Current Journal of Applied Science and Technology

34(5): 1-23, 2019; Article no.CJAST.48441
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

A Review on Managing Solid Waste Produced from Homes in Malaysia

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Authors' contributions

This work was carried out in collaboration among all authors. Author WCT performed a comprehensive review on managing solid waste produced from homes in Malaysia. Author UN supervised the work and designed the content layout for this article. Authors STWL and SM collaborated with Malaysian government namely to streamline the paper contents with the government initiatives on managing solid waste. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2019/v34i530148
Editor(s):
(1) Dr. Sylwia Myszograj, Professor, Department of Water Technology, Sewage and Wastes, University of Zielona Gora, Poland.
Reviewers:
(1) Doris Chirinos Peinado, Universidad Nacional del Centro del Perú, Perú.
(2) Nkwoada Amarachi Udoka, Federal University of Technology Owerri, Nigeria.
Complete Peer review History: http://www.sdiarticle3.com/review-history/48441

Review Article

Received 25 January 2019
Accepted 09 April 2019
Published 18 April 2019

ABSTRACT

There has been a sharp rise in the rate of waste generated on a global scale, owing to a rapid growth in population and urbanization. Enormous amounts of waste are being produced yearly. To illustrate the gravity of this situation, in 2018, there was a gargantuan estimate of 85 tons of waste disposed in Malaysia. Most of this disposed waste is not properly recycled, thus making waste a prevailing global threat against mankind and the environment. Waste originates from several different sources such as residences, industries, agriculture and manufacturing plants. In this work, the writers seek to dedicate a compilation of developments in research for managing solid waste produced from homes in Malaysia. Further, the generation of solid waste from households, their characteristics and impacts are also reviewed herein. In addition, the flow of waste from the time it is produced in homes until its disposal in Malaysia will also be examined and presented. The concept of '3R' is implemented to manage the waste generated. This paper attempts to examine and solve the shortcomings in past works and to pave the way for future research on the solutions to control the pollution cause by the waste produced from homes.

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Keywords: Solid waste; waste management, 3R's; Malaysia; future research.

1. INTRODUCTION

Environmental quality on an international plane is on a rapid decline. This situation is only further worsened by the amount of waste being produced globally. Resultantly, this challenging issue is one that is a prevailing task in most developing countries as well [1]. The expected solid waste to be globally generated by 2025 is 19 billion tons [2]. First and foremost, identifying what constitutes 'solid waste' is the first most important step. Solid waste is defined as the unwanted or useless products in a solid state [3] derived from socioeconomical activities [4]. Types of solid waste are classified in different sources as shown in Table 1. Residential solid waste is defined as solid waste generated by households, whereas public solid waste is defined as solid waste generated by public places which falls under the supervision of local authorities, industrial solid waste is defined as solid waste generated by any industrial activity, commercial solid waste is defined as solid waste generated by commercial activities, institutional solid waste is defined as solid waste generated by educational premises, government departments and healthcare facilities, construction and demolition solid waste is defined as solid waste generated by any construction or demolition activity including preparatory, repairs and improvements and agriculture solid waste is defined as solid waste generated by gardening activities.

Different types of solid waste have different methods of disposal. But in general, the ways in which the amount of solid waste produced can be reduced — is called solid waste management. Solid waste management may be defined as an activity or action required to manage waste right from its inception to its final disposal including industrial, agriculture, and household waste. Solid waste management is a major problem for every country due to the complexity involved in its collection, transport, treatment and disposal of the waste, alongside effective monitoring and regulation of the entire waste management process [5].

Disposing solid waste in an improper manner may lead to environmental impacts and entail fatal repercussions for all living beings. A recent event in November 2018 stands cogent evidence of this. A dead whale was founded in eastern Indonesia. Its carcass contained close to 6 kilograms of plastic waste in its stomach as shown in Fig. 1. A team from the Wakatobi Marine and Fisheries Community Academy stated that there were a shocking 115 plastic cups, two flip-flops, four plastic bottles and a nylon sack containing over 1,000 pieces of string, and other plastic debris in its stomach. The coordinator of non-governmental organization Whale Stranding Indonesia also strongly suspects that the plastic debris contributed to its untimely death [6].

Every aspect of Earth's ecosystem is important. When one aspect is crippled, the rest will naturally follow suit. From the case above, it may be clearly appreciated that unwanted plastics that are produced from homes and thrown into drains, eventually flow into the river. These plastics makes their way into marine and coastal environments, and lead to the destruction of the ecosystem [7]. This may seem an exaggeration, but slowly and surely mankind is paving its own way to its end. But what is noble about mankind is that we learn from our mistakes. Efforts are being made to address these global concerns

Table 1. Type of solid waste from different sources [8–13]

Source	Types of solid waste
Residential	Food wastes, paper, cardboard, plastics, textiles, leather, wood, glass, metals, special wastes such as bulky items, consumer electronics, white goods, batteries, oil, tires, and household hazardous wastes
Public	Street sweepings, landscape, mud and tree trimmings, general wastes from parks, beaches and other recreational areas
Commercial	Paper, cardboard, plastics, wood, leaves food wastes, glass, metals, special wastes, hazardous wastes
Institutional	Same as commercial
Agriculture	Plant waste such as crock stalk, livestock and poultry manure such as animal manure, hazardous waste such as pesticide
Construction and demolition	Wood, steel, concrete and dirt

Fig. 1. The dead whale due to waste pollution in the sea

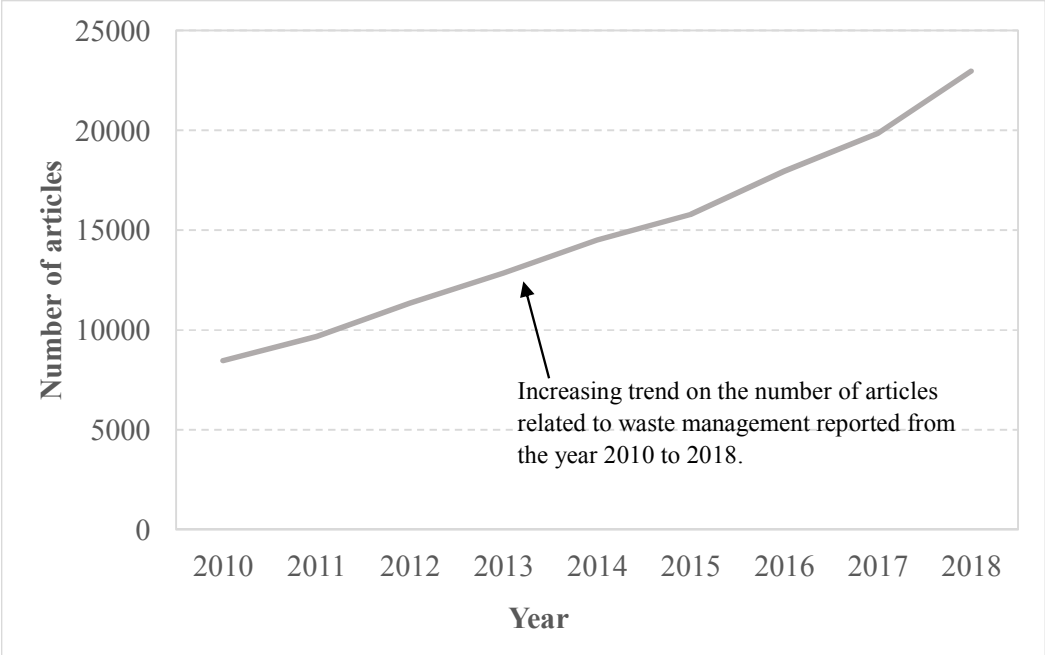

Fig. 2. Number of articles published on waste management from the year 2010-2018
Source: http://www.ScienceDirect.com. Keywords used: waste management

[14]. People are becoming more aware that the little things we do entail a gargantuan effect on a global scale. Fig. 2 shows the rise in the number of articles published on waste management from the year 2010 to 2018. In 2010, there were only 8468 of articles published. But in 2018, the number had increased to 22959. The number of articles published in the year 2018 was almost triple to that in the year 2010. This shows that people are now more concerned about the impacts of waste and the ways to reduce it.

From the above, it can be seen that the handling of waste whether from residential, industrial, commercial, institutional, agriculture, municipal services or construction and demolition sectors; have been crucial in recent years. Therefore, this paper seeks to dedicate a comprehensive review on municipal solid waste management. This paper will only deal with the types of solid waste generated from homes which is sorted under residential solid waste in Malaysia. Relevant research reported and the necessary steps taken to fully utilize waste developed or produce from

homes, will also be reviewed. Pursuant to that, this paper will propose future research pathways on the current topic.

2. HOUSEHOLD SOLID WASTE GENERATION, CHARACTERISTICS AND IMPACT ON MALAYSIA

Malaysia is a tropical country situated in the central part of Southeast Asia. The total land area occupied by Malaysia is 329750km^2. The country is separated into two regions by the South China Sea: West Malaysia and East Malaysia. West Malaysia is the Peninsular, which comprises 11 states. Whilst East Malaysia comprises of 2 more states. Fig. 3 further depicts the thirteen different states in Malaysia [15].

