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Cleaner Production: The Key to Waste, Water and Energy Reduction in Higher Education, Philippines

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ABSTRACT

The fight against the worsening environmental problems has been the battle cry of the world. Environmental sustainability requires balance between development and the environment, is the key towards efficient resource

management. This paper examines a Higher Education Institution through Cleaner Production Assessment, to look for viable and economic options through which the institution can enhance its environmental performance thereby can generate resources' savings; utilizes solid waste and increase worker's productivity. Cleaner Production assessment was successfully conducted to come up with a program for efficient cost reduction measures for water, energy and solid waste generations. The study revealed that, through Cleaner Production, about 8% monthly energy savings is expected by shutting down air-conditioned appliances one hour per day. Eighty percent can be saved on the computer's monthly energy consumption when laptop computers are used instead of desktops. A savings of 28% on monthly water consumption if rainwater will be utilized. Monthly financial savings of not less than 180,000 pesos is expected can be attained under a sustained CP program. More than 50% of solid waste, if diverted for recycling/ processing, the institution can produce at least 35,000 pesos annually. The Cleaner Production program requiring the combined effort of the stakeholders can provide huge benefits to a school institution through improved operating and maintenance practices, cleaner technology and product changes.

Keywords **-** Environmental Engineering, Cleaner Production, Cleaner Production Assessment, Philippines

INTRODUCTION

The diverse environmental problems that exist nowadays left people with persistent drawbacks how to attain a livable and salubrious place to reside. The United Nation Industrial Development Organization (UNIDO, 2013) stressed that the global production and consumption is outpacing the renewal capacity of the natural resources and the ability of the government to manage pollutions, waste, and scarcity of resources. This calls for a balance between development and the environment through integrating environmental sustainability into the different aspect of human activities. United Nations Conference on Environment and Development (UNCED) in 1992 declared that physical development may have greatly exhausted the environment if there's no balance between development and environment. In the Philippines, numerous environmental groups along with concerned citizens both from the public and private sectors are claiming that the environment is in the critical state of destruction, something that must be given preferential attention. World Wide Fund (WWF) Global (2012) has

articulated that the Country is facing major environmental problems associated to deforestation, coastal development, pollutions and the climate change all to be blamed on natural resources mismanagement and weak law enforcement. Furthermore, WWF reported that increasing development activities, the rise of demand of goods, services and energy arising from the significant economic growth in the Country invariably put too much load on the limited capacity of the Country's' biosphere. Indeed, development comes with a price that is the deterioration of the precious resources of the State.

In addition, the Annual Report of the Environmental Management Bureau (EMB) under the Department of Environment and Natural Resources (DENR) in 2012 described the state of the Philippine environment. According to EMB-DENR (2012) the country's air quality still exceeds the DENR guideline value of 90μg/ Ncm which is caused by motor vehicles, traffic and non-compliant industries. Thus, people are at risk of air pollution-related health problems. Out of the 108 rivers 25% failed to pass because they exceeded the water quality criteria of Biological Oxygen Demand (BOD) and the Dissolved Oxygen (DO) levels. Moreover, about 60% of 89 beaches in the Country surpassed fecal Coli form count that means many of the Country's water bodies are unfit anymore for human activity. In United Nation Conference on Environment and Development (UNCED) held in Rio de Janeiro on June 1992, new goals were established for the world that communities should advocate environmentally sustainable development as a response to the global environmental issues. Sustainable development and cleaner production technology are the key to address these environmental issues (UNIDO, 2012). This study applies Cleaner Production (CP) technology to integrate environmentally sustainable initiatives and actions in an educational higher Institution.

