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CURRENT TRENDS IN SOLID WASTE MANAGEMENT IN HIGHER EDUCATION INSTITUTIONS. THE CASE OF WEST BANK REGION, PALESTINE

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Abstract

Higher Education Institutions in Palestine are considered to have one of the main contributors to solid waste generation according to local authorities' annual reporting. Besides being major players in the education field, they are presented with the opportunity of being also key players in the promotion of waste minimization and awareness raising towards solid waste management strategies. In the present paper the results of an extended field research in the Palestinian Higher Education Institutions of West Bank are presented; raw data collected from two separate field researches were mathematically processed, offering interesting outputs which are appropriate for the organization of a solid waste management system in Higher Education Institutions. Currently, the Palestinian Higher Education Institutions were found as generating approximately 34 tons of solid waste per day - an average per capita generation of 0.51kg. Overall out of the ten Higher Education Institutions involved in the research only 25% are practicing waste separation at the source, 25% are implementing awareness raising programs on solid waste management and in 50% of them source separation of hazardous waste generated from laboratories etc. is performed, proving that measures need to be undertaken to improve Palestinian Higher Education Institutions environmental profile and impact.

Key words: higher education institutions, recycling, solid waste management waste generation

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1. Introduction

Through agenda 21UN places great emphasis on resource conservation, pollution control, waste minimization, cleaner production, etc., so that all countries manage to achieve sustainable development (Aliakbari-Beidokhti et al., 2017; Young et al., 2010). Regardless Developing Countries (DC) fail to put such principles into force due to a variety of causes such as poverty, political situations and lack of education. The implementation of waste minimization techniques requires a thorough and in-depth knowledge of the principles of solid waste management for the selection

of the best methods to deal with the urgent matter of managing solid waste from collection point to the final disposal (CODWAP, 2011; Talalaj, 2017). Lack of knowledge may lead in unsustainable paths, present significant obstacles and jeopardize a sustainable future (Coker et al., 2016; Maddox et al., 2011). The implementation of a sustainable Solid Waste Management (SWM) system may face several constraints that could negatively affect its effectiveness. All constraints may be avoided through communication and information sharing in order to increase levels of awareness and promote citizens' participation (De Feo et al., 2010). Lack of

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participation is a serious constraint, which was considered as a "fundamental pre- request for the achievement of sustainable development" in the earth summit (1992) in Rio de Janeiro (Disterheft et al., 2012). Another important constraint is considered the lack of financial resources especially when it concerns the establishment of new technologies and their long term maintenance (Evangelinos et al., 2009).

Higher educational institutions (HEIs) are considered to be similar to small towns due to their large size, high population and the variety of activities taking place on campuses (Alshuwaikhat and Abubakar, 2008). The aforementioned characteristics result in the generation of considerable amounts of solid waste and thus they belong to "large waste generators" (Adeniran et al., 2017; Mbuligwe, 2002).

HEIs have substantial potential to catalyse and accelerate social transitions towards sustainability (Stephens et al. 2008). Large fractions of the generated waste in campuses can be recycled or composted contributing to the desirable extension of the local landfills life span together with the institutions' contribution and active involvement in overall environmental protection (Alabaster and Blair, 1996; Viebahn, 2002). HEIs adoption of environmentally sound technologies or implementation of environmental management activities (Amutenya et al., 2009; Zhang et al., 2011) is expected to encourage other institutions (educational or not) to act towards this direction, thus making HEIs role models. The latter will surely provide local authorities with the initiative and citizens with the necessary awareness and willingness to participate in future municipal or regional SWM plans.

A SWM plan involving recovery, recycling and potential reuse of waste strongly depends on its source and characteristics (de Vega et al., 2008; Suchowska-Kisielewicz et al., 2017). The recycling of both organic and paper waste fractions can reduce the institutional solid waste quantity by 71 to 86%. Similarly and due to their educational character, HEIs generate hazardous waste from laboratories which require special handling, treatment and disposal since it poses substantial or potential hazards to the environment, the humans or other living organisms due to its non-degradable nature (Jerie, 2006). The ignitable, corrosive, reactive, or toxic (Hassanvand et al., 2011) character of this waste should be also taken into consideration. So the hazardous waste generated in a campus due to research and educational activities need to be audited (Liu et al., 2011) in order to achieve sustainability in campus. Therefore, the complete understanding of the generated waste quality and quantity is the key to achieve the implementation of an effective SWM strategy and to identify the existing opportunities for waste reducing, reuse, and recycling in any campus. A field research is the most appropriate method to retrieve qualitative and quantitative data compared to other mimicked methods such as extrapolating data from other institutions whose accuracy is often questionable (Smyth et al., 2010).

2. Background of the region under investigation

Palestine, similarly to many other DC, faces serious challenges in dealing with solid waste and suffers from serious pollution problems caused by the generation of large waste quantities (Al-Khatib et al., 2010) while at the same time has limited options for their management. Overall the management of SW is facing many hurdles at the legislative, organizational, technical, environmental and financial levels, especially in the light of lack of accurate national statistics on the amounts of SW produced, its source or its composition. This resulted primarily in difficulties in the field of planning and decision making which is directly related to the SWM sector (PNA, 2010) and secondly to waste management of municipal, medical, industrial, commercial and institutional solid waste largely being performed by dumping in uncontrolled dumping sites.