The Malaysian population has been on the increase at a rate of 4% per year. At this rate of population growth, the solid waste generated also increases which makes solid waste management essential [8]. In 2005, the average amount of MSW generated in Malaysia was 0.8–1.12 kg/person/day. There were 2.02 million tonnes of waste generated in Malaysia in the year 2017 [16]. By the year 2020, the quantity of solid waste generated is estimated to have increased to 31,000 tons. Fig. 4 shows the increasing waste generation from the year 2005 to 2016 in Malaysia [17]. In 2005, the total waste generated was 19000 tonnes per day while the waste disposed in landfills was 18050 tonnes per day. In contrast, in 2016: the total waste generated increased to 38200 tonnes per day, 35333 tonnes of which was disposed in landfills. However, the disposal percentage dropped from 95% in 2005, to 92.5% in 2016. It can thus be seen that illegal dumping continues to occur, and it may account for 10% of the total waste generated by 2020.

i) Amount of solid waste produced from home

The massive increase in generation of waste from homes recently became a cause for global concern. Waste produced from homes contributed most in the solid waste generated in Malaysia: which is 65% following by commercial and institutional which is 28% and industry which is 7%. Table 2 shows the percentage and amount of solid waste generated from different sources in Malaysia in the year 2017.

ii) Composition of solid waste produced from home

Information on waste composition is essential to identify and selected possible ways for sustainable waste management [18]. Fig. 5 show the composition of solid waste produced from homes in Malaysia in the year 2018 [19]. As it may be seen from Fig. 5, organic waste occupied the highest portion which is 50.3% out of total waste generated from homes, followed by plastics at 13.2%, diapers at 12.1%, paper at 8.5%, others at 8.2%, glass at 3.3%, textile at 3.1% and tetrapak at 1.6%.

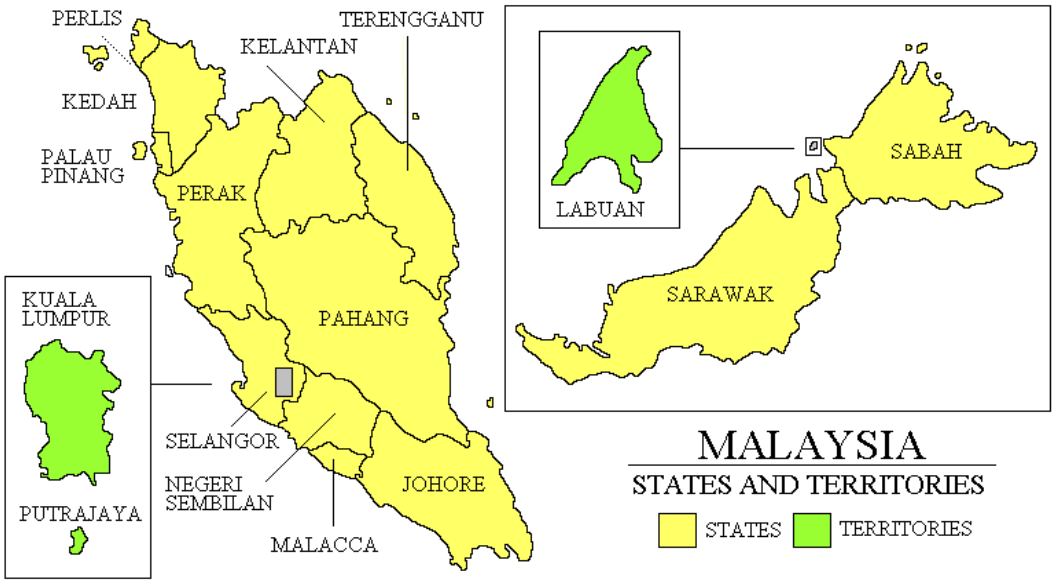

Fig. 3. Map showing different states in Malaysia

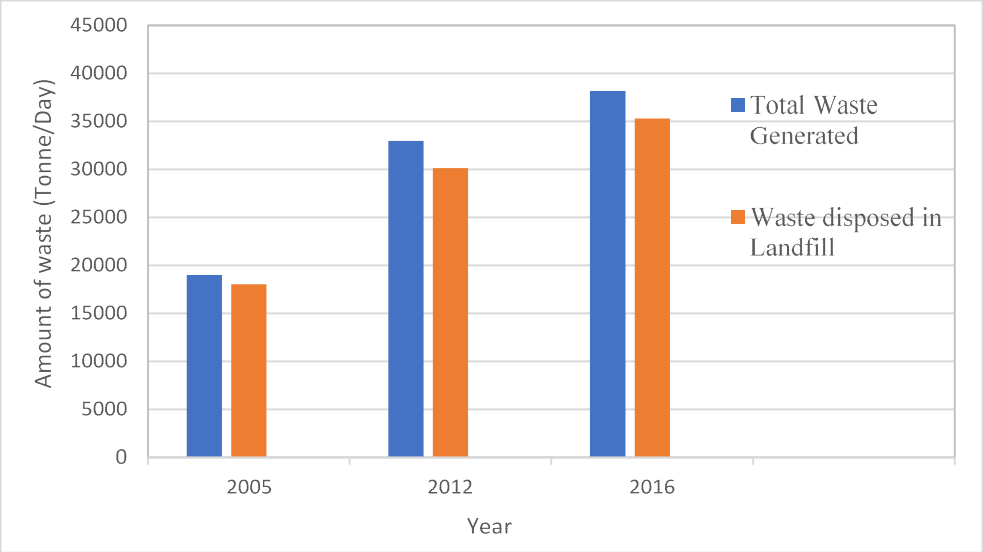

Fig. 4. Amount of waste generated and waste disposal in landfill in Malaysia from the year 2005-2016

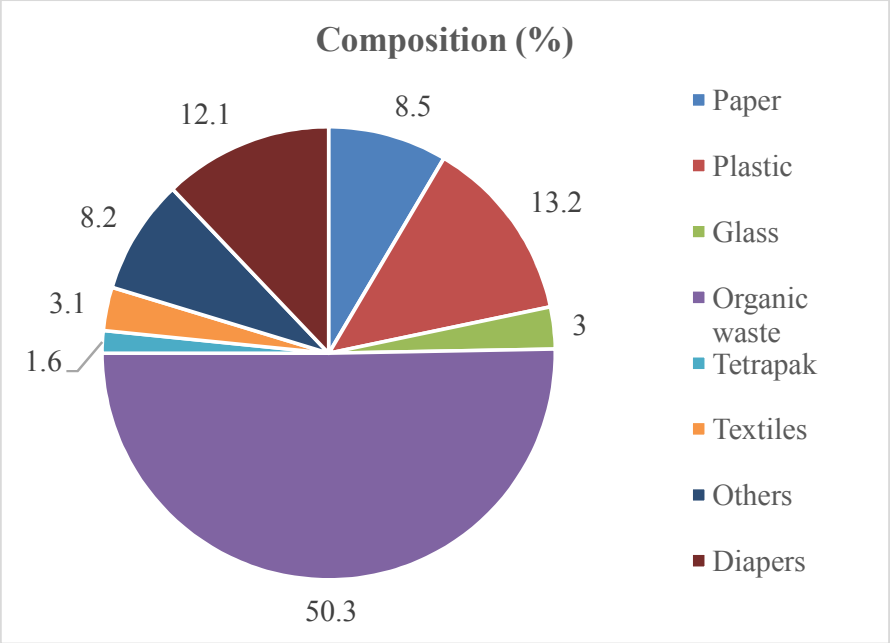

Fig. 5. Composition of solid waste generated in Malaysia in the year 2018 [19]

Table 2. Percentage and amount of solid waste generated from different sources in Malaysia in the year 2017 [20]

Source	Amount of solid waste generated, (tonne/day)	Percentage, (%)
Residential	21,450	65
Industry	2,310	7
Commercial and institutional	9,240	28
TOTAL	***33,000***	***100***

iii) Negative impact of solid waste disposal from home

The improper disposal of waste holds massive environmental impacts and causes serious problems. The most common impact from the waste produced in residential areas in Malaysia is water pollution. Domestic wastewater may contain harmful dissolved or suspended substances. Discharge of wastewater that is not regulated will destroy biodiversity, natural resilience and ecological capacity [21]. In Malaysia, the sewerage system is ineffective and wastewater is not treated properly before being discharged into rivers, as compared to other developed countries [22]. Fig. 6 shows the sewerage system typically found in Malaysian residential areas whilst Fig. 7 shows the sewerage system typically found in Japanese residential areas.

The figures above show the different sewerage systems in both countries. The drain in Japan is in fact even suitable for aquatic life due to their excellent sewerage system while the drain in Malaysia is polluted and in turn destroys the habitat of aquatic life. The drain in Malaysia contains harmfully dissolved or suspended substances as shown in Fig. 5 above due to the piping systems of the houses in residential areas. For example, food residue is thrown into the sink and flushed away with wastewater into the drain without providing any treatment. Hazardous household waste can be particularly dangerous for surface waters which leads to the ecosystem existing in waster being destroyed [23]. Water pollution resulting from the drainage wastewater directly to water bodies not only deteriorates water quality but also will degrade the environment. Various measures for the government to construct wastewater treatment plants is direly needed [24]. Hence, Malaysia could embrace good models of waste management from Japan which Fig. 6 had earlier shown in that Japan has good treatment for waste produce from homes [25].

Fig. 6. Illustration of drain typically found in the residential area in Malaysia

Fig. 7. Illustration of drain typically found in the residential area in Japan

Fig. 8. Accumulation of leaves inside the drain

Further, another negative impact of waste produced from homes is fallen leaves that often cover grids and prevent water from flowing into the drain. Fallen leaves may also make their way into drains and cause internal blockages that often result in flash floods occurring. Fig. 8 shows the condition of a drain typically found in a residential area in Malaysia. There were 498 cases of floods reported in Malaysia in the year 2017 [16]. Some of the residents remove the fallen leaves by collecting them into a plastic bag and sending them to landfills. This method however is not recommended due to the usage of plastic bags that only cause more waste to be produced. And sending such waste to landfills further increase the cost of transportation and occupy space. Some other residents choose to eliminate the unwanted leaves by burning them on the spot. This action however results in air pollution which causes various respiratory diseases and other adverse health effects. Open burning is one of the major sources of air pollution. From the compendium of environment statistic 2018 in Malaysia, open burning contributes 2.1% of emission pollutants to the atmosphere [16]. Residents in residential areas in Malaysia typically conduct open burning for the purpose of eliminating waste in the fastest way. Most of the composition contained in the household waste burnt is dry leaves. Combustion of gases emit harmful substance such as carbon dioxide, carbon monoxide and smoke which are released to the environment in the process of open burning [26]. Those exposed to it may experience lung infections, headaches, eye and nose irritation, difficulty to breathe and other adverse health implications. There is thus still no proper and environmentally-friendly method that may be implemented to eliminate the leaves that accumulate in the housing areas in Malaysia.

