



Separate waste collection in higher education institutions with its technical and social aspects: A case study for a university campus

Betul Hande Gursoy Haksevenler^{a,*}, Fatma Feyza Kavak^b, Aydin Akpinar^c

^a Marmara University, Faculty of Political Science, Department of Political Science and Public Administration, 34820 Beykoz, Istanbul, Turkey

^b Marmara University, Institute of Social Sciences, Public Policy Master Programme, 34820 Beykoz, Istanbul, Turkey

^c Marmara University, Faculty of Political Science, Department of Local Governments, 34820 Beykoz, Istanbul, Turkey

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ABSTRACT

As universities are considered living laboratories with the practical learning of today's students and tomorrow's decision makers, practitioners, as well as parents, it is important to understand to what extent separate waste collection can be achieved in universities. This study aims to determine the amount, composition, and recycling potential of the generated waste in the Marmara University Anadoluhisari campus in Turkey, in order to develop a waste management strategy in line with national legislation and sustainable global practices. In addition, this study aims to evaluate the knowledge, awareness, behavior, and motivation of campus stakeholders towards this strategy. A separate waste collection application was carried out on the campus. In order to determine the amount of mixed waste before this application and the amount of fractionated waste after this application, daily waste weighing was carried out in certain periods between November 04, 2019 and November 01, 2020. For the social aspect of the study, a survey was conducted on campus students, administrative officers and academic personnel studying and working at different faculties. From the technical aspect, it was found that the recycling potential of campus waste was high (69%). However, when the social aspect of the study was examined, it was determined that only 16% of campus occupants had knowledge of Zero Waste Regulation. Furthermore, none of the group felt directly responsible for separated waste collection. Only 26% of the campus population, who carried out this practice on campus, stated that waste is separately collected on campus. Based on plastic bottle discarding behavior reported, only 16% of participants were found to be very conscious about waste recycling. It was concluded that recyclable waste separation was carried out by students who were unaware of its purpose. Among the studied groups, the academic personnel were relatively more conscious than the other groups. According to campus stakeholder's opinions, incentives and basic education were the main factors for improving solid waste management.

1. Introduction

Solid waste is defined as any solid material that has been expended and needs to be removed. Solid waste types can be listed as municipal solid wastes, industrial solid wastes, hazardous solid wastes, medical wastes, and special quality solid wastes (Waste Atlas, 2018). Among these different types, municipal solid waste mainly consists of various components such as paper, plastic, textile, metal, glass, garden waste, organic materials (like food leftovers), and inorganic materials (like metal cans) (Tian et al., 2013). In addition, municipal solid waste contains a significant amount of energy that can be utilized efficiently and

economically using appropriate management and technological facilities (Habib et al., 2013). Today, the rapid consumption of limited resources brought on by increasing populations has caused improved waste management to become an important issue (UNEP, 2015). Through effective solid waste management, the target is to prevent solid wastes from harming the environment and human health by reducing waste production and recycling the generated wastes (Fagnani and Guimarães, 2017). When the waste management practices around the world are examined, it is seen that it is developed countries that are able to transform waste into more efficient and sustainable forms (Moya et al., 2017; Nanda and Berruti, 2020). However, developing countries,

* Corresponding author.

E-mail addresses: hande.gursoy@marmara.edu.tr (B.H. Gursoy Haksevenler), fatmafeyzakavak@gmail.com (F.F. Kavak), aydin.akpinar@marmara.edu.tr (A. Akpinar).

