TOWARDS SUSTAINABLE INTEGRATED SOLID WASTE MANAGEMENT IN UNIVERSITY CAMPUS

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Abstract

University campuses generate large amount of various types and components of solid wastes. Among the types are municipal solid waste like, laboratory waste, and e-waste. Unfortunately, not many universities have considered the solid wastes as resources. The unseen recovery and recycling potentials of the campus solid wastes has made them to be disposed of without significant reduction efforts. This paper discusses a concept on building-up a sustainable integrated solid waste management in university campus, which covers policy-plan-do-check-action-continual improvement stages. Examples of successful implementation of integrated solid waste management in some universities are also discussed.

Keywords: solid wastes, integrated management, 3R, campus, policy.

1. INTRODUCTION

University activities are mostly focused on the academic, research and public service affairs, and usually have limited concern on the activity impacts to the environment. One of the significant impacts of the university activities is solid waste generation from various activity sources, such as office buildings, teaching facilities, laboratories, parking areas, parks, canteens, commercials (banks, shops etc), student center, sport halls etc. Activities in University Campus generate various types of solid wastes, among which is the hazardous type. Some campuses are also facilitated with staff houses and student dormitories, which generate residential type of solid wastes.

The on-going solid waste management system in ITS Campus, for example, has not applied *Reduction, Reuse and Recycling* (3R's) concept yet, although some researchers have taken initiatives to develop ideas for designing an integrated solid waste management system (e.g. Mardhiani *et al.*, 2005; Trihadiningrum *et al.*, 2005). All kinds of solid wastes in this Campus are still disposed of as commingled wastes. Collection of recyclable waste materials is mostly done by the cleaning crew and the scavengers. Interests for the implementation of integrated solid waste management in ITS Campus have been shown by a number of students and some individual academic staff since 2005. A number of socialization programs were made. Yet the ideas have never been implemented due to a number of reasons. The current Rector of ITS, however, has shown a considerable concern on campus sanitation recently, and has just formed a task force to implement an integrated solid waste management within the campus area.

Similarly, the UKM Campus in Malaysia, of which area is 1096 hectares, with a total number of university staff and students of 24,000, still collect the solid wastes as commingled wastes and dispose of it to the disposal facility. As in other university campuses, UKM has student dormitories, canteens/restaurants, and some commercial centers, which generate residential waste type. Insignificant separation of the recyclable components is done by the cleaning service crew, and the solid waste collection is carried out by a private agency.

The solid waste from a university campus is potential for energy and raw material recovery (Mardhiani *et al*., 2005). A campus scale Solid Waste Recycling Centre can be designed to run integrated solid waste management activities, which include reduction, reuse, and recycling (3R) of the solid wastes. The 3R activities, however, require an elaborate study on the solid waste generation rate and characterization in order to estimate the optimum recycling potential of the recyclable components.

Beside the presence of the above mentioned components in campus solid wastes, electronic waste (*e-waste*) might be generated from used electronic devices, such as computers, tubular lamps, over head and LCD projectors, etc. The possible hazards of the components of the e-waste, which contain heavy metals, should be taken into account in the future management of the campus solid waste. Universities are expected to treat the e-waste with care, due to its classification as hazardous waste.

Solid waste reduction efforts will provide a number of benefits, namely: conserves natural resources, prevents emission of many green house gases and water pollutants, saves energy, supplies raw materials, stimulates the development of green technology, and reduces the need for new landfills. In relation to this beneficial aspect of the solid wastes, University, as a higher education facility, should have extended its missions to support the nation sustainable development program through active implementation of solid waste reduction activities and increasing the public awareness.

In Mexico, most educational institutions are classified as “large waste generators”. This category is stated in the Mexican Prevention and Integral Waste Management General Law and the local Solid Waste Law. The large waste generators are those with a waste generation of over 10 tons/year. As a consequence, university as a large waste generator has to develop the corresponding management plans, which include an acquisition policy directed towards sustainable consumption, based on “green purchase” with the subsequent reduction of waste and the consumption of recycled and/or recyclable products. Sustainable consumption based on “green purchase” targeted at the input of the materials is just one of the control points in the management system, pursuing their transformation and finally the reduction of waste generation. Educational institutions have to establish the obligation to formulate and execute management plans which are oriented to prevent the generation of waste, to increase their values and to develop an environmentally sound management of the solid waste (Espinosa *et al*., 2008).