3. SOLID WASTE MANAGEMENT IN MALAYSIA

Solid waste management in Malaysia may be categorized into three classes that are: (i) municipal solid waste management; (ii) scheduled waste management and; (iii) clinical waste management. Each class is placed under the purview of a different government agency or Ministry. To illustrate, the Ministry of Housing and Local Government bears the responsibility to administer city strong waste administration, the Department of Environment manages booked wastage and transfer matters, whilst the Ministry of Health exercises control over clinical waste administration [27].

The aim of solid waste management is to generate an integrated, cost effective, sustainable, and acceptable waste management system to the community, with an emphasis on environmental conservation and technology selections which are affordable and assures that public health is not at risk.

i) Solid waste management history

For the past 30 years, the Malaysian federal government has handed the responsibility of handling municipal waste to the respective state governments of each state. The Cabinet as early as 6 September 1995 had already decided to privatise responsibilities of the Local Authorities (LA) beginning 1998. Since the 1st of January 1997, the solid management responsibility of 48 LA's has been privatised interim to 2 concession companies: Alam Flora and Southern Waste while the northern region of Malaysia was placed under an interim regime for a year. This was while legislation to streamline the strategies and

measures in the Strategic Plan were being prepared for enactment. In 2007, the Solid Waste and Public Cleansing Management (SWMPC Act 2007) was legislated by Parliament on 17 July 2007 and subsequently gazetted on 30th of August 2007. The SWMPC Act 2007 was then enforced on the 1st of September 2011 in 7 states (Peninsular Malaysia) which are Kedah Perlis, Johor, Negeri Sembilan, Melaka, Pahang and Federal Territory of Kuala Lumpur. In addition, the solid management responsibility of the LAs has also now been fully privatised. The vision towards 2020 is a 40% reduction of waste disposed to landfill through 22% recycling and 80% intermediate treatment such as Waste to Energy (WTE), material recovery and composting. The timeline of solid waste management history is as summarised in Fig. 9 [1].

ii) Chain activity of waste generation

In Malaysia, there is in existence a systematic process to convey municipal solid waste that is produced from homes, to disposal. Fig. 10 shows the flow of solid waste generated from homes to disposal.

- ***Generation***

To effectively reduce the amount of waste generated in Malaysia, residential solid waste represents the critical source that must be targeted. A first step in reducing the amount of solid waste produced from home is to first understand the various forms that it assumes. Separating waste into fractions at its of production is one of the most efficient ways of collecting it [28].

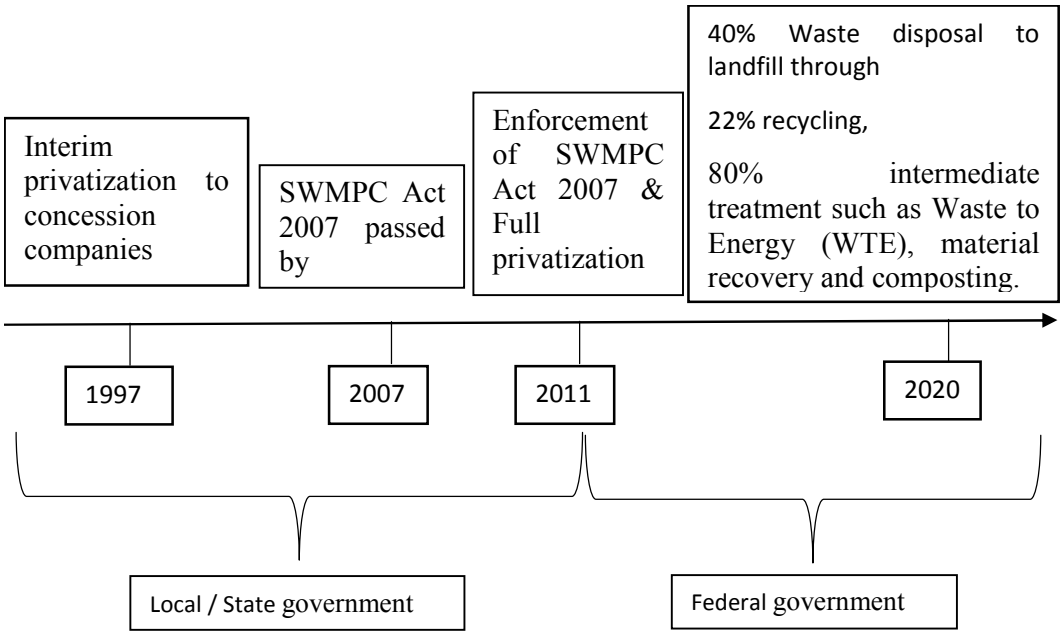

Fig. 9. Flowchart showing timeline of solid waste management history

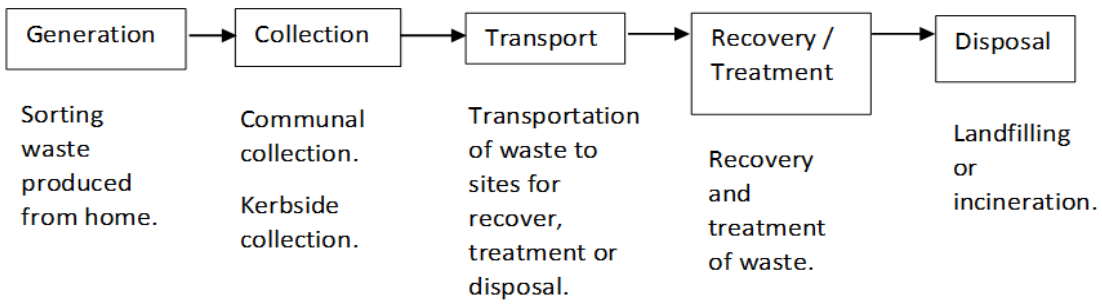

Fig. 10. The flow of solid waste generated from home to disposal

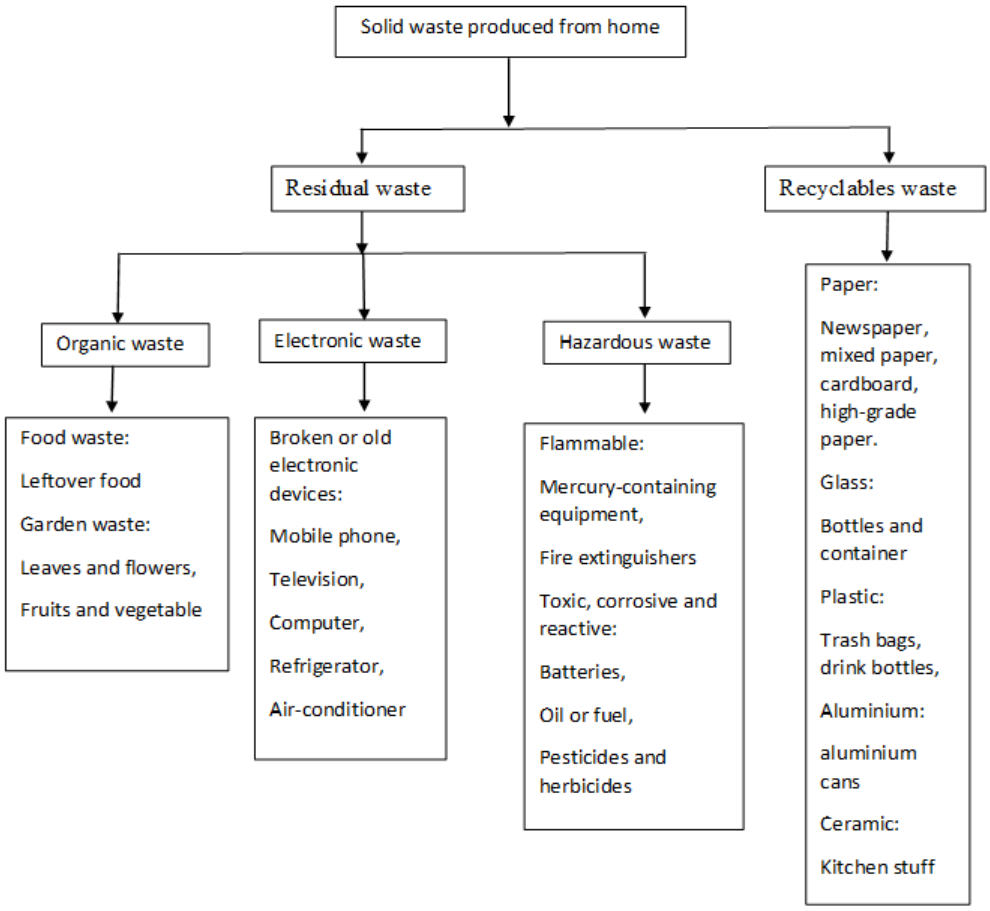

Fig. 11. Flowchart showing type of waste produced from home in Malaysia

Fig. 11 shows the flowchart classifying the types of solid waste produced from homes that are typically found in Malaysian residential areas.

Solid waste is the main type of waste produced from homes. It is then further classified into 2 main types: Residual waste and recyclable waste. Residual waste may be further separated into organic waste, electronic waste, and hazardous waste. Hazardous waste constitutes a small fraction of household waste, which many people have now become aware of. People have to be made aware of this issue of hazardous waste and the potential risks it entails through educational initiatives and they have to be able to identify the hazardous materials that lay within the household waste generated every day. Hazardous waste has to be collected separately and effectively treated. This is because disposal of hazardous waste at conventional landfills could lead to the release of potentially dangerous elements to the environment [29]. The use of less hazardous materials in the manufacturing of goods in everyday life could also provide a further positive effect in dealing with specific waste streams. Improperly disposed of batteries, solvents, cleaners and paint fall into this category as well [30].

