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A Cross-Sectional Study of Knowledge, Practice, and Management of Solid Waste Segregation in Higher Educational Institutes: A Case Study in KSA

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Abstract: Solid waste management is highly considered in the Kingdom of Saudi Arabia (KSA) for the protection of the environment, preserving resources, and producing energy. Solid waste is collected in bins from Qassim University (QU) as a mixture without any segregation processes. The key to obtaining university stakeholders' involvement in the waste separation program is awareness coupled with participation. This study evaluates the stakeholders' knowledge and practices related to solid waste separation at QU, KSA, as well as explores the current collection system of solid waste on the university's campus. A self-administered questionnaire was designed to measure the knowledge and practices of QU stakeholders, as well as the existing management of solid waste in the University. The questionnaire consists of three sections; knowledge, practices, and actual waste management in QU. A total of corrected 437 responses were collected from QU demographic variables based on gender, language, age, and job. Frequency analysis, Chi-square test, *t*-test, and correlation test were utilized to estimate the average values and the association between the survey statements and demographic variables. The results revealed that the awareness level of respondents is high, and their application is good. Although fewer than 50% of the QU stakeholders have practiced waste separation at the generation site in specific bins, the majority are willing to do that with an agreement level of 98%. Additionally, the analysis proved that the solid waste is collected efficiently in QU but the waste separation at the generation point is poor. The responses of the participants implied that the most disposed of waste in QU is paper, followed by plastic. Teaching courses, workshops, and advertisements related to waste are recommended to increase awareness of the benefits of waste separation at the source, both economically and environmentally. The results of this study help the decision-makers in the programs' implementation of sustainable development and resource reservation that is also consistent with KSA vision 2030.

Keywords: municipal solid waste; solid waste separation; survey; Qassim University



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1. Introduction

Municipal solid waste (MSW) is the mixture of solid waste disposed of daily by people as garbage, residue, and refuse [1]. However, many of these waste materials can be reused or recycled. If solid waste is managed properly, it could become a resource for industrial production or energy generation [2]. Waste generation increases with the increase in population and urban areas. In KSA, for instance, the average increase in population growth over the last four decades is recorded as 3.4%, while urbanization increased from 50 to 80% from 1970 to the present [3]. The average generated MSW per capita in KSA is

nearly 1.4 kg/day with a total annual generation rate of 15.3 million tons/year according to the reported data in 2014 [4]. The expected population of KSA by 2025 could reach 30 M in urban areas and the expected rate of waste generation is 1.7 kg/capita/day [5].

Developed countries such as Japan and Germany have good practices of solid waste segregation from sources [6,7]. However, developing countries still face great challenges in waste separation, reuse, and recycling [8]. In KSA the majority management of municipal solid waste is dumping it in landfills without material or energy recovery [3,9]. In addition, most of the landfills in KSA are non-engineering designed and cause environmental problems such as emissions of greenhouse gases, leachate to groundwater, and soil pollution [10]. The only recycling practice in KSA is applied to metals and cardboard with a percentage range from 10 to 15% of the total generated waste [11]. Significantly, some of these problems can be decreased by the segregation of recycling materials at the sources, which leads to economic and environmental sustainability.

Solid waste segregation at the generated point is the practice of individuals separating types of recyclable solid waste at the point of generation to reduce the volume of disposed of waste and enhance the recycling process [12]. The key to obtaining university stakeholders' involvement in the waste separation at sources is awareness coupled with participation. MSW in educational institutes contains three major components: organic waste, paper, and plastics, with most of them being recyclable materials [13,14]. A university is a place where thousands of students, faculty members, and employees spend considerable time with normal life activities including solid waste generation from several sources, such as offices, classrooms, laboratories, restaurants, residence halls, and other facilities [15]. Universities and higher educational institutes around the world are recognized as the leaders of sustainable development [16–18]. When conducting a pilot study of waste management or offering environmental programs, university students and faculty members need to be aware of these studies [19]. Research studies proved that increasing awareness among students and working staff related to waste management increases good practices for solid waste disposal and waste separation [6,20,21].

Several studies have manipulated the effectiveness of awareness related to solid waste management on students' practices in higher educational institutions. Paghasian [22] conducted a cross-sectional study to examine the significant relationship between the awareness and practices of solid waste management among college students at Mindanao State University, Maigo School of Arts and Trades. The results from 253 students showed that the awareness of students on the management of solid waste was high while their practices were good. Furthermore, in Beijing, China, a face-to-face cross-sectional study was carried out at ten universities to assess students' behavior related to waste separation. The study proved that females are more likely to actively participate in waste source separation than males [23]. Descriptive correlational research was also conducted to assess the level of awareness and practice among students at Filipino colleges [24]. His results from 150 respondents revealed that students are aware of solid waste policies and management but, relatively, are not aware of their roles as students in the fulfillment of waste management. In this context, Desa et al. [25] assessed the attitude and performance of waste management among students from the first year at Bangi Campus of Kebangsaan University, Malaysia. The students exhibited high levels of responsibility and practice regarding SWM, with 60% reporting a positive attitude. In the North Central zone of Nigeria, a significant association was found between students' knowledge and their attitudes by Dung et al. [26] through a cross-sectional survey that sampled 1800 students. With the help of a self-administered questionnaire, Ifegbesan [27] measured students' awareness, knowledge, and actions regarding waste management. In his study, the number of participants was 650 students from six secondary schools in Ogun State, Nigeria. His findings revealed that students were aware of waste problems but had poor waste management practices.