CP paves the way for companies/organizations to improve their environmental performance while remaining competitive and profitable (Mamery, 2005). It is through CP technology that company/organizations can reduce or eliminate tradeoff between environmental protections against economic growth (UNEP, 1994). In the industry, according to Baas, L. (1994), roughly 70% of all current wastes and emissions can be prevented at source by the use of technically sound and economically profitable procedures. Such procedures and techniques are among the CP options. There have been lots of possibilities to reduce the environmental burden in the industrial production that exists; like the maximization of the environmental performance through good housekeeping, recycling of wastes, adaptation of clean technological innovations, application of

the end of the pipe techniques, and total quality management (Nowoseielski et al., 2006). These practices in the industry are also recognized CP initiatives and actions. UNIDO (2012) also promoted CP technology as a way to address the environmental issues in the industry sector. On the other hand, higher education institutions have been following this trend arising from the issue of campus sustainability (Disterheft et al., 2012). Based on the study of Disterheft et al. (2012), environmental management system is a powerful tool to enhance the operational environmental performance by integrating sustainable practices in all aspect of the organization's system. CP philosophies and practices are well suited under the programs of environmental management system. However, the knowledge and practices of environmental sustainability do not exist yet in many educational institutions (Disterheft et al., 2012).

Environmental sustainability can be integrated in schools /universities through incorporating CP into the organizational processes. CP is a solution for academic institutions that seek ways for the environmental preservation and reduction of pollution in their vicinity. Likewise, if a CP program is in place in an organization, practicing cost-effective resource management system is within reach. The main goal of this study is to evaluate a higher educational institution to generate means for maximizing water and energy resources and minimizing waste disposal.

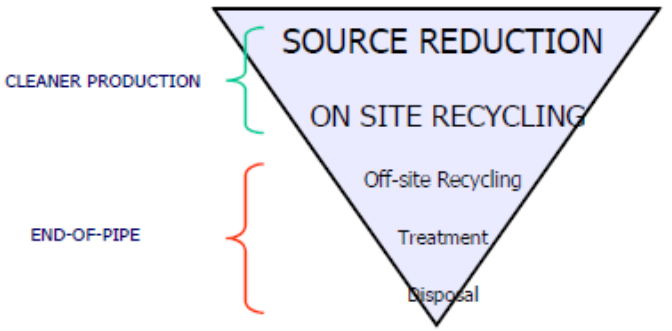
According to the Department of Science of Technology (DOST) in 2008, CP has many benefits. First, it can help companies and institutions comply with stringent environmental regulations. Second, safer and healthy surroundings can be maintained. Third, the products and services can be enhanced making them in demand to the global market. Fourth, the practice of CP can generate savings through increased productivity and environmental management. The main goal of CP is for the protection and preservation of the environment where the source of life emanates. This study purports to conduct a CP assessment in Surigao State College of Technology - a higher education institution to come up with water and energy reduction measures and resources efficiency management initiatives.

FRAMEWORK

Cleaner Production is a continuous application of integrated environmental preventive strategy to product, processes, and services to increase efficiency and reduce risks to humans and the environment (UNEP, 1994). Its ultimate goal is for the optimal use of man's resources so that people would not be dependent so

much on both renewable and non-renewable resources. CP is a result of one or the combination of conservation of resources such water, energy and raw materials, eliminating toxic materials and reducing emissions and wastes in the production processes and/or services (DOST, 2008). It protects the environment, the consumer and the worker while improving organization's efficiency, profitability, and competitiveness.

The guiding principle for resource conservation has evolved into waste management hierarchy (WMH) shown in Figure 1. WMH aims to maximize the use of a product/resource with less impact to the environment. Source reduction is at the top because the best management of the waste is not creating it in the first place (DOST, 2008). As applied to hazardous waste management, the United States Environmental Program (US EPA, 2014) stated that source reduction is the elimination of pollutants, contaminants and toxic components in the waste stream. Minimization of resources consumption like water and energy is an example of resource reduction. Recycling and re-use strategy would also significantly reduce the generation of waste. Conversion of waste materials into useful products is a way of environmental preservation. One of the many problems of academic institutions is the burdens of solid waste generations, if recycled would lead to financial savings. Reducing water consumption or utilizing wastewater that would be generated out from the buildings' use is a form of recycling initiative. If waste cannot be recycled it goes to treatment prior to disposal. CP is focusing on source reduction and recycling techniques while end of the pipe techniques is the treatment and final disposal.



Source: US EPA, 2014
Figure 1. Waste Management Hierarchy

OBJECTIVES OF THE STUDY

This paper evaluated an academic institution through cleaner production assessment with the aim of minimization of solid waste, and generating water and energy cost reduction measures. Likewise, the paper aims to estimate the financial savings out from the integration of CP into the institutional processes.