Together with the rapid development of technology and the constant renewal of electronic devices, people's consumption habits have now changed. A new type of waste called electronic waste has emerged. New products continuously marketed more rapidly, efficiently and economically outdate the electronic devices that we use in just a short period of time. Therefore, electronic items that we previously used go to waste and lead to the generation of unnecessary e-waste that contributes a significant amount in household waste nowadays. The common electronic waste seen are old or broken hand phones, computers, televisions, washing machines, air conditioners,

refrigerators, DVD players, radios, fax machines, printers and others. E-waste is a negative implication from the rapidly development of technology. Ways of preventing electrical appliances and electronic devices from containing a high volume of toxic materials and ensuring they are environmentally friendly are direly needed as well. All people must be well aware of reducing the amount of electronic waste produced [31,32]. Information on the generation and flow of e-waste disposal is important for estimating the possible consequences of mishandling of e-waste and planning cost effective treatment [33].

Furthermore, organic is not really a type of waste but a large variety of materials that are mistakenly identified as waste by people who add them to the waste stream unnecessarily. Anything that is made up of organic materials, from food scraps to fallen dry leaves has no business being in the waste stream or in a landfill. Organic waste has the potential to attain sustainable energy yields with minimum effect on the environment. Organic waste is a major contributor of household waste, especially so in ASEAN countries [34]. There is 45.5% of organic waste in Malaysia. Up to 40% of organic waste is reported to be food waste which can cause odor and public health concerns if its disposal is delayed [35]. The reduction of food waste at home is simple but requires creativity in dealing with leftovers [36]. Therefore, proper waste management of organic waste is more of a concern than compared to other household waste due to the fact that it can reduce waste disposal into landfills and reducing organic waste is also simpler than reducing other types of waste. This percentage can be reduced as the public is better educated about the nature of waste, and about a large number of things that may be easily diverted from the waste stream. Organic waste is a resource that needs to be separated and not wasted onto landfills.

To add, another waste produced daily is recyclable waste. Recyclable waste can be further categorized into 4 main types: Plastic, paper, tins and metals and ceramic and glass. For example, plastic waste which consists of bags, containers, jars, bottles, paper waste which includes packaging materials, newspapers, cardboard and other products, tins and metals such as milo tins and aluminium cans, and ceramics and glass such as the cup, mug, plate, bowl and other kitchen stuff. Recyclable waste can be managed by recycling and thus reducing the amount of waste disposed. However, lack of awareness toward waste recycling may cause the segregation of waste into their proper categories challenging [1].

In a nutshell, waste sorting is a multi-level process to transfer waste materials to suitable collection facilities. Sorting of waste is the first level [37]. The source separated collection enables better resource utilization and waste minimization [38]. Solid waste from homes can be classified into organic waste, recyclable rubbish, electronic waste and hazardous waste. To ensure proper waste removal, it is pertinent to segregate the waste into these different types [39].

- ***Collection and Transport***

Two types of collection systems are implemented in every state in Malaysia. There are communal collection and kerbside collection. In the communal collection system, householders take the waste materials from the household to the collection point. The collectors will collect the waste from the communal storage. This system is commonly used in high rise apartments and condominiums. In the kerbside collection system, waste materials are collected directly from homes. The residents leave their bins on the roadside in advance of collection time. After collection, the owners simply take empty bins back. Kerbside collection is common in low-rise housing areas, which include terrace, semi-detached and detached houses. The separated waste will be collected every week in a fixed schedule. The Ministry of Urban Wellbeing Housing and Local Government had implemented 2+1 collecting system in 1 September 2015 whereby the collection for recyclable waste will be collected once a week while the collection of residual waste will be done twice a week with new standards on waste bin and collection trucks [40] for kerbside collection while 2567 units of recycling cages for high rise residencies and 38 drop off recyclables collection point are being set up. A comparison between collection systems is summarized below in Table 3.

Currently, there are 4 concession companies that operate to collect solid waste. These 4 companies are assigned to different states as shown in Fig. 12. Alam Flora is responsible for the central and eastern regions (Federal Territory of Kuala Lumpur, Pahang, Selangor, Kelantan and Terengganu), E-Idaman Sdn. Bhd for the

northern region (Perak, Perlis, Penang and Kedah), Eastern Waste Management for East Malaysia (Federal Territory of Labuan, Sabah and Sarawak) and Southern Waste Management for the Southern region that includes Johor, Melaka and Negeri Sembilan. These concession companies collect the waste from homes and transfer the waste to collection centers or straight to landfills depending on the type of waste collected.

- ***Recovery / Treatment***

Recycled waste is sent to buy-back or recycling centers set up by local authorities, concessionaires, NGOs and private organizations for the purposes of recovery or treatment of the waste. For example, Concession companies such as Alam Flora and Southern Waste Management have established their own buy back centers and recycling centers in their own responsible region. There are also plenty of other recycling centers set up by NGOs and private organizations that can be found in Malaysia such as Tzu Chi Malaysia Taman University Recycle center, Pertubuhan Amal Seri Sinar, Nikkhsin Agro (Me) Sdn, Bhd, JK Kland Recycle Sdn. Bhd, SPM Plastic Recycling Sdn. Bhd, Victory Recovery Sdn, Bhd and others.

- ***Disposal***

Residual waste that cannot be recycle is sent to disposal. For the past few years, landfilling is the only method employed for the disposal of solid waste in Malaysia and most landfills are open dumping areas that entail serious environmental impacts such as emission of methane gas and greenhouse gases which contribute to the greenhouse effect [41]. Further, the disposal of waste into landfills also becomes more difficult due to the rate at which an existing landfill is filled than compared to the time taken to construct a new landfill [42]. Currently, there are 4 levels of landfill sites found in Malaysia as shown in Table 4. Table 5 shows the operating and non-operating landfill sites in Malaysia. There are 300 landfills, 170 of which are still

Table 3. Comparison between collection systems [38]

Type of collection systems	Description	Areas	Program implemented
Communal collection	Waste is collected from collection point.	High rise apartments and condominiums	2567 units of recycling cage for high rise residency and 38 drop off recyclables collection point is being set up
Kerbside collection	Waste is collected directly from homes.	Terrace, semi-detached and detached houses	2+1 collecting system

Fig. 12. The concession companies and their areas of responsibilities during the privatization in Malaysia [43–46]

operational, but only 14 sanitary landfills. Table 6 shows the list of sanitary landfills in Malaysia. Besides landfilling, incineration is a new method of waste disposal to replace the landfilling method. Minister of Housing and Local Government Zuraida Kamaruddin believes that this would ensure a cleaner process of solid waste disposal and save on land use, as it would not require opening new landfill sites in the future. The number of incinerators depends on the amount of waste is generated in each state. Table 7 shows the list of incinerators and its capacity to reduce waste in Malaysia.

Table 4. Classification of landfill sites in Malaysia [42,47–49]

Levels	Type of landfill sites	Description
I	Controlled dumping	Facilities with soil cover.
II	Sanitary landfill with daily cover	Same facilities in level I with additional of embankment, drainage facility and gas venting
III	Sanitary landfill with leachate circulation	Same facilities in level II with additional of leachate collection and leachate recirculation system
IV	Sanitary landfill with leachate treatment	Same facilities in level III with additional of leachate treatment system

Remark: Level I to IV indicate the rank of landfill sites; i.e. the higher the level of landfill sites, the more facilities provide

Table 5. Number of operating and non-operating landfill sites in each state of Malaysia [50]

State	Operating non-sanitary landfill sites	Operating sanitary landfill sites	Non-operating landfill site	Total
Johor	12	2	23	37
Melaka	2	1	5	7
Negeri Sembilan	7	0	11	18
Selangor	5	4	14	23
Federal Territory of Kuala Lumpur	0	0	7	7
Penang	2	0	1	3
Kedah	8	1	6	15
Kelantan	13	0	6	19
Perlis	1	0	1	2
Perak	17	0	12	29
Terengganu	8	0	12	20
Sabah	10	0	2	21
Sarawak	46	6	14	66
Federal Territory of Labuan	1	0	0	1
Total	**157**	**14**	**130**	**300**

Table 6. List of sanitary landfill sites in Malaysia [50]

State	Name of sanitary landfills
Johor	Seelong, Sanitary Landfill, Tanjung Langsat Sanitary Landfill
Melaka	Sungai Udang Sanitary Landfill
Selangor	Bukit Tagar Sanitary Landfill, Jeram Sanitary Landfill, Air Hitam Sanitary Landfill and Tanjung 12 Sanitary Landfill
Kedah	Polai Sanitary Landfill
Sarawak	Kemuyang Sanitary Landfill, Mambong Sanitary Landfill, Sibuti Sanitary Landfill, Miri Sanitary Landfill, The Kuching Integrated Waste Management Park and Bintulu Sanitary Landfill

Table 7. List of incinerators and its capacity in waste reduction in Malaysia [51]

Name of incinerator	Capacity (Tonne/Day)
Pulau Tioman Island Incinerator	15
Pulau Pangkor Island Incinerator	20
Cameron Highland Incinerator	40
Langkawi Incinerator	100
Pulau Labuan Incinerator	60

4. REDUCE, REUSE AND RECYCLE (3R's) OF WASTE

From a policy perspective, the two main purposes of waste management are the reduction of waste generation and the reduction of resource use [52]. However, the waste management methods enforced in most developing countries today is performed by collecting mixed waste which contains of residual and recyclable from every household and sending it to landfills for it to be decomposed. This however causes mistreatment of waste and entails many negative impacts on the environment [53]. For example, large amount of waste has caused emission of gases that has largely contributed to global warming. To overcome this conundrum, an appropriate and efficient approach such as designing products that incorporate the 3R's (Reduce, Reuse and Recycle) for an entire life cycle is very much required [37].

i) Developing of 3R's Programme in Malaysia

3Rs in Malaysia was first launched in the late 1980s. In the year 1987, an Action Plan for a Beautiful and Clean Malaysia (ABC) was outlined to treat solid waste as a resource and efforts to be made to recycle and recover. The campaign focused mainly on recycling activities such as the first national recycling day in the year 1993 and second national recycling day in the year 2000. But unfortunately it failed to improve the existing waste management practice. In the same year as the second national recycling day, despite the relative lack of success and receptivity of the concept of recycling, the government initiated several measures to improve the image of recycling among the general public. 3Rs were relaunched in 2001 by Ministry of Housing and Local Government in the 3rd outline perspective plan. In year 2005, a National Strategic Plan (NSP) was adopted with periodic review to ensure its relevance up to the year 2020. Under this plan, a waste minimization hierarchy was endorsed to provide a waste management framework in Malaysia. The development of 3R's programme is summarized in Fig. 13. As a policy objective, the waste minimization target needed socialization of the 3Rs idea on a large scale and this encouraged the government to focus on the waste minimization hierarchy.

ii) Waste minimization hierarchy

The waste hierarchy was established to help the government manage waste according to a sustainable agenda. The waste minimisation hierarchy is a concept that promotes a cylindrical approach to waste management [54]. The main purpose of the waste minimization hierarchy is thus to minimize the effects from waste disposal [55] This hierarchy is used as the main framework to establish further subsidiary waste management policies. Fig. 14 shows the waste minimisation hierarchy [56].