A sustainable integrated solid waste management should include not only the provision of technical support and facilities, but also a total involvement of the waste generators, decision makers, and the managing unit(s). Several cases showed a merely provision of complete solid waste treatment facilities without any support and involvement of waste generators and decision makers, did not result in satisfactory implementation (Mardhiani *et al.*, 2005). It is expected that the 3R based solid waste management in university campuses involve the students as part of the educational process. In addition, the internal policy of the campus will have a commitment to look after the environment and to promote values for the rational use of natural resources. This paper describes a fundamental concept on how a university can promote a sustainable integrated solid waste management.

2. CAMPUS SOLID WASTE GENERATION AND COMPOSITION

The university campus is a significant generator of various components of solid waste, particularly decomposable organics, paper, plastics, and metals. The landscaping area and

canteens contribute decomposable organic waste material, which is potential for energy and compost production. In addition to this component, practical and research works in laboratories may generate hazardous waste, which needs a particular management system. ITS Campus, for example, with a total area of 180 hectares, with about 17,000 students, 1000 academic staff, and 1100 non-academic staff generates solid waste of 8.17 m^3/day or 1.32 tons/day. The solid wastes are composed of biodegradable material (55.78%), paper (21,82%), plastics (14.5%), glass (3.06%), metals (2.36%), and other waste materials (2.48%) (Trihadiningrum *et al.*, 2005).

Using recovery factor values as recommended by Tchobanoglous, Theisen and Vigil (1993) for organic material, paper, plastics, metals, glass and others of 80%, 50%, 50%, 80%, 30%, and 0% respectively, a material balance of the recoverable and residual solid waste components can be prepared (Table 1). The potential material recovery from the campus solid waste is 65.59%, leaving 34.41% of residual waste, which should be disposed of to the landfill. At present almost all of the solid waste have been subject to direct collection and disposal. A plan and feasibility study on the construction and operation of a solid waste recycling center at ITS campus has been made, and resulted promising quantity of recovered materials, which could generate revenue for the university (Mardhiani, 2005).

Table 1. Material Balance of Daily Instutional Solid Waste of ITS Campus

Waste component	Percentage (%)	Total volume (m^3/day)	Total weight (kg/day)	Recovery factor	Potential Recovery		Residue estimate	
				(%)	Kg	%	kg	%
Organics	55,78	4,56	736,8	80	589.44	68.04	147.36	32,43
Paper	21,82	1,78	288,2	50	144.10	16.63	144.10	31,71
Plastics	14,5	1,18	191,5	50	95.75	11.05	95.75	21,07
Metals	2,36	0,19	31,2	80	24.96	2.88	6.24	1,37
Glass	3,06	0,25	40,4	30	12.12	1.40	28.28	6,22
Others	2,48	0,2	32,8	0	0	0.00	32.80	7,22
Total	100	8,17	1320,8	-	866,37	65,59	454,43	34,41

3. GENERAL PATTERN OF SOLID WASTE MANAGEMENT IN UNIVERSITY CAMPUSES

The following discussion will be focused on the solid waste management in Indonesian and Malaysian cases, which have not implemented integrated solid waste management. Example of the Indonesian case is ITS campus, and that of the Malaysian is University Kebangsaan Malaysia (UKM) Campus. These universities have just started to develop an integrated solid waste management, which includes solid waste separation and the 3 R principle.

Solid Waste Management at ITS Campus

The solid waste management in this campus area is managed by two authorities, namely the University Administration & Management Bureau (BAUK) for the solid waste management of the institutional units, and the community authority for the solid waste management of the residential area of the staff members.