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including Turkey, realized the importance of waste management later and therefore, are a few steps behind (Al-Khatib et al., 2007; Ikhlayel, 2018). For instance, while the municipal waste recycling rate is 67% in Germany and 57% in Austria (EEB, 2018), it is only 13% in Turkey (Turkish Statistical Institute, 2021). Of the total waste produced in Turkey, 27.3% is municipal waste, 23.0% is industrial waste, 26.3% is mining waste, 23.2% is thermal power plant waste, and 0.1% is medical waste (Turkish Statistical Institute, 2021). Municipal waste, which constitutes 27.3% of the total waste, is approximately 32.3 million tonnes/year (Turkish Statistical Institute, 2021). The municipal waste characterization varies between 20 and 80% for organic waste, 12–44% for recyclables and 0.3 and 64.5% for inert and other wastes for different regions of Turkey depending on climatic conditions, sampling seasons, as well as sampling years (Coruh and Ozen, 2016). In Istanbul, where the examined university in this study is located, 50–55% of municipal waste is determined as organic waste, 20–25% is determined as recyclable waste (paper-cardboard, glass, plastic and metal), and the rest is determined as combustible and inert waste (Canli, 2020). According to the data of the Turkish Statistical Institute, the collected municipal wastes are disposed of by regular landfills (69.4%) and irregular landfills (17.0%), and only 13.2% of the waste is recycled (the rest is illegally disposed of, such as incineration, burial and dumping into a stream or field) (Turkish Statistical Institute, 2021). The Ministry of Environment and Urbanization of the Republic of Turkey aims to reduce the rate of municipal waste disposal (for both regular landfills and irregular landfills) from 87% to 65% at the national level by 2023. In other words, there is a target to increase the national municipal waste recycling rate from 12% to 35% by 2023 (MoEU, 2017). In this context, the Zero Waste Regulation was published in Turkey on July 12, 2019 and waste minimizing (by waste reducing, reusing, recycling and recovering) became mandatory for local administrations, public institutions and organizations, industrial facilities and educational institutions, among others (MoEU, 2019).

For effective solid waste management, the first step needs to be understanding the amount of solid waste generation. In addition, the composition of the solid waste generated, the separation process and the technical, financial and administrative feasibility of the strategies adopted should be also considered (Starovoytova and Namango, 2018). Apart from all these, an effective solid waste management approach requires the adoption of an appropriate mentality, not only in industry and production, but also in daily life. At this point, it appears that the establishment of environmentally conscious mindsets, behaviors and cultures are a priority, as a solution for many environmental problems. Changing certain habits, especially consumption habits, is essential for the realization of this mentality (Raghu and Rodrigues, 2020). The acquisition of positive attitudes and behaviors towards the environment starts in the family and continues in educational institutions. Universities with the most educated/growing individuals of the society are defined as “small cities” due to their high population density and urban and scientific activities at different scales (Alshuwaikhat and Abubakar, 2008). University campuses are accepted as living laboratories with practical learning (Berchin et al., 2017). The adoption of separate waste collection (SWC) within the university campus has great potential for adoption in general society and larger sectors, by providing a synergistic effect (Adeniran et al., 2017). There are several universities, such as Cornell University, which recycles and composts >70% of its waste (Cornell University, 2020), the University of Florida, which recycles 30% of its waste (UF Sustainability Task Force, 2002), and the University of Lagos, which recycles 53% of its waste (Adeniran et al., 2017), applying integrated waste management practices. In addition, there are several studies in the scientific literature regarding integrated waste management in higher education institutions (Adeniran et al., 2017; Dahlawi and El Sharkawy, 2021; de Vega et al., 2008; Iresha and Prasjojo, 2018). However, these are so limited when compared with studies focusing on domestic waste management on a municipal level. In addition, in most of the studies, the technical aspects of solid waste

management are mostly examined and the social dimension is not given appropriate attention.

There is a total of 207 universities in Turkey, of which 129 are state universities and 74 are foundation universities. According to Turkish Council of Higher Education, there are more than 7.8 million students registered in these universities in Turkey (Turkish Council of Higher Education, 2021).

Marmara University is one of the oldest and largest educational institutions in Turkey and is located in Istanbul. The purpose of this study is to evaluate the applicability of SWC on campuses, while taking into consideration both technical and social aspects. For this concept, Anadoluhisari Campus, which is one of the seven campuses of Marmara University, has been selected as a pilot area. For this purpose, the first step was to collect the waste resources and quantities within the campus; then, waste was collected separately as paper, metal/plastic, glass, compostable and non-recyclable waste. Then a survey was applied to evaluate the extent to which the most educated/growing members of the society could adopt separate collection practices. In addition, the approaches of not only students, but also academic personnel and administrative, cleaning, and security staff, to SWC, were compared. The results obtained would be a guide for policy makers and implementers to solid waste management more effectively in higher education institutions.