Little research has been found regarding cross-sectional studies of solid waste management in Saudi Arabia Universities. Abubakar et al. [28] examined students' perceptions of environmental sustainability components by surveying 152 students at the College of

Architecture and Planning, University of Dammam. The results showed that even though the students showed a great deal of awareness and concern about the environmental sustainability of the campus, they lacked interest and willingness to participate in initiatives toward achieving sustainability. Alsawah et al. [29] designed a questionnaire that consists of 5 sections and contains 23 questions to collect data from 199 female students at Princess Norah Bint Abdulrahman University. The questionnaire evaluated the attitudes and preferences of students towards food waste in their community rather than in the university. The authors measured the respondents' attitudes toward some policies of food reduction such as hospitality policies, education and raising awareness, and legislation. Other researchers studied environmental preservation such as Khan et al. [30]. They administered a survey questionnaire to 365 students at Prince Sattam University and other universities in Saudi Arabia. The questionnaire included some statements about environmental conservation activities. The results showed that environmental awareness can be increased using awareness activities on sustainability issues in a university setting. Saleem et al. [31] studied the existing practices of solid waste management in the College of Engineering, at Imam Abdulrahman Bin Faisal University. They proved that the adoption of the E-learning system and sustainable drinking water has led to a reduction in paper and plastic waste. The mentioned studies did not investigate the current waste collection or the expected recyclable waste in KSA universities.

To the best of our knowledge, there were no investigations that manipulated solid waste segregation at the generation sites, either in Saudi universities or in the community. The present study is the first step toward an ambitious plan to enhance the waste management system for separation, reduction, recycling, and protecting the environment, as well as preserving the resources in KSA. Importantly, this study aims to evaluate the stakeholders' knowledge and practices of solid waste separation at Qassim University together with assessing the current collection method of solid waste in the university. The study aims also to encourage the university to lead the community toward a sustainable waste management system based on national regulations and KSA's vision for 2030. The results of the study will be used in the next step of our project to implement a pilot study of recyclable waste separation in designated bins.

2. Materials and Methods

Solid waste in Qassim University (QU) is collected daily from offices, corridors, and cafeterias via a contracted company. Solid waste in QU does not accumulate at any site of the university, and it is transported to a non-designed landfill as an endpoint without any separation or recycling processes. Qassim University includes 35 educational institutes with a total number of students of almost 70,000. The university recruited 5482 national and international faculty members. Most of the international faculty are Arabic speakers with a considered number of non-Arabic speakers. Female faculty members represent 21% of the total faculty members of QU.

This study designed a self-administered questionnaire to measure the knowledge and practices of QU stakeholders related to solid waste in the University and to evaluate the infrastructures and authority's participation in solid waste management. The questionnaire consists of three sections with 24 statements. The sections are knowledge (10 statements), practices (8 statements), and existing waste management in QU (6 statements). The questionnaire was based on yes/no questions for the knowledge section and a five-point Likert scale for the other two sections. The instrument also measures the most disposed of recyclable waste via a multi-choice statement. A pilot study to examine the survey instrument was conducted on 23 respondents of specialist faculty members to identify potential problems and prevent biases. Cronbach's alpha [32] was used to measure the reliability of the survey, and testing the questionnaire's core items was found to have a value of 0.760. The study was approved by the Committee of Research Ethics, Deanship of Scientific Research, Qassim University (approval number 21-04-07).

Multiple WhatsApp channels and official QU emails were used to distribute the questionnaire. Participants were asked to circulate the online questionnaire to their colleagues, friends, and relatives of the QU community by a non-probability sampling strategy utilizing the snowball sampling method. The size of the required sample is estimated based on the number of stakeholders in QU using some known formulas [33], giving the sample size as 382 participants. To adjust for any stratification and to eliminate any invalid replies, the sample size increased where the collected responses were 461. The net respondents were 427 after excluding 34 cases due to inconvenience with the inclusion criteria. Microsoft Excel was used to arrange and code responses, which were then exported to Statistical Package for the Social Sciences (SPSS) version 25 for analysis. Data were analyzed using descriptive statistics (frequency and percentage), while cross-tabulation and a nonparametric Chi-square (χ^2) test were applied in the inferential part. In addition, Pearson's coefficient of contingency was applied to examine the relationship between some continuous variables. Five hypotheses were designed to measure the relationships between respondents' knowledge and practice with waste source separation behavior; they are as follows:

H1. *Participants are well aware of the benefits of solid waste separation.*

H2. *Most participants have not engaged in waste source separation.*

H3. *Knowledge is strongly correlated with sound practice.*

H4. *There is no trash separation in designated bins in QU.*

H5. *The most disposed of solid waste in the university is paper.*

3. Results

Table 1 outlines the demographic features of the participants, revealing that of the 437 participants, 258 (60.4% of the total) were male, 294 (69%) were students, and there was a poor response from employees. We have a low participation rate from non-Arabic speakers 33 (7.7%), so the language variable was removed from analysis and interpretations.

Table 1. Basic statistics of the solid waste survey participants in QU ($n = 437$).

Variable	Category	<i>n</i>	%
Gender	Male	258	60.4
	Female	169	39.6
Position	Students	294	68.9
	Faculty members	118	27.6
	Employees	15	3.5
Age	Less than 25	265	62.1
	From 25 to 40	60	14.1
	More than 40	102	23.9
Language	Arabic	394	92.3
	English	33	7.7

3.1. Participants' Knowledge of Solid Waste

Ten statements were designed to measure the basic knowledge of QU stakeholders for solid waste such as waste types, recyclable waste, environmental protection, and waste legislation, as presented in Table 2. The knowledge statements are designed to be positive and coded with three answer choices; Yes (3), I do not know (2), and No (1). Some statements are about waste classification (from K1 to K7), while other statements measure the participants' awareness related to the national and QU legislation to protect the environment (K8 and K9). The level of awareness is considered "High" if the average

score is greater than 2.5, “Medium” if the average is between 2.5 and 2, and “Low” if the average is less than 2. The highest weighted mean (2.97) belonged to the statement of the responsibility of environmental preservation; “K10: Environmental preservation should be everyone’s responsibility”. However, the least average value (2.03) belongs to the statement of solid waste legislation in the University; “K9: Regulations in place to reduce the waste disposal”. The general weighted mean value for the knowledge section is 2.66 which implies that the respondents in QU have a “High” awareness of the importance of solid waste separation. Therefore, we can accept the hypothesis “H1: Participants are well aware of the benefits of solid waste separation”. A similar result was obtained also in the University of Dammam, KSA [28], and the Philippine State University with a satisfaction of 74% in knowledge assessment [34].

Table 2. Level of knowledge of participants related to waste and the environment.

Key	Knowledge Statement	Mean	St. Dev.	Assessment
K1:	Solid waste can be classified into organic waste such as food waste and inorganic waste such as paper, plastics, and glass waste	2.69	0.664	High
K2:	Solid waste can also be classified as biodegradable and non-biodegradable products	2.85	0.449	High
K3:	Solid waste such as paper and plastics has economic value if it is exploited	2.94	0.276	High
K4:	Recycling solid waste can help to protect the surrounding environment	2.96	0.258	High
K5:	Recycling solid waste preserves natural resources.	2.92	0.316	High
K6:	Solid waste disposal represents an economic burden	2.26	0.835	Medium
K7:	Universities have a major role in social and environmental issues	2.77	0.553	High
K8:	There is a national government regulation for the integrated management of waste	2.23	0.647	Medium
K9:	There are strict regulations in place to reduce the disposal of solid waste in its specified places	2.03	0.865	Medium
K10:	Environmental preservation should be everyone’s responsibility	2.97	0.215	High

Cross-tabulation analysis (Table 3) referenced that a high percentage of respondents (>90%) responded “yes” to the statements that waste recycling protects the environment; K3, K4, K5, and K10. Furthermore, the knowledge statements K1, K2, and K7 received “Yes” responses for a percentage from 80% to 90%. For the statement “K6: Solid waste disposal represents an economic burden”, half of the respondents have a low awareness of the economic costs of waste disposal. Most respondents, 65% for K8 and 61% for K9, are unaware of the existence of national and QU waste legislation.

Table 3. Variation in knowledge respondents' answers based on their, age, gender, and occupations related to waste awareness.