METHODOLOGY

This study employed a Cleaner Production Assessment (CPA) based on DOST standards to gather relevant data necessary for the basis of action planning. The assessment generated the CP options comprising the solid waste management actions, water and power cost reduction measures which were the basis for the environmental management program of the organization.

The CPA activities include the gathering of water and electric bills, inventory of equipment and lightings including estimation of their energy consumption, facility walkthrough, cause diagnosis analysis, interview for the selection of the priority area of assessment, waste characterization study, statistical analysis of data gathered, and CP option generation. Then the selected CP options were the basis for the CP program.

Water and power bills provided the baseline data as to how much was the consumption monthly of the buildings and facilities. Maximum consumption was taken from each year since 2010 for comparison so that the trend may be established. Then, the inventory of all appliances and lightings was conducted so that the total power consumption could be estimated and for verification purposes. The estimate of power consumption was used to compare which among the appliances and facilities consumed the highest power. It was also used to assess the power savings of some appliances if the use of the facilities is controlled. Literature review was done to gather energy reduction measures that are applicable in higher education institution. A feasibility analysis for the solar panel technology from the Engineering Department of the institution was incorporated in this study to establish the payback period of the technology. Comparison of the power consumption between laptop and desktop computers was estimated to distinguish which of the two is more energy efficient. Water reduction options were also generated from a comprehensive review. Estimation of potential water savings coming from the existing water refilling station and the construction of a water harvesting facility were performed. The period of return of investment of rainwater facility was then computed to know how many years

the institution can get a profit.

The determination of the nature of solid waste generated from the institution was determined through a waste characterization study (WACS). WACS was done through collecting all the waste in the school for four consecutive days. Waste was manually segregated, weighted and recorded. This gave the baseline data of the type of waste, amount of waste and frequency of generation. WACS provided an essential input to the solid waste management measures. Solid waste handling and treatment actions were taken from literatures.

RESULTS AND DISCUSSION

Water and energy expenditure at SSCT in year 2012 is about 2% and 9% respectively of the total maintenance and operating cost. Figure 2 provides the highest energy monthly consumption each year for the past four years based on the recorded electric bills. Every year there is about 10,000 Kilowatt-hour (KWH) increase since 2010, roughly expenses of about 63,000 pesos. At present, the energy consumption increased to almost 80,000 KWH with a difference of more than 20,000 KWH relative to the previous year and costs more than P78,000.00 (1,813. 9 USD).

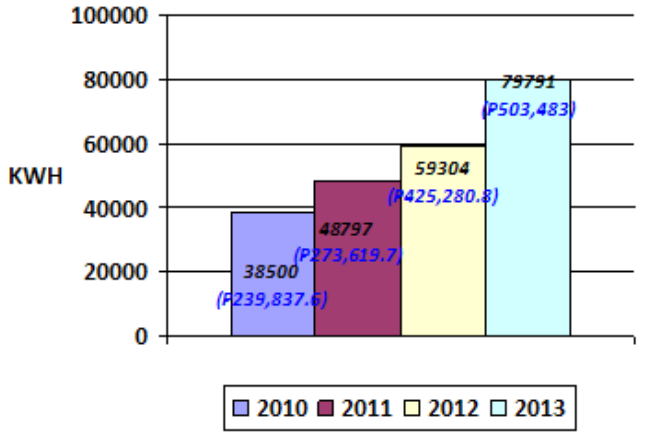


Figure 2. Comparison of energy consumption in SSCT Main Campus (2010-2013)

