



# Appraisal of student's awareness and practices on waste management and recycling in the Malaysian University's student hostel area

Mohammed J. K. Bashir<sup>1</sup> · Yong Zi Jun<sup>1,2</sup> · Lee Jia Yi<sup>1</sup> · Mohammed F. M. Abushammala<sup>3</sup> · Salem S. Abu Amr<sup>4</sup>  · Lawrence M. Pratt<sup>5</sup>

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## Abstract

Urbanization accompanied by mass consumption leads to tremendous waste generation, environmental pollution and public health issues. Tackling solid waste management issues addresses more than half of the sustainable development goals. Low awareness and participation of Malaysians in practicing waste segregation and recycling cause serious threats in managing solid waste. Thus, a new waste segregation program was introduced within university students' hostel area to measure waste generation, composition and students' attitude and practice toward waste segregation and recycling. The impact of segregation educational program was measured via survey questionnaires in conjunction with waste measurement and composition analysis. It was found that there was a reduction in waste generation by 24.8% from 0.165 to 0.124 kg/capita/day, reaching recycling rate of 25% and reduction of recyclables entering landfill by 62.6% from 0.091 to 0.034 kg/capita/day. The university students' awareness increased to 75.3% after the program was implemented. Therefore, cooperation from various stakeholders, namely residents, housing management, educational institute, private waste collectors, local council, retailer, manufacturer and recyclers is utmost needed to grant success of the new waste segregation program.

**Keywords** Municipal solid waste · Waste composition · Segregation program · University students · Attitude · Recycling  
Sabuamr@hotmail.com

✉ Mohammed J. K. Bashir [jkbashir@utar.edu.my](mailto:jkbashir@utar.edu.my)

✉ Salem S. Abu Amr

<sup>1</sup> Department of Environmental Engineering, Faculty of Engineering and Green Technology (FEGT), Universiti Tunku Abdul Rahman, 31900 Kampar, Perak, Malaysia

<sup>2</sup> Centre for Global Sustainability Studies (CGSS), Institute of Postgraduate Studies, Universiti Sains Malaysia, 11800 Penang, Malaysia

<sup>3</sup> Department of Civil Engineering, Middle East College, Al Rusayl 124, PB No 79, Muscat, Sultanate of Oman

<sup>4</sup> Malaysian Institute of Chemical and Bioengineering Technology, Universiti Kuala Lumpur (UniKL, MICET), Melaka, Malaysia

<sup>5</sup> Department of Chemistry and Environmental Science, Medgar Evers College, The City University of New York, 1638 Bedford Ave., Brooklyn, NY 11225, USA

## Introduction

Solid waste management (SWM) is a part of urban environment and planning infrastructure to provide waste collection and disposal services to the population to ensure healthy urban environment and good public health while promoting sustainable economic growth [1]. The generation of domestic solid waste in developing countries has increased over the past few decades, which eventually brings numerous negative impacts toward the environment and public health [2, 3]. Proper waste management via 3R (reduce, reuse and recycle) carried out by good governance holds the key toward “sustainable society” and can potentially reduce land use to reduce the need for new landfills, recycle food waste as fertilizers in returning nutrients into topsoil and reduce greenhouse gases’, GHGs, emissions from landfills [4, 5]. However, SWM remains one of the main environmental challenges in developing countries, which includes Malaysia. In 1992, the World Bank identified that SWM is one of the three major environmental problems faced by Malaysian municipalities [4, 6]. Malaysia has undergone rapid population, urbanization and

waste consisting of municipal solid waste (MSW) mainly from households and commercial areas dominates at 64% of the entire waste generation from other areas. Food/organic waste dominates the MSW at 45%, followed by 13–24% of plastics, 12% diapers, 7–9% of papers, 3–6% of glass, 3–6% of metals, 3% of textile and others [10–13]. However, most of the collected waste will be a burden toward the life span of 296 landfills sites throughout Malaysia [12]. Out of these 296 landfills, only 12 are sanitary landfills [14]. Although landfilling remains the main disposal method in Malaysia, landfilling should not be the main disposal method in managing solid waste due to land scarcity and environmental pollution from landfill in terms of air (unpleasant odor, risk of fire, methane emissions), land (complex mixed waste to contaminate topsoil) and water (leachate leaching into groundwater; leachate surface runoff into surface water bodies), which causes public health issues such as acute heavy metal poisoning and infectious diseases from exposure of decaying organic waste [9, 15, 16]. In addition, landfills pose other hazards including explosion, vegetation damage and landfill settlement. Prevention at the source by encouraging household practice in segregating and recycling of inorganic waste together with bio-composting of organic waste would be a better approach toward an integrated sustainable waste management system in Malaysia.

The Malaysia government has taken several actions to minimize waste-related issues for decades, yet has failed to implement these in an effective manner: for example, the Action Plan for a Beautiful and Clean (ABC) Malaysia dates all the way back to 1988; Reduce, Reuse, Recycle (3R) in the 8th Malaysia Plan (2001–2005) and Master plan on National Waste Minimization (2006–2010). None of these efforts are effective due to lack of public participation [13].