2. Materials and methods

2.1. Study area

The study was carried out in the Anadoluhisari Campus of Marmara University, which has an area of 121.991 m². There are two faculties and one vocational school: the Faculty of Political Sciences (FPS), the Faculty of Sport Sciences (FSS), and the Vocational School of Social Sciences (VSSS), as well as the staff and student refectories, canteen, swimming pool, sports fields and gym on the campus. The Anadoluhisari campus has a population of 6985 in total, 6668 of whom are students. During our study, the canteen located on the campus was closed, and possible wastes from the canteen could not be evaluated. In the period of 04 November 2019–01 November 2020, monitoring studies regarding waste collection were carried out before and after the establishment of the SWC system. Before SWC, the main sources of waste in the buildings were identified as classrooms, offices, toilets and photocopy rooms. The waste generation points and the number of active students (who actively use the campus and generate waste) and the number of relevant staffs in the faculties and refectories are presented in Table 1.

2.2. Determination of technical aspect

2.2.1. Determination of waste generation and its recycling potential

Before SWC was carried out within the faculty buildings, there were i) trash bins in common areas, ii) individual trash bins in offices and classrooms and, iii) packaging waste collection units (intended to be used together for paper, metal and glass waste, but used as trash bins) in faculty corridors. These packaging waste collection units were not suitable for separate collection and none of the campus stakeholders were aware of their existence. As a first step in the study, the mixed waste amount and the types of waste sources generated in the faculties and refectories were determined by daily weighing from 04–23 November 2019 (15 weekdays).

After SWC, both common and individual bins (in classrooms and offices) were removed in faculty buildings. New separated collection units having fractions of i) paper, ii) metal/plastic, iii) glass and iv) non-recyclable waste were placed at selected common points and all waste generated from faculties was collected in these units. After applying SWC, each waste fraction was weighed daily from the periods of 14–25 January 2020 (10 weekdays), 11–22 February 2020 (10 weekdays), and 21 October–1 November 2020 (10 weekdays).

Table 1
Waste sources and amounts detected before applying SWC.

Units	Waste Generation Points	No of Generation Points	No of Active Students	No of Technical Staff	No of Academic Staff
FPS	Toilets, Copy Rooms, Classrooms and Offices	12	500	30	110
FSS	Pool, Library, Toilets, Tea Rooms, Copy Room, Offices and Classrooms	16	550	35	36
VSSS	Classrooms, Offices, Tea Rooms, Toilets, Copy Room	12	550	36	62
Refectories	Packaging waste (such as plastic water cups, bread bags) and leftovers	2	456	10	
Total		42	2056	111	208

For the refectories, the waste was collected without any separation before SWC. After applying SWC, the waste was separated as i) compostable organic, ii) metal/plastic, and iii) non-recyclable waste, using separated collection units (which consists of three units for each category). Weighing for the refectories were carried out on the same days as the faculty buildings.

In order to measure the amount of waste, the digital electronic hand scale (from the brand, Isgor) with a sensitivity of 10 gr per 50 kg was used for wastes below 50 kg, while Akpınar branded, EPB model stainless electronic scales with a sensitivity of 1 gr per 100 kg were used for wastes above 50 kg. Each fraction of each separated collection unit has a capacity of 80 L and dimensions of 30 cm width x 144 cm length x 60 cm height (Fig. 1). Wastes collected separately inside the faculty buildings and in the refectories were collected in the larger scale waste collection unit in the campus garden. This waste collection unit placed in the campus garden was 300 cm width x 230 cm length x 400 cm high.

The following formulas were used to determine the amount of mix waste before SWC in faculty buildings (equation (1)), and refectories (equation (2)), the amount of fractionated waste after SWC in faculty buildings (equation (3)) and in refectories (equation (4)). During measurement periods, each waste container (as mixed waste before SWC, and as fractionated waste after SWC) was measured daily. While determining the amount of waste (as mixed waste before SWC and as fractionated waste after SWC), the following steps were followed: first, the mixed waste/individual waste fraction was weighed daily and the values obtained were added during the measurement periods; then, the weight of the mixed waste/individual waste fraction divided by the number of days measured (kg/day) and finally, the value obtained was divided by the number of active campus stakeholders/campus stakeholders using the refectories (kg/day/capita).