Knowledge Statement	Percent of the Total Respondents			Significance (<i>p</i>) from the Chi-Square Test		
	No	I Do Not Know	Yes	Gender	Position	Age
K1	11.2	8.9	79.9	0.521	0.002	0.001
K2	3.5	8.4	88.1	0.780	0.586	0.228
K3	0.9	4.2	94.8	0.765	0.106	0.643
K4	1.4	1.2	97.4	0.951	0.000	0.006
K5	1.4	4.9	93.7	0.539	0.301	0.035
K6	25.3	23.9	50.8	0.343	0.000	0.000
K7	6.3	10.5	83.1	0.140	0.119	0.405
K8	11.9	52.7	35.4	0.829	0.647	0.508
K9	35.8	25.3	38.9	0.256	0.035	0.014
K10	0.9	0.9	98.1	0.221	0.869	0.644

The Chi-square test examines if there is a significant relationship between dependent and independent variables. The test was carried out to explore the association between the knowledge status of the QU's stakeholders and their demography variables. The test results shown in Table 3 indicated that the awareness level of types and classes of solid waste did not depend on the gender variable where the computed *p*-value is greater than 0.05 for all statements. The test referenced also that there is a significant association between the knowledge statements K1, K4, and K6 with the age and position categories. The cross-tabulation analysis referenced that awareness increases by increasing the age for the statement of waste classification (K1). According to the statement about the economic burden of waste disposal, 64% of the respondents who were more than 40 years old answered "Yes" as opposed to (44%—Yes) in the age less than 25 years old group, while the category from 25 to 40 years answered 60% "Yes". The same association was observed among the position category and the awareness of the economic burden of waste disposal, where faculty members (67%—Yes) had more awareness than employees (60%—Yes) and students (44%—Yes). The analysis explored that less than 40% of the participants have knowledge of the existing national or university regulations related to waste management.

The results of this study revealed that students in QU generally have a high level of knowledge regarding the types and classification of waste management; however, their awareness of the existing national and university regulations for waste management is low. The cross-tabulation analysis referenced that awareness increases by increasing the age based on the statement of waste classification (K1). This implies that the students have lower awareness than the faculty and staff members. Faculty knowledge and awareness are very important when designing programs for environmental educational tools such as courses, workshops, and brochures related to waste management that are essential for students to raise their awareness. Furthermore, as the youth are the future of any country, raising students' awareness will enhance any national program for waste segregation and recycling.

Crosstabs' analysis concluded that the students have low awareness of the economic burden of waste disposal without any processes (K6). The national center for waste management (MWAN) has an executive regulation to regulate all the processes of waste management such as collection, transportation, segregation, storage, treatment, recycling, and disposal. The awareness of the MWAN regulation is considered in statement K8 and the result implied that the awareness of such regulations is low. This implies that an educational program should contain national waste regulations and the economic benefits of waste segregation, recycling, and reuse.

3.2. Practices of Solid Waste Management in QU

A set of statements was developed to measure the attitudes and practices of the university's stakeholders toward solid waste separation, as given in Table 4. The question

(P7) is designed to measure the degree of willingness to participate in an intended pilot study about waste separation in specific bins of recyclable materials. Respondents were asked to rate the likelihood of their practice through seven statements with five Likert scale choices. The choices were “Strongly disagree” (1), “Disagree” (2), “Neutral” (3), “Agree” (4), and “Strongly agree” (5). The average values and standard deviation of the responses to the practice statements are presented in Table 4. The practice evaluation is classified as “Very good” if the mean is greater than 4.5, “Good” if the mean ranges from 4 to 4.49, “Fair” for the mean value range from 3.5 to 3.99, and “Poor” if the mean is less than 3.5. The results of average values in Table 4 implied that the statement “P7: I am ready to classify solid waste in designated bins” obtained the highest weighted mean (4.81). Two attitudes also obtained very good ranks (mean > 4.5). The two statements are related to putting the waste in its specific place (P1) and not throwing the waste on the street (P2). The least average result (3.3) belonged to the practice of waste separation in classified bins, which was denoted as a poor practice that is consistent with the second hypothesis “H2: Most participants have not engaged in waste source separation”. The general weighted mean value for the waste practice in QU is 4.2, which implies that the respondents in general have “Good” practices.

Table 4. Results of practice questions related to solid waste management in QU.

Key	Practice Questions	Mean	St. Dev.	Assessment
P1:	I always set the waste at the specified places	4.67	0.656	Very Good
P2:	I never throw away waste on the streets during driving my car	4.70	0.727	Very Good
P3:	I exploit old empty papers of finished projects and assignments in my studying	4.20	1.012	Good
P4:	I respond positively to national projects and regulations that invite to protect the environment and economic resources	4.02	0.990	Good
P5:	I had previously practiced the separation of solid waste into its specific bins	3.32	1.333	Poor
P6:	I use some solid waste to do useful items	3.52	1.211	Fair
P7:	I am ready to throw solid waste (paper-plastic...) into its specified containers in the University if they are available	4.81	0.493	Very Good

Cross-tabulation analysis (Table 5) referenced that 95% of the responses agreed with the practice of disposal of waste in its specified bins if the facilities are available. However, only 51% of the respondents are exploiting the empty pages in the used papers (P3), while less than 50% of the respondents have participated in waste separation at the generation site (P5). In addition, the data revealed that 56% of respondents repurposed outdated materials for beneficial purposes (P6). The association between the practices and the demographic variables was also examined using the Chi-square test, as given in Table 5. The test implied that the gender variable has significant statistical relationships with three attitudes: P2, P5, and P6, while the age and position variables are significantly associated with practices of responding positively to national projects related to the environment.