Nowadays, waste composition changes from mainly organic (putrescible) toward more inorganic (not easily putrescible), namely packaging materials, plastics and paper that are complex in nature due to rapid development and changing lifestyles in growing cities [17]. Therefore, waste segregation at the source is encouraged to be integrated into waste management system, so as to maximize the collection of these recyclables and furthermore due to its benefits toward environmental sustainability, economic development and sustaining public health (social). Hence, the integration covers the three pillars of sustainable development which can potentially fulfill more than half of the 17 United Nations Sustainable Development Goals [18]. In terms of financial support, more money can be allocated by the government into other areas for development as in Japan, since only 3.6% of the annual budget is for waste-related expenses [19]. In terms of social benefits, public health and

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economic growth ever since the independence of Malaya in 1957 and the formation of Malaysia in 1963. Malaysia's urban population has increased more than 50% in the past decades and the number of cities in Peninsular Malaysia has increased 400% as compared to the number of cities in 1957 [7], hence leading to the tremendous increase in solid waste generation [8]. According to Mohamad and Keng [9], the waste generation was 0.5 kg/capita/day in the 1980s, 0.8 kg/capita/day in 2005 and increased to 1.3 kg/ capita/day in 2009, while up to 89% of the collected waste ended up in landfills and open dumping sites. This indicates traditional waste management system practice by the Malaysian government and local municipalities to be inefficient and environmentally unsustainable [4, 10]. On average, Malaysia had an increase of 2% of MSW generation annually and is expected to reach 3% due to the continuous rural to urban migration and economic growth. There are now 33,130 tons/day of solid waste generation in Malaysia and is expected to reach 36,138 tons/day by 2020, 41,035 tons/day by 2026 and 49,670 tons/day by 2030 [10, 11]. Urban

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safety can be guaranteed and issues regarding scavengers at the landfill can be reduced, as less waste is dumped into landfills. Moreover, the reduction in waste being landfilled can prevent heavy metal poisoning and infectious diseases of water resulting from the infiltration and leaching of landfill leachate [2, 4]. Although waste generation is inevitable in most developing countries, if high percentage of waste is converted into new materials or energy source through waste segregation, recycling and composting, this can lessen the burden of landfills hence extending the life span of existing landfills [4].

At present, a little effort regarding waste generation minimization through segregation, recycling and composting had been conducted on residential/university hostel areas in Malaysia. Until today, the majority of Malaysians do not practice waste reduction at source by segregating household waste including students at the university level due to poor waste management, lack of proper waste segregation infrastructure and facilities provided, and low cultural and practice of waste segregation. In this paper, a new waste segregation and collection program has been established at the student hostel area in Universiti Tunku Abdul Rahman (UTAR) Perak Campus, Malaysia. The student's awareness and practices toward waste segregation was measured by surveys. In addition, the improvement in terms of waste generation, segregation and recycling were measured by analyzing the waste composition before and after the waste segregation program. It is important for the waste collectors to have information regarding waste composition and quantity at university students' hostel areas, which could have effect on the interval of collection and recycling efficiency.

## **Materials and methods**

### **Study area and timeline**

This study was conducted from early June 2016 to the end of March 2017, a 9 months' period of research at UTAR's student hostel area (Westlake and Harvard Home), a location known as Bandar Barat located in Kampar, Perak, Malaysia. Figure 1 shows the location of Kampar district. A total of 1044 houses accommodating students are present in the study area, while 92.3% of the houses are owned by Danish House Sdn. Bhd. and 5.7% owned by KT Management Sdn. Bhd. The remaining 2% is owned

by individual house owners. The majority of the tenants are UTAR students. The number of students present at the hostel area fluctuates during the period of study due to the fluctuating enrollment, as UTAR is on a trimester system. There were 12,852 residents in June 2016 (long semester), 9580 residents in October 2016 (short semester/internship period) and 12,852 residents in January 2017 (long semester). Majlis Daerah Kampar (MDK) is the local authority responsible for the MSW collection, whereby dump trucks are deployed on every Tuesday, Thursday and Saturday to collect MSW from house to house. The collected MSW is then disposed at the Sahom landfill which also receives MSW from South Kinta Valley including Kampar, Mambang Diawan, Tronoh Mines, Gopeng, Kopisan, Lawan Kuda, Kota Bharu, Jeram, Kuala Diapang, Malim Nawar and Sungai Siput.

**Sampling and survey design**

In this research, the sample size was calculated based on 9,000 students living in Westlake and Harvard area. The most commonly used confidence level and interval for surveying work are 95% and 5%, respectively [4], as this combination can provide accurate results with a moderate sample size. The Raosoft® Sample Size Calculator available online was used to determine the 369-sample size for survey and was confirmed using the Krejcie and Morgan [20] sample size table. Therefore, a total of 740 survey questionnaires were deployed to collect information, which consisted of 370 survey questionnaires before and after the implementation of the new waste collection and segregation system in Westlake hostel area. The first and second parts of the questionnaire focused on measurement of awareness and general practice of the students regarding waste segregation, their awareness of the local waste management



system and the students' opinion about the encouraging and discouraging factors of waste segregation practice. The Likert rating scale (1—strongly disagree; 2—disagree; 3—undecided; 4—agree; 5—strongly agree) was employed for part 3 and 4 of the student survey questionnaires which can be analyzed quantitatively by using Microsoft Excel. The score for each response was divided by the total score to express the agreement level in terms of percentage, %. Scores higher than 60% (majority of students answer either "strongly agree" or "agree") indicate a positive result, while scores lower than 60% (majority of students answer either "undecided/neutral", "disagree" or "strongly disagree") indicate a negative result.

