

## Solid Waste Management: Classification and Public Perception on Management Options at Applied Science University

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### ABSTRACT

The recycling and management of the growing amounts of solid waste have become a major challenge in many communities, mainly in the developing countries. Solid waste management can be at different levels, from households to local bodies, such as educational institutions and municipalities. Solid waste recycling can be a valuable resource, contributing to generated income in marginal communities as well as in high-income communities. Solid waste management can go through a series of activities, which are included in the three R's: *Reduce, Reuse and Recycle*. Public participation and willingness towards solid waste management are key issues to have successful integrated solid waste management. In this study, solid waste generated in an educational institution is analyzed and segregated and management options are investigated. A survey among the students in this institution is performed; the survey is to find the degree of awareness of solid waste management and knowledge on environmental consequences of improper management of solid waste. The study was carried out in the Applied Science University campus, which is located in the northern part of the Jordanian Capital Amman.

The daily solid waste generation rate per student during the study varied from 0.02 kg to 0.09 kg with an average of 0.05 kg. The percentages of different types of solid waste show that the highest percentage is for paper and cardboard (40.0%), while the organic constituent in the solid waste is minimal for the student building and other waste types form 13.7%, including organic, glass and other non-recyclable materials. Results related to the knowledge on solid waste management show that most of the students do not have knowledge on solid waste handling and management. More than 80% of the students do not have information on solid waste management, while about two thirds don't know how wastes are collected and dumped. About half of the respondents have information on how to minimize solid waste generated at house level. On the other hand, about half of the respondents know about solid waste segregation and 80% of them support doing this in the house. The results of the survey on seriousness of some issues related to solid waste management show that the seriousness rate is high to very high (4.2 to 4.5 out of 5).

**KEYWORDS:** Solid waste, Management, Generation rate, Community perception, Jordan.

### INTRODUCTION

Solid waste is the byproduct of human activities; it

increases with the expansion of urbanization and improvement of living standards. The change in consumption pattern in communities increased the amount and diversity of solid waste generated with limited actions to proper handling and disposal of solid waste (Dey, 2015; Cheng and Urpelainen, 2015;

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Bruggen, 2012). Recycling and management of the growing amounts of solid waste have become a major challenge in many communities, mainly in developing countries. The challenge of local communities in developing countries to have proper solid waste services and management is due to finance, logistics and unmanaged urban growth (Eugene and Busch, 2011; Guerrero et al., 2013). The proper collection and disposal of solid waste have drawn increased attention in developing countries due to the growing effect of solid waste disposal on public and environmental health. Poor handling and management of solid waste can have severe consequences on human health (Herath et al., 2015; Kaoje et al., 2017; Anjali and Asmita, 2015). The solid waste management can be in different levels, from household to local bodies, such as educational institutions and municipalities of large cities (Singh et al., 2007). The global attention of solid waste management increased in the late years, but with little emphasis on basic concepts of waste disposal. People in most of communities around the world are aware of the serious consequences of improper management of solid waste and undertake little actions on this manner (Twumasi, 2017).

Solid waste recycling can be a valuable resource, contributing to generated income in marginal communities as well as in high-income communities. In a study by Metin et al. (2003) on solid waste management practices and review of recovery and recycling operations in Turkey, they found that about one quarter of municipal solid waste is recyclable materials. Most of the municipal waste generated in developing countries is organic matter (Campuzano and González-Martínez, 2016; Pathania, 2011). The large organic matter portion of solid waste can cause an environmental problem when it biodegrades emitting greenhouse gases (GHGs), such as methane and CO<sub>2</sub>. Nevertheless, proper management of organic fractions through technology and intervention can help in reducing GHG emission and gaining economic benefits (Babel and Vilaysouk, 2016; Dey, 2015).

Solid waste management involves different levels of stakeholders; community people with both diverse and common interest can reach agreement on holistic action to approach a shared issue. An appropriate policy and full awareness of stakeholders are the main elements for sustainable solid waste management (Fauziah, 2009; Singh et al., 2007; Massoud and El-Fadel, 2002; Webler et al., 1995). Public participation and willingness towards solid waste management are key issues to achieve successful integrated solid waste management (Kumar and Nandini, 2013). The public perception of solid waste issues is very important to have proper handling and management of solid waste. Community-based and private sector initiatives for solid waste management are gaining more emphasis as means of addressing the short-comes of the public system (Getahun et al., 2012; Kirama and Mayo, 2016).