Table 5. Cross-tabulation analysis and variation in respondents' practice of solid waste in QU.

Practice	Percent of Respondents of Each Likert Scale					Significance (<i>p</i>) from the Chi-Square Test		
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Gender	Position	Age
P1	0.7	0.5	4.7	19.9	74.2	0.095	0.847	0.656
P2	1.2	1.6	4.0	12.2	81.0	0.022	0.423	0.716
P3	1.6	6.6	13.6	26.7	51.5	0.202	0.083	0.279
P4	0.7	6.8	23.2	28.1	41.2	0.280	0.000	0.000
P5	11.0	19.9	19.7	24.6	24.8	0.001	0.353	0.180
P6	7.5	13.6	23.2	31.1	24.6	0.001	0.004	0.114
P7	1.2	0.9	13.6	84.3	1.2	0.372	0.280	0.138

Further analysis of the practice activities that have significant statistical relationships was carried out using crosstabs. The practice of “responding to national projects and regulations for environmental protection (P4)” has a significant association with position and age. Employees have more practice protecting the environment than faculty members, and faculty members respond positively to environmental projects more than students. Furthermore, it is concluded that as age increases, the response to environmental protection increases. Statement P5 measures the previous practices of respondents toward the separation of waste types in specific bins. The cross-tabulation results proved that females (59% Agree) had more practice in waste separation at the generation point than males (43% Agree). However, it is found that English speakers with a percentage of 76% practiced waste separation more than Arabic speakers (47%). The practice of reusing old waste to create useful things (P6) has a significant association with gender and position where females (64%) are exploiting old waste more than males (50%). The result shows that the students, faculty, and staff members in QU will participate effectively in any integrated program for waste management. Moreover, they will follow the guide to put each type of solid waste in each specific bin if the facilities are set up in suitable sites. According to the discussion with the Sustainability Development Center (SDC) in QU, solid waste is collected by a contracted company. The workers collect waste from everywhere, even the litter on roads and yards. Students are committed, based on the result of the statement P2, to not throwing solid waste on roads and yards, which helps the workers to clean the campus.

Although the participants are willing to participate in waste segregation, most participants have not engaged in waste source separation. This indicated that the segregation of solid waste in specific bins is not implemented in the community such as houses, malls, and other public areas. At least in the Qassim community, the program of solid waste segregation is not seen at any site. However, this program is implemented in several countries [6,7], and it showed economic and environmental values. Therefore, it is time to begin this late step, especially since Saudi Arabia's vision 2030 is interested in sustainability and environmental programs. Universities are the right place to lead the community to such programs. The results of this study proved that 80% of the participants will respond positively to the national projects and regulations that invite protection of the environment and economic resources (P4).

Using solid waste to make useful items (P6) is not an encouragement option for waste management according to the results of the responses. The result is logical as the Saudi community is considered a high-income country and the local culture considers waste as just dirty things. The results of the crosstabs analysis indicated that females are more interested in waste separation than males. Similar results were obtained by Sarbassov et al. [35], Barloa et al. [34], Babaei et al. 287 [36], and Van Niekerk [37], where they concluded that females are more active in waste separations than males. This result is useful for the decision-makers, as the implementation of the national program to segregate waste from houses will be enhanced by the house's leaders (women).

3.3. Evaluation of Solid Waste Collection in QU

The waste management system in QU was assessed through six statements, as presented in Table 6. The suggested statements were designed to investigate the quality of waste management (M4), existence of separate bins for each waste type (M2), the awareness and the advertisement in QU related to waste separation, and environmental protection (M1 and M3). The respondents were asked to choose one option from a five-point Likert scale. The choices were “Strongly disagree” (1), “Disagree” (2), “Neutral” (3), “Agree” (4), and “Strongly agree” (5).

Table 6. Analysis of responses to solid waste management in QU.

Key	Management Statement	Mean	St. Dev.	Assessment
M1:	There are advertisements in the University related to solid waste segregation	2.42	1.18	Poor
M2:	There are specific bins for each solid waste type in the university	2.32	1.29	Poor
M3:	Awareness programs of Environmental protection are implemented in the university	2.86	1.28	Poor
M4:	The waste management processes at your workplace are well managed	4.15	1.02	Good
M5:	Environmental protection and sustainability should be taught as a university course requirement	3.61	1.25	Fair
M6:	There is a strict protocol concerning protecting the environment inside the university campus	2.80	1.25	Poor

The average values and standard deviation of the responses for the waste management status on QU are presented in Table 6. The waste management situation is classified as very good if the mean is greater than 4.5, good if the mean ranges from 4 to 4.49, fair if the mean is from 3 to 3.99, and poor if the mean is less than 3. The general average value of the estimated means is 3.0, which implies that waste management related to waste source separation is almost fair in QU. The highest obtained mean was for the good collection of solid waste in working sites (M4—4.15), which is the only good level in the management section. The least mean fell on the availability of specific bins for each waste class (M2—2.3). It is worth saying that waste separation at generated sites needs decisions from the authorities to activate this practice in QU.

