Assessment of Solid Waste Management (SWM) Practices in Hawassa University Campuses, Ethiopia

[1]HELELO, AB; *[2]SENBETA, AF; [1] ANSHEBO, ST

*[1]Department of Chemistry, *[2]Department of Biology Department, Hawassa University, P. O. Box, 05, Hawassa, Ethiopia*
[2]Corresponding Authors Email: abatefs@yahoo.com, Tel: +251-910283502

ABSTRACT: This study was conducted in four campuses of Hawassa University (HU), Ethiopia, with the aim of identifying the major sources, composition and quantity of solid wastes and solid waste management (SWM) practices. Key informant interview and visual assessment was carried out to identify the major sources, sampling sites, measurement points and management practices. The wastes were segregated and categorized into classes and measured for seven consecutive days in each campus. The result showed that about 35,364.2 Kg of food leftover and more than 10,541.4 kg of paper, plastic, grass and leaves, medical waste, and some other mixed solid waste were generated every week. From the total waste more than 92 % was recyclable and 81.5% was organic. The food leftover was managed by selling to ranchers, giving it to poor-of-the poor, and the remaining was managed through damping. The clinical wastes, papers and some other wastes were burned and only limited solid waste was recycled. Generally, the SWM practice in HU is reactive to the problems and a more proactive solution is required. For instance, conversion of organic waste to biogas could reduce the cafeterias cooking firewood spending, greenhouse gas emission and other socio-economic and environmental impacts associated with SWM problem. Recycling of paper waste by selling to pulp and paper factory can also be a feasible and win-win strategy for the university and the environment as the experience gained from Adama Science and Technology University.

In developing countries significant portion of population does not have access to a waste collection service and only a fraction of the generated waste is actually collected. Most of the solid waste is disposed in open dumps due to its simplicity and low cost (Nas and Bayram, 2008; WHO, 1996). The most problematic functional elements of poor Solid Waste Management (SWM) identified in developing countries include absence of proper disposal of solid waste, non-existence of separation of the solid waste into its constituents at the sources, absence of the timely information about the generation rate and characteristics and lack of reliable database on SWM (Bhat *et al.*, 2014; Buenrostro *et al.*, 2001; Gomez *et al.*, 2008; Jansen, 2010; Mbuligwe, 2002; WHO, 1996). The lack of knowledge, financial and technological deficiencies has also contributed to the poor management of solid wastes (Mbuligwe, 2002). In Ethiopia large amount of solid waste remains unmanaged and it affected the public health and the environment significantly (Cheever, 2011; Haylamicheal *et al.*, 2011). This is particularly true in Ethiopian higher institutions where SWM has become one of the priority issue in the institutional sustainability. The introduction of higher education

system in Ethiopia began in the mid-1960s and the country had only two universities for much of the 20th century. Since mid-1990s, the country's higher education system has expanded and the numbers of public universities have reached 43 and that of the private higher institutions has also increased remarkably. The student enrolment rate in public and private higher institutions has increased from 58,632 in 2003/04 to 860,378 in 2016/17, with an annual average enrolment rate increase of 26.1% (EMIS, 2016/17). The expansion of programs and the increased student intake and staff number undoubtedly increased the solid waste generated from these institutions. Consequently solid waste management in the higher education has become one of the greatest challenges for institutional sustainability. One of the major problems in solid waste management in the university campus is determining the composition and quantity of solid waste generated (de Vega *et al.*, 2008;Mbuligwe, 2002; Starovoytova, 2018). The sources, quantity, characteristics and composition of solid waste generated and the management practices was not studied and documented in Hawassa University (HU). Therefore, the objective of this paper is to identify the major sources, evaluate the

Corresponding Authors Email: abatefs@yahoo.com, Tel: +251-910283502

composition and quantify the solid wastes and solid waste management (SWM) practices in HU campuses of Ethiopia.