## Solid waste generation and composition study

The MSW study was conducted with the support from MDK. To conduct the MSW generation at the Westlake and Harvard student hostel areas, the total mass of the collected MSW was measured by the floor scale balance at the Sahom landfill. To accurately quantify the amount of solid waste generation, the mass of the MSW collected in a week entering the landfill from Westlake and Harvard areas was recorded and Eqs. (1) and (2) were used to determine the waste generation in terms of kg/day and kg/capita/day:

$$\text{Generation(kg/day)} = \frac{\text{TotalMSWmasscollectedinaweek(kg)}}{7\text{days}}, \quad (1)$$

$$\text{Generationpercapita(kg/cap/day)} = \frac{\text{TotalMSWmasscollectedinaweek(kg)}}{.7\text{days} \times \text{numberofpeople}} \quad (2)$$

The waste composition study was conducted before and after the program by employing a specially assigned truck driven into the study area to collect MSW from 50 out of the 1044 houses randomly chosen with the help of the random number generator in Microsoft Excel. At the landfill, the collected waste was separated manually into paper/cardboard, plastic, metal, glass, food/organic and other/non-recyclable waste. In Malaysia, plastics easy to be recycled include polyethylene terephthalate (PETE) and high-

density polyethylene (HDPE), while the hard-to-recycle plastics include polyvinyl chloride (PVC), low-density polyethylene (LDPE) and polypropylene (PP). The remaining plastics, such as polystyrene (PS), polycarbonate (PC), styrene acrylonitrile (SAN), acrylonitrile butadiene styrene (ABS), acrylic and nylon together with electronic waste, E-waste, are classified as non-recyclable due to the limitation of technology, low market demand and high operational cost [21]. In addition, universal waste includes batteries, fluorescent lamps, mercury-containing equipment and pesticides; medical waste, wood, tissue, textile, rubber and some composite materials such as aluminium-foiled plastic packaging are treated as non-recyclable waste [22]. The total mass of the collected waste and the mass of each type of waste were measured by a scale balance at the landfill to determine the composition of waste in the waste stream. Equation (3) was used to calculate the waste composition in percentage, %:

$$\text{Waste composition in percentage, \%} = \frac{\text{mass of TYPE of waste(kg)}}{\text{total mass of collected waste(kg)}} \times 100. \quad (3)$$

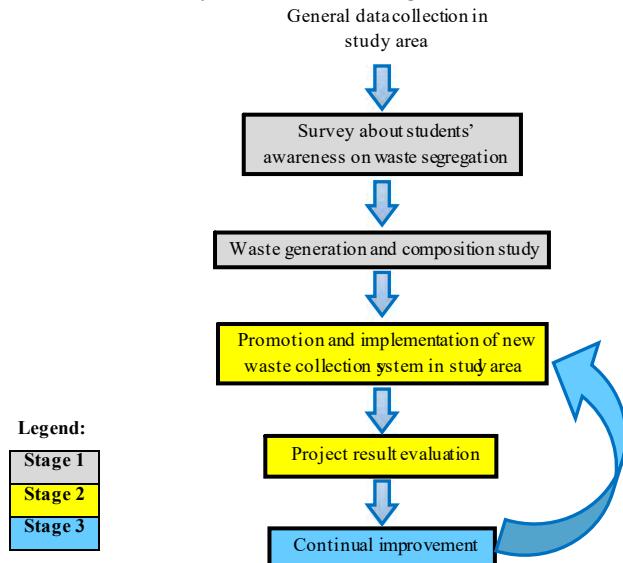
## Design of new waste segregation collection system as pilot project

Starting in early August of 2016, several programs, campaigns, promotions and seminars were carried out to promote awareness as well as to inform students about the new waste segregation program that was to be implemented in the Westlake and Harvard student hostel areas (Fig. 2). The first waste segregation seminars and talks were initially carried focusing on:

1. The MSW management and its problem in Malaysia.
2. The result of the first student survey before the implementation of the waste segregation program in Westlake and Harvard student hostels.
3. The result of waste generation and composition study in Westlake and Harvard student hostels.
4. Concept and benefits of waste segregation toward the environment, society and economy.

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**Fig. 2** Theoretical framework that shows the main procedure conducted in this research

5. The implementation of the new waste collection system around the Westlake and Harvard student hostels.

Aside from seminars and talks, waste segregation and recycling promotion flyers, posters, banners and social media page were deployed as media to advertise the waste segregation program to UTAR students. To further enhance the students' awareness, a 10 min class presentation was conducted from lecture hall to hall, together with an indoor exhibition which was conducted in UTAR campus within a week to introduce the program.

In terms of the waste collection system, the municipality council uses a kerbside collection method. In another country such as Japan, municipalities implemented kerbside recycling programs which requires residents and households to separate, sort and clean their recyclables at home to participate in the recycling program [23]. In Japan, kerbside collection method was effective for collecting household's food and kitchen waste for organic waste composting to make fertilizers [24]. The new waste collection system was officially implemented starting from 16th August 2015, which includes the placement of waste collection facilities such as recycle bins, distribution of individual food waste containers to tenant volunteers, and food waste bins at the student hostel areas. This system shares the following similarities with the municipality waste collection system in Japan:

1. Students are requested to separate the waste at their hostel before disposal.
2. Students must place recyclable waste outside of their hostels every Sunday morning to be collected by MDK. Kerbside collection method can maximize and achieve the highest recycling rate [25].
3. Electric and electronic E-waste can be collected together during the kerbside collection by MDK.
4. Students must separate food waste from other wastes and place them into the food waste bins located outside the hostels provided by MDK.