Fauziah et al. (2009) in a study on public perception on solid waste management in Malaysia found that about 78% of the respondents are aware of waste management issues, such as final disposal option of municipal solid waste and about 64% agree on the necessity of regulations that force solid waste segregation. Kumar and Nandini (2013) studied the community perception of solid waste management in the Indian city Bangalore and found that 63% of households are willing to be part of better management, 82.5% preferred to segregate waste into different bins and about 71% are willing to use recyclable products. Kaoje et al. (2017) found in a study on people perception in the Nigerian city of Sokoto that 41% of the respondents think that the community members should take sole responsibility for solid waste management, while 40% think that the public authority should do that.

Solid waste management can go through a series of activities which are included in the three R's: *Reduce, Reuse and Recycle*. The detailed steps are:

- 1) Waste reduction from the source; this involves education and awareness of the community members, as well as reuse and recycling at the household level.

- 2) Recycling, where solid wastes are segregated at the collection point or at a central solid waste management facility. If segregation is to be done at the collection point, the collection system of solid waste should have different containers to collect different types of waste.
- 3) Disposal and treatment, where the collected solid waste or the byproducts of the recycling system are transferred into the areas for last treatment.
- 4) Incineration, where the non-recyclable waste and in

some cases all solid waste is burnt and transformed into materials that can be dumped with controlled effect on environment. The heat generated due to incineration can be used to generate power.

- 5) Landfill, where solid waste is buried in soil. The organic portion of the buried solid waste is digested with time and generates energy gases that can be recovered and used in energy generation.

Figure 1 illustrates the various management options with their preference.

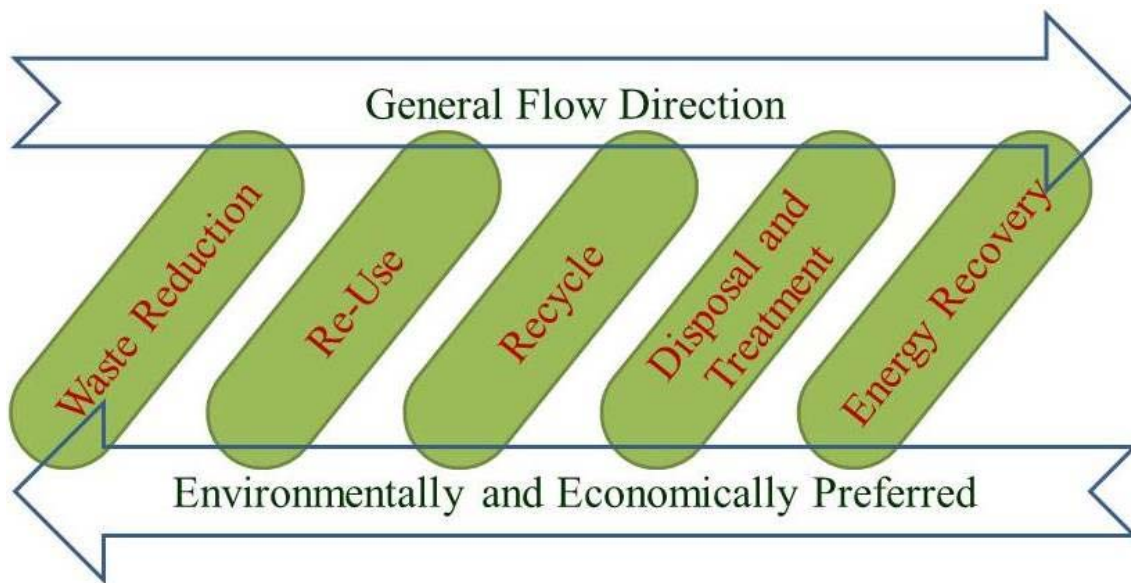


Figure (1): Solid waste management options

In this study, solid waste generated in an educational institution is analyzed and segregated and management options are investigated. A survey among the students in this institution is performed. The survey is conducted to find the degree of awareness of solid waste management and knowledge on environmental consequences of improper management of solid waste.

## MATERIALS AND METHODS

### Study Area

The study was conducted in Applied Science University campus at Al-Khawarizmi building. The university campus is located in the northern part of the Jordan Capital Amman. Al-Khawarizmi building is about 4100 square meters per floor and consists of 4 floors, accommodating the College of Engineering departments and part of the Art College. The total number of students within these departments is 1963 students. Figure 2 illustrates the location of Applied

Science University campus and Al-Khawarizmi

building within the university campus.



**Figure (2): Location map of the study area**

### **Solid Waste Collection and Segregation**

In order to collect and separate solid waste within the study building, a total of 96 trash bins each with a size of 50 liters are used. The targeted waste is to be separated into plastic, paper, metal and other trash. The bins for each type of waste are identified using colored stickers on bins with the name of waste to be put in each

bin: a yellow sticker for plastic, blue for paper, green for metal and red for other waste. A group of four different bins are distributed over the different floors of the building, around the building and at the entrances of the building to make it easy to find a place to dispose of the different types of waste. Figure 3 shows an image of a group of the waste collection bins used.



