TOTAL WASTE MANAGEMENT USING CLEANER PRODUCTION AND INDUSTRIAL ECOLOGY PRINCIPLES IN SRI LANKAN HOTEL SECTOR

*A.M.G.E Weerawansa[1], W.M.S.M. Samaraweera[1], A.K. Kulatunga[1], M.T.R Dissanayake[2]

[1]Dept. of Production Engineering, University of Peradeniya
[1]E-mail:*gayan.weerawansha@gmail.com[1], sumith.samaraweera@gmail.com[1], aselakk@pdn.ac.lk[1]
+94716619146, +94772399079, +94718222535

[2]Institute of Post Harvest Technology, Anuradhapura
[2]mrdisanayake@yahoo.com

Abstract: Hotel sector is one of the main revenue earners in current Sri Lankan economy. This sector is rapidly growing post war period. Since tourists arrive Sri Lanka comes for diverse reasons hotels are located in all around the country to attracting these tourist groups and mostly this industry is located adjacent to environmentally sensitive places such as virgin forests, beaches and archeologically significant locations. Due to this number of protests and demonstrations also happened in certain places for opposing this industry expecting that there would be environmental damages sometime ago. Therefore, proper environmental management practices are of paramount importance. Waste disposal is one major area which needs to be addressed first and foremost.

Waste generated in this industry can be divided into solid waste and waste water. Furthermore, solid waste can be divided into biodegradable and non degradable waste. Waste water is generated from the laundry, kitchen, toilet /bathroom cleaning etc. Some of the waste categories depend on the occupancy of the hotels and some depend on the reception functions which are held in hotels (ex. Kitchen waste generated after wedding functions etc). However, it is impossible to minimize this type of waste generation or to educate the guests on waste generated issues due to the nature of the industry and high competition in this sector. Therefore, best possible options remains are to have proper waste management system to run this industry in sustainable manner. If there is a way to reuse waste generated then there will not be much impact to the industry. Conversely Cleaner Production (CP) and Industrial Ecology (IE) principles are being used successfully in manufacturing sector for many years to address the waste generated in those industries.

Hence in this research these two concepts are used in local hotel sector to manage waste generated. There are number of ways waste is reused in productive manner. Out of them energy harnessing from biogas generators are significant. The biogas generator which converts all biodegradable waste generated to useful flammable biogas Methane (CH_4). This gas is used completely as a fuel to pre-heat water which is used in steam boiler for laundry purposes thereby reduces diesel consumption for boiler firing considerably. Only percentage of waste water is used for biogas generation, rest of the wastewater and wastewater mixed with chemicals are treated in treatment plant and treated water is used for gardening purposes and organic farming and some studies are carried out to use them for water fountains etc. Furthermore, non-degradable wastes are segregated at the point of generation and sell them for recycling purposes. A pilot project is carrying out in one of the leading hotels in Kandy and preliminary studies were done with already established hotel which has bio gas generator in Uva province. Results reveals that shows that diesel and LP gas consumption can be reduced considerably.

Keywords: *Wastewater, solid waste, Cleaner Production, Industrial Ecology, bio gas, organic farming*

1. Introduction

Sri Lanka has all of a sudden become one of the safest tourists destinations post war era. To support this fact, many western countries which previously imposed travel restrictions have lifted. Even US times named Sri Lanka as the best place to travel in the recent past. Conversely,

many popular destinations of other countries such as Indonesia (bali), Thailand (Puket), India etc. suffering from unrests and terrorists activities. This creates overwhelming advantage over the other regional tourist destinations. These geo-political issues leads to arrive large number of tourists in the first half of the year and it is expected that this year the foreign tourist arrival will hit record 700,000 figure for the first time. The Sri Lankan government expects to increase room capacity to 16,000 by year 2012 where present capacity is around 6,000. Due to these expansions, many damages can happen to the environment since most of the hotels put up in the vicinities of beaches, forest reservations or archeological sites. In addition during the operations many environmental impacts can happen (waste generation from the hotels, Green house gases emissions etc.). Therefore, proper environmental management practices are paramount importance. Waste disposal is one major area which needs to be address first and foremost.