Based on the inventory of equipment and lightings, air-conditioner ranked the highest in terms of energy consumption, followed by desktop computers, and lastly, the other miscellaneous devices that cannot be traced yet. Untraced appliance may be due to the use of LCD projectors, charging of cellular phones, welding machine and construction-related activities. Figure 3 shows the distribution of monthly energy consumption with Air-con consumes more than 29,000 KWH monthly, more or less 36% of the total SSCT's energy consumption. Desktop computers placed second highest energy consumers, about a quarter of the entire electricity consumption. Putting the air-con off for one hour only it can save about 14,000 or 8% on its monthly consumption and in a year can save up to P170, 000.00 (3,953.5 USD) enough to finance a room improvement. Comparison of energy consumption between desktop and the laptop computers revealed that the laptop can save up to 80% of the monthly energy cost more or less P100, 000.00 (2325.6 USD). Laptop computers can use up to 60 Watts (W) only compared to 250 W of desktop computers. Based on the feasibility analysis of Solar Panel technology, using a 40 KW panel amounting to six million, the organization has an annual cost savings of more than P500, 000.00 (11,927.9 USD). This would yield 8% savings of the total power consumption and more than 10 years return of investment.

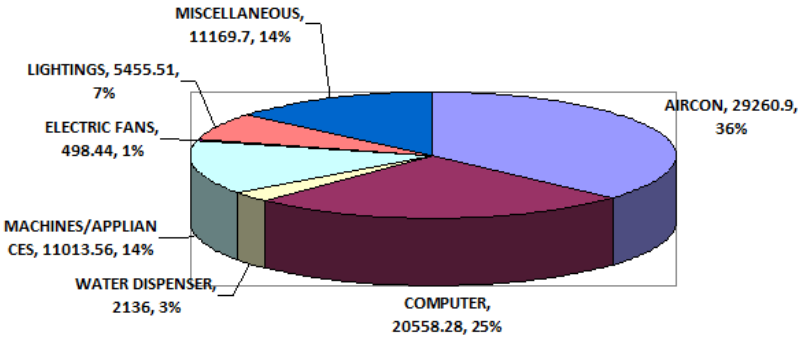


Figure 3. The distribution of energy consumption of appliances and lightings

Figure 4 compared the highest monthly water consumption for the past four years since 2010 up to 2013. Data shows a record high of more than 7,000 cubic

meter was consumed in July 2013 more than doubled the water consumption in 2012, even if the population was only less than 10 % increase. The water consumption expenditure was also doubled which costs about P272, 000.00 (6325. 6 USD).

The institution's water refilling station processed water at a monthly average of 20 cubic meters of which 60% is considered waste. If this wastewater is utilized, it can save up to more than 5000 a year enough to send a student to school. The school can also utilize rainwater to augment water demand. Using the monthly average rainwater of the Philippine Atmospheric Geophysical Astronomical Services Administration (PAG-ASA) and considering the roof catchment area almost 2000 cubic meters can be generated which can save more than 70,000 monthly. Rainwater water harvesting study of the school shows that for 1.8 million rainwater facility, it could save as much as 8 hundred thousand annually. Return of investment for the facility is just two years.

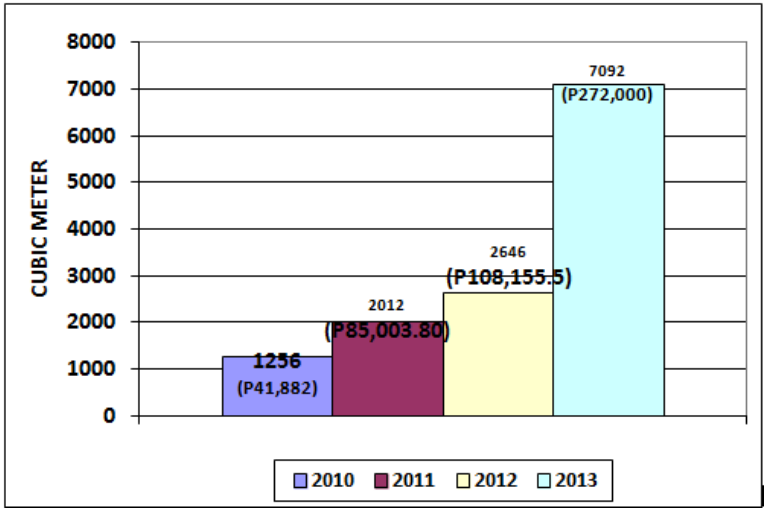


Figure 4. Comparison of water consumption in SSCT Main Campus (2010-2013)