MATERIAL AND METHOD

Study area: The study was conducted in HU, one of the governmental-owned higher learning institutions, that is located in the Southern Nations, Nationalities and Peoples Regional State (SNNPRS), Ethiopia. The university was established in April 2000 and at the time of this study, the university has five campuses: HU Main Campus (Main Campus), College of Medicine and Health Sciences (Health Science Campus), College of Agriculture (Agriculture Campus), and Wondogenet Forestry and Natural Resources College (Wondogenet Campus), and Awada Business and Economics Campus (Awada Campus). Except, Wondogenet Campus and Awada Campus, all the other three campuses are located in Hawassa City. The Main campus of the university is located at 275 Km south of Addis Ababa, the capital city of Ethiopia. The total numbers of students in the campuses were 23,062 in Main campus, 1,370 in Agriculture campus, 2,714 in Health Campus, 592 in Awada Campus and 1,600 students in Wondogenet Campus (Table 1).

Table 1: Total number of student and staff at each of the five campuses of HU (2013/2014)

Name of campus	Number of students using cafeteria	Total number of students	Total Number of Staff
Main Campus	11,426	23,062	2,618
Wondogenet Campus	1,300	1,600	644
Health Campus	1,537	2,714	1,176
Agriculture Campus	1,300	1,370	493
Awada Campus	ND	592	302
Total	**15,563**	**29,338**	**5,233**

Sampling technique: Except Awada campus all other campuses were purposefully included in the study and the former was excluded due to its new establishment and insignificant solid waste generation. In the remaining four campuses all possible solid waste sources, sampling sites and measurement points were identified through interviews, questionnaires, visual assessment and field investigations. Several data collection methods were employed: on-site measurement of solid waste, key-informant interview, observation, experience sharing and secondary data collection.

Measurement of solid waste: The waste composition was determined by segregating the solid waste into its components at the respective sources and measured and quantified. From the seven student cafeteria in Main Campus, four of them were selected for food leftover measurement, representing 63.24% (7,226 students out of 11,426) cafeteria users. For Agriculture Campus, Wondogenet Campus and Health Campus, the food leftover from all student cafeterias (100%) were collected in a bucket (40 L and 80 L capacity each with 0.5 and 2.5 Kg weight respectively) and measured using measuring balance. The waste generation rate and bulk density was determined according to Mbuligwe (2002). The dry matter (TS) and moisture content of food leftover and peels were determined in Chemistry Department of HU according to the standard operation procedure (SOPs) as to the method specified in DIN 38 414 – S_2. The organic dry matter (oTS) was measured according to DIN 38 409-

H 1-3 as documented in SOPs (VDI, 2006). Other categories of solid wastes generated from offices, workshops and training centres, classrooms and dormitories were measured using hanging balance.

Interview: Semi-structured interview was held with key informants from the campuses (Facility Management and Beautification Directorate Director, Beautification team leader, Student Affairs Directorate Director, Cafeteria Case Team Leaders of respective campuses and some selected Cafeteria workers). The key-informants were purposively selected based on their exposure, position and responsibility in SWM issues. The informants were asked questions about the present management practice of solid waste generation, storage, collection, transportation, reuse, recovery, recycling and disposal.

Observations and experience sharing: The waste generation sources, handling, transport method and disposal sites were observed and photographed during visual inspection and during field investigation period. The observation data was used to supplement the interviews, and to assess the esthetic quality of the study areas, and to get firsthand experience of how solid waste is actually managed. Adama Science and Technology University (ASTU), a sister university in Ethiopia, were visited to share experience on SWM.

Secondary data collection: the data of enrolled students, cafeteria user students and staffs was obtained from the HU registrar office, student service

directorate and human resource management directorate office of the University, respectively (Table 1).

Data Analysis: The data was analysed qualitatively and quantitatively. The quantitative data was filled into an excel data sheet and subjected to simple descriptive statistics. The qualitative data were organized and summarized from the responses obtained from interviews and secondary data.

RESULTS AND DISCUSSION

Solid waste major sources and Amount : The major solid waste sources identified in the four campuses in HU were classrooms (mainly paper and sawdust), offices (papers), laboratories, libraries (mainly papers), duplication rooms (papers, and ink packets), dormitories (khat, paper, plastics, peels), staff residence (food leftovers and plastics), hotels,

restaurants, lounges and cafeterias (food leftover, peels, plastic bottles), maintenance rooms (wood, metals), hospital and clinics (gloves, syringes, plastics), abattoir, poultry, dairy and ranching centres (dung and fodder remain), workshops and training centres (papers), wood and metal work centres (sawdust, metals, old cars). The composition, quantity and characteristics of wastes generated vary mainly depending on the sources and season.