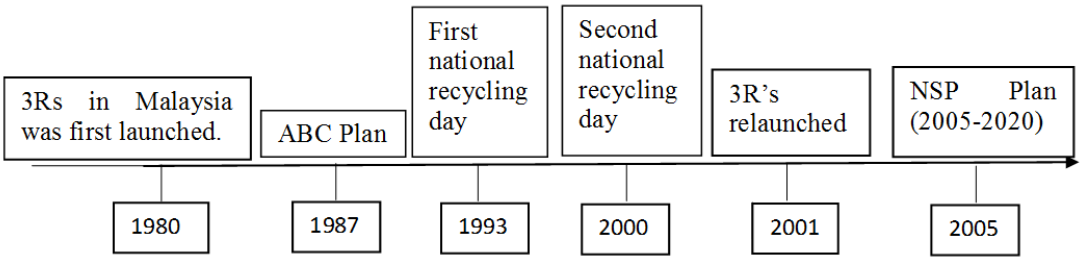

Fig. 13. The developing of 3R's programme

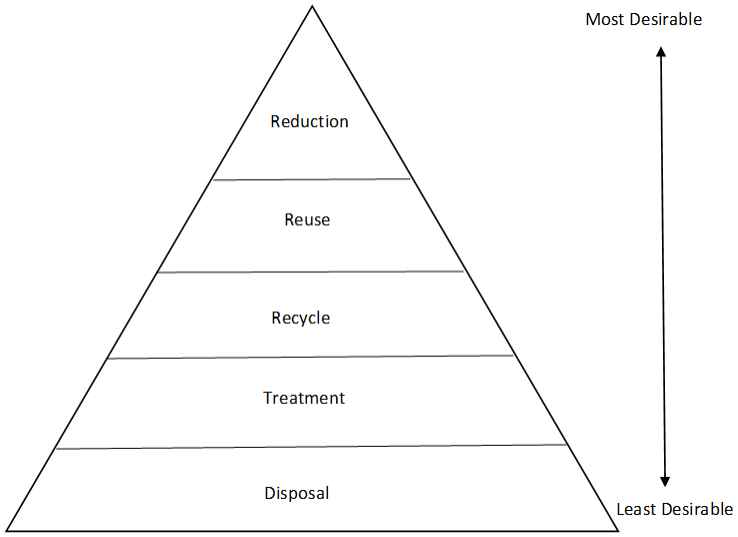

Fig. 14. Waste minimisation hierarchy [56]

It is every person's moral responsibility to minimize the amount of waste generated and to dispose of waste in a manner with least impact to environment. The waste minimisation hierarchy aims to minimize the environmental effects of waste disposed by reducing the amount of waste set for the landfill.

A very first step in this concept of 3R's is waste reduction. It is also known as waste prevention that is to reduce the amount of waste generated at the source by decreasing the use of unwanted waste. This step includes minimising the material in design and manufacture, extending the lifespan of a product and using less hazardous materials. Source reduction is also important in designing and manufacturing because it can save natural resources, reduce pollution, conserve energy and save money for consumers. It involves any activity that reduces or eliminates the generation of waste. Waste reduction is an effective tool to solve the waste problem and is assigned the highest priority. An appropriate environmental policy to prevent waste produced is also suggested for implementation [57]. For example, Penang was the first state in Malaysia to launch the "No Free Plastic Bag" campaign in July 2009 to reduce the use of plastic bags for carrying items purchased from convenience stores. On 1 January 2011, Penang created history by being the first state to do it every day of the week, every week of the month and every month of the year [58]. Plastic waste takes a lot of time to degrade and contributes to air, water and soil pollution. Hence, this program discourages consumers from using plastic bags to carry item purchased in order to reduce the consumption of plastic bags [59].

The second step in the concept of 3R's is reuse. It is defined as the reemployment of old materials to be used in the same or a lower grade application. In short, reuse means to use an item for more than one time. This includes where the item is used again for the same function or a different function [60]. Reusing is a great way to cut down on waste. The main reason for this step before recycling is that there is still a cost for recyclable waste management systems. Hence, we can try our best to reduce the amount of household waste produced before sending the waste for recycling or disposal. At this moment, there is no programme organized by the government for reuse in Malaysia. However, everyone can nevertheless make their own effort to reduce waste by reusing the items ourselves or passing them to someone else for use. For example, we can reuse carrier bags, scrap paper for writing notes, buy goods in refillable containers, take old clothes, books, usable electronic devices, unwanted furniture to charity shops, use rechargeable batteries and green decoration or furniture inside the homes by using unwanted waste.

The third step is recycling. It includes the implantation of waste material for other purposes, treating and reapplying it in the same process. Recycling is the process of collecting waste, sorting and processing the recyclable

products into raw materials and retransforming the raw materials into a new product. Recycling is economically profitable, reduces the cost of collect and disposal of waste and reduces the land required [61].

Waste should be treated to energy recovery when recycling is not feasible [62]. Energy recovery from waste is the conversion of non-recyclable waste into fuel, heat or electricity energy through some processes including anaerobic digestion, pyrolysis, combustion and gasification. This process is often called waste to energy (WTE) [63]. From the WTE point of view, waste cooking oil, waste lubricating oil and plastics with high heating values have been considered as good candidates for feed-stocks during the process of converting waste to energy [64]. Malaysia has large biomass resources that may be utilised for generating electricity. However, landfills still remain the widely practiced method of waste disposal. This is because utilization of waste by using WTE technologies remain unprofitable due to its high operating and maintenance costs [65]. Therefore, it is necessary for Malaysia to look into the value of waste and increase the thermal efficiency of the power plant as part of renewable energy mix to reduce dependency on coal which could lead to a reduction in operation costs. The effective use of waste could also supply the required fuel for electricity generation in the future.

The final and most inefficient step is disposal. It involves the final product that cannot be recycled, reduced, reused or energy recovered, and hence goes to landfills or incinerators. This step is common in many countries. Disposal decisions depend on the cost, land availability and population characteristics. Disposal into landfills require a large disposal area which contain several smaller cells and waste is then deposited into these cells by using specially designed bulldozers and by using soil to cover them within a thin layer [66]. Hence, disposal of waste is the most inefficient method in waste minimization.

In the upshot, to implement waste management based on the concept in Fig. 4 gives priority to waste reduction through the 3Rs, energy recovery and final disposal. The government of Malaysia needs emphasis its focus on this concept to improve the existing waste management system and to promote home composing behaviour to enhance a sustainable household waste management strategy at the household level [67].

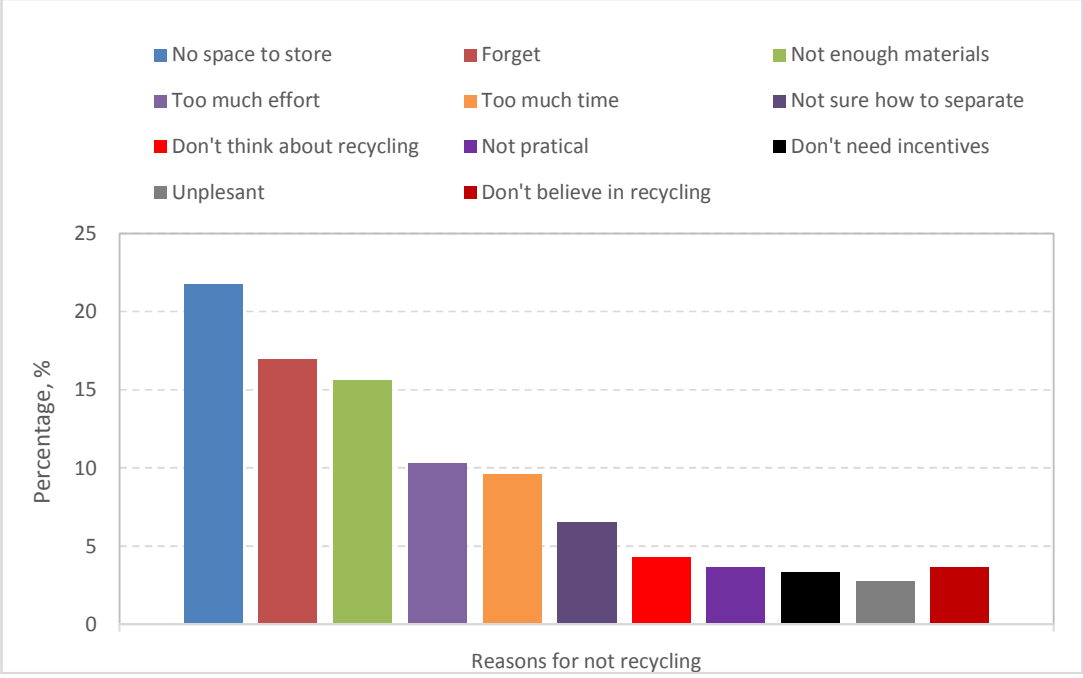

Fig. 15. Reasons for not recycling among Malaysian households [1]

iii) Barrier to 3R's Implementation

The awareness of public on the 3Rs is low, in spite of the Malaysian government's funding for public information campaigns [68]. There is a lack of policy to promote 3Rs and a low public participation. According to the findings reported by Y. Moh, L.A. Manaf [1], the reasons for non-recycling among Malaysian households is illustrated in Fig. 15. Attitude remains the major challenge that significantly affects recycling.

iv) World Recycling Rate

A country with good practices in solid waste management can be ascertained by its recycling rate. Fig. 16 shows the world ranking of recycling rate with its percentage in the year 2015 [17]. The recycling rate in Malaysia is relatively low compared to developed countries with the best practices. Among 26 countries, Malaysia ranks one of last 5 countries with a low recycling rate across the world that is 17.5%. The Malaysian government is aiming for a 22% of recycling rate by 2020 as well as an increase in the ranks of world recycle rate. Singapore has the highest recycling rate followed by South Korea and Germany. A review study on the waste managements from homes applied in the countries with a higher recycling rate are examined in the next section.