The current solid waste reduction effort is still limited. The recyclable waste material pick up is generally done by the cleaning clerks and scavengers. To date the scavengers still have had free access to enter the university buildings and staff housing areas. This condition shows the limited awareness among the University management staff and the community authority in reducing and treating the solid waste, which causes the

"lost" of resources from the recyclable solid waste.

The solid waste storage facilities within the Campus area is provided by the management of the smallest University units, such as departments, faculties, university offices, canteens, dormitories etc. The bins, which are mostly open top, are of different types and sizes. Cleanliness of the university parks is maintained by contracted cleaning service crew. Burning of the solid waste has been commonly done to date, particularly the solid waste from the university parks and the residential area. Solid waste from parks and parking areas is often dumped in heaps prior to burning.

The solid waste collection from the campus area is under the responsibility of BAUK, who provides an open top collection pick-up vehicle of 3 m^3 volume capacity. This vehicle collects the solid waste from each university building daily. The solid waste is placed in a small capacity transfer depot, which was built by ITS in 2003. An arm-roll waste container of 10 m^3 capacity is provided in the transfer depot. The secondary collection activity, which is hauled the solid waste to the final disposal site (Benowo landfill), is carried out by transfer trucks provided by the Municipal Cleansing Authority (MCA). Figure 1 shows the general pattern of solid waste management of ITS, which represents the pattern in most of university campuses in Indonesia.

Generators →	Storage →	Onsite Handling →	Primary Collection →	Transfer →	Secondary Collection →	Disposal
1. Campus Area - Offices - Classrooms - Laboratories - Commercial - Health Center - Sport Center	- open bins - closed bins - heaps	- Limited separation - burning	Small size pick-up truck or hand-carts	Local transfer depot, facilitated with arm-roll truck container	Arm-roll collection trucks	Controlled landfill
Responsible Unit	Householders	- Householders - Scavengers	Communal authority			
2.Staff Houses	- open bins - closed bins - heaps	- Limited separation - burning	Hand-carts			
Responsible Unit	University unit	- Cleaning clerks - Scavengers	BAUK	Municipal Cleansing Authority	Municipal Cleansing Authority	Municipal Cleansing Authority

Figure 1. General Pattern Of Solid Waste Management at ITS

Solid waste management at UKM Campus

The solid waste management at UKM has not been managed by applying 3R approach. However, a group of researchers of Department of Civil and Environmental Engineering has developed ideas to build an integrated waste management system in the campus (Anonymous, 2008). The solid waste collection has been currently done by a private agency, who serves cleaning activity and solid waste collection under a two-year contract. Solid waste containers and collection trucks are provided by the contractor. Selection of contractor by the university is done through a tender system. The successful contractor will have a two-year contract, with an additional year if the work is considered to be satisfactory. When the contract time is due, the University will advertise a contract offer in newspapers. Interested contractors will be introduced to the service area in the campus (Nuping, 2007).

The solid waste which has been collected is directly hauled by the contractor trucks to the solid waste disposal site in Hulu Kembong, Bangi (Abdul Hamid, 2006). The main difference of ITS Campus solid waste from that of the UKM is the privatization of waste storage and collection system. The solid waste bins provided by the contractor are layered with plastic bags. However, the bins are still of open type, which have not met the criteria of proper solid waste container. Limited solid waste separation is done by the cleaning service crew. Some recyclable components of the solid waste are sorted, and sold by the individual crew. A simplified scheme of the solid waste management in UKM is shown in Figure 2. In addition, the trucks are of open top dump-trucks, where collection crews sit on solid waste heap on the truck.

Generators →	**Storage** →	**Onsite Handling** →	**Collection** →	**Disposal**
- Offices - Classrooms - Laboratories - Commercial - Health Center - Sport Center - Dormitories	- open bins , layered with plastic bags - heaps	- Limited separation	Collection trucks	Landfill
Responsible Unit	Contractor	- Individual Cleaning Clerks	Contractor	Local Government

Figure 2. General Pattern of Solid Waste Management in UKM Campus, Malaysia

4. HIERARCHY OF SOLID WASTE MANAGEMENT IN UNIVERSITY CAMPUS

The existing solid waste management system in the above mentioned campuses is still of a conventional hierarchy, in which most of the solid waste quantity is disposed of to the landfill, and very little amount is sorted for further 3R processes. This hierarchy is formed of the highest rank of waste prevention, to the lower ranks, namely: waste minimization, reuse, recycling, energy recovery and final disposal. The waste handling cost towards the lower ranks is increasing (Figure 3a).