Based on the result of the waste characterization study (WACS) that was conducted at SSCT in year 2013, it shows that the three biggest waste generations were Paper (34%), plastics (26%), and food waste (16%). Plastics component was composed of cellophane, bottles and Styrofoam. Figure 5 reveals the composition

of solid waste in SSCT. It further shows that more than 50% of the waste can be recycled under appropriate treatment strategies prior to disposal. More or less an average of 67 kilograms (kg) of solid waste was produced coming from different sources in the campus, approximately 9 grams (g) per capita per day that is below the 0.5 kg per cap per day generation of a Municipal Solid Waste (MSW). The school can generate as much as P35,000.00 (813.9 USD) yearly through recycling and selling the recyclable waste to the junk shops.

Cleaner production program (CPP) can set the tone in managing the increasing power and water consumption, as well as the burden of solid waste in SSCT. This CPP formed the basis of the water and energy cost reduction measures outlined in table 1-3. The CP program shown in table 1 and 2 targeted a reduction in both water and energy consumption by 20%, which is translated to monthly savings of P150, 000.00 (3,488.4 USD). CP options under each table from Table 1 to 3 were divided into two, short term and long-term options. Short term CP options are those measures and initiatives that do not require big capital investment and longer approval by officials. The long-term options require more than six months accomplishing because of the considerable financial considerations needed. It also requires the support and approval of the higher officials before those CP options would be integrated into the school system. Some long- term options are still subject for feasibility analysis and further research studies to establish their viability and the economy of use.

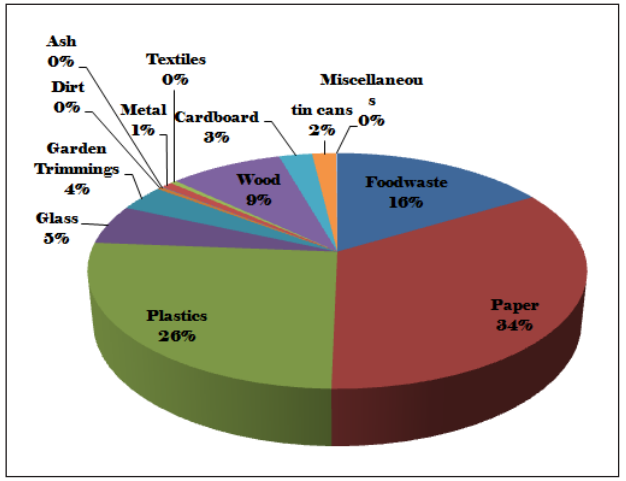


Figure 5. Solid waste composition based on WACS in SSCT

Cleaner production options cover improvement on operating conditions; product changes, improving equipment/technology, good housekeeping practices, input material change, and waste management. The CP program will have evaluation and monitoring for its proper implementation and making sure of the sustainability of the program at the same time form the basis of the creation of environmental management system.

Some of the cleaner production options as stated in table 1, 2 and 3 presents exemplary technological innovations in the industry that is also can be very effective environmental management tool for an academic institution like SSCT. Technological innovations such as the use of clean technology, modification of the production process, improvement on cleaning methods reducing water, energy and material consumptions brings the best profit (Nowosielski R. et al. (2007). Ashton et al. (2002); Huhtala (2003); and Geiser (2001) also said that these CP measures such minimization on waste resources may increase productivity including lots of benefits that can have both environmental and economic gains. Moreover, the work of Mamery in 2005 asserted too that using energy saving bulbs and energy saving equipments and devices have high energy saving potentials including the utilization of biogas and solar power technology. Education and training about CP is one of the important findings that need to be given preferential attention for the CPP to be integrated successfully. The work of Huisingh et al. (2000) and Luken et al. (2004) recognizes the significance of training to broaden the knowledge and deepen the skills of people regarding CP considering that no formal education is available for this CPP.