The average daily amount of mixed waste in buildings/refectories: The unfractionated daily waste amount before SWC in faculty buildings or refectories. Mixed waste was weighed daily in mixed collection units (where they are) during measurement period and then the average value was taken.

The average daily amount of fractionated waste in buildings/refectories: the fractionated (paper, plastic/metal, glass, compostable and non-recyclable) daily waste amount after SWC in faculty buildings or refectories. Each fractionated waste was weighed daily in each fraction of separated collection units during measurement period and then the average value was taken.

The number of active campus stakeholders: This was determined by considering active students who attend classes and benefit from campus facilities and all administrative and academic staff (having potential to generate waste). It was determined by taking information from the authorized units in faculties and vocational schools.

The number of campus stakeholders using refectories: The number of campus users/stakeholders eating food per day.

2.3. Determination of social aspect

In order to analyze the knowledge, awareness, behavior and motivation towards SWC, surveys were conducted on the students just before the mid-term exam session in May of 2019. While preparing the questions, different likert scales were used and both a multiple-choice question model and a single-answer question model were preferred. In the survey, 30 questions were asked to the participants. The first seven of these were on demographic information (regarding gender, age, marital status, position and education). Seven questions were aimed at determining the participant’s knowledge of solid waste (such as what the first thing is that comes to mind when they hear the word solid waste). Eight questions were on awareness (such as responsiveness of

$$\text{Waste amount in faculty buildings before SWC (kg/day/capita)} = \frac{\text{the average daily amount of mixed waste in buildings (kg/day)}}{\text{the number of active campus stakeholders on campus (capita)}} \tag{Equation 1}$$

$$\text{Waste amount in refectories before SWC (kg/day/capita)} = \frac{\text{the average daily amount of mixed waste in refectories (kg/day)}}{\text{the number of campus stakeholders using refectories (capita)}} \tag{Equation 2}$$

$$\text{Waste amount by fraction in faculty buildings after SWC (kg/day/capita)} = \frac{\text{the average daily amount of fractionated waste in buildings (kg/day)}}{\text{the number of active campus stakeholders on campus (capita)}} \tag{Equation 3}$$

$$\text{Waste amount by fraction in refectories after SWC (kg/day/capita)} = \frac{\text{the average daily amount of fractionated waste in refectories (kg/day)}}{\text{the number of campus stakeholders using refectories (capita)}} \tag{Equation 4}$$



Fig. 1. Photo of separated collection units in faculty buildings (blue bin paper, yellow bin plastic and metals, green bin glass, black bin non-recyclable waste).

campus stakeholders). Four questions were about the participant's practices in their private life and on campus (such as what they do with their recyclable waste, like a plastic water bottle). The remaining four questions were on motivation (such as the ways to make SWC more effective and active).

During the period when the survey was being conducted, the number of active students (who provide continuity in the courses, benefit from the refectory and campus facilities) on the campus was approximately 1600. A total of 300 students' questionnaires (100 students from each faculty) were analyzed, considering 5% margin of error and 95% confidence interval (RAOSOFT, 2019). This sample was determined to be balanced from each department and class. In the questionnaire given to the students, the "answering under observation" method (in which the questionnaire forms were distributed to the participants and conducted collectively) was used.

The number of academic personnel was around 200, and the number of administrative, cleaning, and security personnel was around 100 in campus. Since the number of academic and administrative personnel is relatively less and they were more accessible than students, the questionnaire was sent to all campus personnel (including officials in administrative units, cleaners, refectory attendants and security guards). However, the most reliable answers received were from the academic staff (38) and from administrative and cleaning personnel (55) because the response was left to their discretion (unlike the students who were under observation in the questionnaire). To summarize, the questionnaire was applied to 300 students under observation, as well as 38 academic personnel and 55 administrative personnel who conveyed their answers to us from the entire campus. The results of the survey were evaluated on the basis of frequency (f) and percentage (%) values.