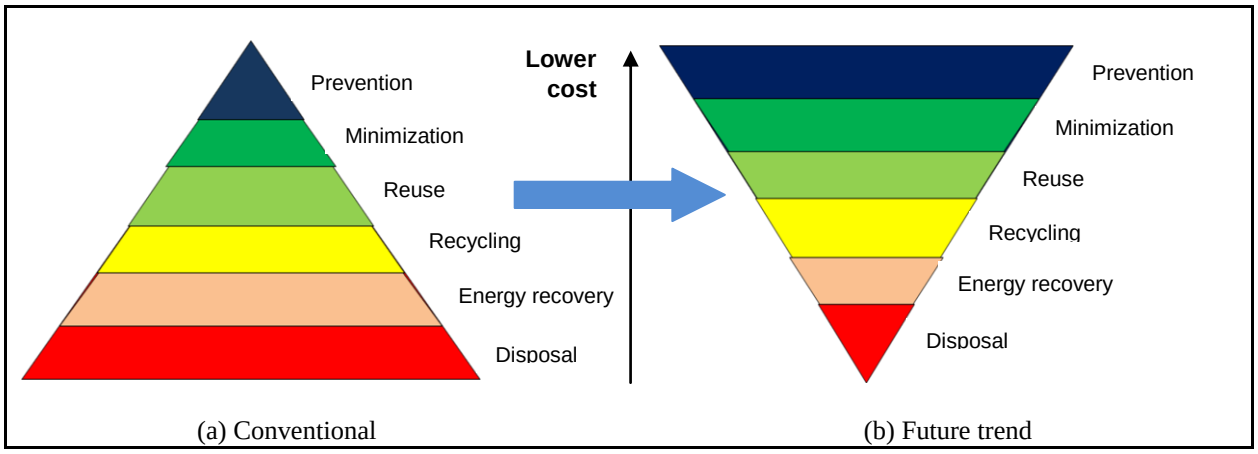

Figure 3. Solid Waste Management Hierarchy.

Waste prevention

Waste prevention is given the highest priority in integrated solid waste management. This is a preventive action that seeks to reduce the amount of solid waste by triggering people to consume less. By not creating solid waste, fewer collection vehicles and a fewer number of refuse collectors would be needed; fewer and smaller waste handling facilities would be required, and it would extend the life of the landfills. Society as a whole would be benefited from a successful implementation of a waste prevention program.

Waste minimization

Waste minimization is the second best alternative in integrated solid waste management, where consumers are encouraged to use products with refilled, reusable or recyclable packaging systems, for minimizing solid waste generation from the packaging materials.

Reuse

Once the waste prevention and minimization program has been implemented, the next priority in an integrated solid waste management approach is promoting the reuse of products and materials. Reuse consists in the recovery of items to be used again, after some cleaning and refurbishing. Reusing materials and products saves energy and water, reduces pollution, and lessens society's consumption of natural resources compared to the use of single-use products and materials.

Reuse of materials and products is regarded as more socially desirable than recycling the same materials. Cardboard boxes that are used for shipping products, for example, can be folded and sent back to the manufacturer to be reused for shipping the same or other products. Cardboard boxes can also be recycled at paper mills, but in order to recycle the boxes water and energy are required. Paper recycling also generates sludge in the process, which need to be disposed of. Beverage bottles can be disposable, returnable (reusable) or recyclable. Reusable bottles have the lowest environmental impact of the three, while disposable bottles require the most energy, water and generate the largest amount of waste and pollution. Products, such as office furniture and appliances, can also be reused.