Proposed CP Program

FOCUS AREA: SURIGAO STATE COLLEGE OF TECHNOLOGY
A.) CP TARGET: Reduce Electricity consumption by 20%

Table 1. Energy cost reduction measures

FINDINGS	BENEFITS	CP OPTIONS		RESPONSIBLE PERSON
		Short Term Action (<6 months)	Long-Term Action (>6 months)	
A.)Intensify initiatives on energy conservation	Significant savings on electric consumption as much as 25%	*Educate employee on energy saving tips *Turn-off lights when, not in use *Put the computer in Sleeping mode *Avoid unnecessary air-conditioning *Unplug appliances if turned-off * Turn off the computer monitor if I'm not going to use my computer for more than 20 minutes *Turn off your screensaver. *Turn off all equipment at the end of the day. *Appoint someone to monitor energy consumption * Change the thermostat settings in rooms to 25.5^0 during warmer months and 20^0 during cooler months. *Encourage everyone to keep doors and windows closed when heating or air conditioning is running. * Use recycled paper towels instead of electric hand dryers in toilets.	*Develop a comprehensive Energy management system. *Initiate Education & training * Incorporate energy conservation initiatives in the operations	Administration/ Faculty/Staff/ Students

FINDINGS	BENEFITS	CP OPTIONS		RESPONSIBLE PERSON
		Short Term Action (<6 months)	Long-Term Action (>6 months)	
		* Using fans can make people feel degrees cooler, at much less cost than air conditioning. * Create a "Save Energy" Sign *Adjust Temperatures to ensure minimum energy use for a given comfort level * Clean my air conditioning unit's condenser of dirt and debris regularly *Look for energy star label on devices/lightings in planning to purchase *Plant deciduous trees to cover window during hot season *Establish Electricity Conservation Manager and a team to monitor *Turn-off the Aircon 1- 2 hours per day *Replace desktop with laptops *Implement energy efficiency for motors	*Develop a comprehensive Energy management system. *Initiate Education & training * Incorporate energy conservation initiatives in the operations	Administration/ Faculty/Staff/ Students
2.) Utilize energy saving technology	Electric savings of 20% on lightings and as much as 50% on appliances.	* Use Compact fluorescent lamp (CFL) with energy star label (10,000 hours) *Avoid turn-on & off CFL several times * Use light-emitting diode (LED) lightings (30,000 hours) *Use air-con with thermostat	*Install smarter switches ($96) with infrared heat detection that sense people proximity & motion to turn the light on and off. *Use Solar Photovoltaic panels technology	

			* Use of Solar heater *Install high-quality electronic ballasts with T8 florescent tubes. *Purchasing Energy-saving devices/fixtures.	Administra-tion
3.) Intensify Education and Training on electricity reduction strategies	Increased awareness encourages more participation	* Conduct Trainings on a regular basis	* Build Experts in Electric conservation	Energy conservation officer/ Monitoring Team(Cause Champion)

Source: Mahlia, T. et al. (2010)/ Tseng, M. et al. (2013)/ Zhang, N. et al. (2011) Park, C. et al. (2009)/ Nedevschi, S.(2008)/ Akbari, H. (2002)/ Arms, S. et al. (2005)/ Lorch, J. (1998)/ Seligman, C(1977)/ Peattie, K.et. al (2009).

B.) CP TARGET: Reduce Water consumption by 20%

Table 2. Water cost reduction measures

FINDINGS	BENEFITS	CP OPTIONS		RESPONSIBLE PERSON
		Short Term Action (<6 months)	Long-Term Action (>6 months)	
A.)Intensify management practices on water conservation	Significant savings on water consumptions as much as 20%.	* By fixing dripping hot water faucets, can save water *Check water consumption regularly * Repair water leaks and leaky toilets. * Bring a water bottle to school to avoid using a drinking fountain that can use more water than a person drinks.	*Integration of water conservation policies in the employee orientation manual and training program * Recycle wastewater *Recycle rainwater	Administration/Faculty/ Staff/Students