Table 7 provides a descriptive analysis of respondents’ perspectives regarding the management of institutional wastes based on the Likert scale agreement levels and the results of the Chi-square test. Results showed that 61% of respondents disagree with the existing facilities for solid waste separation (M2) while 20% of participants responded positively with the existing separated waste bins. Hypothesis number 4 is not rejected based on the analysis of question M2; “H4: There is no trash separation in designated bins in QU”. Furthermore, 60% of the participants believed that QU should provide an environmental course as a university requirement to increase the culture of solid waste separation (M5). In addition, only 17% supported the existence of advertisements (M1) to encourage stakeholders to separate wastes and protect the environment. It is worth saying that 71% of the stakeholders agreed that waste collection is implemented well on their sites and only 6% reject this case. In higher education institutes in China, Zhang et al. [23]

found only 14% of the respondents agree that the current system of waste separation is active, which is consistent with this study. A study of the need to teach environmental sustainability including waste management was conducted at Dammam University, where 77% of the respondents state that there are no teaching environmental courses in their study programs [28].

Table 7. Cross-tabulation and variation in respondents related to waste collection in QU.

Practice	Percent of Respondents of Each Likert Scale					Significance (p) from the Chi-Square Test		
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Gender	Position	Age
M1	26.0	30.4	26.2	10.3	7.0	0.681	0.541	0.007
M2	33.5	30.4	16.2	10.3	9.6	0.830	0.031	0.004
M3	18.7	20.8	28.1	20.1	12.2	0.380	0.303	0.191
M4	1.6	4.4	23.0	19.7	51.3	0.539	0.097	0.006
M5	9.1	10.1	20.4	31.4	29.0	0.965	0.001	0.000
M6	18.7	21.8	31.9	15.9	11.7	0.108	0.006	0.000

The association between demographic variables and the management system in QU is examined using the cross-tabulation test, as presented in Table 8, where considered relationships are found between the age and positions of the respondents with the waste management processes M2, M4, M5, and M6. The analysis implied that 72% of the age category from 25 to 40 disagreed with the existing separate bins for waste separation compared to 68% of younger participants (>25 years old), but only 50% of those older than 40 years disagreed with the same statement. The interpretation is that some offices for faculty members and employees are equipped with classified waste bins. The teaching of environmental courses is refused by 26% of the age category less than 25 years old, which matches the same percentage of the student category, while faculty members agreed to teach an environmental course in QU with a percentage of 88%.

Table 8. Perception variations of respondents related to waste collection in QU.

Item	Position			Age		
	Students	Faculty	Employees	Less than 25	From 25 to 40	More than 40
M1	-	-	-	57	58	53
M2	68	53	67	68	72	50
M4	-	-	-	15	4	7
M5	25	6	7	26	15	4
M6	46	26	47	45	53	22

The result of this section concluded that solid waste is collected efficiently in QU. The waste is collected daily from all sites on the campus without any accumulation in any site, as proven also in this result. However, the availability of specific bins for each waste class is rarely implemented. This result indicates that all types of solid waste in QU are collected in a single bin without segregation. This fact is confirmed during the discussion with the SDC's members in QU, where they addressed that all types of waste in the university are collected in bins, transported in the same truck, and disposed of in the landfill. The solid waste produced from QU sites has an economic value that is not recovered even with a low percentage. Furthermore, the collected waste is transported directly to the landfill, which may negatively affect the neighboring environment. It is recommended that the university becomes involved in an integrated sustainable waste management program to segregate the waste in specific bins. The program requires the availability of facilities to implement the segregation processes including specific bins, collecting waste types on certain days, trade marketing, and disposal of the waste residual. In addition to that, it needs intensive workshops, seminars, etc., to increase the awareness of the stakeholders about the benefits of waste segregation.

3.4. Exploring the Types of Solid Waste Disposed of QU

To investigate the most types of solid waste that are disposed of at Qassim University, a statement is devised to choose one or more of six waste types. The respondents are allowed to select one or multiple choices of the following solid waste: paper, plastic, glass, metal cans, wood, and leather. Some respondents (2.1%) selected all the available six choices, as presented in Table 9. The highest percentage selected by the participants was “paper and plastic” 41.5%, followed by plastic with a percentage of 20%, while the choice of disposing of only paper was the third-ranked (11%). The most individually selected type of solid waste was plastic with a percentage of 42%, followed by paper at 35%, and the third rank was glass at 8%, as illustrated in Figure 1. Based on these results, hypothesis number 5 cannot be accepted: “H5: The most disposed of solid waste in the university is paper”. Waste segregation and recycling programs should consider the amount ranking of solid waste types in QU.