Figure (3): Different trash bins used to collect waste during the study

For 10 working days, the waste in the different bins is collected around the end of the students' school day (around 3:00 pm), where the total weight of each type is recorded. The recyclable materials (plastic, paper and metal) are collected by a local vendor who takes them to recycling, while the other waste is moved to the University waste collection center, where the waste is collected by Greater Amman municipality.

#### Student Perception on Solid Waste Management

Attitude represents the individual agreement or disagreement on an issue. Individuals may have a neutral attitude towards unclear issues and after some awareness on these issues, they will have a solid attitude, being negative or positive. On the other hand, the attitude can be ranked and quantitatively measured with questions that have ranked answers. These types of questions not only measure the attitude, but also rank the seriousness and strength of the answers. In this study, two groups of questions were asked. The first group examines the knowledge of students of issues related to solid waste management with answers of yes and no, where the questions are about the knowledge of solid waste collection and handling, waste management options and waste health and environmental impacts. The second group of questions aim to rank some issues

related to solid waste handling and management, where each issue is ranked from (1) for not an issue to (5) for an extremely serious issue. The seriousness of each issue is relative and measures the environmental and economic costs of the issue from the point of view of the respondent. Respondents are asked to rank the discussed issues from the most to the least environmentally and economically costly issues. A total of 76 questionnaire survey forms were collected from students at the College of Engineering and the College of Art using Al-Khawarizmi building.

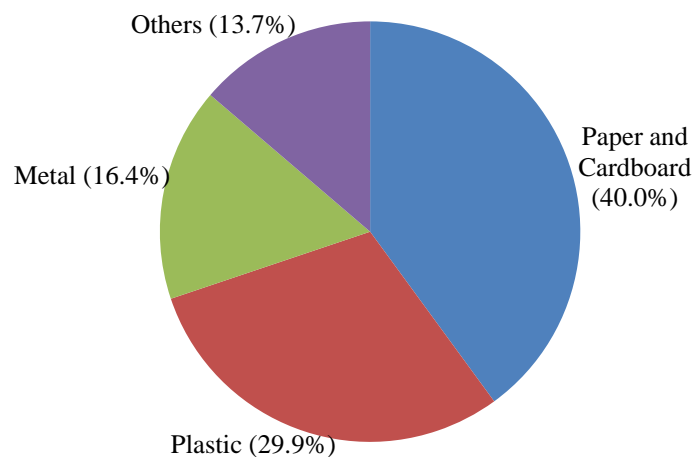
## RESULTS AND DISCUSSION

### Solid Waste Segregation

The different types of waste were collected daily and weighed for 10 working days. The daily weight of paper and cardboard varied from 7.8 to 46.4 kg with an average of 38.4 kg. Plastic daily weight varied from 10.9 to 65.8 kg with an average of 28.7 kg, while metal daily weight varied between 4.4 and 20.1 kg with an average of 15.8 kg. The daily solid waste generation rate per student during the study varied from 0.02 kg to 0.09 kg with an average of 0.05 kg. Table 1 shows the results for different types of solid waste collected and their percentages and Figure 4 illustrates a comparison between the different waste constituents.

**Table 1. Different types of solid waste collected during the study**

Type of Waste	Maximum Daily Waste (kg)	Minimum Daily Waste (kg)	Average Daily Waste (kg)	Average Percentage %
Paper and cardboard	46.4	7.8	38.4	40.0%
Plastic	65.8	10.9	28.7	29.9%
Metal (aluminum cans)	20.1	4.4	15.8	16.4%
Others	43.3	5.8	13.2	13.7%
Total	175.6	28.9	96.1	100%
Per student (kg)	0.09	0.02	0.05	

**Figure (4): Ratios of different types of waste collected in the study area**

The ratios of different waste types are compared to the results of previous studies in Greater Amman Municipality and Applied Science University. Table 2

shows the percentages of different types found in solid waste from different references.