Nevertheless currently the Palestinian authorities decided to construct three regional sanitary engineered landfills in the West Bank of Palestine and close all dumpsites. Two of those landfills have already been constructed whereas the third has remained in the planning phase. Lack of financial resources cannot address the request for further investments, proving that waste minimization is essential to achieve extension of the existing landfills' life span.

The field research presented in this paper was conducted in West Bank (Palestine) HEIs and its outcomes aim primarily to the identification of: the current situation of SWM systems in the HEIs of Palestine, the negative and positive attitudes towards SWM, the extent to which the solid waste sector in Palestinians' HEIs connects and affects the municipal SWM system as well as the environment. Most importantly the primal outcomes that are the quantitative and qualitative data will constitute the foundations for the organization of a SWM strategy in Palestinian HEIs.

3. Material and methods

3.1. Population in West Bank higher education institutions

The general features of the Palestinian HEIs in the West Bank are as shown in Table 1. Based on those data researchers formed the field research sample and scheduled the interviews in order to collect raw data.

3.2. "Solid waste management" practices assessment (Field survey #1)

In order to achieve the objectives of this research, data on the SWM in the Palestinians' HEIs were retrieved via structured questionnaires. The field research focused only at the West Bank HEI's, while Gaza strip was excluded due to the Israeli Occupation restrictions on movement creating high difficulty in raw data access.

Existing literature research largely assisted the development of the structured questionnaires which addressed the services' departments responsible for SWM personnel of each individual HEI. To achieve a representative sample, the questionnaire was distributed to 7 traditional universities in the West Bank, a branch of the Alquds Open University in the Hebron City and to 4 community colleges in West Bank. The questionnaire was completed mainly through direct interviews with targeted institutions key personnel (responsible for managing waste and public services) or in case where a face to face meeting was not possible, through mailing after phone communication aiming to explain the specific purpose of the survey.

Table 1. Features of Palestinian HEIs in the West Bank (Palestinian Ministry of Education and Higher Education, 2011)

Type of institution	No. of institutions	No. of students	No of employees
Universities	8	97,148 (~50%)	7,559 (~83%)
University colleges	10	6,451 (~3%)	1,053 (~12%)
Community colleges	15	8,600 (~4%)	489 (~5%)
Open education sector	n/a	83,431 (~43%)	n/a
Total	33	195,630	9,101^(*)

(*) Excluding workers in the open education sector

At baseline, the aforementioned groups were interviewed by the researchers and were asked to fill out a questionnaire with the following sections: (a) number of students and employees of their institution, (b) the method of solid waste treatment (waste collection schemes, packaging, type and size of the used containers, etc.) and (c) final disposal site. It should be mentioned here that in the questionnaire the waste streams were clearly indicated (i.e. hazardous-laboratory- waste, garden waste, food waste, office activities resulting waste) allowing researchers to investigate also the management practices applied for each one of them (sections (b) and (c)) where those were available.

3.3. Generated waste sampling (Field research #2)

The 2nd field research was divided into two sub-researches and it was performed parallel to the 1st one. The corresponding main purposes were to determine the quantity and quality of the waste generated within the HEIs.

Research to quantify the volume of waste was performed similarly to the one described in de Vega et al. (2008). The scientific personnel involved in the research constructed an extended database which was filled in with the following data:

- net weight of all waste collection vehicles (WCV) involved in the waste collection from HEIs (before their entrance into the campus);

- total weight of the WCV after the end of the waste collection (at the exit of the campus).

The above data were collected for 10 HEIs (7 universities and 3 community colleges) for a period of 5 consecutive days. It must be noted that the days were the quantitative research took place are judged as regular days for HEI operation as there were no holidays, strikes or any other reasons affecting the overall generation of waste of any type.

The procedures followed for the purposes of the research allowed the scientists to determine the weight of the generated waste, the fluctuation per week and the average weekly/ daily generation as well as the frequency patterns of waste collection and transportation.

Following the quantification of waste, a waste characterization study was conducted since it constitutes an important element of the SWM plan (the composition of the collected samples was identified in the frame of this field research). In order to do that, random solid waste samples were taken from three different locations per each involved institution: (i) academic and administrative buildings (including laboratories), (ii) gardens and corridors, and (iii) the community centre (store, and cafeteria areas). These places were selected to reflect the diversity of the domestic waste stream generated in any HEI campus, while construction waste was excluded. The classification was carried out in accordance with the modified method for household waste characterization (Buenrostro-Delgado, 2001; de Vega et al., 2008); the samples were taken during 5 consecutive days to reflect the consumption pattern and ensure representation of the waste stream. Those 5 sampling days followed 2 days of trial samplings to ensure validity of collected data. All of the samples were taken using the same sized aluminium bin with a net weight of 2.5 kg and a volume of 50 litres.