Moreover, recycling waste collection trucks used for the collection of the bins in Westlake have a unique appearance. Trucks are equipped with speakers to make announcements whenever the trucks enter Westlake to conduct the kerbside recycle waste collection.

## Results and discussion

### General distribution data of questionnaire respondents

A total of 370 UTAR students were involved in this survey. About 41.9% of the 370 students were males and the remaining 58.1% were females. All the sampled students were aged between 17 and 26 years. Among them, 55.4% were younger than 21 years and 44.6% were older than 21 years.

### Student perception toward local waste management

In terms of the local authority responsible for local waste management, only 40.6% of the students correctly identified MDK as the local authority responsible for MSW collection and management in Kampar, including Westlake and Harvard areas. 24.2% students mistook Tzu Chi organization (慈济), 23.1% considered Danish House Sdn. Bhd, 4.6% considered private contractors and 1.3% considered other organizations to be responsible for local waste management in Kampar, while 6.2% responded as not knowing. Concerning the student's awareness of how solid waste is treated in Malaysia, approximately 42.4% of students responded correctly that the waste will be sent to landfill directly without any pre-treatment and separation of waste into recyclable and non-recyclable. The remaining respondents' misconception was that: waste will be separated before landfill disposal by 41.1%, waste will be incinerated by 15.9%, and 0.7% of the respondents did not care about the ultimate fate of waste.

Despite the misconception about local waste management and the fate of waste by large groups of students, Mohamed Akil et al. [26] mentioned that proper education was effective toward encouraging people to separate waste. The recycling rate of the local community will increase if the community understands the importance of waste separation at source and are knowledgeable about the current real scenario of MSW management in Malaysia.

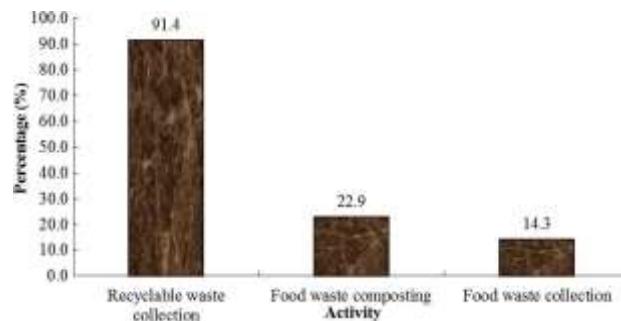
## Student's awareness and acceptance toward the waste segregation program

It was observed that before the implementation of the waste segregation program, 69.1% of the students were aware about waste segregation, while the remaining 31% were not aware about this aspect. After 3 months of implementation of the program, the percentage of students who were aware about waste segregation rose from 69 to 75%, which indicates that the program does promote awareness in waste segregation and management. However, despite that more than half of the students were aware before the waste segregation program was organized, only 38.7% of the students were actually practicing waste separation. Among the rest 61.3% of students who did not practice waste separation at source prior to the waste segregation program, 52.7% of them were willing to separate waste in the future, and only 8.6% of students did not have future plan for waste separation.

After 3 months of implementing the program, the results indicate an increase in the participation of students who practice waste segregation from 38.7 to 44.1%. Of the 44.1% of students who practiced, 19.2% involved themselves directly with the newly introduced waste segregation program and 24.9% involved themselves indirectly by using other methods to deal with their waste by donating recyclable items to Tzu Chi (慈濟) a non-government organization which collects recyclable items by using small trucks and has recycle stations in Kampar. The remaining 31.2% of students, who did not totally involve even after the implementation of the program, claim that they are not aware of the waste segregation program. However, they will take part in future if they are aware of the existence of such a program happening around their hostel.

## Student's activities in the waste segregation program

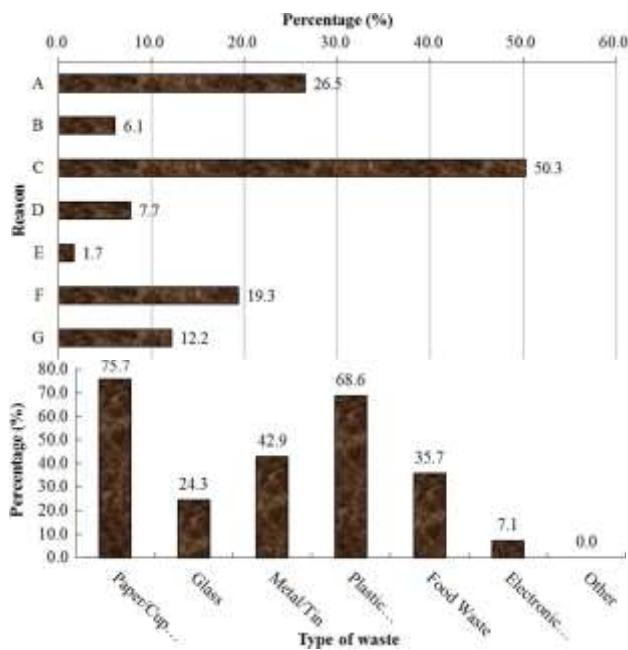
Figure 3 shows the type of participation activity during the program. It was found that the majority of students (91.4%) actively involved themselves in the collection and segregation of recyclable waste, while only 22.9% of students practiced food waste composting at their hostels using the composting container provided by MDK. The remaining 14.3% of the students were involved in food waste collection by depositing kitchen/food waste into the red food waste bin at the drop-off point. The high percentage of participation in recyclable waste is due to the acknowledgement from the local community that paper, plastics, metals and