3. Results and discussion

3.1. Technical aspect

3.1.1. Solid waste recycling potential

Within the scope of SWC, the aim was to collect wastes in categories of i) paper, ii) plastic-metal, iii) glass, and iv) non-recyclable in faculty buildings. When setting up the separate collection system in faculties, trash bins in classrooms and offices were removed, and separated

collection units were placed in common points. After applying SWC, the total waste (corresponding to 0.111 kg/day/capita) separated into 25% glass, 27% paper, 24% metal/plastic, and 23% non-recyclable waste (in other words, the rate of non-recyclable waste in faculty buildings decreased from 100% to 24% after SWC) (Table 2).

Another important source of waste in the campus was the refectories, and the wastes generated from these were divided into i) compostable organic, ii) metal/plastic and iii) non-recyclable waste. Following the SWC application, 22% of the refectory waste was compostable (leftovers such as non-oily vegetable wastes), 42% was collected as metal/plastic (such as plastic cups) and 36% was separated as non-recyclable waste. While all refectory waste (100%) was unsorted/non-recyclable before SWC, this value was reduced to 36% after applying SWC (Table 2).

As presented in Table 2, the total amount of waste (originating from both faculty buildings and refectories) from the Anadoluhisari campus was determined as 0.295 kg/day/capita. When the studies in the literature are examined, the daily waste generation amount was reported to be 0.059 kg/day/capita for Northern British Columbia (Smyth et al., 2010), 0.437 kg/day/capita for the University of California Berkeley (Berkeley Office of Sustainability, 2021), 0.400 kg/day/capita for the Middle East Technical University (Bahcelioglu et al., 2020), and 0.830 kg/day/capita for Malaysian University of Technology (Zen et al., 2016). As can be seen, the amount of unit waste can vary in university campuses, which can be explained by the different consumption habits and the presence of different facilities (such as dormitories) on campuses.

As shown in Table 2, the wastes in the Anadoluhisari campus were separated into 10% glass, 10% paper, 35% metal/plastic, 14%

Table 2

Waste amount and characterization after SWC application on campus (kg/day/capita, %).

Waste Categories	Faculties	Refectories	Total
Glass	0.028 (25.3%)	–	0.028 (9.5%)
Paper	0.030 (27.0%)	–	0.030 (10.2%)
Metal/Plastic	0.027 (24.3%)	0.077 (41.9%)	0.104 (35.3%)
Compostable Organic	–	0.040 (21.9%)	0.040 (13.6%)
Non-Recyclable	0.026 (23.4%)	0.067 (36.2%)	0.093 (31.4%)
Total	0.111 (100%)	0.184 (100%)	0.295 (100%)

compostable organic and 31% non-recyclable fractions, after SWC was applied. It was observed that the metal/plastic group with the highest proportion of recyclable wastes consisted mainly of plastic packaging, plastic bottles and aluminum cans. In a similar study conducted at the Malaysian University of Technology, the waste was classified as compostable/organic (46%) and recyclable waste. It was found that plastic packaging (32%), plastic bottles (17%) and aluminum cans (11%) constituted significant proportions of recyclable wastes (Zen et al., 2016). When the studies in the literature are examined, it is seen that the waste fractions can be in different distributions. For instance, the composition of waste was reported to be 28% organic, 6% paper, 5% plastic and 61% mixed (including mostly construction and demolition waste) in a campus of the Islamic University of Indonesia (Iresha and Prasojo, 2018). In a study conducted at the Unilag Akoka campus of the University of Lagos, it was found that the waste consisted of 24% polyethylene bags, 15% paper, 15% organic matter, 9% plastic, 8% inert material, 7% sanitary waste, 7% textile, 4% leather, 3% metal, 2% glass, and 6% others (Adeniran et al., 2017).

3.2. Social aspect

3.2.1. Examination of knowledge and awareness towards SWC

A survey was conducted among 1600 students, 54 administrative, cleaning, and security staff and 38 academic personnel to determine campus users' knowledge, awareness, behaviors and motivations regarding SWC in May 2019. The first group of questions aimed to evaluate the general knowledge of basic terms on solid waste management. While most of the participants (about 70%) answered the question of "what is solid waste" correctly, some of them answered that solid waste is packaging waste (18% of students, 13% of academic personnel

Table 3
Responsiveness of campus stakeholders to SWC (frequency and percentage).