4. Results and discussion

4.1. Quantification and characterization outcomes

The results indicated great variation in the frequency of collection between universities and community colleges. The collection frequency at the majority of the universities is taking place on a daily basis, while only one third of the community colleges have the same collection frequency as shown in Fig. 1. The main reason for that is the fact that in total the universities are generating greater quantity of waste (~34.5t/day) due to the greater number of students compared to that of the community colleges (almost 30 times higher).

In accordance with the records kept by the Palestinian ministry of education, there are 195,630 students and 9,101 employees in the West Bank's HEIs; all of them participated in the field research.

Based on the aforementioned population and the fact that the daily average of generated waste amounts to 104,458 kg, the calculated average generation per capita is 0.51 kg (shown in Table 2).

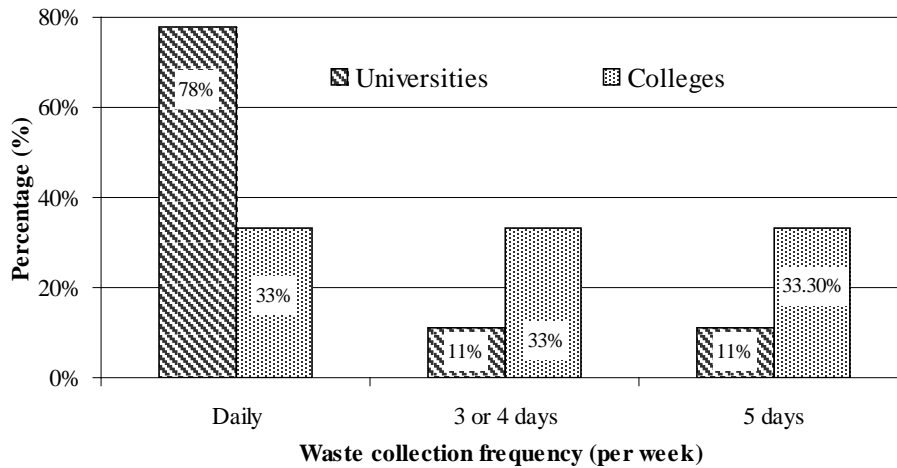


Fig. 1. Frequency of waste collection performed by the local authority weekly

Table 2. Daily average of generated waste in higher education sector establishments investigated (8 universities and 4 community colleges) in the West Bank

No.	No. of Students	No. of employees	Total HEI population	Average waste generation		Generation index (kg/day/person)*		
				kg/day	%	Total	Universities	Community colleges
1	14,000	1,200	15,200	8,056	23.86%	0.53	0.53	-
2	5,250	81	5,331	1,493	4.42%	0.28	0.28	-
3	3,000	200	3,200	992	2.94%	0.31	0.31	-
4	5,500	600	6,100	3,477	10.30%	0.57	0.57	-
5	5,000	270	5,270	2,003	5.93%	0.38	0.38	-
6	6,329	396	6,725	3,497	10.36%	0.52	0.52	-
7	20,000	2,100	22,100	11,934	35.35%	0.54	0.54	-
8	850	160	1,010	1,505	4.46%	1.49	-	1.49
9	600	110	710	398	1.18%	0.56	-	0.56
10	520	80	600	402	1.19%	0.67	-	0.67
Total	61,049	5,197	66,246	33,757	100	0.51	0.45	0.91

Table 3. Field research outputs regarding the number of containers per each institution investigated (7 universities and 3 community colleges)

No.	No. of Students	No. of employees	Total	No. of containers	Containers' sizes					
					30m ³	12m ³	10m ³	4m ³	1.1m ³	50 lt
1	11,000	800	11,800	623	-	-	-	-	23	600
2	14,000	1,200	15,200	310	3	7	-	-	-	300
3	5,250	81	5,331	59	4	-	5	-	-	50
4	3,000	200	3,200	230	-	-	-	20	30	200
5	5,500	600	6,100	300	4	-	6	40	-	250
6	7,100	657	7,757	350	10	-	-	10	30	300
7	5,000	270	5,270	210	-	-	10	-	-	200
8	6,329	396	6,725	232	-	-	-	-	32	200
9	20,000	2,100	22,100	404	-	4	-	10	0	400
10	850	160	1,010	35	1	-	-	4	-	30
11	600	110	710	54	-	-	-	-	4	50
12	520	80	600	44	2	-	-	2	-	40
Total	79,149	6,654	85,803	2,851	24	11	21	86	119	2,620

A wide variety of containers sizes ranging from 50 litres up to 30 cubic meters are currently in use. Those with capacity of 50lt are located inside the buildings of the campus and are kept locked by each institution responsible personnel. The other containers (sized: 30m³, 12m³, 10m³, 4m³, 1.1m³) are located outside the buildings and are kept locked by local authority personnel. It has been found that the

Palestinian HEIs have an average of 237.6 containers per each institution. The current sizes of containers and its distribution per institutions are shown in Table 3.