		* When washing hands, do not let the water run while soaping up your hands. *Shut-off faucet when, not in use * Dispose tissues or solid waste in a trash container rather than in the toilet. * Take shorter showers * When washing dishes by hand, fill one sink or basin with soapy water. *Quickly rinse under a slow-moving stream from the faucet. *Do not use running water to thaw meat or other frozen foods. Defrost food overnight in the refrigerator. * Kitchen sink disposals require a lot of water to operate properly. Start a compost pile as an alternate method of disposing of food waste instead of using a garbage disposal. * Always use a broom to clean walkways, driveways, and entrances rather than hosing off these areas.	*Maximize the use of natural vegetation by establishing smaller lawn. Shrubs and ground covers provide greenery for much of the year and usually demand less water. * Waste treatment technology	
2.) Utilize of water-saving technology assured of water less cost.	Reduce 20% or more on water consumption	*Utilize water-saving technology (low flow faucet and toilet) *Use water free urinals *Utilize new cleaning methods/technology	*Use economical toilet flush systems *Plan out and build rain water facility *Install automatic shut-off devices on faucets	Administration

			* Retrofit all wasteful faucets by installing aerators with flow restrictors. *Water conservation program be implemented.	
3.) Intensify Education and Training on electricity reduction strategies	Encourage awareness as well as initiatives	*Conduct Awareness Campaign and Training	* Build experts on water conservation	Water conserva-tion Officer/Monitoring Team (Cause Champion)

Sources: Gavrilescu, M. et .al (2008)/ Niemczynowicz, J. (1993)./ Lindahl, M. et al. (2013)/ Tseng, M. et. al(2013)/ Zhang, N. et al./ Brown, R. R. (2005). (2011)/ Gleick, P. H. / Roberts, I. M (2004)

C.) CP TARGET: Reduce solid waste generation by 25% and recycle 50% of the solid waste.

Table 3. Solid waste reduction measures

FINDINGS	BENEFITS	EPI	CP OPTIONS		RESPONSIBLE PERSON
			Short Term Action (<6 months)	Long-Term Action (>6 months)	
A.)Improve management practices on solid waste	Significant SW reduction by 20%		* Use recycled notebooks and stationery * Recycle aluminum cans and plastic bottles. * Use paper-reducing strategies. *Consider double-sided printing, re-using paper and using e-mail instead of mailing or faxing documents.	* Implement incentive scheme	Administration/ Faculty/Staff/ Students

			*Sell recyclable waste *Design appropriate storage and collection mechanism		
2.) Waste to energy conversion and modernizing process and waste material recovery	Gain additional profit in SW recycling, reuse and treatments.		* *Provide containers enough to store SW temporarily at strategic locations	*Biogas Technology Build an MRF enough to process waste *Composting facility *Material and Energy Recovery Facility	Administration
3.) Intensify Education and Training on SW reduction strategies	Encourage awareness as well as initiatives		*Initiate waste reduction program & training.		Solid management Committee officer/ Monitoring Team(Cause Champion)

Source: Darlington, R.(2009)/ Tseng, M. et. al(2013)/ Zhang, N. et al. (2011)/ Tınmaz, E. et. al (2006)/ Stefan, A. et. al (2008)/ He, Y (2014)/ Lahore, P. S. W. C. (2010)/ Beattie, A. (2014)/ Ostrem, K. M. et. al (2004)

CONCLUSIONS

Cleaner production program is the key to efficient resource management of the Institution. CPP would address the growing environmental degradation because of too much demand of the people on the environment. Optimizing the use of available water and energy resources at minimal waste generation is the goal of CPP. The CPP in this study comprises water and energy cost reduction measures as well as solid waste minimization. CPP as integrated program advocates sustainable development. Sustainable development requires that there should be a balance between institutional development and environmental preservation. An institution can generate more money without compromising the need to protect the environment. With CP advocating reduction or minimization of waste, it would greatly enhance the environmental performance. Wise spending and utilization of resources through CP entails lots of savings at the same time would have less impact to the environment.

RECOMMENDATIONS

Intensifying the initiatives and efforts on conservation of water and energy through improvement of the operational practices may significantly reduce if not eliminate unnecessary wastage. CP based policies and guidelines would support strongly the said initiatives. Although big capital is needed for the investment on cleaner technology, but this technology would guarantee economic return and environmental protection. Education and training of people also may increase participation and the rate of success on CP integration. Thus, it is important to have as many partners in the CPP with appropriate expertise to be able to accurately resolve the high resource consumption. Successful application of cleaner production requires the concerted effort of the management and the stakeholders.

With less waste means savings, with more savings means more productive and the more productive, the greater the success is expected of an institution.

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