Waste generated in hotel sector can be divided into solid waste and wastewater. Furthermore, solid waste can be divided into biodegradable and non degradable waste. Waste water is generated from the laundry, kitchen, toilet /bathroom cleaning etc. Some of the waste categories depend on the occupancy of the hotels and some depend on the reception functions which are held in hotels (ex. Kitchen waste generated after wedding functions etc). However, it is impossible to minimize this type of waste generation or to educate the guests on waste generation due to excessive usage food due to the nature of the industry. Therefore, best possible options remains are to have proper waste management system to drive this industry in sustainable manner. If there is a way to reuse waste generated then there will not be much impact to the industry. Conversely Cleaner Production (CP) and Industrial Ecology (IE) principles are being used successfully in manufacturing sector for many years to address the waste generated in those industries.

Therefore, in this research we proposed hotel ecological cycle based on CP and IE concepts to convert solid waste into useful products. These two concepts already proven that business performance can be enhance by practicing them [1]. This cycle uses already discovered technologies yet the concepts can be used to operate the hotel sector more environment friendly atmosphere. In developed countries already proven that good environmental practices helps to increase the hotels performance [2]. Therefore this concept is useful to operate this industry in sustainable manner in the long run. There are number of ways waste is reused in productive manner. Out of them energy harnessing from biogas generators are significant. The biogas generator which converts all biodegradable waste generated to useful flammable biogas Methane (CH4). There are many types of biogas generators. Depends on the feeding frequency and operating atmospheric temperature, type varies [3]. The gas generated can be used completely as a fuel to pre-heat water which is used in steam boiler or even for cooking purposes. Only percentage of waste water is used for biogas generation, rest of the wastewater and wastewater mixed with chemicals are treated in treatment plant and treated water is used for gardening purposes and organic farming. Furthermore, non-degradable wastes are segregated at the point of generation and sell them for recycling purposes. Furthermore, non-degradable wastes are segregated at the point of generation and sell them for recycling purposes.

Rest of the paper is arranged as follows; in section 2, overview of biogas plants is given. In section, three the proposed hospitality industry cycle is presented. This is followed by a case study and finally the conclusion and discussion.

2. Anaerobic Digestion

Anaerobic digestion is a series of processes in which microorganisms break down biodegradable material in the absence of oxygen, used for industrial or domestic purposes to manage waste and/or to release energy. It is widely used as part of the process to treat wastewater. As part of an integrated waste management system, anaerobic digestion reduces the

emission of landfill gas into the atmosphere. Anaerobic digestion is widely used as a renewable energy source because the process produces a methane and carbon dioxide rich biogas suitable for energy production, helping to replace fossil fuels. The nutrient-rich digestive which is also produced can be used as fertilizer. The digestion process begins with bacterial hydrolysis of the input materials in order to break down insoluble organic polymers such as carbohydrates and make them available for other bacteria. Acidogenic bacteria then convert the sugars and amino acids into carbon dioxide, hydrogen, ammonia, and organic acids. Acetogenic bacteria then convert these resulting organic acids into acetic acid, along with additional ammonia, hydrogen, and carbon dioxide. Finally, methanogens convert these products to methane and carbon dioxide. Anaerobic digestion is particularly suited to organic material and is commonly used for effluent and sewage treatment. Anaerobic digestion is a simple process that can greatly reduce the amount of organic matter which might otherwise be destined to be dumped at sea, land filled or burnt in an incinerator. Almost any organic material can be processed with anaerobic digestion. This includes biodegradable waste materials such as waste paper, grass clippings, leftover food, sewage and animal waste. In developing countries simple home and farm-based anaerobic digestion systems offer the potential for cheap, low-cost energy for cooking, lighting, heat generation and electricity generation. The conversion process is given in Figure 1.