The available container size (given the population in HEIs (students and employees)) amounts approximately: 0.02 m³/capita whereas the quantity of SW generated (0.51kg/day). Taking into

account the “Waste conversion factors” (EA, 2012) one can calculate that the available container size is 200kg/capita for all the HEI investigated. The available container load is a lot higher than the one required based on literature, leading into high collection cost as the WCV are collecting waste from half full/half empty waste containers. The emerged collection cost is high and is a significant parameter that should be changed during the organization of a SWM plan for HEIs through the readjustment of the container size and thus the minimization of the frequency of the SW collection routes.

The SW composition is also a significant parameter which plays a key role in SWM. Fig. 2 presents the fractions of solid waste generated by HEIs in the West Bank which participated in the research. The results reveal that paper and cardboard constitute the highest solid waste fraction at (36.5%), followed by the food waste which comprise (35.0%).

The results were compared to other institutions from DC. For example, Ilaboya et al. (2011) reports that in Lgbinedion University Okada, Nigeria the generated waste is constituted by: paper (40%), plastic (20%), metal (16%), food waste (10%), glass (7%), rags (5%) and other materials (2%). Additionally at the Autonomous University of Baja California, Mexico (de Vega et al., 2003) the waste fraction distribution is paper (43%), organics (10%), plastics (7%), glass (4%), metals (3%), demolition waste materials (2%), other waste (31%). It’s noticed that the food waste percentages in the Palestinians HEIs are much higher than other cases; while the generated paper and glass wastes almost close to the other mentioned cases.

Some of the investigated HEIs involve in their educational activities laboratory tests or practice. Additionally the maintenance services in the HEIs campus buildings produces also a considerable amount of hazardous waste such as paints, oil and bonding materials. Since it is well known that the waste produced by the laboratories in HEIs include a wide range of hazardous chemicals it was expected by laboratory responsible personnel or course supervisors

to apply collection practices of these hazardous wastes. The results indicate that half of the total investigated HEIs are dealing with hazardous waste separately (i.e. temporarily storing them); universities (~56%) and community colleges (33%). The rest of the investigated institutions are handling hazardous waste like other institutional waste from the point of waste production to final disposal (i.e. disposing it into municipal landfills and dumpsites) without any labelling, storage in specific container, and compatibility, affecting directly nature and human health. This situation is almost similar to the situation in HEIs in Iran, where hazardous waste does not receive adequate care and proper management, but are disposed of with household waste without treatment or attention to their involved hazard (Hassanvand et al., 2011).

The situation is different in developed countries where special attention is paid for hazardous waste management at HEIs. For example, at the University of Toronto, the majority of chemical wastes from laboratories were recycled and also 100% of the food waste produced is recycled through various industrial processes. Regarding inorganic chemical wastes, 50-70% of them are being recycled, whereas external contractors are treating those chemicals that cannot be recycled (University of Toronto, 2013). At California University, there were different recycling programs, just as other universities in the USA in order to reduce the overall waste generated on campus (Allen, 1999).

The vast majority of the Palestinian HEIs have no treatment plan for garden waste. Regardless the results revealed that universities are exerting more efforts to treat garden wastes separately compared to community colleges. This behaviour could be referred to two main reasons: the gardening space at universities is greater than those of the community colleges resulting into higher garden waste fraction generation. Also the education and awareness level at the universities is higher than the one assessed in community colleges and thus the universities proceed into more environmentally sustainable solutions.

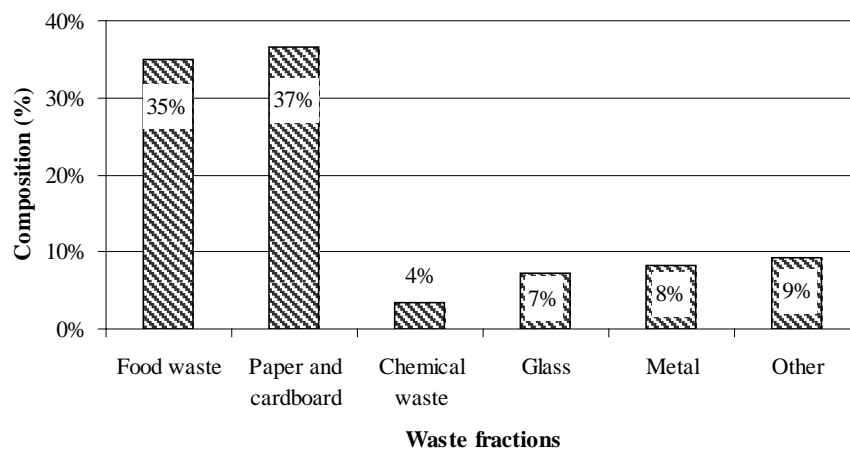


Fig. 2. Composition of solid waste generated by Palestinian HEIs investigated in the field research

