowed increasing the level of recycling and land filling is almost reduction. In developing countries, most MSW is disposal of in open dumpsites. They need to much effort and be provided better finances, legislation, appropriate infrastructure, technology and equipment, public awareness, and trained consultants to create waste-free nations.

3.4. *Key interventions to improve MSWM in developing countries*

McAllister (2015) did a research on factors influencing solid waste management in the developing world and recommended key interventions to help improve MSWM in developing countries as the followings: improvement on education and awareness, community involvement, infrastructure and technology, creation and enforcement of legislations on MSWM.

For developing countries, the improvement on education and awareness programs about solid waste is an important step in more effective MSWM. This includes the creation of awareness among the citizens for ensuing proper management of waste including systematization of procedures relating to collection, segregation, storage and transportation of wastes. Governments should take steps to educate the citizenry on waste reduction and separation as a matter of national policy and they should enact waste-minimization legislation as a first step.

Another major social intervention for more effective MSWM is the increasing on community involvement in waste management activities such as recycling, and the increasing on participation in decision making when it comes to waste management programs. Moreover, the intervention to increase the effectiveness of waste management systems is through incentives. The incentives, both economic and socio-psychological, can be incredible tools to help change behavior and are considered an effective social intervention in developing countries. Economic incentives, as an important tool in changing behavior and in some cases, market and financial incentives, can be even more effective in modifying the public behavior and increasing the waste diversion.

Improvements to infrastructure and technology within the waste management system need to be accompanied with the community involvement and participation as well as educational and awareness campaigns in order to be successful in creating the sustainable waste management systems. These include the improvements to the local infrastructure such as upgrading roads, trucks, routes schedules, conversion and updating of storage containers, investing in community collaborations, and formalizing recycling facilities; the improvements to service operations, technology, and accessibility utilization of recycling initiatives. The last is the improvements in disposal landfill creation. Creating new sanitary landfill sites is important to the sustainable waste management systems. While the sanitary landfills are expensive to maintain, that does not mean that communities in developing countries do not have sustainable waste removal options at their disposal. Composting and recycling initiatives as well as waste reduction are all available options for the developing world to take advantage of.

Finally, developing governments should pay much attention on creation and enforcement of legislations on MSWM. Standards and restrictions may limit the technology options that can be considered. The policy of government regarding the role of the private sectors (formal and informal) should also be taken into account. Involvement of stakeholders, in which there is private sectors is necessary to obtain any meaningful and sustainable municipal solid waste management.

4. Conclusions

Thanks to well done of the waste reduction policies over the last ten years, the European Union and Japan have gradually reduced the generation of the MSW. Recyclable material often contributed to around 50% of the total MSW amount in developed countries. Incineration with energy recovery and waste recycling

were priority in those countries. On the other side, the MSW in developed countries had 50% - 60% of organic matters. Most of the MSW in developing countries was disposed of in open dumpsites representing a loss of materials that could be composted or anaerobic digested to the recover energy. Key interventions that help to improve the MSWM in developing countries were that they should improve legislation, infrastructure, technology, equipment, public awareness, and saved better finances to create waste-free nations.

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