The results illustrated that large amount of solid waste was generated from HU (about 46,705.7 Kg/week) (Table 2). The generation rate was calculated to be 0.32 Kg/capita/day for Wondogenet and 0.33 Kg/capita/day for the other three campuses each. The quantified waste included food leftover (77.4%), leafs and grasses (4.1%), papers (9.2%), plastics (0.8%), medicinal wastes (5.1%) and other mixed wastes (3.4%).

Table 2: Amount of solid waste generated in HU campuses (in Kg/week)

Type of Solid Waste	Main Campus	Health Science Campus	Wondogenet Campus	Agriculture Campus	Total
Food leftover	12390.5	2649.5	1858.0	1556.0	18454.0
Potato peels	4528.9	220.5	351.0	860.0	5960.4
Onion peels	3242.1	550.6	385.0	331.0	4508.7
Cabbage peels	6463.2	140.9	348.0	289.0	7241.1
Paper	786.2	2137.1	838.3	524.7	4286.3
Plastics	36.6	292.8	6.8	36.2	372.4
Grass and leafs	526.4	234.0	107.9	1049.0	1917.3
Medicinal Waste	ND	2395.3	ND	ND	2395.3
Miscellaneous	432.4	725.2	166.6	246.0	1570.2
Total	**28406.3**	**9345.9**	**4061.6**	**4891.9**	**46705.7**

Food Leftover Management Practice: In the Main Campus food leftover (locally called *bule*) was sold to an individual who in turn sells to poor-of-the poor in Hawassa city. However, the health risk on leftover users forced the university to damp the waste at the back site of its compound using handcart and daily labourers. The open-damping attracted scavenger birds, flies and other pests to the site and caused offensive smell and became a potential health risk for the community. Later the university started selling the waste to a rancher, who transports the waste using minibuses (Figure 1). Yet the breakfast leftover and most of the cabbage and potato peels were collected occasionally and part of the leftover was damped. Figure 2 and 3, respectively, show vultures and children scavenging on the open-damping site of Main campus. Health Science Campus also follows similar trend of selling food leftover for ranching and the income was used to help poor female students in the campus. In Wondogent and Agriculture Campus the food leftover used by poor of the poor (locally known as *tesfegnoch)* and the remaining part was damped in the pit. However, the disposal site was poorly

managed and caused foul smell and attracted scavengers such as hyenas, birds and other wild animals.

Fig 1: Food leftover collection, Main Campus

Fig 2: Scavenger birds feeding on leftover cleaned from the cafeteria, Main campus

Fig 3: Children scavenging from damping site, Main Campus

Options for organic waste management: Most of the solid waste generated from HU (81.5%) was organic (food leftover and peels of onion, cabbage and potatoes). When looking at food leftover characteristics, breakfast bread had the lowest bulk density (218.8 Kg/m^3) and "*injera*" with lentil sauce had the highest bulk density (668.8 Kg/m^3). From peels, potato peel had the largest bulk density and cabbage had low bulk density. The high bulk density of "*injera*" with lentil and peels was attributed to high moisture content. The percentage of moisture content and volatile organic content of the wastes range from 69.514±0.8-86.923±4.564 and 85.1947±0.4880-97.1215±0.0191 respectively (Table 3). The high volatile organic matter indicates the availability of combustible organic matter of the waste during energy conversion. The moisture content is also high and it is an important indicator to estimate leachate, biological processes of organic matter and to design composting