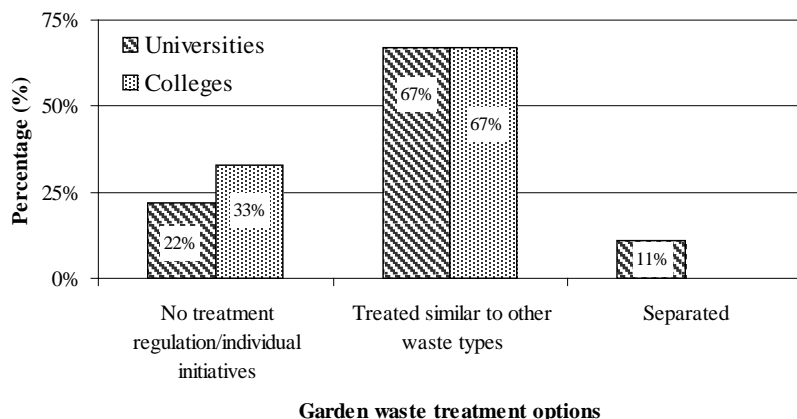


Fig. 3. Dealing with garden waste at HEIs level

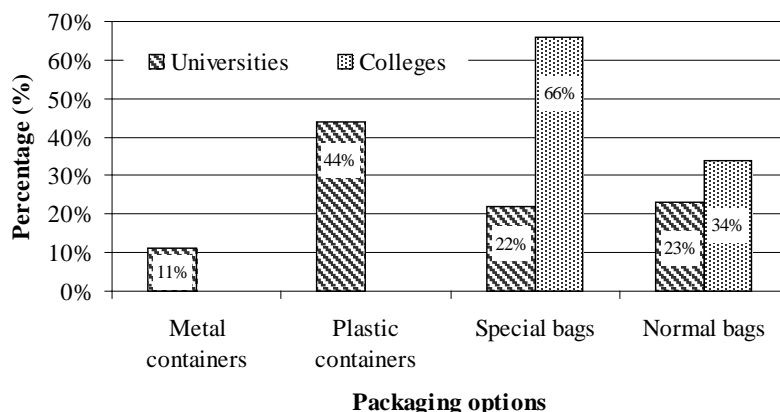


Fig. 4. Packaging methods of solid waste at the HEIs.

Fig. 3 shows the results of how Palestinian HEIs are dealing with garden wastes. In the 11 universities where garden waste is separated the responsible personnel proceeded into either burning it, disposing it with the domestic waste or keep it on the ground to decay. The selected treatment method (recorded in the frame of the field research) is not based by any means on environmental terms but to the personnel’s habit.

4.2. Assessment of the SWM practices in HEIs

Assessing the current SWM practices is the first step of the roadmap towards the tracking of the strengths and constraints of each institution in the field of SWM as well as the appropriate methodology towards the development and implementation of an integrated SWM plan. The survey resulted as shown in Fig. 4, that 33% of the Palestinian HEIs use special bags (high quality, thick and hard-ridden due to waste weight) as a package method for the collected waste, while the metal and plastic containers, and normal bags (low quality that can be easily torn e.g. from supermarkets) are used in percentages of 8.3%, 33%, and 25%, respectively.

The survey results revealed that waste disposal constitutes the sole responsibility of the local authorities, since the majority of the HEI’s (92.0%) are using open containers that belong to the local

authorities. Few institutions (8% of total, constituting 11% of the universities) are using their own closed containers but in either way the collection and transfer to the disposal site is carried out by the local authority (Fagnani et al., 2017).

The survey results have shown that the SWM in the Palestinian HEIs presents no variation compared to that of current SWM in Palestine in general. Waste separation is still in its preliminary phases and for specific fractions only. The current waste separated is characterized by: 50% paper and cardboard, 25% food wastes and 25% chemical wastes. The packaging of the separated wastes is performed by special bags for 67%, while 33% is performed by other not identified methods of packaging. The results reveal that universities are characterized by higher levels of responsibility toward environmental protection than community colleges since 33% of the universities are practicing waste segregation at source in comparison to zero source segregation in the community colleges.

The aforementioned is perhaps due to the higher level of education and availability of resources which characterise the universities; responsible personnel often undertake measures towards sustainable waste management.

Although the benefits of solid waste recycling on the environment are numerous (Andrews et al., 2013), the research pinpointed that none of the Palestinians HEIs implements any recycling program

even though the waste recovery potential stands high. In accordance with the International Finance Cooperation (IFC), the estimated recoverable wastes per fraction are as follows: 60% of paper, 80% of plastic containers, 90% of metal, 70% of organics (IFC, 2012). However, Bernstad and Jansen (2010) reported the losses of materials through the recycling process at 18% for food wastes, 9% for cardboard, 10% for glass and 11% for metal. Waste segregation programs can significantly facilitate recycling to produce many kinds of new materials (Bernstad et al., 2010) and at the same time limit the use of raw materials. Considering the waste recover percentages provided by the IFC and the total waste found to be generated by the Palestinian HEIs (33,757 kg/day), the expected waste recover quantities for all of the Palestinian HEIs in the West Bank are as presented in Table 4.