Recycling

After the reuse of materials and products, recycling comes next in the integrated waste management hierarchy. Recycling is the recovery of materials for melting, repulping and reincorporating as raw materials. It is technically feasible to recycle a large amount of materials, such as plastics, wood, metals, glass, textiles, paper, cardboard, rubber, ceramics, and leather. Besides technical feasibility and know how, demand determines the types and amounts of materials that are recycled in a particular region.

Recycling can render social, economic, and environmental benefits. It provides an income for personnel who recover recyclable materials. Recycling also saves energy, water, and generates less pollution than obtaining virgin raw materials, which translates into lower operating costs. Recycling also reduces the amount of wastes that need to be collected, transported and disposed of, and extends the life of disposal facilities, which saves money to the municipalities. Recycling can result in a more competitive economy and a cleaner environment, and can contribute to a more sustainable development

Recycling can be conducted in a number of ways. Recycling programs usually involve separation of recyclable materials at the source of generation. In this type of programs, individuals separate their recyclable materials in a different container. The materials commonly separated at the source include metals, glass, paper and plastics. The cleaner and the more homogeneous a material is, the higher the price industry is willing to pay for it. Therefore, source separation is preferable to salvaging materials from mixed wastes.

Materials Recovery Facilities (MRFs) can be built for waste component separation and treatment. MRFs can either process source-separated recyclables from a recycling program, or mixed wastes from residential and other sources.

Energy recovery

Energy recovery from solid wastes can be done through several ways, such as incineration, anaerobic fermentation for biogas production, and Refuse Derived Fuel (RDF) production. It is also possible to produce electricity by converting the methane that is generated from landfills. Energy recovery from solid waste through incineration is generally unsuccessful in tropical countries, due to the high moisture and high content of organic waste. Therefore, the most appropriate methods for energy recovery from the solid waste are biogas and RDF productions.

Disposal

Final disposal of solid wastes is the lowest priority in an integrated solid waste management approach. Disposing of all municipal wastes at landfills is not desirable from a social, economic and environmental point of view. Sanitary landfills require significant investments and they often present political obstacles for their construction, due to local opposition. Residents who live near a proposed landfill may oppose its construction, as shown by people who lived near the Keputih and Benowo landfills in Surabaya City, Indonesia in 2001. This opposition is termed "Not in My Backyard" or NIMBY syndrome. Extending the life of landfills and diverting as much as possible by waste prevention, reuse, recycling, and composting can make economic sense. Diverting materials from landfills can also create jobs, reduce poverty, improve economic competitiveness, reduce pollution and conserve natural resources.

The conventional solid waste management hierarchy, which is delineated as a standing triangle in Figure 3a, should be diverted "up-site-down" in order to reduce the quantity of solid waste which should be disposed of (Figure 3b). Using this approach, solid waste management costs can be reduced. The last approach reflects the concept where solid waste is considered as a resource, which can generate recoverable materials, energy and revenue. Future solid waste management in university campus should be oriented more to solid waste prevention, minimization and the 3R efforts as shown in Figure 3b.

5. EXAMPLES OF SUCCESSFUL INTEGRATED SOLID WASTE MANAGEMENT SYSTEM IN UNIVERSITY CAMPUS

Case 1 Boston University

Boston University has implemented the 3R programs, of which examples are shown in Table 2. The first step orientation of this university in minimizing the environmental impact of solid waste is to reduce or create less waste. It is the most difficult part of the 3 R's, because it needs to adjust people behavior to consume less. At Boston University, many offices and departments get certain reused supplies from other offices and departments, such as furniture, computers, and manila envelopes. For years, this trade was done informally between offices. The solid waste recycling system in Boston University is quite extensive and has undergone numerous improvements in the recent years (Anonymous, 2008a).