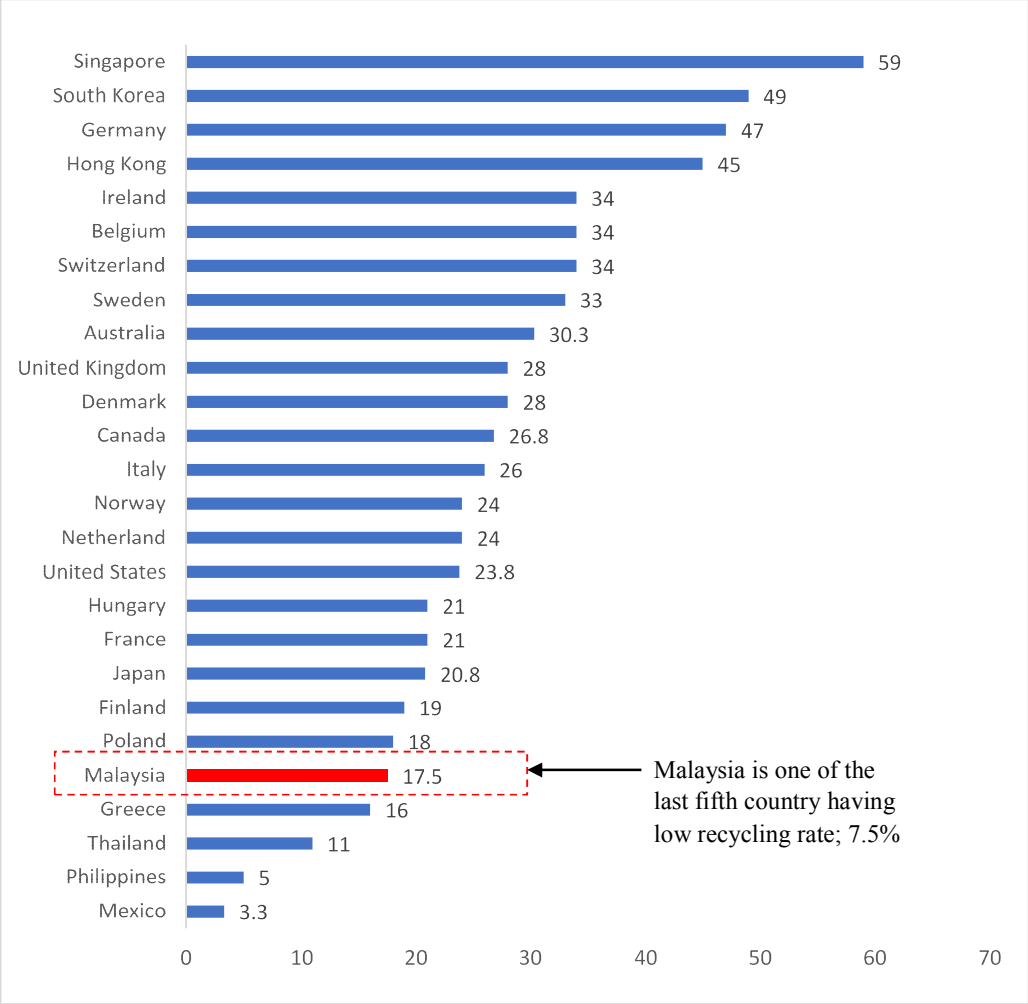

Fig. 16. World ranking showing percentage of recycling rate [17]

5. REVIEW OF WORK DONE BY OTHER COUNTRIES

In the countries with a high recycling rate, various institutional mechanisms are established and introduced to promote recycling of major recyclable items. The key institutional mechanisms for recycling that are established in these countries are illustrated in the Table 8.

In Singapore, the Environmental Public Health Act (EPHA) was enacted in 1968. Under the Act, it is an offence to throw or leave behind any bottle, can, food container, food wrapper, glass, particles of food, cigarette butt, or other item of trash in any public place. The EPHA provides for penalties if a person is caught littering entailing a fine not exceeding S$1000 for a first conviction; and a fine not exceeding S$2000 for a second conviction; and a fine not exceeding $5000 for third or subsequent conviction. Littering is a serious offence which directly causes pollution and gives rise to cleaning problems. Such penalty provisions in theory serve to stop people from committing any offence. In addition to penalties, the Singaporean government also introduced Corrective Work Orders (CWO) in 1992 with the aim of reforming the behaviour of recalcitrant littering offenders as well as those who commit serious littering offenses.

In Korea, the Waste Control Act was implemented enacted on the 20th of July 2015. Proposed by the Ministry of Environment, it aims to focus on the general recycling principles, designation of environmental assessment institution, the environmental assessment performance, and the necessity of complying with the standard of harmfulness regarding the recycled product and raw material. Further, the Enforcement Ordinance of Wastes Control Act was also enacted on the 21st of July 2016. In the Act, matters of compliance for waste recycling, wastes prohibited against recycling and approval conditions for recycling according to the environmental assessment were added.

In Germany, source separation of packages and containers is promoted. There are obligation placed on manufacturers and distributors to participate in the collection and recycling of packages and containers is regulated by the Packaging Ordinance (1991). Closed substance cycle and waste management act (1996) also mentions basic obligations with respect to safe and good quality recycling and management practices as well as product responsibility, manufacturing of products geared towards effective and environmentally sound waste management and recycling, and return, recovery and disposal obligation by the manufacturers.

In the UK, the Waste Implementation Programme (WIP) is carried out to increase awareness of waste issues, support LAs both financially through schemes such as the waste minimisation and recycling fund and through best practice advise, sponsoring research into waste minimisation methods, and sponsor the work of the Waste Resources and Actions Programme (WRAP). WRAP aims to accelerate resource efficiency by creating efficient markets for recycled materials and products, while removing barriers to waste minimisation, reuse and

Table 8. The key institutional mechanisms for recycling that are established in other countries [69–72]

Country	Key institutional mechanisms for recycling
Singapore	• Environmental Public Health Act (EPHA) • Corrective Work Orders (CWO)
Germany	• Packaging ordinance 1991 • Closed substance cycle and waste management act 1996
Korea	• Waste Control Act 2015 • Enforcement Ordinance of Wastes Control Act 2016
Sweden	• Tariff schedule for waste management • Special systems separate collection of food waste.
UK	• Waste Implementation Programme (WIP) • Waste Resources and Actions Programme (WRAP) • Landfill tax
Japan	• The Basic Law for Environmental Pollution Control 1967 • The Nature Conservation Law 1972 • Waste Management Law

recycling. There is also a landfill tax is designed to encourage business to produce less waste and use alternative forms of waste management. Revenue from the landfill tax is used to provide new support to businesses that specifically targets waste minimisation, diversion of waste away from landfill and improvements in resource efficiency.

In Sweden, a tariff-based waste management systems is enforced whereby local municipalities have the right to charge a fee for the collection, transport, recovery and disposal of waste. However this charge is not permitted to exceed the overall planning, operating and capital costs related to refuse collection. The tariff based waste management system is classified into volume-based tariff system where the volume of the waste container throw affects the tariff that households pay and weight-based tariff system where households pay for each kilogram of waste they dispose. In respect of other systems of waste collection, there is also a special system for food waste to collect food waste separately from other forms of waste.

In Japan, two fundamental environmental laws are implemented which are the Basic Law for Environmental Pollution Control enacted in 1967 and the Nature Conservation Law enacted in 1972. These two laws were drafted to address industrial pollution and to preserve the environment. However, as Japan's socio-economic system and consumer lifestyles began to rely more on industrial mass production, mass consumption and mass disposal, the two laws which consisted mainly of restrictions were found to be inadequate to address some of the newer and more complex environmental problems that emerged, particularly those relating to urban and household-generated pollution and the global environment. Hence, in November 1993, the Basic Environmental Law was enacted to clearly stipulate national, local, and corporate responsibilities related to the environment. Supplementing the Basic Environmental Law is the Waste Management Law. The Waste Management Law aims to preserve the living environment and improve public health through the restriction of waste discharge, appropriate sorting, storage, collection, transport, recycling, disposal, and conservation of a clean environment.

In Malaysia, National Recycling Programmes are carried out in cooperation with LAs, concessionaires, private sectors and NGOs. However, there are no laws and regulations which provide obligation or role of stakeholders to promote waste minimisation. Although there is an incentive for waste recycling activities which aims to promote waste recycling activities, any measures to encourage producing less waste are not taken for waste minimisation. Therefore, Malaysia should consider institutional mechanisms to provide obligations of stakeholders and further promote waste minimisation from view point of source separation and producing less waste.