Table 4. Estimated recoverable waste generated from the Palestinian HEIs investigated

<i>Waste fraction</i>	<i>Daily generation (kg)</i>	<i>Potential processing and recovery (%)</i>	<i>Recoverable quantity (kg/day)</i>
Food	11,814.95	70	8,270.47
Paper & cardboard	12,321.31	60	7,392.78
Glass	2,464.26	90 *	2,217.84
Metal	2,801.83	90	2,521.65

*Recoverable percent is as per Bernstad and Jansen (2010)

It is worth to highlight that HEIs are not able to establish and operate small scale recycling schemes individually due to the economic feasibility aspects related to such an initiative. However, composting of organic fraction including kitchen and garden waste has potential benefits since it primarily serves as an educational program for students and community by promoting sustainable waste management and secondly minimizes the costs related to the provision of gardening products e.g. fertilizers.

The recycling sector is currently organised in Palestine but its operation is endangered by (a) problems associated with export and high cost of transfer (case of cardboard and paper), (b) under-utilization of the market and non-compliance with environmental and social safeguards (case of plastic recycling), and (c) lack of standards and adaption of suitable technologies as well as development of local markets for e.g. locally produced compost. It is worth mentioning that most of the Palestinian universities have environmental courses at graduate and undergraduate level taught by highly qualified staff; the graduates are expected to make the difference in the development of the recycling sector over the next decade. Overall HEIs have the ability to act as row models for solid waste recycling and secondary materials' utilization that can be reflected to community and contribute to increase of environmental awareness levels. Awareness Programs are a key approach towards the organization of a

sustainable SWM program. Unfortunately, the survey results revealed that the Palestinian HEIs have not been putting a lot of effort since only 25% of the universities and none of the community colleges are informing their students and staff on SWM issues or strategies that can be applied in the campuses.

5. Discussion

Based on the field research Palestinian HEIs can recover large quantities of paper/cardboard (7.4 kg/day), glass (2.2 kg/day) and metals (2.5 kg/day). Their communication with local industries which utilize the above-mentioned waste fractions as secondary instead of raw materials will provide a sustainable solution for their recovery/recycling. The latter is expected to have bilateral advantages; primarily the institution will minimise its ecological foot-print and secondly the income of the implementation of such a project may fund additional environmental related activities in the campus or even finance the waste disposal services offered by the local authority.

When it comes to food waste the recovered amount per day is significant and the conduction of an investigation regarding the purchasing of composting bins, will also present bilateral benefits; the campus will have available raw material for the gardening works which will limit the use of fertilisers and the students will have the opportunity to witness the sustainable waste treatment presenting them with the initiative to practice it in their own homes or community. Additionally elementary school students and their teachers as well as interested citizens may be invited to participate in this activity and part of the generated compost quantity may be offered to them to use it in their own gardening activities. A change in individual values in the environmental behaviour of the members of the educational community is the primal goal. The latter will probably provide them also with the initiative to apply environmental practices e.g. composting the food waste generated in their households (Maddox et al., 2011; Smyth et al., 2010).

In general Palestinian HEIs, to the largest extent, depend on the corresponding municipalities for the management of the generated waste. But due to the integrated nature of their activities HEIs authorities are invited to investigate the potential of implementing their own small scale SWM system, which can reduce the duties (and hence the pressure) of the municipalities they belong.

Application of a pilot or a small scale resource recovery and waste recycling can more easily and effectively be incorporated and monitored as to its effectiveness. The scientific impact of this project is also expected to be high for academics, personnel and students. Future collaborations with foreign countries HEIs and enterprises also present high potentials.

The organization of frequent info days where the outcomes of the implemented program will be announced can be combined with the organization of awareness programs with participants coming from

local authorities, non-governmental organizations, citizens' organizations, school students and teachers as well as stakeholders from industry or private and public sector, etc. Thus the waste minimization culture will be promoted in the community and the importance of environmental protection will be highlighted. Such programs may also assist in closing the gap between education and industry due to the engagement in lobbying activities with the private sector, improve the attitudes towards waste management and create new job opportunities in this field.

It has to be emphasized that in order to guarantee the success of a solid waste management program in a HEI, besides the active support from the authorities of the institution, the involvement of the community and its interdisciplinary work are very important. The findings of this paper actually set the basis for the SWM project launching in the campuses. The pertinent revision of the program in order to accomplish an ever increasing participation, not only in regard to the problems of solid wastes, but in general, in relation to environmental protection is of great importance and it involves the conduction of similar waste characterisation researches in the future. To this direction Palestinian HEIs as well as HEIs in all DC are already playing an important role in environmentally educating students and presenting them with initiatives so that graduate students may seek for career opportunities in the field of solid waste management (reduction, reuse and recycling as alternatives to mere disposal). Additionally they will be motivated to bear profound responsibilities to increase technologies, knowledge, awareness, and tools in order to create an environmentally sustainable future. Furthermore, such initiatives are building up the expertise necessary to develop the conceptual framework and intellectual to achieve sustainability for local community through advanced research, policy development, information exchange, etc.