facilities (Somboonmark, 2016). This suggests that there is a great potential of recovery of organic waste from the campuses if the waste is segregated at the source. In agreement with this study studies in other university campuses found that most of the waste is the organic and is suitable for compost production and biogas generation (de Vega et al., 2008, Mbuligwe, 2002, Vázquez, 2008). The conversion of waste to renewable energy sources: waste cooking oil-to-biodiesel, waste paper-to-fuel pellets and food waste-to-biogas was suggested to be achieved sustainably at the University of Cincinnati, USA (Zhu, 2014). The dung generated from Wondogenet dairy farm is currently used as organic manure in sugarcane farm, tree plantation and grasses in the surrounding area. There is no anaerobic biogas digester to convert organic waste into biogas, and the plan was delayed due to financial constraint. The unmanaged portion of food leftover in combination with animal dung can be composted or processed for energy recovery through anaerobic digestion. The HU student cafeterias fire wood consumption for cooking was 19.95m^3 per day in 2014, and the use of electricity and biogas is not known. The conversion of the organic waste into biogas is therefore, a win-win scenario to reduce the environmental pollution and the cost of firewood. According to Zhu (2014) the conversion of organic waste-to-biogas is more efficient in reducing greenhouse gas emissions even as compared to composting.

Table 3: Total solid, Moisture content and volatile organic matter of cafeteria waste

Item Description	Moisture Content (%)	Total Solid Content (%)	Volatile organic matter (%)
Food leftover	69.514±0.81	30.486±0.815	97.1215±0.0191
Cabbage, Potato and Onion Peels	86.923±4.564	13.077±4.564	85.1947±0.4880
Mixture *	75.987±1.138	24.013±1.138	95.3208±0.0866

*Mixture of food leftover, cabbage, potato and onion peels in various proportions

Non-Organic Solid Waste Management: Clinical wastes, papers and other wastes cleaned from dormitories, classes, offices and roads were damped or burned/incinerated. The on-site primary waste storage facilities such as plastic bins, metal bins, baskets and cartons were not sufficient and littering of solid waste on the roads was commonly observed. During the investigation it was observed that most of the paper wastes (examination papers, assignments, quiz and test papers) were locked in staff offices and quantification of used paper per year was difficult. The paper wastes are burned through controlled means. Yet it was confirmed that paper waste generation rate was increasing with increasing student intake, expansion of undergraduate and postgraduate programs and with the implementation of continuous assessment evaluation approach. In addition, the

students were copying lecture notes by themselves and most of the used paper was being burned by waste workers. In Adama Science and Technology University (ASTU), a sister university in Ethiopia, solid wastes were segregated into its constituents and recycled (ASTU Solid Waste Management Case team, 2014). The paper waste was stored in a separate room and sold for recycling to Wonji paper and pulp factory for 1.75 birr/kg. The conversion of waste into resource reduces greenhouse gas emission and generates income for the university. Thus, dealing with paper recycling companies such as Wonji paper and pulp factory, even with lesser price, can be a win-win scenario for sustainable SWM HU.

Solid waste Recycling Practices in HU: Only limited solid waste was recycled or reused in HU. Wood waste

from maintenance office in Agriculture and Wondogenet campus was used by workers or sold to residents in the city. The plastic containers, oil jerry cans and sugar sacs and metallic substances were collected for selling to the recycling market. Margarine cans, oil jerry cans and were stored at university main store for sell to recycling companies. Old and broken trays, cups, spoons were stored in the storehouses. Plastic bottles are collected by waste workers and mostly reused/sold for recycling. The old chairs, tables and other furniture including electronics, computers and metals were given in the form of aid to high schools and junior schools. The damaged beds and chairs were maintained and reused, or counted and reported to ministry of finance and economic development (MOFED). But a single committee established by MOFED was not efficient at follow-up and collection of metal wastes (Campus Beautification directorate director, 2014; ASTU Solid Waste Management Case team, 2014). The poor metals collection efficiency in institutions like HU would strongly reduce the recyclability, even though pure metals are often considered to be 100% recyclable (Kuusiola *et al.*, 2012).

Solid waste workers awareness of SWM: As demonstrated in the finding, the majority of solid waste workers and university community have no awareness of sustainable SWM strategies. There was no trend of sorting solid wastes into its components and no separate storage for different waste constituents, which is the first and basic process in solid waste management. The solid waste generated from sweeping was left on the field for days to weeks creating bad scenes and smell. The shortage of litter bins and lack of codes of waste handling practice has greatly contributed for poor management of solid waste in the campuses. Also, Mbuligwe (2002) observed shortage of the primary storage bins and problem of emptying the storage bins when they were full in three academic institutions in Tanzania. As a centre of learning and research institutions, HU has a moral responsibility to encourage and support sustainability and sustainable behaviour. After all Universities are believed to have the capacity to increase awareness, knowledge, technology and tools necessary to promote innovative and sustainable SWM practices in their technology villages (showcase areas for sustainability in practice) (Coker *et al.*, 2016; de Vega et al., 2008; Zhang *et al.*, 2011).