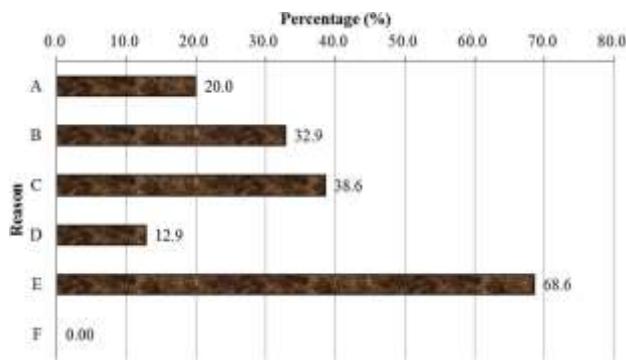
**Fig. 3** Types of participated activities by students in the waste segregation program

glass are common recyclable items, while the low participation in recycling food waste was because food waste is not commonly seen as a recyclable material. According to Mohamad and Keng [9], the Malaysian government through various recycling campaigns and policies only emphasize on recycling paper, plastic, glass and metal wastes, while food/kitchen waste is largely ignored. Food waste recycling is considered a new kind of recycling activity which is not commonly known in Malaysia. Therefore, most students did not immediately recognize that food waste collection is part of the recycling program.

Figure 4 shows the type of recyclable waste recycled by students during the program. Paper and cupboard top the list at 75.7%, followed by plastics at 68.6%, metal and tin at 42.9%, food waste at 35.7%, glass waste at 24.3% and lastly electrical and electronic waste (E-waste) at 7.1%. Paper and cupboard had the highest recycling rate. This is due to the high market value of recycle waste papers. The recycling rate of glass was surprisingly lower than food waste in this study. This is due to the nature of glass material which is brittle and heavy while having the lowest market price at 32



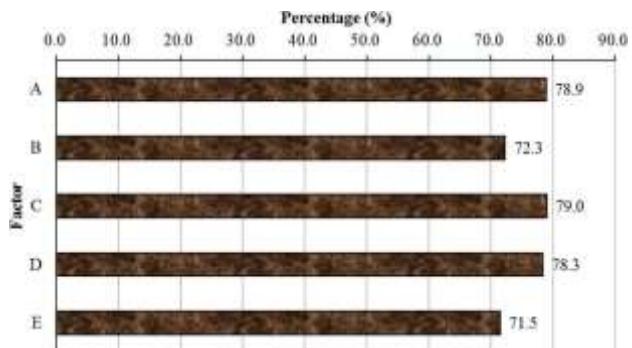
**Fig. 4** Types of recyclable waste recycled by students in the waste segregation program



**Fig. 5** Students' reasons for participating in the program. **a** There is a similar program in my hometown; **b** waste segregation is already my habit for a long time; **c** to get rid of recyclable waste easily; **d** people around me are doing it; **e**, I understand the benefits of waste segregation to the environment; **f** other

**Fig. 6** Students' reasons for not participating in the waste segregation program. **a** Waste segregation is troublesome and time consuming; **b** I do not like the methods implemented in this program; **c** I use other ways to handle my recyclable waste; **d**, I do not know what benefit this program can bring; **e** waste

USD/ton [27]. Recycling of E-waste was the lowest in this study, because there are no direct regulations dealing with the recycling of E-waste by the Malaysian government. Furthermore, E-waste is treated as schedule waste in the



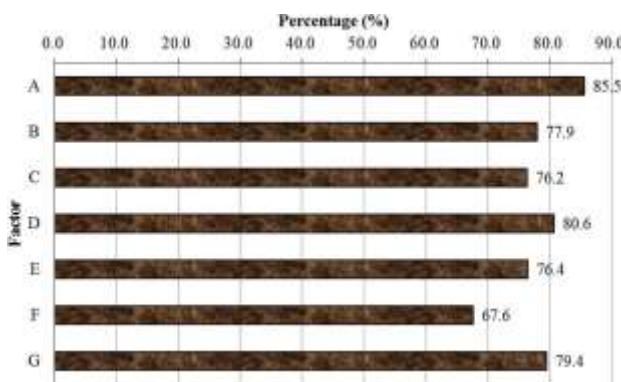
Environmental Quality (Schedule Waste) Regulations 2005 and there are very few recycling facilities for recycling E-waste in Malaysia [28]. Figures 5 and 6 show the student's reason for participating and not participating in the waste segregation program, respectively. "I understand the benefits of waste segregation to the environment" is the top most reason for students to participate in the program at 68.6%; therefore, there is a need to acknowledge and educate the public about the benefits of the program toward the environment as an effective way for more people to participate in the waste segregation activity. "Using other ways to handle recyclable waste" is the top most reason for students not participating in the waste segregation program at 50.3%. These other ways include the usage of existing recycle bins in UTAR, donation of recyclable waste to charitable organization and selling of recyclable waste to some private recyclers. This indicates a positive outcome from the program, as students are successfully influenced directly and indirectly to support the waste segregation and recycling program which does not depend solely on a single program to boost the participation rate in segregating waste at source.