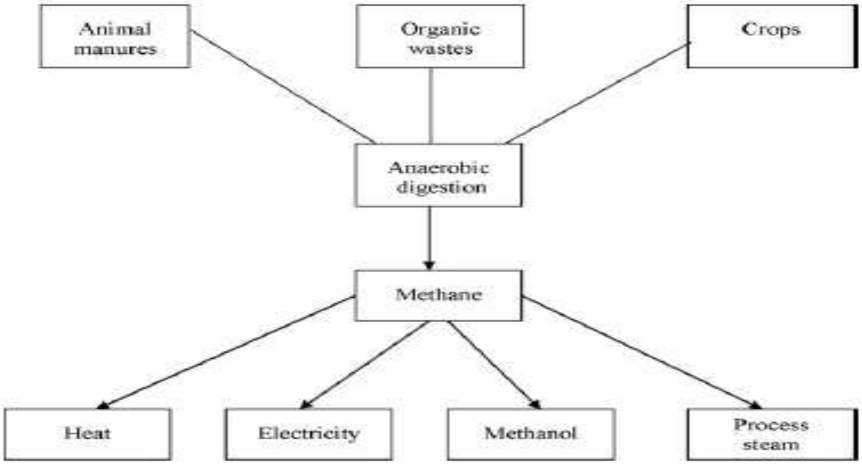

Figure 1: *Process of methane generation [4]*

3. Methodology – Hotel eco cycle

There are number of methods already adapted in many industries to manage waste generated in their own industries. Early days everybody tried to dump waste wherever possible. However due environmental pollution related issues, due to rules are regulations industrialists had to stop discharging wastewater and even dumping solid waste to environment and began to start waste management. During this era end of pipe wastewater treatment plants became famous to handle wastewater and compost fertilizer processing was the solution or to dump solid waste and covered them with soil were the methods practiced. However, when resources used in the industries became scar especially the water, fuel and energy, many industries realized that they are using the resources inefficiently. In order to address this Cleaner production (CP) tool was developed in early 1990s. Instead of treating the waste at the end of the pipe, CP tries to reach the point of waste generation and to address problem with the view of minimizing waste generation. In addition, due to same resource scarcity situation, Industrial Ecology concept became famous among the cluster of industries to reuse the waste generated at one industry as raw material in anther industry. In the proposed hotel-ecology cycle, this research focused to used both CP and IE concepts together for the single industry: the hotel sector since many hotels at the moment experiencing high operational costs due to high fuel/electricity and food

items prices from one side and environmental management problems due to higher waste quantities generated daily in solid and liquid from the other side.

In the first phase of the proposed cycle, main waste streams are identified by walk through assessments and material balancing. Here in hotel sector, and main waste streams are coming from restaurants and kitchen. Higher amount of wastewater is generating from cleaning and housekeeping operations. In the second phase, waste types are segregated into different categories and later addressed each category separately. In the third phase bio-degradable waste is used for useful energy generation purposes through anaerobic digesting process and biogas is harnessed and thereby energy requirements of the hotel can be reduced certain percentage. In addition, there will be compost fertilizer as by product from bio-gas plants which can be used for gardening and organic farming. Furthermore, another waste generated from hotels kitchen: the fried cooking oil is used to mix with boiler fuel after filtering and used after blending and this also helps to dispose waste and to reduce the energy bill even at small scale. In the fourth phase, untreatable and unrecyclable waste at the location is segregated and stored at controlled conditions thereby they can be easily sell to potential buyers. These waste groups include solid non-degradable wastes such as empty bottles, waste papers etc. Infect, waste papers also can be recycled and used for rapping and other requirements which will attract foreign tourists and this can be used as marketing purposes as a sustainable eco friendly organization. The wastewater as usual treated by treatment plant, however, the wastewater load to be treated will be less since waste streams are minimized at the source of generation and some of the solid waste mixing with water. Ultimately this will minimize energy requirements to operate wastewater treatment plant. Furthermore, treated water is used for farming and gardening purposes thereby to minimize fresh water usage. The proposed Hotel-ecology cycle is presented in Figure 2.