Conclusion: This study revealed that HU Campuses generate huge amount of solid waste, but the management practices in the university is mainly reactive to the problems. Since the solid waste generation is likely to continue with expansion of the university more proactive and sustainable institutional SWM practices such as reuse, recycling and conversion of organic wastes to biogas and compost. Further, awareness raising program of solid waste management is needed for the university community.

REFERENCES

Bhat RA; Nazir R; Ashraf S; Ali M; Bandh SA; Kamili AN (2014). Municipal solid waste generation rates and its management at Yusmarg forest ecosystem, a tourist resort in Kashmir. *Waste Manage. Res.* 32(2): 165-169.

Buenrostro O; Bocco G; Vence J (2001). Forecasting generation of urban solid waste in developing countries: A case study in Mexico. *J. Air Waste Manage. Assoc.* 51(1): 86-93.

Cheever M (2011). Waste Management in Ethiopia. *Environ. Policy Review*.

Coker A; Achi C; Sridhar M; Donnett C (2016). Solid Waste Management Practices at a Private Institution of Higher Learning in Nigeria. *Procedia Environ. Sci.* 35: 28-39.

de Vega CA; Benítez SO; Barreto MER (2008). Solid waste characterization and recycling potential for a university campus. *Waste manage.* 28: S21-S26.

EMIS (2016/17). Education Statistics Annual Abstracts. Ministry of Education, Federal Democratic of Ethiopia, Addis Ababa, pp. 158.

Gomez G; Meneses M; Ballinas L; Castells F (2008). Characterization of urban solid waste in Chihuahua, Mexico. *Waste Manage.* 28(12): 2465-2471.

Haylamicheal ID; Dalvie MA; Yirsaw BD; Zegeye HA (2011). Assessing the management of healthcare waste in Hawassa city, Ethiopia. *Waste Manage. Res.* 29(8): 854-862.

Jansen JIC (2010). Anaerobic digestion: technology. *Solid Waste Technol. Manage.* 1: 601-617.

Kuusiola T; Wierink M; Heiskanen K (2012). Comparison of collection schemes of municipal solid waste metallic fraction: the impacts on global warming potential for the case of the Helsinki metropolitan area, Finland. *Sustainability*, 4(10): 2586-2610.

Mbuligwe SE (2002). Institutional solid waste management practices in developing countries: a case study of three academic institutions in Tanzania. *Resource. Conserve.Recycling*, 35(3): 131-146.

Nas SS; Bayram A (2008). Municipal solid waste characteristics and management in Gümüşhane, Turkey. *Waste manage.* 28(12): 2435-2442.

Somboonmark C (2016). Municipal Solid Waste Management and Feasibility Study of Composing Technology in Local Government: Case Study Sub-District Municipality Suratthani Province. MSc Thesis, Thammasat University.

Starovoytova D (2018). Solid Waste Management (SWM) at a University Campus (Part 1/10): Comprehensive-Review on Legal Framework and Background to Waste Management, at a Global Context. *J. Environ. Earth Sci.* 2225-0948.

Vázquez RV (2008). Enhanced stabilisation of municipal solid waste in bioreactor landfills: UNESCO-IHE PhD Thesis. CRC Press.

VDI (2006). VDI 4630. Fermentation of organic materials - Characterization of the substrate, sampling, collection of material data, fermentation tests. STANDARD published 04/01/2006 by Verband Deutscher Ingenieure /Association of German Engineers

WHO (1996) Guides for municipal solid waste management in Pacific Island countries. Kuala umpur: WHO Western Pacific Regional Environmental Health Centre.

Zhang N; Wiliams I; Kemp S; Smith N (2011). Greening academia: Developing sustainable waste management at Higher Education Institutions. *Waste manage.* 31(7): 1606-1616.

Zhu C (2014).Food Waste Treatment Options at the University of Cincinnati: Life Cycle Assessment and Economic Evaluation, University of Cincinnati.