Campus and faculty management is very responsive to SWC.						
Options	Yes		Undecided		No	
	N	%	N	%	N	%
Participants	101	26	210	54	81	21
Position						
Student	73	24	162	54	65	22
Administrative Officers	19	35	25	46	10	19
Academic Personnel	9	24	23	61	6	16
Staff working on campus are very responsive to SWC.						
Options	Yes		Undecided		No	
	N	%	N	%	N	%
Participants	98	25	214	55	80	20
Position						
Student	81	27	163	54	56	19
Administrative Officers	14	26	27	50	13	24
Academic Personnel	3	8	24	63	11	29
Campus student is very responsive to SWC.						
Options	Yes		Undecided		No	
	N	%	N	%	N	%
Participants	66	17	181	46	145	37
Position						
Student	58	19	145	48	97	32
Administrative Officers	5	9	18	33	31	57
Academic Personnel	3	8	18	47	17	45

and 22% of administrative officers). Another indicator question to examine the knowledge of the participants was "do you know about Zero Waste Regulation?" which has recently become mandatory for many institutions (even on university campuses). According to the responses, only 12% of the students, 32% of the academic personnel and 28% of the administrative officers had knowledge of Zero Waste Regulation (in other words, only 16% of the total campus population surveyed had knowledge of Zero Waste Regulation).

The second group of questions was aimed at measuring the awareness and perceived environmental responsibility of the participants and respondents by asking "who is responsible for the SWC". The majority of the participants (75%) stated that each individual is responsible for SWC. However, when each group was asked about the responsibilities of students, academic personnel, and administrative officers about SWC applied on campus, it was answered that no group was sufficiently responsible (Table 3). The participants were asked whether the waste was collected separately for recycling. While only 22% of students, 37% of academic personnel and 41% of administrative officers stated that waste was recycled on campus (in other words, 26% of campus stakeholders answered "yes" to this question), most students (47%) and academic personnel (42%) answered 'undecided'. Considering the separate waste collection rate (69%) presented in the previous section and considering that this separate waste collection was provided by campus stakeholders, the results of the survey are surprising. The difference between the results of the practice and the survey can be explained by the fact that the campus stakeholders perform the action of separating waste without knowing the purpose of it. In the literature,

Table 4
Environmental behavior of campus stakeholders (frequency and percentage).

"What do you do with your recyclable waste (like a plastic water bottle)?"						
	I will throw it in the nearest trash bin.		I will throw it in the separated collection units.		If I cannot find a separated collection unit, I will carry it with me until I do.	
	f	%	f	%	f	%
Participants	167	46	139	38	56	16
Gender						
Female	86	44	87	45	22	11
Male	81	49	52	31	34	20
Marital Status						
Single	146	47	117	38	46	15
Married	21	37	22	42	10	19
Age						
18-25	132	49	99	37	40	15
26-40	25	43	27	47	6	10
41-65	10	30	13	39	10	30
Position						
Student	135	48	104	37	41	15
Administrative Staff	21	45	20	43	6	13
Academic Staff	11	31	15	43	9	26
Education Status						
Literate and primary education	2	22	6	67	1	11
High School	11	55	7	35	2	10
Associate Degree	51	53	30	31	16	17
Bachelor's Degree	85	46	76	41	25	13
Postgraduate Education	5	46	4	36	2	18
Grad Student	13	33	16	41	10	26

there are similar studies that support our results (Olli et al., 2001; Desa et al., 2011; Arshad et al., 2020).

3.2.2. Examination of environmental behavior towards SWC

For evaluation of the environmental behavior of the participants, the key question of “what do you do with your recyclable waste (like a plastic water bottle)?” was asked. Among the optional responses, “I throw it in the trash bin” was deemed to represent the lowest level of environmental consciousness. On the other hand, the answer to “throw it in the separated collection unit” represented that the person is conscious; the answer “I carry it with me until I find a separated collection unit” was accepted to represent that the person is very environmentally conscious. As can be seen from Table 4, the “I throw my plastic bottle in the trash bin” answer was given by 48% of the students, 45% of the administrative officers and 31% of the academic personnel. On the other hand, the option “I carry it with me until I find a separated collection unit” was preferred by 15% of the students, 26% of the academic personnel, and 13% of the administrative officers (this corresponded to only 16% of campus population surveyed). The results indicate that the students and administrative officers are not very conscious about environmental protection. Additionally, the academic personnel are relatively more environmentally conscious than other groups. Among the administrative officers, which includes administrative, cleaning and security staff, the campus security guard were found to have the lowest environmental awareness. When the answers to this question were analyzed according to the demographic characteristics of the participants, it was observed that the awareness increased as age and education level increased. It is stated in the literature that there is a direct relationship between environmental awareness and education (Debrah et al., 2021; Esteban Ibáñez et al., 2020; Yusuf et al., 2022) as well as age (Wang and Li, 2021; Yusuf et al., 2022).