## Student's opinions on the waste segregation program

Opinions gathered from the student survey questionnaires is important for the feedback, which produces continuous improvement in the program to perform better.

**Fig. 7** Level of agreement of students on factors that encourage people to practice waste segregation. **a** The recyclable waste can be sold for extra income; **b** enforcement by government, **c** existence of proper education about waste segregation and its benefits, **d** availability of waste segregation facility near housing areas; **e** surrounding people are doing it

According to Fig. 7, the top three most encouraging factors for the participation of waste segregation program was “The existence of proper education about the benefits of waste segregation” at 79.0%, followed by “Recyclable waste sold for extra income” at 78.9% and “Availability of waste segregation facilities near housing area” at 78.3%. While the top three most discouraging factors for the participation of the program was “Laziness” at 85.5%, followed by “Not many people are doing it” at 80.6% and “Absence of waste segregation facilities near housing area” at 79.4% as shown in Fig. 8. However, laziness is a reference of personal attitude, therefore eliminating this factor through waste segregation program may be very challenging. The majority of the students agreed upon the influence of other people surrounding him/her as affecting his/her doings, for example the



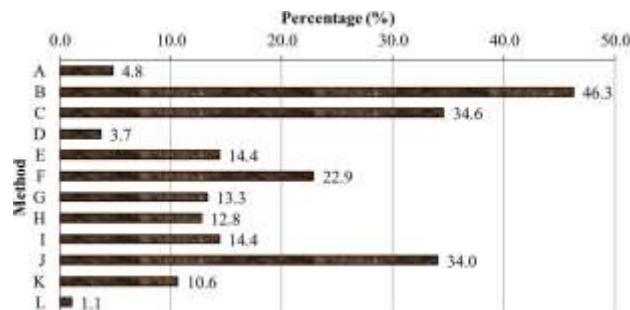
**Fig. 8** Level of agreement of students on factors that discourage people to practice waste segregation. **a** Laziness; **b** time consuming; **c** lack of enforcement by government; **d** not many people are doing it; **e** lack of knowledge about waste segregation and its benefits; **f** not profitable; **g** absence of waste segregation facility near the housing area  
unlikelihood of practicing waste segregation is because there is low participation rate of waste segregation around him/her. It is not surprising to find that the majority of students find the absence of recycling facility as another most influencing discouraging factor, as there is no recycling facility such as recycle bin and recyclable waste transportation in West Lake before the start of the waste segregation program.

In reality, “Lack of enforcement by government” at 19.3% is the main contributor toward the unsuccessful waste segregation program, as this factor is the main problem in Malaysia for not implementing waste

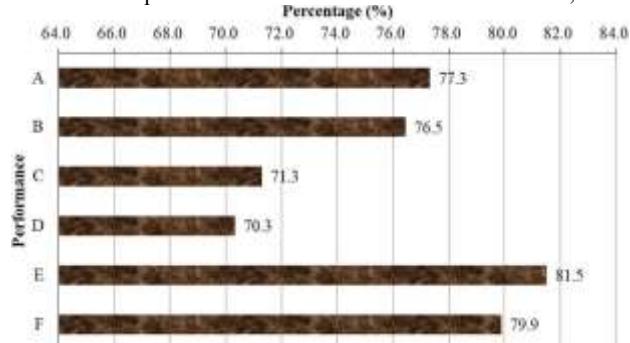
segregation seriously throughout the nation. Furthermore, recycling facilities have become available after the enforcement of such a governmental program nationwide. Unfortunately, the jurisdiction of the enforcement of waste segregation at the national level can only be executed by the federal government or state government; therefore, this is something which MDK does not have power to change.

## Performance of the program

Figure 9 shows the effectiveness of each type of medium used for the promotion of the program to students. Method B, C, J and F are the top four most effective methods, namely “5 min’ class presentation tops the list” at 46.2%, “Social media (Facebook)” at 34.5%, “The presence of recyclable waste collection lorry every Sunday” at 34.0% and “Banners hanging at the entrance of student hostel areas” respectively. This suggests that direct public confrontation through class presentation is more effective than social media advertisement in promoting the program. For every 5 min class presentation, 100–200 students can be covered at once, compared to using Facebook for promotion. There is a great competition for appearing on the student’s news feed on Facebook,

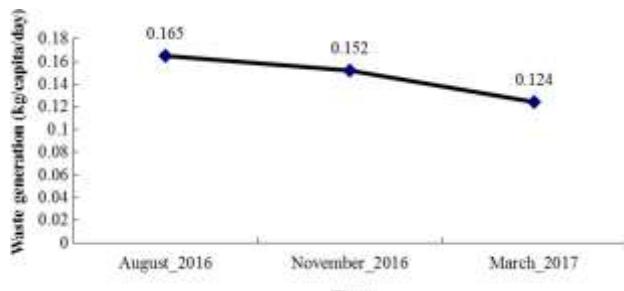


**Fig. 9** Methods used by students to know about the waste segregation program. **a** Seminar; **b** 5 min class presentation; **c** social media (Facebook); **d** informed by faculty staff/lecturers; **e** posters around UTAR; **f** banners at the entrances of West Lake; **g** housemate/course mate/ friend; **h** flyers at Danish House offices; **i** web announcement by Danish House and KT Management; **j** aware of the presence of recyclable waste collection lorry in West Lake every Sunday morning; **k** aware of the presence of food waste bins around West Lake; **l** other