6. SUMMARY OF LITERATURE SURVEY

Based on the literature survey, several important points are highlighted which is as below:

- An increase in waste production and its subsequent disposal into the environment without any proper and effective management, is a grave and prevailing threat to the environment and society at large;
- The ecosystem is under threat of imminent destruction due to a lack of awareness regarding proper waste management control methods. Improper waste management derived from homes may also lead to the extinction of sea animals;
- In Malaysia, illegal dumping continues to occur and it could possibly account for about 10% of the total waste generated in the year 2020;
- Residential waste constitutes a significant portion of the total waste generated. Hence, this paper focuses on the waste produced from homes. Information on waste composition is essential to identify and select possible ways of sustainable waste management;
- In Malaysia, concession companies are authorized to manage solid waste produced from homes to its disposal. Most household waste currently makes it way to landfills, with or without preliminary sanitary measures;
- Integrated, cost effective and sustainable methods coupled with 3Rs is certainly needed;
- Despite the relative lack of success and receptivity to the concept of recycling, the government has initiated several plans such as ABC plan and NSP plan to improve the image of recycling amongst the Malaysian public;

- A lack of public awareness toward the 3R's is the main obstacle in implementing waste minimisation in Malaysia. Policies and stringent enforcement towards the 3R's by the government is needed to overcome this issue; and
- The key institutional mechanisms for recycling that are established in other countries is highlighted for use as reference by the Malaysian government in order to draft better and effective waste management plan and policies in future.

7. FUTURE RESEARCH

Based on the reviewed works, there are some important points as highlighted below which provide useful information for new research pathways in the future that focus on solutions to control the pollution caused by waste produced from homes. They are as follow:

- The concept of recycling waste should start from homes. An example would be having a user-friendly recycling device such as a food crusher to crush solid waste into 'liquid paste like' substance that may be used as plant fertilizers;
- Large filters can be installed in drainage systems to filter out harmful debris that may harm the ecosystem. Sensors may be mounted to these filters that will monitor the performance of these filters and hence trigger the maintenance department in the event the filters need to be serviced;
- Waste from humans and food; i.e. waste generated from homes, should be directly channelled to a centralised sewage systems rather than to open drainage systems;
- The concept of waste management should be introduced in schools particularly at preschools and primary schools (i.e. kids with age 4 to 10 years old). This is to cultivate the idea of managing waste effectively from a very young age (i.e. pre-school such as MUMTAZ Generation International Sdn. Bhd at Melaka, Malaysia had taken several initiative to aware kids on managing waste effectively);
- Centralized CCTV's could be installed around residential areas to monitor open burning. In the event where open burning has spotted, the relevant authorities could be informed and appropriate action may be taken;
- Plastic waste could be recycled into useful products such as tiles and wall decorations. This could be some of the initiatives undertaken by the government whereby appropriate funding could be allocated for such innovative projects; and
- The main obstacle to implement the 3R's is primarily linked to households. Hence, enhanced awareness and increased public education efforts on sustainable waste management is also direly needed.

ACKNOWLEDGEMENT

The authors would like to thank the government of Malaysia and Mr. Kang Chi Keng for their valuable comments and efforts contributed to the realization of the current write-up.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Moh Y, Manaf LA. Resources, conservation and recycling solid waste management transformation and future challenges of source separation and recycling practice in Malaysia. Resources, Conserv. Recycl. 2017;116:1–14.
DOI: 10.1016/j.resconrec.2016.09.012
2. Wang F, Cheng Z, Reisner A, Liu Y, Jambeck JR, Denise B, Brooks AL, Friend T, Teleki K, Fabres J, Beaudoin Y, Bamba A, Francis J, Ribbink AJ, Baleta T, Bouwman H, Knox J, Wilcox C, et al. Telukdarie, resources , conservation and recycling will they recycle ? Design and implementation of eco-feedback techno-logy to promote on-the-go recycling in a university environment. Resources, Conserv. Recycl. 2018;202:256–263.
DOI: 10.1016/j.wasman.2017.07.031
3. Gu B, Zhu W, Wang H, Zhang R, Liu M, Chen Y, Wu Y, Yang X, He S, Cheng R, Yang J, Bi J. Household hazardous waste quantification, characterization and management in China's cities: A case study of Suzhou, Waste Manag. 2014;34: 2414–2423.
DOI: 10.1016/j.wasman.2014.06.002
4. Andersen FM, Larsen HV. FRIDA: A model for the generation and handling of solid waste in Denmark, Resour. Conserv. Recycl. 2012;65:47–56.
DOI: 10.1016/j.resconrec.2012.04.004

5. Kouloughli S, Kanfoud S. Municipal solid waste management in constantine, Algeria. J. Geosci. Environ. Prot. 2017;05:85–93. DOI: 10.4236/gep.2017.51006
6. George S. A dead whale washed with 13 pounds of plastic in its stomach, time com. 2018;1. Available:httpfile:///C:/Users/User/Desktop/mendeleywatchfolder/MultimediaUniversity Library Integrated Access (MULiA).html
7. Willis K, Maureaud C, Wilcox C, Hardesty BD. How successful are waste abatement campaigns and government policies at reducing plastic waste into the marine environment? Mar. Policy. 2018;96:243–249. DOI: 10.1016/j.marpol.2017.11.037
8. Ayeleru OO, Okonta FN, Ntuli F. Municipal solid waste generation and characterization in the City of Johannesburg : A pathway for the implementation of zero waste. Waste Manag. 2018;79:87–97. DOI: 10.1016/j.wasman.2018.07.026
9. Chickering GW, Krause MJ, Townsend TG. Determination of as-discarded methane potential in residential and commercial municipal solid waste. Waste Manag. 2018;76:82–89. DOI: 10.1016/j.wasman.2018.03.017
10. Dai Y, Sun Q, Wang W, Lu L, Liu M, Li J, Yang, S Sun Y, Zhang K, Xu J, Zheng W, Hu Z, Yang Y, Gao Y, Chen Y. Chemosphere utilizations of agricultural waste as adsorbent for the removal of contaminants : A review. 2018;211. DOI: 10.1016/j.chemosphere.2018.06.179
11. Baldwin E, Dripps W. Resources, conservation and recycling spatial characterization and analysis of the campus residential waste stream at a small private liberal arts institution. Resources, Conserv. Recycl. 2012;65: 107–115. DOI: 10.1016/j.resconrec.2012.06.002
12. Su Y, Wang L, Zhang F. A novel process for preparing fi reproo fi ng materials from various industrial wastes. 2018;219:332–339. DOI: 10.1016/j.jenvman.2018.05.005
13. Merino RPVS, New quanti fi cation proposal for construction waste generation in new residential constructions. 2015;102: 58–65. DOI: 10.1016/j.jclepro.2015.04.029
14. Saphores JDM, Nixon H. How effective are current household recycling policies? Results from a national survey of U.S. households, Resour. Conserv. Recycl. 2014;92:1–10. DOI: 10.1016/j.resconrec.2014.08.010
15. Malaysia; 2012. Available:http://psephos.adam-carr.net/countries/m/malaysia/statsmalaysia.shtml
16. Mahidin DSDMU, Malaysia CS, M. Department of Statistics, Compendium of Environment Statistics, Malaysia; 2018. Available:https://www.dosm.gov.my
17. Mohd Pauze Mohamad Taha. Intergrated solid waste management: Challenge and future, Natl. Environ. Heal. Action Plan Conf. 2016;1–53. Available:http://nehapmalaysia.moh.gov.my/wp-content/uploads/2016/03/Paper-2-Solid-Waste.pdf
18. MSAMS, Kadir AA. Solid waste composition study at taman solid waste composition study at Taman Universiti, Parit Raja, Batu Pahat; 2016. DOI: 10.1088/1757-899X/136/1/012048
19. Managing KL's Rubbish; 2016. Available:http://www.fomca.org.my/v1/index.php/fomca-di-pentas-media
20. Pemandu. Solid waste management lab. 2015;1–432. Available:http://www.kpkt.gov.my/resources/index/user_1/Attachments/hebahan_slider/slaid_dapatan_makmal.pdf
21. Munusami C, Othman J, Ismail SM. Using choice modelling to reveal household demand for wastewater treatment in Malaysia. APCBEE Procedia. 2014;10:64–68. DOI: 10.1016/j.apcbee.2014.10.017
22. Ariffin M, Sulaiman SNM. Regulating sewage pollution of Malaysian rivers and its challenges. Procedia Environ. Sci. 2015;30:168–173. DOI: 10.1016/j.proenv.2015.10.030
23. Dahlén L. Household waste collection factors and variations; 2008.
24. Rammont L, Amin ATMN. Constraints in using economic instruments in developing countries: Some evidence from Thailand's experience in wastewater management, Habitat Int. 2010;34:28–37. DOI: 10.1016/j.habitatint.2009.05.003
25. Lim WJ, Chin NL, Yusof AY, Yahya A, Tee TP. Food waste handling in Malaysia and comparison with other Asian countries. Int. Food Res. J. 2016;23:S1–S6. DOI: 10.1016/j.resconrec.2013.11.004
26. Solorzano-Ochoa G, de la Rosa DA, Maiz-Larralde P, Gullett BK, Tabor DG, Touati

A, Wyrzykowska-Ceradini B, Fiedler H, Abel T, Carroll WF. Open burning of household waste: Effect of experimental condition on combustion quality and emission of PCDD, PCDF and PCB, Chemosphere. 2012;87:1003–1008.
DOI: 10.1016/j.chemosphere.2011.11.038