Table 9. Frequency and percentage of disposed of solid waste in QU.

Waste	<i>n</i> of Choices	%
Paper, Plastic	177	41.5
Plastic	84	19.7
Paper	46	10.8
Paper, Plastic, Glass	33	7.7
Paper, Plastic, Metal (Cans)	16	3.7
Paper, Plastic, Glass, Metal (Cans)	9	2.1
Paper, Plastic, Glass, Metal (Cans), Wood, Rubber	9	2.1
Metal (Cans)	5	1.2
Plastic, Glass, Metal (Cans)	5	1.2
Plastic, Metal (Cans)	5	1.2
Sum	389	91
Some of the other 24 mutual choices	38	9

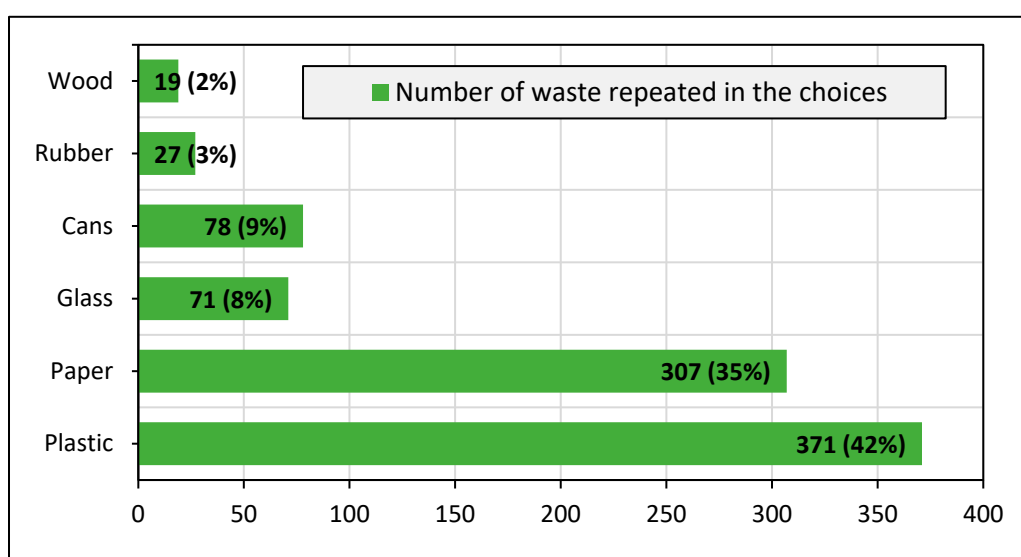


Figure 1. Types of disposed of solid wastes among QU stakeholders.

Analysis of the association between the disposed waste types and demographic variables is conducted using the cross-tabulation tool in SPSS, as given in Table 10. The association is not significant for the gender variation, while it is significant for both age and position variables. Table 10 implied that students are disposing of plastic more than faculty members and employees. For the wastepaper, faculty members and employees dispose of paper more than students. This result reflects that the collected trash paper will be more from offices than in libraries or corridors, while plastic waste is more in corridors, libraries, and cafeterias.

Table 10. Association of waste disposal type with gender, position, and age.

Waste Type	Gender ($p = 0.064$)		Position ($p = 0.000$)			Age ($p = 0.000$)		
	Male	Female	Students	Faculty	Employees	Less than 25	From 25 to 40	More than 40
Paper, Plastic	39	45	38	50	33	37	43	51
Plastic	21	17	26	7	7	28	7	7
Paper	14	6	10	14	13	9	10	15
Paper, Plastic, Glass	6	10	8	7	13	7	12	7
Paper, Plastic, Metal (Cans)	4	4	4	3	0	5	2	3
Paper, Plastic, Glass, Metal (Cans)	2	2	2	2	7	2	3	2
Metal (Cans)	2	0	1	1	0	2	0	1
Plastic, Metal (Cans)	1	2	1	1	0	1	2	1
Paper, Plastic, Glass, Metal (Cans), Wood, Rubber	1	4	1	4	7	1	8	2
Plastic, Glass, Metal (Cans)	1	2	2	0	0	2	0	0
Sum	91	92	93	89	80	94	87	89

The major waste produced in QU is paper and plastic with a percentage together of 75% based on the participants' opinions. Despite this result being based on a questionnaire, it is matching some studies carried out on universities in KSA. The same percentage of waste distribution was found at Imam Abdulrahman Bin Faisal University [38], where the percentage of cardboard and paper is 45%, plastics (28%), tissue paper (11%), and food (8%). These percentages were concluded from the standard method of physical sampling of the produced waste at Imam Abdulrahman Bin Faisal University. At Jordan University, Moqbel [39] found that 87% of disposed waste may be recycled with 30% of this component being paper waste, while plastic waste is only 13%. At the University of Northern British Columbia, paper products made up 32% of the total waste [40] where the waste samples were hand-sorted by a team of student and faculty volunteers.