Case 2. Ohio University

Ohio University was one of six state awardees that received a US $250,000 grant through Ohio Division of Natural Resources' (ODNR) Division of Recycling & Litter Prevention program. The funding will be used to purchase and install an in-vessel composting system for the Athens campus. It will be the first full-scale composting project at an Ohio college or

university. ODNR also awarded Ohio University an additional $50,000 toward the in-vessel composting initiative. The additional funds went toward the purchase of a 6.15-kilowatt solar photovoltaic array expected to generate 35 percent of the electricity needed for the composting site. Using a solar array to power the composting system would offset 4.5 tons of carbon emissions each year, resulting in roughly 135 tons of carbon avoided over an operational period of 30 years. The installation of a solar energy source for the system also would free up additional resources for the Department of Facilities Management in a time of rising energy costs (Anonymous, 2008b).

Table 2. Some Examples of 3 R Programs in Boston University (Anonymous, 2008a).

Reduce	Reuse	Recycle
Teachers and students should strive to reduce paper use in the classroom. Instructors ensure that only handouts that are absolutely necessary are passed out. Students should refrain from unnecessary printing of course materials, and print materials on the back sides of used paper, etc.	With *Reusable Office Supply Exchange* (ROSE) Program, staff members can use an online forum to post items that are no longer required. Other staff can browse the items to look for what they need. The giver and the receiver can communicate directly and are responsible for making arrangements to exchange items.	All major dormitories have commingle and paper recycling program. At the beginning of each academic year, each resident receives a reusable plastic recyc-ling bag. The students empty the recyclables in campus drop-off location. The bag makes recycling convenient, and having the bag will remind the students to recycle.
Starbucks in on-campus shops give customers an incentive to reduce paper cup use. Those who bring in a reusable mug, receive a 10¢ discount.	An option to get rid of an unwanted item of personal property is the *Boston University Today Classified Utility*, which is open to students, faculty, and staff. Post items, such as furniture, electronics, sports equipment, dishes, books, along with the asking price and contact information. If a person is seeking an item, or just wants to browse, they can visit the site and view posted items.	Landscaping waste is collected and composted. Wood pallets, scrap wood, and paints are recycled. Universal waste and electronics are collected and recycled by the Institution Recycling Network, a non-profit that works with colleges and universities to facilitate recycling.
Students are encouraged to use Nalgene bottles and similar containers to carry drinking water from home or the campus tap water to avoid the purchase of bottled mineral water, which generate plastic bottle waste.		Students who have small electronics to be recycled must drop off items in the drop-box. Larger items, like computer monitors, must be brought to the Office of Environmental Health and Safety.

Table 3. Some examples of 3 R Programs at Ohio University (Anonymous, 2008b).

Reduce	Reuse	Recycle
Students did actions like carrying a re-useable coffee mug, which will not only save on the amount of waste that is generated daily, but will often provide a discount at the coffee houses. .	The *Campus Recycling* sets up sites at every dormitories, where students can donate unwanted goods, such as clothes, school supplies, furniture and food. Volunteer community groups go around to the sites daily and collect the donations. These groups then distribute these items to people who need them.	With over 16,000 recycling bins spread across the University area, *Campus Recycling* works towards their goal of recycling 80% of the waste generated at the university. *Campus Recycling* is responsible for maintaining, monitoring, and upgrading the recycling and solid waste management at campus buildings and on the grounds
The Green Network developed a pledge for students and staff to sign. The pledge committed signers to stop purchasing bottled water on campus. Instead, they committed to carrying a reusable container for water and other beverages.	Ohio University tries to prolong the life of surplus materials, whether its office equipment, excess building materials, or non-perishable food items. Used equipment from the university is picked up and organized by the Moving and Surplus Department. These items are offered for sale at a reduced cost to other Ohio University departments, as well as at monthly auctions that are open to the public.	Ohio University operates an in-vessel composting unit, which can treat up to two tons of compostable organic waste per day. This waste is processed into a nutrient-rich soil within 14 days.
In the past the *Printing and Graphics Services* used one-time-use, non-recyclable plastic films covered in silver to make the metal plates, which print the paper. They have made a decision to modify old methods to pre-printing using only a computer and a metal plate, thereby eliminate altogether the silver covered plastic films and solid waste.	In summer 2006 a semi-truck load of beds and mattresses were sent to Honduras through *Recycling Network*. The cost to send the materials to Honduras was comparable to sending the used goods to the landfill. In addition, 500 used chairs were also sent to the *Materials Assistance Providers*, an NGO that serves the provision of a free furniture bank for families and individuals in need.	Ohio University and Miami University have co-founded the famous *RecycleMania* competition since 2001. It is a 10-week competition between university and college recycling programs across the US. Awards go to each university or college who has the largest amount of recyclables per capita, the largest amount of total recyclables, the least amount of trash per capita, and the highest recycling rate. The competition has grown every year, with over 400 participating schools in 2008.