The process of obtaining bilateral benefits requires careful planning and collaboration. HEIs environmental strategy will be developed by those who currently possess the scientific background and applied by those in charge (e.g. chancellor council), is expected to involve all relevant actors; head of schools and laboratories, other academic personnel as well as students (undergraduate, MSc and PhD), administration and cafeteria employees. The overall success of the waste minimization and management plan presents notable limitations that must be regarded; both training provision to all involved staff and frequent quality control checks are a prerequisite. To ensure the success of the SWM plan in HEIs a committee of experts should be established in order to advise and oversee the plan implementation. All preparatory procedures are practicable and do not require high budgets.

The latter is a significant parameter affecting the overall success since in Palestine the level of available resources is low. Investment in this field will surely prove profitable in the long term for the

Palestinian HEIs, local communities, etc., so collaborations with the private sector should be thoroughly investigated and be a significant part of the overall strategy and of the aspired outcomes.

6. Conclusions

Advancing the overall sustainability of a HEI by the implementation of comprehensive solid waste management programs is one of the greatest challenges; the starting point to achieve this is to conduct a waste characterization study. The findings presented in this paper can serve as the motivating force during the preliminary stages of a broader sustainability initiative, starting within the higher education sector. There are a variety of educational and policy techniques in international literature, which may be used to promote campus community waste minimisation behaviours in the long term thereby contributing to the overall sustainability of higher education institutions. Given that in DC such as Palestine data are limited, usually unreliable and originate from estimations, waste characterisation studies/researches are considered to be the most appropriate starting point.

The results presented in this paper on one hand confirmed that the SWM sector in the Palestinian HEIs in the West Bank has no clear features and still has a long way to go in order to achieve environmental sustainability and on the other hand presented researchers with valuable raw data. The generation per capita in community colleges was found to be higher than that calculated for the universities indicating the lack or the ineffectiveness of the waste minimization programs applied to some of them. Being one of the largest SW generators (~ 34 tons of waste per day, average per capita generation of 0.51 kg) according to local governmental reports published, educational institutions are expected to undertake sustainable environmental measures. Knowledge alone is insufficient to promote successful SWM projects without the necessary logistics; the information collected and the conclusion which the researchers drew will contribute to the development of an integrated strategy inspired by the rules for sustainable development which will be applied in all regional HEIs; waste diversion will be one of the first measures which will be undertaken in Palestinian campuses (promotional campaigns encouraging students to participate in pro-environmental behaviours coupled with other publicity techniques such as brochures development for the application of specific environmental practices in campuses).

Such initiative is expected to lead to both environmental and financial sustainability and also present local authorities with the necessary initiative to implement similar programs in a larger municipal level. Such configuration and extension of the SWM strategy requires further research on the field of the assessment of participants' behaviour, practices and attitudes towards solid waste reduction, reuse and recycling.

The potential future application an environmental strategy in municipal level will surely be benefited by the knowledge and experience gained from the application of a similar strategy in local HEIs and the cooperation and exchange of ideas between academics and local authorities assisting into bridging the existing gap among them in order to achieve sustainability.

Abbreviations

HEI	Higher Education Institutions
SWM	Solid Waste Management
WCV	waste collection vehicles