Solid waste is produced in QU from classrooms, faculty and staff offices, and cafeterias. The university converted to an electronic system in most procedures such as official documents, lecture notes, student reports, and so on. Only the student exams are still implemented using paper exams, therefore, paper is produced less currently than in the previous years, and most wastepaper is produced by faculty and staff offices, as presented in Table 10. Based on the discussion with the SDC members in QU, the waste paper and packaging cardboard are collected in the same containers together with other waste without any segregation. The quality of tap water in the university is not valid for drinking purposes, therefore, university stakeholders are depending mainly on the water in small bottles (0.33 L to 1.5 L). This is the reason that plastic waste is more than other waste components in QU. The degradation of plastic is very slow and may take hundreds of years, which affects the environment for a long period of time [20]. Thus, collecting plastic waste in an integrated program of waste management will protect the environment, recover its economic value, and preserve the resources from the production of new bottles. Article number eleven, chapter three of MWAN executive regulations recommended five processes that should be implemented by any waste producers, as given in Figure 2 [41]. Although

the MWAN has specific regulations for all processes of waste management, there are no articles to enforce waste producers to apply waste segregation at the site. The QU is highly recommended to follow these procedures.

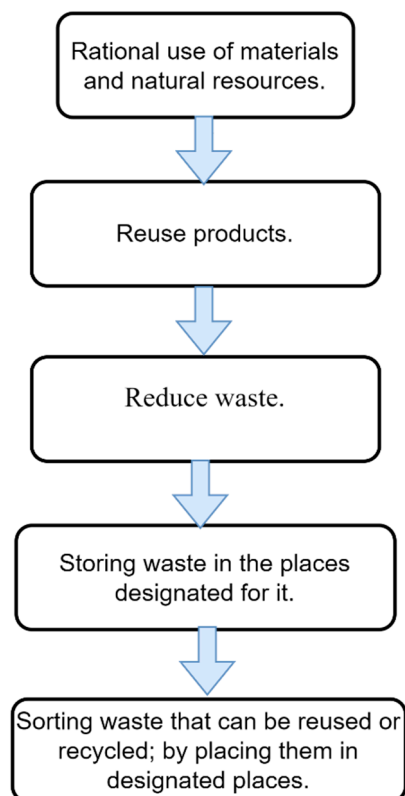


Figure 2. Frameworks of the waste regulation extracted from MWAN [41].

4. Conclusions and Recommendations

Municipal solid waste (MSW) combines several useful materials that can be reused or recycled. If solid waste is managed properly, it can become a source of industrial production or energy generation. In KSA, the major management of solid waste is dumping it in landfills without any further procedures, which is expected to create environmental problems. Segregation of solid waste at the generation sites enhances the recycling processes and reduces the dumping of waste into landfills. Although the solid waste in Qassim University, KSA is collected efficiently, it is mixed in bins without any separation. Universities and educational institutes are the leaders in the development of any society. Therefore, this study was conducted in QU to measure the knowledge and practices of stakeholders and to assess the actual processes of solid waste separation. The knowledge level of the survey related to the types of solid waste is ranked as high where the average percentage was 85% for “Yes” responses and the gender variation has no effect on the result based on the values of the Chi-square test. Some practices are classified as good where the average achievement was 4.5/5 on the Likert scale. The willingness to dispose of solid waste types in specific bins obtained the highest weighted mean (4.81 out of 5), which implies that university stakeholders will cooperate in the implementation of segregation processes. Although 26% of students refused to study environmental courses, faculty members agreed to teach environmental courses with a percentage of 88%. Teaching a course related to waste management will increase the knowledge and awareness of environmental issues and enhance the sustainable development pursued by the KSA vision of 2030. In universities, the most expected waste to dispose of is paper, while at Qassim university, the amount of plastic waste (42%) is more than paper waste (35%). The second part of this project will study the physical separation of solid waste in QU using a pilot study that will be applied

in two colleges: one for males and the second for females. This study is a little step toward an ambitious program to apply waste separation and recycling in such controlled sites and then apply procedures in the urban community and the whole country.

Colleges in QU should put more emphasis on disseminating information about the importance of the Solid Waste Management program. Students should attend seminars and workshops related to waste management. The SDC should facilitate specific trash bins for each solid waste type and allocate them to suitable sites within the campus. The complete cycle should be pursued by collecting and transporting each segregated type. Trade marketing for the produced segregated waste should be advertised. The SDC should assist the community to implement such an integrated waste management program.

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Data Availability Statement: The authors clarify that the data from this study are available upon request. The data includes the developed instrument to measure knowledge, practice, and management of solid waste separation. Furthermore, the data includes the respondents of Qassim university stockholders on an Excel sheet.

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