**Fig. 11** Waste collection garbage before the segregation program (left) and after waste segregation program (right)



**Fig. 10** Level of agreement of students on performance of waste segregation program. **a** Promotion methods used are appropriate; **b** methods of collection are appropriate; **c** information about this program can be easily obtained; **d** the overall performance of the program is outstanding; **e** the initiative of this program is good; **f** this program is a good solution for the local solid waste problem

as there are plenty of other advertisements, news and posts that will push down the news about the waste segregation program. Despite this, it is undeniable that social media are still performing well in promoting the program, as the targeted participants are mainly students of age 17–26 years who are tech-savvy in the use of information communication technology (ICT) devices to get the latest information.

Figure 10 indicates the level of student's agreement toward the performance of the program from different aspects. The "Program's initiative is good" tops the list at 81.5%, as one of the objectives of this program is to introduce the culture of waste segregation into UTAR students, which is a meaningful culture that should be practiced by local people for a cleaner environment. The next is the "Program is a good solution of local solid waste problem" at 79.9%, as the waste segregation practice is a good solution to solve local solid waste problems such as uncontrolled solid waste disposal at landfill and open dumping sites around Malaysia.

## Waste recycling before and after the waste segregation program

Figure 11 shows the newly added community recycling bins and food waste bins around the student hostel area, together with implementation of kerbside collection after the new waste segregation program was implemented. Based on our observation, the waste collected per capita per day before the waste segregation program was 0.165 kg/capita/day, which was lower than the national average waste generation per capita per day at 0.8–0.9 kg/capita/day by Malaysia [29]. The low waste generation is because the purchasing power of students are not as high as working adults, since students at the university still receive higher education study loans from the government (Malay: Perbadanan Tabung Pendidikan

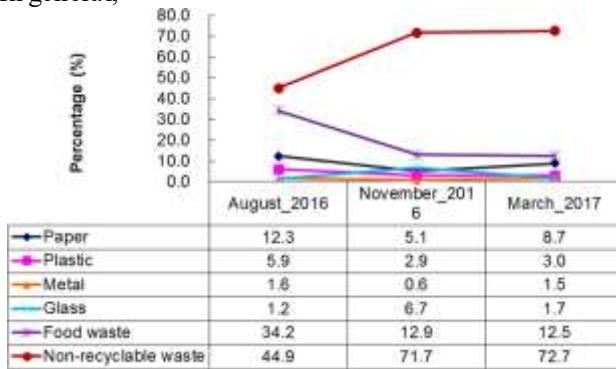
**Fig. 12** Waste generation throughout the program (kg/capita/day)

Tinggi Nasional, PTPTN) and a allowance from their family members, as they do not have the ability to work and gain income by themselves. Hence, fewer goods purchased leads to less consumption, and less consumption leads to less waste being produced among students at Westlake and Harvard hostel areas. After the implementation of the program, the reduction in collected waste from 0.165 to 0.124 kg/ capita/day (Fig. 12) implies a 25% of recycling rate, which is a good improvement over the 5% average recycling rate in Malaysia. This clearly shows that the

program had successfully reduced and diverted waste from the hostel areas entering landfill by 7.9% reduction of waste from August 2015 to November 2015 and a reduction of 18.4% from November 2015 to March 2016. The increase in the reduction from 7.9 to 18.4% of waste generated indicates that through the continuous improvement of the program by letting students provide feedback and opinions, the performance of the program can be sustained or even perform better than the previous one.

## Waste composition before and after the waste segregation program

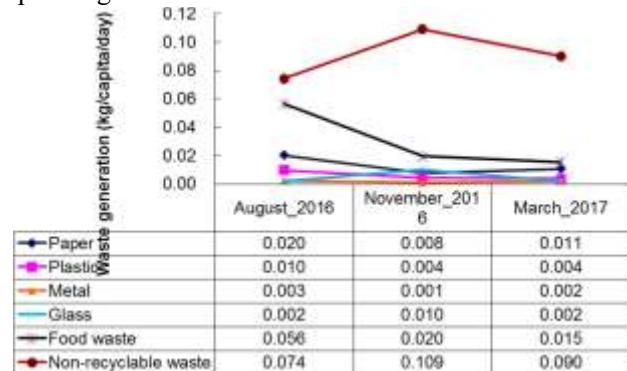
The changes in waste generation can be justified with the results in the waste composition based on Fig. 13. In general,



**Fig. 13** Waste composition in percentage, % in students' hostel area throughout the program

there is a decreasing and increasing trend in the percentage of recyclable waste (paper, plastic, metal, glass and food/kitchen) and non-recyclable waste (E-waste, universal waste and others) entering the landfill, respectively, after the implementation of the segregation program. This indicates that the program is effective in diverting recyclable waste for recycling purposes rather than landfilling. During the period studied from August 2016 to March 2017, nonrecyclable waste (from 44.9 to 72.6%) dominates the MSW composition, followed by food waste (from 34.2 to 12.5%), paper (from 12.3 to 8.7%), plastic (from 5.9 to 3.0%), glass (from 1.2 to 1.7%) and metal (from 1.6 to 1.5%). Before the waste segregation program started, only 34.2% of food wastes were present during August 2016, which was lower than the national average percentage of 45% of food waste composition in Malaysia [8]. According to Premakumara et al. [30], the Takakura home method