**Table 2. Percentages of different types of solid waste for Amman and ASU**

	GAM with ASU (2012) for ASU	Salah Abu-Salah, RSS (2013) for Amman	GIZ (2014) for Amman	MoMA (2015) for Amman	Jordan Green Building Council (2016) for Amman	Current Study (2017) for ASU
Paper and Cardboard	30	14.7	15	14	14	40
Metal	12	0.9	1.5	5	4	16.4
Plastic	13	15.7	16	10	15	29.9
Organic	32	49.7	50	59	51	included in others
Others	13	19	17.5	12	16	13.7

The percentages of different types of solid waste show that in a university teaching building, the highest percentage is for paper and cardboard (40.0%), since paper materials are major in a student community and will create most of the waste in a student building. On the other hand, for the university as a whole, paper waste forms a high percentage (30% in GAM and ASU, 2012), but less than the percentage in the student building in this study. For the organic constituent in solid waste, it is minimal for the student building as shown in this study, where the organic percentage is included in other waste types which form 13.7%, including organic, glass and other non-recyclable materials. Comparing that to the results of a study conducted on all the university buildings, organic waste formed 32% due to studying all the university buildings including food courts. But, the percentage of organic waste in the university is still less

than that for Greater Amman Municipality where organic waste formed more than 50% in many studies.

### Students' Attitude towards Solid Waste Management

The survey has two parts; the first one includes questions on the knowledge of waste management options to find whether students are aware of the various options on waste management or not. The second part has questions on some environmental issues related to waste, where students are asked to classify each issue from "not a problem" to "serious problem" with ranks from 1 to 5.

A total of 76 questionnaire survey forms were collected from students at the College of Engineering and College of Art using Al-Khawarizmi building. Tables 3 and 4 summarize the results of the survey.

**Table 3. Students' response about knowledge of waste management**

Item	Yes (%)	No (%)
Do you know who collects and dumps solid waste in your area?	32.9	65.8
Do you have information on public solid waste management?	18.4	81.6
Do you have information on how to minimize solid waste generated?	48.7	51.3
Do you have information on solid waste segregation?	52.6	47.4
If you have information on waste segregation, do you support in-house segregation?*	80.0	20.0
Do you have information on environmental and health consequences of improper management of solid waste?	59.2	40.8

\* Results for individuals who answered the previous question by yes.

**Table 4. Results of survey on students' response on seriousness of issues related to solid waste management**

Item	1	2	3	4	5	Mean
Dumping solid waste in public land	1.3	1.3	9.2	27.6	60.5	4.4
Dumping used tires	1.3	1.3	5.3	27.6	64.5	4.5
Dumping house chemicals' containers after finish	1.3	2.6	7.9	27.6	60.5	4.4
Burning waste between houses	2.6	3.9	6.6	21.1	65.8	4.4
Dumping waste in open areas between houses	3.9	3.9	11.8	28.9	51.3	4.2
Dumping solid waste in landfills	15.8	21.1	18.4	22.4	22.4	3.1

1: Not a problem, 5: Serious problem.

The results for the knowledge on solid waste management show that most of the students do not have knowledge on solid waste handling and management. More than 80% of the students do not have information on solid waste management, while about two thirds don't know how wastes are collected and dumped. Nevertheless, about 60% of the respondents don't know the health and environmental consequences of improper handling and management of solid waste.

When it comes to the solid waste management at house level and regardless the low knowledge of solid waste handling and management at public level, about half of the respondents have information on how to minimize solid waste generated at house level. On the other hand, about half of the respondents know about solid waste segregation, 80% of them support in-house segregation.

The results of the survey on seriousness of some issues related to solid waste management show that the seriousness rate is high to very high (4.2 to 4.5 out of 5) in all the discussed issues, except for the issue of dumping solid waste in public land, where the rate is average (3.1 out of 5). The issue of dumping used tires showed the highest rate (4.5 out of 5).

## CONCLUSIONS AND RECOMMENDATIONS

The study covered two main issues; solid waste generation rates and types within an academic institution and the students' awareness and knowledge on solid waste handling and management and issues related to solid waste. The average generated daily waste is about 50 grams per student in an academic building; this is expected, since the main activity of the building users is to attend classes, where waste is generated by the

building staff (administrative and academic staff). Most of the waste generated is paper (40%), while other waste including organic matters is relatively low (13.7%) compared to the national rates shown in many studies. Other recyclable wastes, such as plastic and metal, have ratios higher than the ones for domestic waste. These results reveal that the percentage of recyclable waste in academic institutions is much higher than that of domestic waste and that recycling options for academic institutions will be promising.

The targeted students on the solid waste perception survey are mostly engineering students. In the first part of the survey, students are asked about their knowledge on solid waste handling and management; the results show that students have low level of knowledge on solid waste handling and management. This leads to draw the conclusion that more awareness and educational programs on solid waste management are needed for a group of people who will be the community leaders in the future. On the other hand, results of the second part on rating some issues related to solid waste management show that students gave these issues a high seriousness rate.

It is recommended that solid waste management options, such as segregation and recycling, should be encouraged at the university level, since most of the waste generated there is of recyclable types, such as paper, metal and plastic.

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