When examining whether the gender of the participants has an effect on the environmental consciousness level, 11% of females and 20% of males were found to be very environmentally conscious. In other words, males are slightly more conscious than females. There are both studies revealing that gender has an effect on environmental attitude and behavior (Chan et al., 2019; Hansmann et al., 2020), and stating no relation between them (Chuvieco et al., 2018). In the studies conducting correlation between gender and environmental concern, most reported that females behave in more environmentally friendly behaviors than males (Chan et al., 2019; Chekima et al., 2016). However, in concordance with our study, there are also studies showing that men are more environmentally conscious than women (Muderrisoglu and Altanlar, 2011). Another question measuring participants’ environmental behavior was “whether they segregated their waste at home”. 33% of the students, 68% of academic personnel and 46% of administrative officers stated that they separated their wastes at home. In order to compare the waste separation attitudes of participants on campus and in their home, the answers to the questions of “are the campus stakeholders responsive to SWC?” and “do you sort your wastes in your home?” were matched. Based on the answers taken, it was obtained that the participants were (relatively) more responsible to waste separation in their own homes rather than on campus. This can be associated with the fact that the participants accept their own homes to be within their own area of responsibility rather than the campus. In other words, it can be said that they do not feel themselves as a part of waste management on campus. As a result of a survey conducted by Bahcelioglu et al. (2020) at Middle East Technical University, similar results were obtained and it was concluded that the most important source of motivation for the participants was to feel themselves to be a part of the system.

3.2.3. Examination of motivations

For effective solid waste management, the key factors are known to be involving people in the program and making them feel responsible (Zen et al., 2016). Environmental knowledge and awareness are the main factors for successful solid waste management implementation. As

Table 5

The ways of accessing information (responses that could be marked as more than one option were received).

How did you get information about zero waste regulation?				
	Internet	TV/Public Spot	Application Examples	Regulation
	N	N	N	N
Participants	169	139	73	26
Gender				
Female	97	64	38	23
Male	72	73	35	11
Marital Status				
Single	156	32	59	23
Married	13	29	14	7
Age				
18–25	146	99	45	23
26–40	16	25	15	7
41–65	7	15	13	4
Position				
Student	12	12	11	5
Administrative Personnel	150	102	48	14
Academic Officers	7	25	14	7
Education Status				
Literate and primary education	–	2	5	4
High School	3	13	3	2
Associate Degree	53	40	18	13
Bachelor’s Degree	98	61	32	9
Postgraduate Education	3	7	4	–
Grad Student	13	14	11	6

stated by Ramayah et al. (2012) knowledge, awareness, attitudes and social norms are highly related to each other. In order to increase environmental awareness and knowledge, it seems important to use the ways of accessing information more effectively. For understanding which way is more effective in spreading information, the participants were asked “how they learned about Zero Waste Regulation”. As an answer to this multiple-choice question, “internet, TV/public spot, application examples, regulation” options were presented in a way that could be selected more than once (Table 5).

According to the obtained results, most of the students and academic personnel use internet (150 out of 300 students and 12 out of 38 academic personnel) and TV/public spot tools to access information (102 out of 300 students and 12 out of 38 academic personnel), while administrative officers obtain knowledge through TV/Public spots (25 of 54) and application examples (14 of 54) (Table 5). These answers do not only address the question asked for SWC, but also give the result of which tool is effective in accessing any information today. As a result of the cross-analysis on this question, it was seen that the rate of getting information from the internet was higher in females while getting information from TV/Public spot was higher in males. The rate of learning from the internet increases as age decreases, and the rate of learning from the application examples increases as age increases. In addition, the source of the information differed according to marital status. It was concluded that single participants received the most news from the internet, while married participants preferred TV/public spot.