(THM) is an effective food/kitchen waste composting method which had been successfully implemented in Surabaya City, Indonesia, whereby THM helps to reduce 20% of the MSW generation over 4 years and achieve a total cost saving of 350,000 USD/ year in the waste management operating cost. The THM



**Fig. 14** Waste composition and generation (kg/capita/day) in West Lake student hostel area throughout the program

**Table 1** Income earned from selling recyclable waste collected from August 2016 to November 2016 at Westlake and Harvard student hostel area

Waste type	Recycling price per kg (RM)	Quantity (kg)	Total price (RM)
Cardboard	0.20	371	74.2
Paper	0.10	1877	187.7
Alloy	0.20	87	17.4
Iron	0.15	143	21.4
Tin	0.10	58	5.8
Plastics (PETE/ HDPE)	0.40	216	86.4
Aluminium	3.00	4	12.0
Grand total		2756	404.9

food composting program, introduced as part of the waste segregation program, helped to reduce food waste entering landfill from 0.056 kg/capita/day in August 2016 down to 0.020 kg/capita/day in November 2016 and further decrease to 0.015 kg/capita/day in March 2017 as shown in Fig. 14. According to Fig. 14, a great reduction of food waste entering landfill was observed, and the waste segregation program also helped to increase the collection and recovery of recyclable waste. Paper and plastic wastes stand third and fourth in the MSW composition and had a reduction from 0.02 kg/ capita/day and 0.01 kg/capita/day in August 2016 down to 0.008 kg/capita/day and 0.004 kg/capita/day in November 2016, respectively. However, there was a slight increase for glass wastes entering landfill from 0.002

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kg/capita/day in August 2016 to 0.01 kg/capita/day in November 2016.

### **Fulfilling sustainable development pillars and goals**

Sustainable development is an important goal, where-by world's society needs to achieve economic development, environmental sustainability and social inclusion for the human civilization [31]. In terms of economic development, the program helps to support the local YSR Recycling industry, located near Gopeng in Perak which is 18.7 km north from Kampar. On average, every kilogram of recyclable items is worth RM 0.15. As presented in Table 1. MDK earns a grand total of RM 404.9 from recyclable waste collected from student hostel areas during the period from August 2016 to November 2016 by selling 2765 kg of all types of recyclable wastes, namely cardboard, paper, alloy, iron, tin, plastics (PETE and HDPE) and aluminum. This income can be used to maintain or to increase the number and quality of recycling facilities around student hostel areas. Moreover, the program creates jobs, as MDK had assigned scavengers to be in charge of taking care of the drop-off collection bins around Westlake and Bandar Baru after the implementation of the program as a strategy to reduce scavengers' issue in Kampar. Hence, the working status from scavengers to green collar workers together with a more stable income can be guaranteed by the local authority. In terms of environment sustainability, both the waste segregation and THM composting programs helped to divert recyclable items and food waste from the landfill. This contributes greatly toward the preservation of virgin resources by reusing old materials and reducing the usage of new raw materials to make finished products. Moreover, the risk of water pollution can be reduced at the landfill, as less waste generation will lead to less generation of leachate, because after the closure of an average landfill, hazardous leachate will continue to be generated for the next 30–50 years [32].

### **Conclusion**

In this study, the waste segregation program helped to improve the student's awareness and behavior toward residential SWM at Universiti Tunku Abdul Rahman, UTAR's Westlake and Harvard student hostel area in

Kampar, Perak, Malaysia. There was an increase of awareness and practice of waste segregation among UTAR students from 69.1 to 75.3% and from 38.7 to 44.7%, respectively, after the implementation of the program. Within 8 months after the implementation of the program, a reduction of 24.8% regarding waste generation from student hostel from 0.165 to 0.124 kg/capita/day was achieved. Moreover, recyclable items entering landfill were reduced by 62.6% from 0.091 to 0.034 kg/capita/day. These changes indicate the effectiveness of the program in encouraging the awareness and participation of waste segregation and recycling activities among students. Thanks to the continuous improvement strategy through study feedback and constant follow-up being employed in the methodology for this study; the program can be sustained for 8 months starting from early August 2016 to the end of March 2017. However, several challenges including misuse of recycle bins at the drop-off point, misplacement of recyclable waste type, confusion among students on how to place recyclable waste for Kerbside collection, low recycling availability of certain plastics and lack of local recycling industry dealing with hard-to-recycle plastics and glass waste were faced during the implementation of the program. The program fulfilled the three pillars of sustainable development, namely economic development, environmental sustainability and social inclusion. Furthermore, according to the United Nation's sustainable development goals, goals no. 4, 8, 10, 11, 12, 13, 14, 15 and 17 are being fulfilled through the implementation of the waste segregation program at Kampar UTAR students' hostel.

This study only focuses on the segregation of four main recyclable wastes (paper, plastics, metal and glass), kitchen/food waste and E-waste from general MSW. Hence, it is recommended to include other types of solid wastes such as medical, universal, and hazardous from residential areas in future studies. Moreover, to implement the waste segregation program as part of the strategy toward sustainable waste management in Malaysia, full cooperation from all parties including residents, housing area management company, educational institute, private waste collector, government waste management authority, retailer and manufacturer is needed.

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