From the above mentioned cases, it can be concluded that successful 3 R's program can be carried out by universities, when a responsible body exists (i.e. *Green Network* at Boston University and *Campus Recycling* at Ohio University). These units can actively take initiatives in developing ideas and running 3R's programs, organize training courses or competitions for building-up public awareness, and conduct monitoring and control programs during the implementation of solid waste management in the Campus area.

6. APPROACH TO SET-UP SUSTAINABLE INTEGRATED SOLID WASTE MANAGEMENT IN UNIVERSITY CAMPUS

Most universities in developing countries in Asia have not developed specific policies for integrated solid waste management. The existing solid waste management in campuses is still generally placed as the least important rank of the University Management Bureau's responsibility. Reasons for this may include: a lack of interest; the environment and public health have not become the main priority of concerns in the academic activity, inadequate capabilities of the designated responsible institutional organization, responsibilities of the concerned university units have not clearly defined yet; a lack of trained professional and managerial skills, and the absence of motivational and educational programs on the campus solid waste management.

The construction of a sustainable solid waste management in university campus should be started from a policy build-up. The policy provides future directions for all key elements of solid waste management, such as storage, on site treatment, collection, transfer and transport, and disposal. In designing a workable policy, the decision makers of the university can include students through the student unions, and the academic and non-academic staff.

The policy build-up is to be followed by a plan-do-check-action (PDCA) activities. The plan (P) should describe the university policy in solid waste management, objectives and components, the roles of the responsible unit and various levels of university units in solid waste management, fund allocation, estimation of revenue, and finally provision of a comprehensive action plan with clearly identified programs. This plan should be provided with clear guidelines on the solid waste management principles to be executed by the university staff and students. Results of the policy and plan establishment are further socialized to the university staff and students through small workshops, demonstration, distribution of brochures and pamphlets, etc. During the socialization stage, inputs which might be raised by the grass root level can be used to complete the solid waste management plan.

The next stage is the implementation of the plan or the Do stage (D). In this stage construction and provision of facilities are to be done. The facilities may include separate bins for particular solid waste components, treatment facilities, such as composting unit, washing unit for plastic waste, storage unit for collected recyclables, packaging unit, and office for running business activities. When these facilities have been provided, all university staff and students execute the handling of solid waste that they generate as described in the guidelines. The solid waste handling comprises waste reduction, treatment, storage, collection, transfer, transport, and disposal.

During the implementation of the solid waste management activities, the Check (C) stage is carried out by the appointed university unit(s), who monitor and control whether the performance of solid waste management work activities. If unexpected case occurs, necessary actions (A) should be done in order to improve

the incorrect measures. The final stage is continual improvement. Based on the monitoring and the corrective measures, new strategies can be developed to create new and better policy, for improving the solid waste management performance. These consecutive stages may form a close loop, which will produce improving performance of the campus solid waste management from time to time (Figure 4).