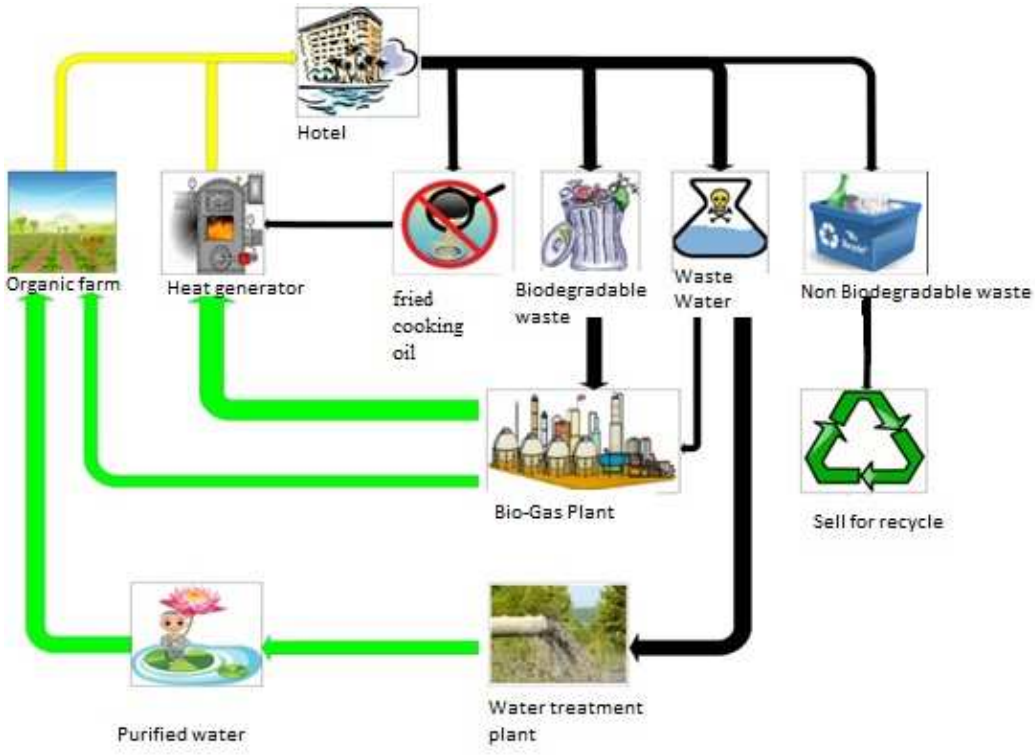

Figure 2: – *Hotel Eco Cycle*

4. Case Study

A pilot project was carried out at a hotel maintained by Uva Provincial council situated at the beneath of Namunukula mountains near to palgahatenna town. This hotel consists of 200 numbers of rooms and a garden with small area for organic farming. As our hotel-ecology cycle proposes, initially waste steams were identified and tried to minimize at the point of generation and latter kitchen and restaurants bio-degradable waste based bio gas plant was put up with the technical assistance from Uva management Development and training Institute of Uva provincial council. In order to operational difficulties fixed dome type biogas plant was designed to match with average daily bio degradable solid waste of 50kgs which accounts from approximately 100 plates for breakfast, 200 plates for lunch and 150 plates for dinner. Main advantage is of this type of bio gas plants is that waste can be fed daily basis and digested sludge also can be collected regularly. Basically it has one dome and it is separated to the two partitions by a wall. And one side is open to the inlet and other side is open to the outlet. The generated bio-gas also contain in the same dome. It is very easy to maintain that kind of bio-gas plant with very low operational cost. Since there is no separate tank to collect biogas, pressure of the dome has to be maintained at safety limits. In order to facilitate this, separate pressure relief valve is connected with auto igniting burner since the main constituent of biogas CH4, is a green house gas.

In order to minimize waste load on wastewater treatment plant and to get more inputs to convert useful biogas, sewage system of the hotel also connected to the biogas plant which facilitated solid waste – water ratio to maintain anaerobic reaction efficiently. The figure 3 shows the schematic of the fix dome type bio gas plant.

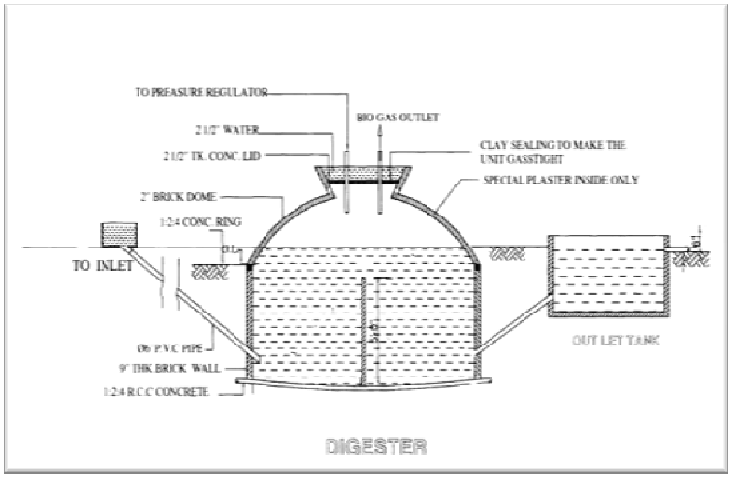

Figure 3: *Schematic of the Chinese type fix dome bio gas plant* [5]

The Figure 4 and Figure 5 show the solid waste handling before and after the pilot project. Before the project all the waste dumped together, however after the projects solid waste is segregated as much as possible. Therefore unusable wastes such as bottles, plastics etc. can be easily sell to interested parties.