References

- Adeniran A.E., Nubi A.T., Adelopo A.O., (2017), Solid waste generation and characterization in the University of Lagos for a sustainable waste management, *Waste Management*, **67**, 3-10.
- Alabaster T., Blair D., (1996), *Greening the University*, In: *Education for Sustainability*, Huckle J., Sterling S., (Eds.), Earthscan, London, 86-104.
- Aliakbari-Beidokhti, Z., Ghazizade M.J., Gholamalifard M., (2017), Environmental impact assessment of municipal solid waste disposal site using rapid impact assessment matrix (RIAM) analysis in Mashhad city, Iran, *Environmental Engineering and Management Journal*, **16**, 2361-2369.
- Al-Khatib I., Monou M., Abu Zahra A., Shaheen H.Q., Kassinos D., (2010), Solid waste characterization, quantification and management practices in developing countries. A case study: Nablus district – Palestine, *Journal of Environmental Management*, **91**, 1131-1138.
- Allen A.S., (1999), *Greening the Campus. Institutional Environmental Change at Tulane University*, Environmental Studies Program, Alcee Fortier Hall, New Orleans, LA 70118, On line at: http://green.tulane.edu/PDFs/Aaron_Allen_Greening_the_Campus.pdf.
- Alshuwaikhat H.M., Abubakar I., (2008), An integrated approach to achieving campus sustainability: assessment of the current campus environmental management practices, *Journal of Cleaner Production*, **16**, 1777-1785.
- Amutenya N., Shackleton C.M., Whittington-Jones K., (2009), Paper recycling patterns and potential interventions in the education sector: A case study of paper streams at Rhodes University, South Africa, *Resources, Conservation and Recycling*, **53**, 237-242.
- Andrews A., Gregoire M., Rasmussen H., Witowich G., (2013), Comparison of recycling outcomes in three types of recycling collection units, *Waste Management*, **33**, 530-535.
- Bernstad A., Jansen C.J., (2010), A life cycle approach to the management of household food waste – A Swedish full-scale case study, *Journal of Solid Waste Technology & Management*, **36**, 446-457.
- Buenrostro-Delgado O., (2001), *Municipal Solid Waste: Perspectives from a Multidisciplinary Research*, Universidad Michoacana de San Nicolas de Hidalgo, Mexico.
- CODWAP, (2011), Solid waste management systems (CHE 5202), module in MSc course “Sustainable Solid Waste and Resource Management”, deliverable of Collaborative curriculum Development on Waste management in Africa and the Pacific region (Specific Targeted Research Project of the ACP-EU Cooperation Programme in Higher Education (EDULINK) - A programme of the ACP Group of States, with the financial assistance of the European Union), On line at: www.codwap.hs-bremen.de.
- Coker A.O., Achi C.G., Sridhar M.K.C., Donnett C.J., (2016), Solid Waste Management Practices at a Private Institution of Higher Learning in Nigeria, *Procedia Environmental Sciences*, **35**, 28-39.
- De Vega C.A., Armijo Ojeda-Benítez S., Ramírez-Barreto M.E., (2003), Mexican educational institutions and waste management programmes: A university case study, *Resources, Conservation and Recycling*, **39**, 283-296.
- de Vega C.A., Ojeda-Benítez S., Ramírez-Barreto M.E., (2008), Solid waste characterization and recycling potential for a university campus, *Waste Management*, **28**, 21-26.
- Disterheft A., Da Silva C.S.F., Ramos M.R., De Miranda Azeiteiro U.M., (2012), Environmental management systems (EMS) implementation processes and practices in European higher education institutions – Top-down versus participatory approaches, *Journal of Cleaner Production*, **31**, 80-90.
- Evangelinos I.K., Jones N.E., Panoriou E.M., (2009), Challenges and opportunities for sustainability in regional universities: a case study in Mytilene, Greece, *Journal of Cleaner Production*, **17**, 1154-1161.
- Fagnani E., Guimarães J.R., (2017), Waste management plan for higher education institutions in developing countries: The Continuous Improvement Cycle model, *Journal of Cleaner Production*, **147**, 108-118.
- Hassanvand M.S., Naddafi K., Nabizadeh R., Momeniha F., Mesdaghinia A., Yaghmaeian K., (2011), Hazardous waste management in educational and research centers: A case study, *Toxicological & Environmental Chemistry*, **93**, 1636-1642.
- Ilaboya I.R., Atikpo E., Asekhome F.F., Onaiwu D.O., Omofuma F.E., (2011), Design of an integrated solid waste management scheme: A model design for Igbinedion university community, *Journal of Applied Technology in Environmental Sanitation*, **1**, 125-138.
- IFC, (2012), Solid waste management in Hebron and Bethlehem Governorates, assessment of current situation and analysis of new system, International Finance Cooperation, Report, Palestine.
- Jerie S., (2006), Analysis of institutional solid waste management in Gweru, Zimbabwe, Eastern Africa, *Social Science Research Review*, **22**, 103-125.
- Liu K.H., Shih S.Y., Kao J.J., (2011), Planning for hazardous campus waste collection, *Journal of Hazardous Materials*, **189**, 363-370.
- Maddox P., Doran C., Williams I.D., Kus M., (2011), The role of intergenerational influence in waste education programmes: The THAW project, *Waste Management*, **31**, 2590-2600.
- Mbuligwe E.S., (2002), Institutional solid waste management practices in developing countries: a case study of three academic institutions in Tanzania, *Resources, Conservation and Recycling*, **35**, 131-146.
- Palestinian Ministry of Education and Higher Education, (2011), Palestinian higher education statistics, On line at: <http://www.mohe.gov.ps/>.
- Palestinian National Authority (PNA), (2010), National strategy for solid waste management in the Palestinian Territory 2010-2014, On line at: <http://www.sweep-net.org/ckfinder/userfiles/files/country-profiles/>.

- Smyth D.P., Fredeen A.L., Booth A.L., (2010), Reducing solid waste in higher education: The first step towards 'greening' a university campus, *Resources, Conservation and Recycling*, **54**, 1007-1016.
- Stephens J.C., Hernandez M.E., Roman M., Graham A.C., Scholz R.W., (2008), Higher education as a change agent for sustainability in different cultures and contexts, *International Journal of Sustainability in Higher Education*, **9**, 317-338.
- Suchowska-Kisielewicz M., Sadecka Z., Myszograj S., Pluciennik E., (2017), Mechanical-biological treatment of municipal solid waste in Poland - case studies, *Environmental Engineering and Management Journal*, **16**, 481-491.
- Talalaj I.A., (2017), The effect of socio-economic parameters on waste generation at county level, *Environmental Engineering and Management Journal*, **16**, 2025-2033.
- University of Toronto, (2013), Laboratory hazardous waste management and disposal manual, chemical waste management, On line at: <http://www.ehs.utoronto.ca/>.
- Young C.Y., Ni S.P., Fan K.S., (2010), Working towards a zero waste environment in Taiwan, *Waste Management & Research*, **28**, 236-244.
- Zhang N., Williams I.D., Kempa S., Smith N.F., (2011), Greening academia: Developing sustainable waste management at Higher Education Institutions, *Waste Management*, **31**, 1606-1616.