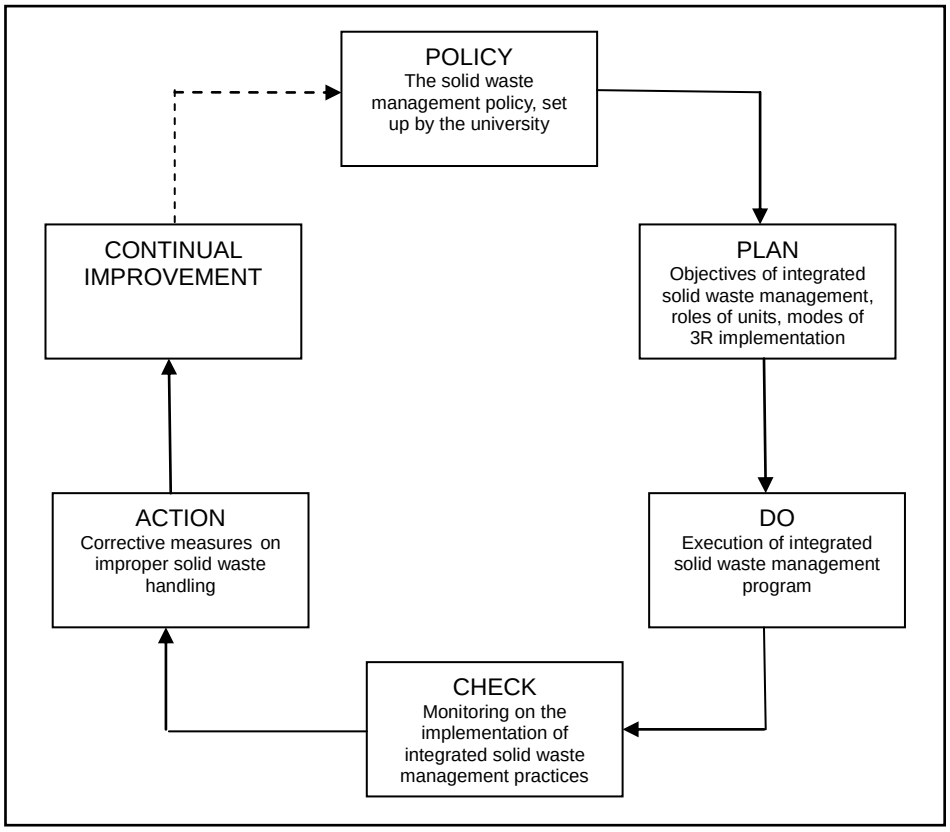

Figure 4. Pathway of The Implementation of Integrated Solid Waste Management in University Campus.

In building-up a sustainable integrated solid waste management in university campus, the approach can be started by either bottom-up or top-down approach. The target of both approaches are the same, namely to create the soul of awareness and willingness to be involved in carrying out an integrated solid waste management activities among the university staff.

7. INVOLVEMENT OF UNIVERSITY STAFF AND STUDENTS

A sustainable integrated solid waste management in university campus can work well, if the *souls* and *hearts* of the stakeholders are touched and attached for a total involvement. University staff and students should really understand that a successful integrated solid waste management in the campus can not be achieved with the provision of facilities only, but also with active participation of the waste generators in doing all of the management stages, which starts from sorting the waste components at source, placing the sorted waste materials in the right bins, reminding their colleagues to do the right things, and supporting the other planned solid waste management activities. The appropriate approach for introducing an integrated reduction based solid waste management can be from both of the grass root and the top management levels. Such an introduction effort can be done through scheduled meetings and

workshops, implementation of action research activities, visiting successful integrated solid waste management program.

Another factor which may support the success of integrated solid waste management in university campus is revenue generation from the recoverable materials and possibly energy. Careful revenue estimation should be done during the planning stage for efficient use during the implementation stage.

8. CLOSING REMARKS

University campuses generate large amount of solid waste daily with various components. Among the solid wastes, e-waste and laboratory wastes have to be taken into consideration for proper management in order to avoid the hazardous impacts to the environment. The solid waste in university campuses has a considerably high recycling potential, which can reduce the waste quantity at least 65% for energy and recovered material production. This potential of the campus solid waste has not been seen as promising new resource and revenue generators by many universities. A sustainable integrated solid waste management in university campus can be established with total involvement of the waste generators, and supported with a workable policy and PDCA system. The revenue generation from the 3R activities is an important factor, which supports the sustainability of this program.

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