In order to get the opinions of the participants on more effective implementations of solid waste management, the question of “How can

Table 6

The ways making SWM more effective and active (responses that could be marked as more than one option were received).

How can SWM be made more active and efficient?					
	Basic education should be given	There should be a penal sanction	Noticeable directions should be made	Incentives should be given	Making it compulsory
	N	N	N	N	N
Participants	229	103	197	247	158
Gender					
Female	125	54	105	123	88
Male	104	49	89	124	70
Age					
18-25	161	72	144	181	105
26-40	43	21	36	39	35
41-65	25	9	17	27	18
Marital Status					
Single	188	85	158	205	123
Married	41	18	39	54	35
Position					
Student	165	73	148	185	108
Administrative Officers	38	16	29	34	32
Academic Personnel	26	14	20	28	18
Education Status					
Literate and primary education	–	6	4	7	4
High School	10	5	13	16	16
Associate Degree	61	25	49	56	40
Bachelor's Degree	108	47	101	130	70
Postgraduate Education	11	5	9	8	8
Grad Student	28	15	21	30	17

solid waste management be made more active and efficient?" was asked. Optional responses (that could mark more than one option) such as "providing basic education, sanctioning punishment, increasing noticeable directions, giving incentives, making it compulsory" were presented (Table 6). The responses of "incentives should be given" and "basic education should be given" were mostly marked while "sanctions for the penalty" was the least preferred option. When the responses were analyzed according to gender, age, marital status and education status, these two options were predominantly preferred for each category. It is seen that similar results were obtained in studies examining the motivation, intention and behavior of individuals on solid waste management (Fan et al., 2019; Nyborg et al., 2006).

4. Conclusion

In the present study, the applicability of SWC on a university campus has been extensively examined from both technical and social perspectives. According to the obtained results:

- It was determined that 69% of the waste generated on campus was recyclable. Wastes produced on campus were separated as 10% glass, 35% metal/plastic, 10% paper and 14% compostable organic waste.
- When the knowledge and awareness of the campus population on SWC were examined, it was concluded that they did not have enough knowledge and awareness.
- When environmental behavior was examined, it was determined that most of the campus stakeholders were not conscious of SWC.
- In order to improve the SWC application by spreading more awareness, more effective use of internet and TV/Public spot, which are means of access to information, is required.

- According to the views of campus stakeholders, the main way to make solid waste management more effective and active is to provide incentives and basic education.

Within the scope of this study, the target is to contribute to the literature with both quantitative and qualitative analysis on SWC practice on university campuses. In line with the results obtained, information and education activities should be expanded and increased for the whole society, regardless of education level. Awareness should be created that environmental activities should be a habit integrated into the daily lives of the public rather than being a necessity. For high education institutions, the university administration should increase the incentives for creating environmental awareness. In order for SWC to be implemented, it is necessary to adopt a behavioral pattern and culture as well as a competent technical infrastructure. Therefore, special attention should be paid to studies based on the social dimension of solid waste management. Even though our study was conducted in a university campus where, generally, the most educated members of the society are located, it was observed that the knowledge, awareness and behaviors of the campus stakeholders were not sufficient but could be improved. Future studies could be conducted to deal with the current stage of consciousness and how it can be developed. Making comparative analyzes for groups and institutions at different socio-economic levels may also be useful for developing effective public policies in the field of solid waste management. It is thought that the results obtained in the study show the sensitivity of people not only about SWC, but also on environmental protection on a larger scale. Hopefully, this study, which took place in Marmara University Anadoluhisari Campus, could shed light for decision makers, practitioners and future studies.

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Competing interest

The authors declare that they have no competing interests.

CRediT authorship contribution statement

Betul Hande Gursoy Haksevenler: Conceptualization, and, design, Data curation, Formal analysis, Writing – original draft, all authors commented on previous versions of the manuscript. **Fatma FeYZa Kavak:** Conceptualization, and, design, Data curation, Formal analysis, all authors commented on previous versions of the manuscript. **Aydin Akpinar:** Conceptualization, and, design, Data curation, Formal analysis, all authors commented on previous versions of the manuscript.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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