27. Budhiarta I, Siwar C, Basri H. Current status of municipal solid waste generation in Malaysia current status of municipal solid waste generation in Malaysia; 2012.
DOI: 10.18517/ijaseit.2.2.169
28. Gallardo A, Bovea MD, Colomer FJ, Prades M, Carlos M. Comparison of different collection systems for sorted household waste in Spain, Waste Manag. 2010;30:2430–2439.
DOI: 10.1016/j.wasman.2010.05.026
29. Ongondo FO, Williams ID, Keynes S. Estimating the impact of the "digital switchover" on disposal of WEEE at household waste recycling centres in England, Waste Manag. 2011;31:743–753.
DOI: 10.1016/j.wasman.2010.11.005
30. Inglezakis VJ, Moustakas K. Household hazardous waste management: A review. J. Environ. Manage. 2015;150:310–321.
DOI: 10.1016/j.jenvman.2014.11.021
31. Calıs S, Ergul NR. Determination of science teacher candidates' views on electronic waste pollution, procedia - Soc. Behav. Sci. 2015;186:261–268.
DOI: 10.1016/j.sbspro.2015.04.146
32. Toral-López V, González C, Romero FJ, Castillo E, Parrilla L, García A, Rodriguez N, Rivadeneyra A, Morales DP. Reconfigurable electronics: Addressing the uncontrolled increase of waste electrical and electronic equipment. Resour. Conserv. Recycl. 2018;138:47–48.
DOI: 10.1016/j.resconrec.2018.07.010
33. Lau WKY, Chung SS, Zhang C. A material flow analysis on current electrical and electronic waste disposal from Hong Kong households. Waste Manag. 2013;33714–721.
DOI: 10.1016/j.wasman.2012.09.007
34. Malakahmad A, Ahmad Basri NE, Md Zain S. Production of renewable energy by transformation of kitchen waste to biogas, case study of Malaysia, ISBEIA 2011 - 2011 IEEE Symp. Business, Eng. Ind. Appl. 2011;219–223.
DOI: 10.1109/ISBEIA.2011.6088808
35. Bong CPC, Goh RKY, Lim JS, Ho WS, Lee CT, Hashim H, Abu Mansor NN, Ho CS, Ramli AR, Takeshi F. Towards low carbon society in Iskandar Malaysia: Implementation and feasibility of community organic waste composting. J. Environ. Manage. 2017;203:679–687.
DOI: 10.1016/j.jenvman.2016.05.033
36. Pleissner D. Science direct recycling and reuse of food waste. Curr. Opin. Green Sustain. Chem. 2018;13:39–43.
DOI: 10.1016/j.cogsc.2018.03.014
37. Ahamad NN, Mohamad SY, Midi NS, Yusoff SH, Rahman FA. Automatic waste separation system. 7th Int. Conf. Comput. Commun. Eng. 2018;372–374.
38. Tai J, Zhang W, Che Y, Feng D. Municipal solid waste source-separated collection in China: A comparative analysis. Waste Manag. 2011;31:1673–1682.
DOI: 10.1016/j.wasman.2011.03.014
39. Pakir AH, Ramli M, Aziz HA. Solid waste management practices in Penang State : A review of current practices and the way forward solid waste management practices in penang state: A review of current practices and the way forward; 2009.
DOI: 10.30638/eemj.2009.014
40. Seperation At Source, (n.d.).
Available:http://www.kpkt.gov.my/separationatsource/en/
41. Fauziah SH, Periathamby A. Municipal solid waste management in Malaysia-possibility of improvement ? Malaysian J. Sci. 2005;23(2):61–70.
42. Manaf LA, Samah MAA, Zukki NIM. Municipal solid waste management in Malaysia: Practices and challenges. Waste Manag. 2009;29:2902–2906.
DOI: 10.1016/j.wasman.2008.07.015
43. Alamflora (n.d.).
Available:http://www.alamflora.com.my/collection-services.html
44. E-Idaman (n.d.).
Available:http://www.e-idaman.com/overview
45. SWM Environment, (n.d.)
Available:http://www.swm-environment.com/who-we-are/our-company/
46. Eastern Waste Management, (n.d.)
Available:http://easternwaste.ca/regions.
47. MGS M.I. Ab. Malek. Landfill common method and practices of solid waste disposal in Malaysia; 2014.
48. Zulkifli Z. Improvement of disposal sites in Malaysia. In: Workshop on Partnerships Towards Responsive Solid Waste Management in Southeast Asia,Pulau Pinang, Malaysia; 1993.

49. Fauziah P, Agamuthu SH. Trends in sustainable landfilling in Malaysia, adeveloping country. Waste Mana. 2011; 656–663.
Available:http://dx.doi.org/10.1177/0734242x12437564
50. JPSPN (National Solid Waste Management Department). Department Project (Technical);2015a.
Available:http://goo.gl/FzF0ng
51. Muhamad SASAK, Rosli Sulaiman RI, Husin M. A study on the problems of the usage of incinerators in Malaysia, Sci. Res. J. 2007;4.
52. Niska H, Serkkola A. Data analytics approach to create waste generation profiles for waste management and collection. Waste Manag. 2018;77:477–485.
DOI: 10.1016/j.wasman.2018.04.033
53. Zhang D, Keat TS, Gersberg RM. A comparison of municipal solid waste management in Berlin and Singapore, Waste Manag. 2010;30:921–933.
DOI: 10.1016/j.wasman.2009.11.017
54. Challenger I. Can we fix it? Lets hope so! Turning the waste management hierarchy the right way up., in: WasteMINZ Annu. Conf; 2007.
55. Rasmussen C, Vigso D, Ackerman F, Porter R, Pearce D, Dijkgraaf E. Solid waste management hierarchy-application towards the concept of green technology. Green technology on waste management: current knowledge and practices. Presented at Green Technology on waste management: Current knowledge and practices, Kaula Lumpur; 2009.
56. Kamalski U. Research and practice in waste management, Ctry. Trends; 2010.
57. Chen CC. A performance evaluation of MSW management practice in Taiwan, Resour. Conserv. Recycl. 2010;54:1353–1361.
DOI: 10.1016/j.resconrec.2010.05.003
58. Launching of everyday is no free plastic bags day, (n.d.)
Available:https://www.penang.gov.my/en/dmedia/633-launching-of-everyday-is-no-free-plastic-bags-day?fbclid=IwAR3AvfKhvocBLrw0fmGe2fh7aHxS_DaOYHYSJ4evqhti0HMidMTsWg2mirw
59. Asmuni S, Hussin NB, Khalili JM, Zain ZM. Public participation and effectiveness of the no plastic bag day program in Malaysia, Procedia - Soc. Behav. Sci. 2015;168:328–340.
DOI: 10.1016/j.sbspro.2014.10.238
60. Wang Y, Zhang X, Liao W, Wu J, Yang X, Shui W, Deng S, Zhang Y, Lin L, Xiao Y, Yu X, Peng H. Investigating impact of waste reuse on the sustainability of municipal solid waste (MSW) incineration industry using emergy approach: A case study from Sichuan province, China. Waste Manag. 2018;77:252–267.
DOI: 10.1016/j.wasman.2018.04.003
61. Almasi A, Mohammadi M, Azizi A, Berizi Z, Shamsi K, Shahbazi A, Alireza S. Resources, conservation & recycling assessing the knowledge, attitude and practice of the kermanshahi women towards reducing, recycling and reusing of municipal solid waste, Resour. Conserv. Recycl. 2019;141:329–338.
DOI: 10.1016/j.resconrec.2018.10.017
62. Burnley S, Phillips R, Coleman T, Rampling T. Energy implications of the thermal recovery of biodegradable municipal waste materials in the United Kingdom. Waste Manag. 2011;31:1949–1959.
DOI: 10.1016/j.wasman.2011.04.015
63. Dhar H, Kumar S, Kumar R. A review on organic waste to energy systems in India. Bioresour. Technol. 2017;245:1229–1237.
DOI: 10.1016/j.biortech.2017.08.159
64. Singhabhandhu A, Tezuka T. The waste-to-energy framework for integrated multi-waste utilization: Waste cooking oil, waste lubricating oil, and waste plastics. Energy. 2010;35:2544–2551.
DOI: 10.1016/j.energy.2010.03.001
65. Pina A, Ferrão P, Fournier J, Lacarrière B, Le Corre O. Science direct sciencedirect prospective for power generation of solid fuel from hydrothermal treatment of biomass and waste in Malaysia assessing the feasibility of using temperature function for a long-term district heat demand forecast. Energy Procedia. 2017;142:369–373.
DOI: 10.1016/j.egypro.2017.12.058
66. Agamuthu P, Fauziah S. From sanitary to sustainable landfilling -why, how, and when? Landfills in Malaysia: Past, Present and Future. 2009;1–9.
Available:http://eprints.um.edu.my/11314/1/J2_P-Fauziah_SH.pdf
67. Thi L, Loan T, Takahashi Y, Nomura H, Yabe M. Resources, conservation & recycling modeling home composting

behavior toward sustainable municipal organic waste management at the source in developing countries, Resour. Conserv. Recycl. 2019;140:65–71.
DOI: 10.1016/j.resconrec.2018.08.016

68. Zainu ZA, Songip AR. Policies, challenges and strategies for municipal waste management in Malaysia. 2017;3.
69. Bee I, Ong L, Sovacool BK. Resources, conservation and recycling a comparative study of littering and waste in Singapore and Japan. Resources, Conserv. Recycl. 2012;61:35–42.
DOI: 10.1016/j.resconrec.2011.12.008
70. Andersson C, Stage J. Direct and indirect effects of waste management policies on household waste behaviour: The case of Sweden, Waste Manag. 2018;76:19–27.
DOI: 10.1016/j.wasman.2018.03.038
71. Mühle S, Balsam I, Cheeseman CR. Comparison of carbon emissions associated with municipal solid waste management in Germany and the UK, Resour. Conserv. Recycl. 2010;54:793–801.
DOI: 10.1016/j.resconrec.2009.12.009
72. Um N, Kang Y, Kim K, Shin S, Lee Y. Strategic environmental assessment for effective waste management in Korea : A review of the new policy framework. Waste Manag. 2018;82:129–138.
DOI: 10.1016/j.wasman.2018.10.025

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle3.com/review-history/48441