Figure 4: *Display of the bio gas plant in the hotel*

Figure 5: *Solid waste dumps before the project*

Figure 6: *Waste segregation after the project*

The biogas rector has the capacity of 40m^3 and daily input of solid waste is 50kgs and water content is 40l, after 15 to 21 days of initial commissioning biogas generation was started slowly currently per day around 1 m^3 is harnessed and savings from LP gas for cooking is 12.5 kg cylinder within every two days. The design calculations and breakeven analysis of the biogas rector is given in the appendix and the specific details of the biogas plant and cost for the project, daily harnessing and savings are given in Table 3. The other saving aspects of the pilot project are not presented in this study though the different phases of the proposed cycle are adapted. The second pilot project is already started in medium scale hotel in Kandy and preliminary studies shows that this project also will deliver good results.

Table 3: *Specific details of the biogas rector*

Capacity	$40m^3$
Type	Chinese fix dome
Daly waste input	40-50 kg
Daily output Biogas	$1.5m^3$
Saving per day	1/4 to1/2 LP gas cylinder
Daily fertilizer gain	15-20 Kg

Figure 9: *Hotel biogas plant and the Natural beauty after project*

5. Conclusion

This paper presented an environmental friendly self sustainable hotel ecology cycle to minimize waste generated and to use waste generated into useful products such as energy and fertilizer. This cycle was based on the two popularly used environmentally friendly concepts of CP and IE which are currently practiced in manufacturing sector extensively. The main outcome of the project was the design and development of biogas rector which transform bio degradable waste into biogas which can be used for cooking purposes. Results reveal that from daily waste of 50 kgs the hotel can save up to Rs 35000/- per month and will get dry compost fertilizer of 30-35 kgs per month.

6. References

1. S.X. Zeng, X.H. Meng, H.T. Yin, C.M. Tam, L. Sun, (2010), “Impact of cleaner production on business performance”, Journal of Cleaner Production, 18 (2010) 975-983
2. J. F. Molina-Azorı´n, E. Claver-Corte´s, J. Pereira-Moliner, J. Jose´ Tarı, (2009), “Environmental practices and firm performance: an empirical analysis in the Spanish hotel industry”, Journal of Cleaner Production 17 (2009) 516–524
3. M. Nazir (1991), “Biogas Plants Construction Technology for Rural Areas” *Bioresource Technology* 35 (1991) 283-289
4. R. M. Jingura, R. Matengaifa, (2009), “Optimization of biogas production by anaerobic digestion for sustainable energy development in Zimbabwe”, Renewable and Sustainable Energy Reviews 13 (2009) 1116–1120
5. Chinese type biogas reactor – Schematic drawing of National Engineering Research Centre (2009)

7. Appendix

Feasibility Analysis (change according to Uva Project)

Daily Biodegradable Kitchen Waste generation =50 kg (per day)

Considering the previous experimental results

Amount of bio gas generation = 1500 liters ($1.5m^3$)

Volume of CH_4 = 1.5X60/100 (60%of CH_4 in Biogas)
= $0.9m^3$

Bio gas will be generated just 500 Pa at room temperature

Mass of methane = 6.528X0.9

= 5.9kg

Energy generated = 5.9X55.7 (Methane produces more heat per mass unit =55.7 MJ/kg)

= 329Mj

Equivalent LPG saving =329/46.1 (LP Gas typically releases about 46.1 MJ/kg)

= 7.1kg

Saving from LPG per month =7.1X1700X30/13.5 (13.5kg Gas cylinder is to be Rs 1700.00)

= **Rs 26282.00**

Compost fertilizer generation per Day

=15kg

Economic value of fertilizer =15X30X10(Rs 10/- per 1kg)

=Rs**4500.00**